UNIVERSITY OF NOVI SAD
Technical faculty "Mihajlo Pupin"
Zrenjanin, Republic of Serbia

Industrial Engineering and Environmental Protection

IIZS conference 2012

PROCEEDINGS

II International Conference - Industrial Engineering And Environmental Protection (IIZS 2012)

Zrenjanin Town Hall
Zrenjanin, 31st October 2012.

II International Conference - Industrial Engineering And Environmental Protection (IIZS 2012)

University of Novi Sad
Technical faculty “Mihajlo Pupin”
Zrenjanin, Republic of Serbia

II International Conference Industrial Engineering and Environmental Protection (IIZS 2012)

Proceedings

Zrenjanin, 31st October 2012.

II International Conference - Industrial Engineering and Environmental Protection (IIZS 2012)

Organizer of the Conference:
Technical faculty "Mihajlo Pupin", Zrenjanin, University of Novi Sad, Republic of Serbia

Reviewers:
Ph.D James G. Speight, CD&W Inc., Laramie,Wyoming, USA
Ph.D Slawomir Kurpaska, Professor, University of Agriculture in Krakow Institute of Agricultural, Engineering and Informatics
Ph.D Dragiša Tolmač, Professor, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia
Ph.D Miroslav Lambić, Professor, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia

Publisher:
Technical faculty "Mihajlo Pupin", Zrenjanin, University of Novi Sad

For publisher:
Ph.D Milan Pavlović, Dean of Technical faculty "Mihajlo Pupin", Zrenjanin

Technical treatment:
Ph.D Eleonora Desnica, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia
Ph.D Ljiljana Radovanović, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia
MSc. Jasmina Pekez, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia

Design:
MSc. Stanislava Sinđelić, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia

Lecturer:
MSc. Dragica Ivin, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia

Printed by: Printig office »Diginet«, Zrenjanin
Circulation: 100
ISBN: 978-86-7672-184-9

CIP – Каталогизација у публикацији
Библиотека Матице српске, Нови Сад

502/504 (082)

INTERNATIONAL Conference Industrial engineering and Environmental Protection (2; 2012; Zrenjanin)
Proceedings / II International Conference Industrial Engineering and Environmental Protection (IIZS 2012), Zrenjanin, 31st October 2012; [organizer of the Symposium] Technical faculty "Mihajlo Pupin", Zrenjanin . – Zrenjanin: Technical faculty "Mihajlo Pupin", 2012 (Zrenjanin: Diginet) – 490 str. : ilustr.; 30 cm.

Tiraž 100. – Str. 5: Introduction/ Dragiša Tolmač
Bibliografija uz svaki rad.

ISBN 978-86-7672-184-9
1. Technical faculty "Mihajlo Pupin" (Zrenjanin). – I. IIZS conference (2; 2012; Zrenjanin) v. International Conference Industrial Engineering and Environmental Protection (2; 2012: Zrenjanin)

а) Животна средина – Заштита - Зборници
COBISS. SR-ID 274556935

Organizing Committee:

Ph.D Dragiša Tolmač, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia
Ph.D Živoslav Adamović, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia
Ph.D Miroslav Lambić, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia
Ph.D Slobodan Stojadinović, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia
Ph.D Slavica Prvulović, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia
Ph.D Eleonora Desnica, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia
Ph.D Ljiljana Radovanović, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia
MSc. Jasmina Pekez, Technical faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia

INTRODUCTION

Departments of Mechanical engineering and General Technical Sciences, at Technical Faculty "Mihajlo Pupin", Zrenjanin, organized two international conferences:
1. »PTEP 2011. - Process Technology and Environmental Protection»,
2. «IIZS 2012. - Industrial Engineering and Environmental Protection».

Industrial engineering is a field of technique, which includes the processes and procedures, plants, machinery and equipment used in manufacturing final products in different industries. The task of industrial engineers is that on the basis of theoretical and practical knowledge, solve specific problems in engineering practice, and the development of technology in the field of industrial production process. Graduate industrial engineer deals with the organization of people, materials, equipment and information in order to achieve better business results. Industrial engineers have the opportunity for employment in different sectors - manufacturing and service.

The theme of scientific conference «IIZS 2012», covers the fields of industrial engineering, which are defined in the program of the conference, such as: Process technology, Engineering, Environmental protection, Health and safety, Manufacturing technology and materials, Machinery maintenance, Design and maintenance of process plants, Basic operations, Machines and processes, Information technology and engineering education, Biotechnology, Reengineering and project management.

The main goals of the conference can be indentified here: innovation and expansion of knowledge engineers in industry and environmental protection; support to researchers in presenting the actual results of research projects, establishing new contacts with leading national and international institutions and universities; popularization of the faculty and its leading role in our society and the immediate environment, in order to attract quality young population for studing at our faculty, cooperation with other organizations, public companies and industry; initiative for collecting ideas in solving specific practical problems; interconnection and business contacts; introducing professional and business organizations with results of scientific and technical research; continuous improvement and learning in terms of economy, presentation of scientific knowledge and exchange of experiences in the field of industrial engineering, review of development trends in Serbia and abroad with the aim of expanding international cooperation and expansion of professional and scientific work at Technical Faculty «M. Pupin».

We express gratitude to: Ministry of Education and Science of the Republic of Serbia, Zrenjanin Town Hall, Regional Chamber of Commerce, as well as the management of Technical Faculty «Mihajlo Pupin», University of Novi Sad, for supporting the organization of the conference «IIZS 2012. - Industrial Engineering and Environmental Protection». We are also grateful to all the authors who have contributed with their works to the organization of the scientific meeting «IIZS 2012.».

We would like our Conference to become a traditional meeting of researchers, every year. We are open and thankful for all useful suggestions which could contribute that the next, International Conference - Industrial Engineering and Environmental Protection (IIZS 2013.), become better in organizational and program sense.

President of the Organizing Committee
Prof. Ph.D Dragiša Tolmač

Zrenjanin, 31st October 2012.

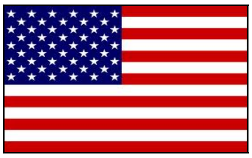
Conference participants are from the following countries:

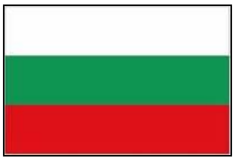

Serbia


Bosnia and Herzegovina


FYR Macedonia

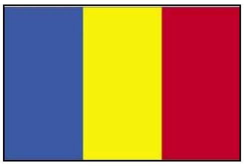

Slovakia


United States of America


Bulgaria


Montenegro

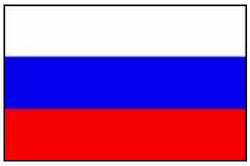

Hungary

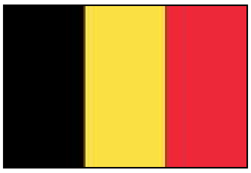

Romania


United Arab Emirates


Germany


Croatia


Russia


Belgium

CONTENTS

SESSION 1: Process Technology………………………………………………………….. 11

METHODS FOR DETERMINATION OF BIOMASS ENERGY PELLETS QUALITY (Zorica Gluvakov, Miladin Brkić, Todor Janić).. 12

THE UTILIZATION OF PENETRATION METHODS AT THE SOIL PROTECTION (Jozef Bajla, Ján Gaduš, Tomáš Boďo, Štefan Jančo)……………………………………………….. 21

BIOMASS IN SERBIA – RESOURCES, BARRIERS AND POSSIBLE SOLUTIONS (Dragoljub Živković, Marko Mančić, Velimir Stefanović, Saša Pavlović)……………………... 27

MULTIFUNCTIONAL USE OF SOIL RESOURCES AND ITS INFLUENCE TO CROP PRODUCTION-PROTECTION AND RECOVERY (Vesna Kraišnik, Husnija Resulović, Esad Bukalo)…………………………………………………………………………………….. 35

OVERVIEW OF RELEVANT INFORMATION ON THE USE AND PRODUCTION OF BIODIESEL (Zoran Carkic, Jörg Lükert, Dragana Dimitrijević, Slavica Prvulović, Dragiša Tolmač, Jasna Tolmač)……………………………………………………………………….. 40

SUPERCRITICAL FLUID EXTRACTION – PERSPECTIVE OF NEW TECHNOLOGY (Snežana Filip, Kiril Lisičkov, Nina Đapić)... 46

SESSION 2: Engineering Environmental Protection and Safety at Work………………... 52

THE EVOLVING REFINERY AND RISK ANALYSIS (James G. Speight, Ljiljana Radovanović, Dragana Glušac)………………………………………………………….... 53

SOME EXPERIENCES FROM RISK ASSESSMENT AT "HEALTHY" FOOD PRODUCTION (Vangelce Mitrevski, Tale Geramitcioski, Vladimir Mijakovski, Monika Lutovska)…………………………………………………………………………….............. 58

USE OF ALUMINIUM IN THE PRODUCTION OF CARS (Radoje Vujadinović, Uroš Karadžić)…………………………………………………………………………………..... 65

IMPROVING SAFETY AND HEALTH AT WORK THROUGH A STANDARD OHSAS 18001 (Biljana Gemović)………………………………………………………………… 69

REVIEW INFORMATION ABOUT THE RECYCLING OF TIRES (Dragiša Tolmač, Dimitar G. Petrov, Slavica Prvulović, Dragana Dimitrijević, Jasna Tolmač)............................. 78

IMPROVEMENT OF THE WOOD BIOMASS HEATING SYSTEM CONTROL (Saša Prodanović, Srđan Vasković, Zoran Radović).. 83

ECO- INNOVATION AND ENVIRONMENTAL MANAGEMENT IN SMEs IN EU (Milica Stanković, Dragana Drinić, Nikolina Krneta).. 86

SESSION 3: Manufacturing Technologies and Materials………………………………... 92

DEVELOPMENT OF TECHNOLOGIES FOR PRODUCING SPECIAL COATED ELECTRODES BASED ON DOMESTIC RAW MATERIALS (Nikola Bajić, Slobodan Stojadinović, Jasmina Pekez, Mihailo Mrdak, Zoran Karastojkovic, Zoran Radosavljevic)….... 93

DEGRADATION OF TCE IN COLUMN EXPERIMENTS WITH MICROSCALE ZEROVALENT IRON (Milica Velimirović, Simons, Q., Bastiaens, L.)…………………….... 100

THE INFLUENCE OF POWDERS CLADDED WITH ELECTRIC CHARGES ON THE OHMIC RESISTANCE OF THE LAYERS THAT ARE DEPOSITED BY METALLIZATION (Roata Ionut Claudiu, Iovanas Radu, Iovanas Daniela Maria)……….…..... 105

SHEET METAL DESIGN AND PRODUCTION IMPROVEMENTS BY USING SOLIDWORKS (Branislav Vorgic, Habil Mulaji)…………………………………………… 112

WELDABILITY OF THE MICRO ALLOYED STEELS AS A FUNCTION ON THE COLD AND HOT CRACKING APPEARANCE (Slobodan Stojadinović, Nikola Bajić, Jasmina Pekez).. 117

CORROSION BEHAVIOUR OF AN Al-Zn-Mg-Cu ALLOY AFTER DIFFERENT HEAT TREATMENTS (Ana Alil, Bore Jegdić, Biljana Bobić, Marko Ristić)...................................... 121

COMPARATIVE ANALYSIS OF THE FORMABILITY OF THE TWO LOW-CARBONCOLD-ROLLED STEEL SHEET (Gorde Ivanoska, Jovan Lazarev, Jasmina Caloska).. 129

SESSION 4: Maintenance…………………………………………………………………... 135

AN INVESTIGATION ON THE LOADING DURABILITY OF POLYMERIC GEAR WHEELS WITH VACUUM DEPOSITED COATINGS (Dimitar G. Petrov, Petar Hr. Shindov, Dimitar N. Dimitrov, Petar L. Dimitrov)………………………………………….. 136

SUSTAINABLE DEVELOPMENT AND MAINTENANCE AS A LOGISTICS (Miodrag Bulatović)……………………………………………………………………………….. 142

THE DEVELOPMENT OF THE ELECTRIC BRAKE MODEL ON STAND FOR TESTING THE RELIABILITY OF AGRICULTURAL CARDAN SHAFTS (Aleksandar Ašonja, Živoslav Adamović, Radojka Gligorić, Aleksandar Pastukhov, Danilo Mikić)......................... 147

THE VALIDATION OF CHARACTERISTICS OF ROTATIONAL EXCAVATOR EFFECTIVENESS (Slavica Prvulovic, Zhetcho Kalitchin)……………………………………. 152

APPLICATION OF THE METHOD OF THERMOGRAPHY IN DIAGNOSTICS OF POWER PLANTS (Božo Ilić, Živoslav Adamović, Ljiljana Radovanović, Branko Savić Nenad Stanković)……………………………………………………………………….. 157

ROTATING EQUIPMENT VIBRATION DIAGNOSTICS IN FUNCTION AN EARLY FAULT DETECTION AND MALFUNCTION PREVENTION (Đorđe Latas)……………….. 165

SESSION 5: Design and Maintenance of Process Plants……………………………………. 171

ANALYSIS OF THE GYROSCOPIC EFFECT OF ANGLE PEDESTAL BALL-BEARING (Ljubica Lazić Vulićević , Branko Pejović, Cvijan Žepinić)... 172

RESULTS OF RESEARCH OF CONVECTIVE DRYING (Béla Takarics, Imre Orban, Dragana Dimitrijević, Dragiša Tolmač, Jasna Tolmač)…………………….............................. 180

MECHANICAL MODELING OF INDUSTRIAL MACHINES (Danilo Mikić, Eleonora Desnica, Aleksandar Ašonja, Živoslav Adamović)... 185

IDEAL SOLUTION FOR GRINDING PLANTS AND PNEUMATIC CONVEYING STRAW (Dragana Dimitrijević, Slavica Prvulović, Zvonimir Blagojević, Dragiša Tolmač)...... 192

SURVAY OF APPLIED POWER SOLUTIONS FOR WIND FARMS (Vladimir Šinik, Željko Despotović, Slobodan Janković, Vojin Kerleta)... 196

APPLICATION OF ANALYTICAL HIERARCHY PROCESS IN THE SELECTION OF OPTIMAL TECHNOLOGICAL SOLUTIONS (Slavica Prvulović, Uroš Karadžić)…………. 203

COMPARATIVE ANALYSIS OF VEHICLE DEPENDING ON TYPE OF DRIVE (Antić, B., Vujanić, M., Pešić D., Anđelković D.).. 208

SESSION 6: Basic operations, Machinery and Processes…………………………………… 216

EXPERIMENTAL INVESTIGATION OF OPERATING AND DYNAMIC PROPERTIES OF ADSORPTION FILTER PROTOTYPE (Miomir Raos, Ljiljana Živković, Amelija Đorđević, Nenad Živković, Jasmina Radosavljević, Emina Mihajlović).................................... 217

WELDING WORKS FROM THE STANDPOINT OF EXECUTION AND FIRE PROTECTION (Martina Balać, Jelena Nikolić, Aleksandra Đerić, Aleksandar Petrović)…….. 225

DRYING BIOMASS IN A FUNCTION OF INCREASING ENERGY RESOURCES (Srećko Ćurčić, Sandra Milunović, Milan Pavlović, Dragiša Tolmač).. 231

CFD SIMULATION OF ENTROPY GENERATION IN PIPELINE FOR STEAM TRANSPORT IN REAL INDUSTRIAL PLANT (Goran Vučković, Gradimir Ilić, Mića Vukić, Milan Banić, Mladen Stojiljković, Gordana Stefanović)... 240

OPTIMAL PARAMETERS FOR THE COMBUSTION OF PELLETS AND WOODCHIPS IN BOILERS (Branislav Stojanović, Jelena Janevski, Mladen Stojiljković, Dejan Mitrović, Marko Ignjatović)........ 250
ENERGY BALANCE OF A TUNNEL DRYER IN REAL INDUSTRIAL PLANT (Edib Dedeić, Goran Vučković)…….. 256
DEPENDENCE OF CHANGE IN THERMAL DIFFUSIVITY AND CONDUCTIVITY COEFFICIENTS ON THE DEGREE OF FLUIDIZATION (Jelena Janevski, Branislav Stojanović, Mladen Stojiljković, Mića Vukić)…….. 264

SESSION 7: Computer Technologies and Engineering Education……… 271

DEVELOPMENT OF REQUIRED SKILLS BY USING COMPUTER SOFTWARE IN THE EDUCATION OF FUTURE ENGENEERS (Cvetanka Mitrevska, Vesna Mundisevska-Veljanovska, Vangelka Trajkovska)........ 272
ENGLISH PHRASES AND TERMS IN CURRICULUM OF MECHANICAL ENGINEERING SUBJECTS (Eleonora Desnica, Duško Letić, Erika Tobolka)…….. 277
EDUCATION OF MECHANICAL ENGINEERS IN USA AND SERBIA (Jesa H. Kreiner, Zvonko Sajfert, Dario Pavlović)........ 282
LEVEL OF REPRESENTATION DEMOCRATIC RELATIONS IN SCHOOLS (Ivan Tasić, Jelena Tasić, Dajana Tubić, Teodora Mitić)…….. 292
CONSTRUCTION FOUNDATIONS OF MODELING ROBOT - MANIPULATORS WITH FIVE DEGREES OF FREEDOM (Slobodan Stefanović, Zoran Janjić, Živoslav Adamović, Danilo Mikić)........ 297
REVERSE ENGINEERING APPLICATION IN CREATION OF 3D CAD MODEL FOR INVESTMENT CASTING OF KNEE IMPLANT (Aleksandar Rajic, Slobodan Stojadinovic, Eleonora Desnica, Dorian Nedelcu)…….. 306

SESSION 8: Biotechnology……… 313

BIOTECHNOLOGICAL APPLICATIONS OF PECTINASES IN TEXTILE PROCESSING AND BIOSCOURING OF COTTON FIBERS (Kiro Mojsov)…….. 314
EXPERIENCES WITH BIOMASS ENERGY CONVERSION USING DRY FERMENTATION TECHNIQUE (Ján Gaduš, Jozef Bajla, Štefan Jančo, Tomáš Boďo)........ 323
ANALYSIS OF BIOENERGY PRODUCTION FROM MISCANTHUS GROWN ON DEGRADED AREA OF LANDFILL OF PRELIĆI, ČAČAK (Snežana Dragićević, Milan Plazinić, Goran Dimić, Zorica Plazinić)........ 330
IMPROVING THE QUALITY OF LANDFILL GAS IN COGENERATION SYSTEMS (Milena Todorović, Biljana Milutinović, Dragan Pavlović, Pedja Milosavljević)…….. 336
BMW MANUFACTURING FACILITY IN SPARTANBURG, THE ROLE MODEL OF LANDFILL GAS UTILIZATION (Biljana Milutinovic, Milena Todorović, Dragan Pavlović, Pedja Milosavljevic)…….. 344

SESSION 9: Reengineering and Project Management……… 350

ABILITY OF MANAGERS FOR CRISIS MANAGEMENT IN SME's (Vlado Medaković)…….. 351
BASIC ASPECTS OF LEAN CONCEPT (Kiril Kosev, Živan Bojić)…….. 357
ROLE OF MAINTENANCE IN PRODUCT OF LIFECYCLE MANAGEMENT (Slavica Prvulović, Ljubiša Josimović, Dragiša Tolmač)…….. 361
MANAGEMENT OF NATURAL RESOURCES AND PARADIGM OF SUSTAINABLE DEVELOPMENT (Slobodan Cvetanović, Igor Mladenovic)…….. 367
APPLICATION OF THE QFD METHOD TO OPTIMIZE THE DESIGN OF FASHION CHLOTHING (Danijela Paunović, Gordana Čolović)…….. 374

THE EFFECT OF STRATEGY ON THE DEVELOPMENT OF AN ENTERPRISE (Jelena Vojnović)…………………………………………………………………………………….. 379

SESSION 10: Process Management and Energy Efficiency……………………………… 388

ENERGY AND MATERIAL OPTIMISATION OF A CORN BRAN DRYING PLANT (Sofija Miškov, Ivona Radović, Mirjana Kijevčanin, Dragiša Tolmač)...................................... 389

SUSTAINABLE USE OF ENERGY IN EUROPE (Dragan Škobalj, Sonja Lukić).................. 394

SOLAR ENERGY IN SERBIA - POTENTIAL, APPLICATION AND DEVELOPMENT (Miroslav Lambić, Erika Tobolka)………………………………………………………………… 402

BPMN & INTOUCH HMI SOFTWARE: A CASE STUDY OF MODELING THE FLOW MEASUREMENT SYSTEM AND DEVELOPING SCADA APPLICATION IN OIL AND GAS INDUSTRY (Jasmina Obradović, Mirjana Prvulović, Marko Ristić, Milorad Kočić, Ljiljana Radovanović, Marina Milovanović).. 411

IMPLEMENTATION OF ENERGY EFFICIENCY (EE) IN SERBIA WITH REGARD TO THE OBJECTIVES IN THE ENERGY SECTOR UNTIL 2020. AND ENERGY POLICIES OF EU MEMBER STATES (Marija Brković)……………………………………………… 421

ENVIRONMENTAL AND FINANCIAL EFFECTS OF SOLAR PANELS (Jasmina Pekez, Miroslav Lambić).. 425

ENERGETIC CHARACTERISTICS OF "ACTIVE" SOLAR WALL (Miroslav Lambić)……. 428

ANALYSIS OF ENERGY EFFICIENCY AND ECONOMIC SYSTEMS HEATING POWER PLANTS - HEATING REFRIGERATING MACHINES (ABSORPTION AND EJECTOR) AND CONDENSING POWER PLANTS - TURBOCOMPRESSOR COOLING STATIONS IN THE SYSTEM SUPLY CENTRALIZED HEAT AND COOLING ENERGY (Šefik M. Bajmak).. 436

IMPACT OF APPLYING ENERGY EFFICIENCY MEASURES IN MULTIFAMILY BUILDING ON GHG EMISSIONS REDUCTION (Bratislav Blagojević, Marko Ignjatović, Mladen Stojiljković, Branislav Stojanović, Mirko Stojiljković).. 443

A MATHEMATICAL MODEL FOR DETERMINING ENERGY EFFICIENCY OF THE ELEMENTS OF THE PASSIVE SOLAR BUILDING DESIGN SYSTEMS (Radivoje Topić, Nenad Ćuprić, J. Topić, Goran Topić)……………………………………………………….... 451

SESSION 11: Students papers………………………………………………………………… 459

GRAPHIC MODELING ASSEMBLY OF INTERNAL COMBUSTION ENGINE PISTON IN 3D WORKING ENVIRONMENT USING AUTOCAD MECHANICAL SOFTWARE (Željko Stojanović, Miroslav Đurđev, Darjan Jonaš).. 460

THE IMPORTANCE OF BRANDS IN THE INDUSTRY (Suzana Gardinovački).................... 467

DEVELOPMENT, DESIGN AND WORK PRINCIPLE OF PACKAGING MACHINE (Neda Smiljčić, Vladimir Fajka)……………………………………………………………………….. 473

EFFICIENCY ANALYSIS OF FURNACES AND DRYER IN THE INDUSTRY OF BRICK PRODUCTS (Mladjana Asimi)………………………………………………………………. 479

ELEMENTS OF AN EFFECTIVE MAINTENANCE PROCESS (Martina Popov)…………... 483

NANOTECHNOLOGY (Kristina Terkelj).. 487

SESSION 1: Process Technology

METHODS FOR DETERMINATION OF BIOMASS ENERGY PELLETS QUALITY

Zorica Gluvakov[1], Miladin Brkić[1], Todor Janić[1]
[1]University of Novi Sad, Agricultural faculty, Novi Sad, Serbia
e-mail: mbrkic@uns.ac.rs

Abstract: In this work are, on the base of existing standards and collected literature, described the methods for laboratory quality examination of biomass energy pellets after pressing and cooling of pressed material. On the base of existing methods, examinations on shape and dimensions, moisture content, bulk density, fine particle content, wipe away, ash content, calorific value of energy pellets were done. On the base of examination result, a range of data is gathered and physical characteristics of biomass energy pellets are estimated on the base of existing literature and standards. Comparing obtained results with existing standards and literary sources it can be said that the methods for examination of mentioned parameters are acceptable, because there were no greater deviation from regular. It is necessary to quickly reach a national standard for defining quality energy pellets and briquettes of biomass. National standards would regulate the methods for testing the quality of energy pellets and briquettes of biomass.
Key words: Biomass, pellet, energy, standards, methods

INTRODUCTION

In most of european countries there are no specific regulations concerning energy pellet quality determination. Biomass regulations are mostly used. Only a few countries have specific regulations (*Brkic and Janic, 2009*). At the moment, only three countries have official standards for solid biofuels: Austria ÖNORM M 7135, Sweeden SS 187120 and Germany DIN 51731 plus. Beside previously mentioned there is also an adopted european standard EN/TS 14961.
European Committee for Standardisation, CEN under Committee TC335 has published 27 techical specifications (preparational standards) for solid fuels during 2003-2006 (*Alakangas, 2010*). This technical specifications are amended and adopted as European standards (EN) 2010. When EN standards become valid, the national standards had to be withdrawn or adjusted to these new standards.
The New European Standard for energy pellets ENplus A1, A2 i B is shown in Table 1. This standard resulted from the standard EN 14961.
Conditions defined with this standard must be respected in order to get energy pellet of standard quality, which can later be placed on market and used.
In our country there are no standard for biomass energy pellets quality. Quality standardization and its correct aplication in production and delivery is of extreme importance for successful usage of energy pellets. It is possible to check quality standards by using methods for examining defined parameters of energy pellets.
The aim of this work is to collect, analyze and examin methods for laboratory examination of quality of energy pellets produced after biomass pressing and cooling.

Table 1. New european standard for energy pellets ENplus

Parameter	Unit	ENplus-A1	ENplus-A2	ENplus-A3
Diameter	mm	6 – 8mm (± 1)	6 – 8mm (± 1)	6 – 8mm (± 1)
Lenght	mm	$3{,}15 \leq L \leq 40$ Max. 45mm (1%)	$3{,}15 \leq L \leq 40$ Max. 45mm (1%)	$3{,}15 \leq L \leq 40$ Max. 45mm (1%)
Bulk density	kg/m³	≥ 600	≥ 600	≥ 600
Calorific value	MJ/kg	≥ 16.5	≥ 16.5	≥ 16.0
Moisture	Ma.-%	≤ 10	≤ 10	≤ 10

Fine particles	Ma.-%	The amount of fine dust must be ≤ 1% counting the amount of dust in the packing pellets or end customer, if it performs bulk transport. The amount of fine dust, may be an agreement between the manufacturer and the customer.		
Machanical durability	Ma.-%	≥ 97.5	≥ 97.5	≥ 96.5
Ash content	Ma.-%	≤ 0.7	≤ 1.5	≤ 3.0
Ash melting behaviour	°C	≥ 1200	≥ 1100	≥ 1100
Chlorine	Ma.-%	≤ 0.02	≤ 0.03	≤ 0.03
Sulphur	Ma.-%	≤ 0.05	≤ 0.05	≤ 0.05
Nitrogen	Ma.-%	≤ 0.3	≤ 0.5	≤ 1.0
Copper	mg/kg	≤ 10	≤ 10	≤ 10
Chrom	mg/kg	≤ 10	≤ 10	≤ 10
Arsenic	mg/kg	≤ 1	≤ 1	≤ 1
Cadmium	mg/kg	≤ 0.5	≤ 0.5	≤ 0.5
Silver	mg/kg	≤ 0.1	≤ 0.1	≤ 0.1
Plumbum	mg/kg	≤ 10	≤ 10	≤ 10
Nickel	mg/kg	≤ 10	≤ 10	≤ 10
Zinc	mg/kg	≤ 100	≤ 100	≤ 100
Mercury	mg/kg	≤ 0.05	≤ 0.05	≤ 0.05

MATERIALS AND METHODS

Energy pellets made of different raw materials were used during this work. Raw materials used in the production process of final product (pellets) were straw, fir sawdust, beech sawdust, as well as mixed biomass. On the base of mentioned raw materials five different kinds of pellets were produced: straw pellets, fir pellets, beech pellets, 87,5% beech and 12,5% fir pellets and 50% fir, 30% beech and 20% straw pellets.

Sampling of energy pellets for analysis of biological, phisical and thermal properties was done in production plants of firms for pellet production. The way of sampling was determined by manual for wheat sampling UP.05.3.002. Energy pellet samples of 3kg were placed in hermeticaly closed bags and stored in refrigerator until analyzing.

Working methods were based on collecting data for analysis of energy pellet quality from literature, standards and regulations, analysis of collected data, building of necessary equipment, laboratory checking of of most important methods for pellet analysis, analysis of gained data and conclusions. Checking of methods for analysis of energy pellets quality was carried out in Laboratory for thermodynamic and processed technique of Department for agrycultural technique, Faculty of Agriculture in Novi Sad.

Method for shape and dimension determination in energy pellets

The shape of biomass energy pellets was established visually. The dimension of energy pellets means diameter and lenght. The necessary equipment for energy pellet dimension determination is nonius (movable measurer). From an average sample for diameter and lenght were measured by nonius. After that an average dimension value of energy pellets was calculated.

Method for moist content determination in energy pellets

Moist content in biomass pellets is the "loss" of mass that chipped pallet mass loses during two hours of drying process at temperature of 105 ºC. Moist content determination in pellets was carried out according to the standard SRS E. B8. 012.

Necessary equipment for moist content determination in pellets is: analytical balance with accuracy of 0,1g, laboratory mill, metal drying pots, electric dryer with possibility of temperature regulation, adjusted at 105 ºC and exicator. 20g was taken from average sample for moist content determination

in pellets and ground. The ground pellets were immediatelly placed in previously measured pot and its mass measured before it absorb any amount of moist.
Afterwards, the pots with ground pellets were placed in the dryer and left in it for two hours. The drying time is counted from the moment of getting the temperature of 105ºC inside the dryer. After drying the pots were moved, with using protective gloves, to the exicator where they were cooling at room temperature. When dry sample was cool, it was placed on electric skale and total mass was measured. It should not be forgotten that the net mass of a sample is got when mass of the pot is subtracted from the total sample mass.
The moist content (moisture) of energy pellets is calculated on the base of mass ratio to get the mass percentage according to formula:

$$\omega = \frac{(m_1 - m_2)}{m_1} \times 100$$

where: ω–moist content (%),
m_1–mass before drying (g),
m_2 – mass after drying(g).

For every moist content determination it is necessary to do at least three measurings at the same time. The difference between these three measurings must not be more than 0,2 % (absolute value). The moist content (moisture) is shown as an average result of measuring, in two decimal figures.

Method for bulk mass determination in energy pellets

Bulk mass (bulk density) is a parameter which is easy to determine, and is the mass and total volume of energy pellets ratio, according to *Mohsenin (1980)* and *Singh and Goswami (1996).*
Necessary equipment for bulk mass determination is: analytical balance and graduated cylindar of known volume (1.0 l). An average sample was placed in graduate cylindar up to certain volume, and after that the mass of the sample was measured at the analytical balance. The sample mass is determined as the difference between total mass and the mass of graduated cylindar.
Bulk mass of pellets is calculated according to formula:

$$\rho_n = \frac{m}{V}$$

where: ρ_n–bulk mass (kg/m³),
m–sample mass(kg),
V–total volume of the sample (m³)

Method for determination of fine particles in energy pellets

Fine particles of energy pellets (sample) are particles (impurity) smaller than 3,15 mm, as well as dust in the sample (*Gluvakov Zorica, 2012*).
Necessary equipment for determination of fine particles is: analytical balance, measuring pot and sieve with dimension of 3.15 mm (in our case it was 3.25 mm, since we did not have the standard sieve). An average sample was placed in previously measured pot and measured on analytical balance. Sample mass is determined as difference between total mass and the mass of the pot. After that the sample was placed in the sieve and sifted. Sample sifting was done manually. After sifting, the sample (pellets) and impurities (particles less than 3,25mm) are measured separately. On the base of these two masses the percentage of fine particles can be measured.
For every determination of fine particles it is necessary to do at least three measurings. Pellet attrition is shown as an average result of fine particles measuring.

Method for determination of energy pellets attrition

Resistance of energy pellets to attrition (wear) is determined in rotational container according to ASAE standard 269.2. The device was constructed in workshop of Department for agricultural technique, Faculty of Agriculture in Novi Sad. Samples of 1kg with deviation of ± 20 g were taken for attrition determination and placed in a box with dimensions 300 x 300 x 450 mm, closed and turned with speed of 13t/min during 3 minutes. When turnig of the standardised box was over, the sample was siftedand detrmination of fine particles percentage was done. Difference minus percentage of fine particles is pellet resistance.

Method for determination of ash content in energy pellets

Ash content Ash content of the sample is the mass of energy pellets remaining after complete combustion of the sample at a temperature of 575 ± 25 ° C, expressed as a percentage,
according to SRS H.N8.136
The necessary equipment for the determination of ash content is: a platinum, quartz, or porcelain pots, cups or bowls, electric furnace with temperature control at 575 ± 25 º C, the catcher for the pot, cup or saucer, laboratory chopper and analytical laboratory scales.
From the average sample used for determination of the ash 20 g was taken and chopped finely. Fragmented pieces of appropriate size were immediately put into a pan and carefully burn at the open flame to full carbonation (carbonization of the sample). After a complete combustion of the sample a mixture of ash and coke was obtained. 1 g of combusted sample was taken from the bowl and put in a cup. The cup was then placed in a kiln, which was gradually heated. Annealing was performed at 575 ± 25 º C the next 3 h. During annealing the coke is completely burnt. Upon completion of the annealing only clean ash stayed. Removing the cup from the electric furnace is performed by using the metal "catcher". While removing the cup from the electric furnace it is necessary first to put the lid on the oven to cool for 15 minutes, to avoid cracking because of the great difference in temperatures. After cooling, the obtained ash was measured at the analytical balance. Ash content in the energy pellets is calculated as follows: first we measure the mass of a sample of crushed pellets before the combustion (20 g), and then we measure the mass of cooled mixture of coke and ash, to find percentage of a mixture of coke and ash in the total sample of pellets. From the total weight of a mixture of coke and ash we took 1 g of sample for annealing. After annealing we measured the mass of cooled ash and calculate the percentage of ash in 1 g of sample mixture of coke and ash. After that, we determined the mass of ash in the total weight of a mixture of coke and ash. Finally, based on the mass of ash in the total weight of the mixture of coke and ash we determined the percentage of ash in the total mass of the sample pellet of 20 g.

Method for determination of the calorific value of energy pellets

Upper calorific value of pellets is determined calorimetrically EN ISO 1716. The mass of dry milled or whole sample of 1 g was measured on the analytical balance and placed in a small bowl. Small vessel with the sample was placed in the upper part (cover) of the "bomb", where the electrodes were connected with a wire. After that the "bomb" was closed and filled with oxygen under pressure up to 30 bar. Before placing the "bomb" into the calorimeter it is necessary to check if there is water in it, if there is not, it necessary to fill it up with water and then drop the "bomb" in the body of the calorimeter. "Bomb" is then fed through the current electrodes. The device causes the process of complete combustion of the sample. A certain amount of heating energy was released by combustion of the sample which is noted by the aparatus and transferred records transferred to the computer. After completion of the procedure is necessary to separate "bomb" and a brush the bowl.
Figure 1 shows the calorimeter, and Figure 2 preparation of the "bomb" with a sample for testing before placing in the calorimeter.

Figure 1. Calorimeter

a) b)

Figure 2. Preparation of a „bomb" for examination
(a – filling the"bomb" with oxygen , b – placing "bomb" into calorimeter)

For each determination of ash content at least three measurements should be done and then calculate the average thermal value of the energy pellets
rounded to two decimal places.
Lower calorific value of pellets obtained from the form:

$$h_g = h_d + 2500\ (9h + w)$$

where: h_g – upper calorific value (kJ/kg),
h_d – lower calorific value (kJ/kg),
h – amount of water after hydrogen combustion (kg),
w – moist content in relative units (′)

RESULTS AND DISCUSSION

The basic results of the above mentioned tests were obtained by laboratory determination of the shape, size, moisture content, bulk mass, the content of fine particles, attrition, thermal values and strength of energy pellets. The tests of physical and mechanical properties and thermal energy pellets from fir, beech, and mixtures of wheat straw biomass (fir and beech, fir, beech and straw) were done. In Table 2, 3 and 4 shows the results of tests of biomass energy pellets.

Table 2. Test results of the form properties of biomass energy pellets

Species materials	Origin of material	Structure of materials	Form	Average length (mm)	Diameter (mm)
Beech 87.5% Fir 12.5%	Sawdust	Crushed	Cylindrical	21,0	6
Wheat straw	Straw	Crushed	Cylindrical	21,0	6

Fir 50% Beech 30% Wheat straw 20%	Sawdust Sawdust Sawdust	Crushed Crushed Crushed	Cylindrical	23,7	6
Fir	Sawdust	Crushed	Cylindrical	14,5	6
Beech	Sawdust	Crushed	Cylindrical	14,9	6

Table 3. Test results of the form properties of biomass energy pellets

Species materials	Bulk density (kg/dm³)	Unit weight (kg/dm³)	Porosity (%)	Fine particles below 3.15 mm (%)	Obliterati on (%)
Beech 87.5% Fir 12.5%	0,554	1,271	50	0,22	0,55
Wheat straw	0,734	1,350	53	0,05	0,19
Fir 50% Beech 30% Wheat straw 20%	0,573	1,500	66	0,45	1.39
Fir	0,735	1,292	50	1,74	2,03
Beech	0,655	1,300	54	3,07	3,75

Table 4. Test results of the form properties of biomass energy pellets

Species materials	Moisture content (%)	Ash (%)	Calorific value (MJ/kg)	Strength (N)
Beech 87.5% Fir 12.5%	8,81	2,48	15,17	165,4
Wheat straw	7,78	8,63	14,70	224,6
Fir 50% Beech 30% Wheat straw 20%	11,48	1,59	15,64	117,4
Fir	9,54	1,17	16,40	186,4
Beech	10,63	0,64	15,00	163,6

The origin of the pellet material is straw or sawdust, and material structure - segmented. Examined energy pellets were of cylindric shape. Diameter of the pellets was the same and it was 6 mm. The average length of the energy pellet samples from fir was 14.5 mm, 14.9 mm of beech, wheat straw 21 mm, a mixture of fir and beech 21 mm, and with a pellet mixture from fir, beech and straw 23.7 mm. Based on these data it can be concluded that the pellets of fir and beech have the same length, that a mixture of wheat straw and beech and fir also have the same length, and that a mixture of fir, beech and wheat straw is having the longest pellets.

Bulk mass of energy pellets from fir is 0.735 kg / dm ^{3}, the beech 0.655 kg / dm ^{3}, from wheat straw 0.734 kg / dm ^{3}, from a mixture of fir and beech 0.554 kg / dm ^{3}, and of a mixture of fir, beech and wheat straw 0.573 kg / dm ^{3} (Table 3). Energy pellets from a mixture of raw materials have the same bulk density, and then pellets of wheat straw and fir are also of the same value, and at the end the beech pellets have the least value of bulk mass. The content of fine particles below 3.25 mm of the samples varied from 0.05 to 3.07% depending on the sample pellets. The content of fine particles of fir is 1.74%, 3.07% of the beech, from wheat straw 0.05% of a mixture of fir and beech 0.22%, a mixture of fir, beech and wheat straw 0.45%. A minimum of fine particles were seen in wheat straw pellets, which indicates the fact that there was the least attrition.

Attrition of the samples varied from 0.19 to 3.75%, depending on the sample pellets. In the fir it is 2.03%, 3.75% beech, wheat straw from 0.19%, of a mixture of fir and beech 0.55%, a mixture of fir, beech and 1.39% wheat straw. Therefore, the least attrition is in wheat straw pellets, which leads to the conclusion that these pellets are the most durable.

Moisture content of energy pellets for pellet was 9.54% of fir, beech 10.63%, of 7.82% wheat straw, a mixture of fir and beech 8.81%, a mixture of fir, beech and wheat straw 11.48% (Table 4). Lowest moisture content was observed in pellets from wheat straw, and the highest in pellets of mixtures of different raw materials.

Ash content in energy pellets from fir is 1.170%, 0.64% from the beech, from wheat straw, 8.63% of a mixture of fir and beech 2.840%, a mixture of fir, beech and wheat straw 1.590%. The lowest values of ash are in the pellets made of wood, and maximum value pellets of straw. Therefore, it is good to mix wood with straw, to reduce the amount of ash in pellets.

Calorific value of energy pellets is: fir 16,400 kJ / kg (16.40 MJ / kg), beech 15,000 kJ / kg (15.00 MJ / kg) of straw 14,700 kJ / kg (14.70 MJ / kg) , a mixture of fir and beech 15,175 kJ / kg (15.17 MJ / kg), a mixture of fir, beech and straw 15,640 kJ / kg (15.64 MJ / kg). The highest calorific value is in pellets made of wood, and straw pellets have the lowest calorific value.

Based on these results it can be concluded that the shape of all examined energy pellets is the same. Energy pellets do not differ in diameter. Differences can be observed based on the measured values of length. Therefore, it can be concluded that the shape and diameter of biomass energy pellets meet the German standard DIN, EN plus standard, EN 14961-1 standard, as well as other authors in the average characteristics of the pellets. The length of the analyzed energy pellets is within the regulated performance standards. Lengths mixture of beech and fir, and mixtures of wheat straw fir, beech and wheat straw meet the interval length of the German DIN standards, and the length of pellets from fir and beech meet other authors in the average characteristics of the pellets. The lengths of all the analyzed pellets are within regulated values of EN plus standard, as well as EN 14961-1 standard.

Based on the results of the bulk density it can be concluded that the bulk density of energy pellets from one of the major raw materials bigger than in pellets made of mixture of raw materials. Based on the literature sources average bulk density of pellets made from one raw material is in the regulated literary interval of 600 to 700 kg/m^3, and the energy pellets made of a mixture there was a negligibly smaller value of the bulk density than from literature sources. Bulk density in biomass energy pellets is defined by EN plus standard ($\geq$ 600 kg/m^3), which coincides with the statement above, compared with the values of the apparent density from literature sources for all tested pellets. Bulk density is not defined in the DIN standard. Bulk density of all analyzed pellets is within the regulated performance standards EN 14961-1 (from $\geq$ 550 to $\geq$ 700 and over 700 kg/m^3). The content of fine particles and attrition are the level of resistance of biofuels to stresses or damage during handling or transportation, but these parameters are not defined in standard DIN or EN standards plus, and even in literature. The EN 14961-1 standard content of fine particles (< 3.15 mm) can be in interval from 1-5%. Moisture content is one of the main problems for the wider application of biomass, since corn stalks not dried enough can have up to 30% moisture. The moisture content of all analyzed samples of biomass energy pellets is in the standard values of (≤ 12%) DIN standard, EN 14961-1 standard (≤ 10% and ≤ 15%) and in the literary range (7 - 12%) of average characteristics of pellets. The moisture content in the EN standard plus has the same set of values (≤ 10%), indicating that the examined samples of energy pellets from a mixture of raw wheat straw corresponds to EN plus standard values, while in the pellet of beech and fir some deviations were observed.

According to the literature, the ash content of the biomass was in the range from 0.40 to 8%. Lower ash content is in sawdust, and the largest in straw. According to literature sources it can be concluded that the ash content in the pellet made of wood was within the regulated limits, while the wheat straw has a significant discrepancy, because the crops are conditioned by a number of factors (location, cultural practices, etc..) and as such can vary in the same species. The ash content in the energy pellets for wood is within the regulated values (<1.5%) of DIN standard and literary interval (0.4 – 1.5%) for fir and beech, deviations were observed in mixture of beech and fir. In EN plus standard defined ash content for wood has the same value (≤ 0.7%), significantly lower than the ash content in the DIN standard, so that the ash content of tested energy pellet is much higher than the regulated values of EN plus standard. Ash content in energy pellets from wheat straw is not regulated by the standards of Western countries (Austria, Germany and Sweden) and is in no literature sources. Ash content of all samples of wheat straw in EN 14961-1 is in the limits of standards (from ≤ 0.5 to ≤ 10 and over 10%).

Calorific value of biomass is certainly one of the most important data analyses, which decide on the applicability and value in use of biomass as a biofuel. There is a strong dependence of heat capacity of water content in the fuel. Thus, the obtained values of thermal energy pellets are valid only for the specified pellets moisture. Calorific value of all the samples are not in the intervals of DIN standards (17.5 to 19.5 MJ / kg), or EN plus standards (16.5 to 19.0 MJ / kg), or from literature sources (16.92 to 17.64 MJ / kg) average characteristics of pellets. Thermal parameters were not defined by standard EN 14961-1, but are a minimum value that is necessary to state, in declaration, as the net calorific value according to EN 14918.

Beside the above-mentioned parameters in DIN standards are regulated values for sulfur, nitrogen, chlorine, arsenic, cadmium, chromium, copper, mercury, lead, zinc and extracted organic particles. In EN 14961-1 and EN plus standard, in contrast to DIN standards, there are only values for sulfur, nitrogen and chlorine. In DIN standard additives are not defined, but are defined in the standard EN plus. Therefore, the above mentioned parameters and standard literature sources, we can conclude that it is necessary to define: diameter, length, moisture content, calorific value, ash content, bulk density, attrition, fine particles and heavy metals to define the quality and the successful application of biomass energy pellets.

CONCLUSION

Methods for analyzing of biomass energy pellets completely define indicators of quality of energy pellets. Indicators of quality pellets are divided into biological, chemical and thermal, physical and mechanical. Biological indicators are determined by types, structure, anatomical structure and particle size of biomass. Chemical and thermal indicators are determined by the content of some chemical elements in pellets, ash content, moisture content and energy value of pellets. Physical and mechanical data show geometric parameters of pellets, pellet density, abrasion and pressure resistance.

Based on the results a series of data are collected, by which physical and mechanical properties of biomass energy pellets are evaluated according to the existing literature and existing standards. Comparing of our results with existing standards and literature sources leads us to the conclusion that method for testing the following parameters are acceptable: the shape and size, moisture content, bulk density, the content of fine particles, abrasion, ash content and calorific values of energy pellets, since there were no significant deviation from the declared standard.

Methods that must be used to determine the quality of the biomass energy pellets are the methods that define the following parameters: diameter, length, moisture content, calorific value, ash content, bulk density, abrasion, fine particles and heavy metals, which can be examined only in analytical laboratories. It is necessary to quickly reach a national standard for defining quality energy pellets and briquettes of biomass. National standards would regulate the methods for testing the quality of energy pellets and briquettes of biomass.

ACKNOWLEDGEMENT

This paper is part of the research project funded by Serbian Ministry of Education and Science under number 42011.

REFERENCES

[1] Alakangas E. (2010) New European Pellet Standard – EN 14961-1, EUBIONET 3, VTT, Jyväskylä, Finland, www.eubionet.net,
[2] ASAE Standard 269.2, SAD,
[3] Brkić M., Janić T. (2009) "Briketiranje i peletiranje biomase", monografija, Poljoprivredni fakultet u Novom Sadu, s. 168-172,
[4] Evropski standard za energetske pelete CEN/TS 1496 2005 Aneks A,
[5] Evropski komitet za standardizaciju: standard EN 14961, EN plus, EN ISO 1716
[6] Gluvakov Zorica (2012) Metode za ispitivanje energetskih peleta od biomase, master rad, Poljoprivredni fakultet, Novi Sad, s. 51-52,
[7] Mohsenin, N., N., (1980) Structure, physical characteristics and mechanical properties of plant and animal materials. Gordon and Breach Press, New York,
[8] Nemački standard za peletirana goriva, DIN 511731/DIN plus, 2003. (www.pelletcentre.info),
[9] Singh, K., K., Goswami, T., K. (1996). Physical properties of cumin seed. J. Agric. Eng. Res., 64, p. 93 – 98,
[10] Tešić M. (1978) Svojstva kobsova od slame, proizvedenim u presama sa valjcima, kao krmiva za preživare, časopis "Krmiva", Zagreb, vol. XX, br. 2-3, s. 35-38,
[11] Institut za standardizaciju: SRS E.B8.012, SRS H.N8.136, Beograd

THE UTILIZATION OF PENETRATION METHODS AT THE SOIL PROTECTION

Jozef Bajla[1], Ján Gaduš[1], Tomáš Boďo[1], Štefan Jančo[1]
[1]Slovak Agricultural University of Nitra, Faculty of Engineering, Slovak republic
e-mail: Jozef.Bajla@uniag.sk

Abstract: Monitoring of soil compaction is done mainly by penetrating devices that are used primarily to map the immediate condition of the soil under cultivation. Different approach to monitor compaction caused creation of different measuring methods and great diversity of devices, which are mostly used for static and dynamic measurements. In Agricultural and forestry are suitable fast, cheap and simple methods that can define the instantaneous state of the soil for the use of techniques in certain circumstances. Soil parameters to describe the response of soil under the load on wheel or tracks are used in conjunction with theoretical models formulated. Generally requires two types of information: deformation (compressibility of soil) vertical load (characterized by resistance) and the response of soil particles on the horizontal force components (characterized by soil shear strength). In agriculture, in farming, it is necessary to know the soil penetration resistance. With the measurement and experimental evaluation of the penetrometric resistance of the soil has got our department of KKS a lot of experience also with the use of own designed devices. The engineers must be focused on design of ground vehicles with minimum damage to soil structure and minimum impact on the soil surface layers. The knowledge of these laws were developed and further improved measurement systems that can help in the development, testing and use of modern mechanized techniques. The knowledge about soil compaction and the extent of its changes under different conditions can help to prevent their negative influence on soil in agriculture and forestry and to ensure effective measures to improve them.
Key words: penetration methods, soil protection

INTRODUCTION

In general, the environment of plants, significantly affect the natural conditions and human intervention. The basic idea of the current approach is friendly treatment to nature and especially with its essential component - soil. Negative and insensitive interventions in the soil environment, create adverse changes of soil physical properties such as increased soil bulk density and decrease of hydraulic conductivity and air permeability. A summary of the complex factors causing the reduction of the root system, the ability of soils to infiltrate rainfall and to retain soil moisture is called soil compaction, which causes further deterioration of soil aeration and ultimately affects the plant growth, their production and health.
To the issue of monitoring of soil properties is given relatively little attention especially in many countries. Changes in soil structure due to a closer arrangement of particles, characterized by aggregate factor is called soil compaction which is a serious problem of agriculture in maintaining soil fertility. In other areas is an important aspect assessment of machine influence on strength, throughput and damage of surface layers of soil. Comprehensively describes these issues and potentially explains the causes of these phenomena terramechanics [23].
Excessive volume changes in soils are a serious problem, which one is associated to shear strength dealing with slope stability. Important factors include the use of soil bearing capacity and the ability to transfer load and driving forces of the wheels on the base. Engineers focus to ensure movement of vehicles in terrain with minimal damage to soil structure and minimum damage to the surface layer of soil (field, turf, leaf), which are of particular importance in anti-erosion measures. In this paper we focus on describing the state of measuring equipment to monitor soil compaction and to define the spatial distribution of a compact layer, in the last 10 years of research at our department.

MATERIAL AND METHODS

The search for appropriate solutions to this complex problem it is necessary to obtain detailed and accurate information about the immediate condition of soil and constantly specify the model of the soil particles spatial changes arrangement. Monitoring of soil compaction is done mainly by

penetrating devices that are used primarily to map the immediate condition of the soil under cultivation.
Historically, there are different approached to the compaction monitoring and measurement methods were selected according to the purpose of the survey [20]. Nowadays are still used static and dynamic methods of measurement which ones are carried out in laboratory and in field conditions.
For the Agricultural and forestry are suitable fast, cheap and simple methods which ones can define the instantaneous state of the soil use for current technique under certain conditions [5]. For the soil compaction survey currently are used variety of devices that are based on different principle and are clearly shown in Table 1.

Table 1. Penetration devices

Principle	Way of measurement	Solid shape	Devices
penetration	vertical probes	with cone, flat, half spherical, conical	vertical penetrometer
	horizontal probes	flat board , tilted , cone	horizontal penetrometer
		knife with one or more segments	knife penetrometer
	pushed plates	round boards	bevameter
		rectangle board	
		pushed and same time rotated solid	

Measuring devices (sensors, measuring apparatus) were evolved differently depending on the equipment and capabilities of individual workplaces. Often were originally designed with the use of measurement methods and practices that persist to this day.
Nowadays is not thinkable to use modern measurement devices without appropriate software solutions that enable operational transformation of the measured data, their appropriate record and finally the corresponding procedures to process and then display in a suitable form, e.g. in the form of soil maps. The newest systems are connected with modules that can store the location of the measurement using the GPS system. This system enables quantitative measurements to define the point of interest (place where penetration measurement took place) and its location, which creates conditions for long-term monitoring of the properties in the locality, its influence, setting trends of changes, respectively boundary limit of the quantity in terms of environmental or technological.
Penetration devices are based on the principles defined by the cone pushed into the ground and pushed against the resistance measurements. This principle was theoretically solved already at the beginning of soil mechanics. The standardized cone as a basic element for comparable tests in different conditions was designed and described in norm: ASABE S 313.3.
In the next section are described the basic groups of devices used for these purposes.
Vertical penetration devices were introduced already in the 19th century, the gradual development led to plenty of versions of the devices, an overview of basic types is in Table 2

Table 2. Types of vertical cone penetrometers

Vertical penetrometers		
Force aplication	Force source	Record
Statical	handed	mechanical
quasi static	handed	electronical
	hydraulical	
dynamic	hydraulical	
	electrical	

From the wide range of development in practice has profiled most frequently used combination of a manually operated quasistatic cone penetrometer with electronic recording of measured values. Representatives of these devices are penetrometer P-BDH 3A (Figure 1.), developed at KKS (TF-SPU), penetrologger ELE or Eijkelkamp.

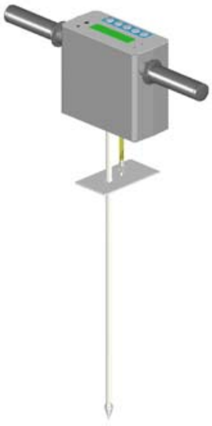


Figure 1. Penetrometer P – BDH 3A

Figure 2. Penetrometer P – HBB

The development of electronics allowed the use of new display systems for control of the measurements. Such a device is new penetrometer P-BH 4 with ultrasonic measurement of the position of the measuring cone. Currently being used increasingly penetrometer with hydraulic or electric drive. It ensures a constant speed of pushed cones and current measurement in number of places (in our case 5 probes). Along with the GPS system allows a substantial increase in the speed measurement of soil compaction on large areas. The design of the penetrometer P - HBB is shown in Figure 2.

Horizontal penetration devices have been developed to increase work efficiency and accelerate the evaluation of large areas of agriculture, currently in combination with GPS allow to create maps of hazardous areas of compacted soil. The concept of horizontal penetrometer is varied, the basic types are shown in Table 3.

Table 3. Types of horizontal penetrometers

Horizontal penetrometers		
Conical	Knife	Lever
one cone	one knife	one shift
	split knife	
multiple cones	combination	multiple shifts

Horizontal cone penetrometer used in most cases the standard type of cone according to ASABE S 313.3 like vertical penetrometer, but they differ mainly in horizontal direction of movement of the cone and continuous measurement method [2] and [12]. Horizontal cone penetrometer P - HPK, made in our department is located on the frame, for measuring is set on demanded measuring depth and by the movement of the tractor at a constant speed is measuring soil penetration resistance in the horizontal direction.

Figure 3. Horizontal penetrometer P – HPN

Horizontal knife penetrometer is the new construction of the classical penetrometers but their shape is adapted to form of an working tool with minimum width in the form of a prism with the angle of 30, respectively 60° and with number of measuring segments. On the Department of Machine Design TF SPU in Nitra was designed device with knife segments designed for continuous measurement of soil resistance with the possibility of measuring the depth in five depth levels simultaneously. Figure 3. shows a horizontal penetrometer P - HPN with 5-measuring segments. The device measures the impedance of the soil, characterizing the apparent resistance of the soil, thus the size of the soil resistance attributable to the prism base unit section, corresponding to the index in the vertical conical penetrometer. The measured data are transmitted from the measuring device using a wireless connection directly to the laptop, then processed and recorded.

RESULTS AND DISCUSSION

The results of the measurements are processed by different procedures and practices. Generally are used statistical methods with the average expression values of penetration resistance at the measuring point in a space large enough to process the soil maps, where the measurement location can be determined by the GPS sensor. Measurements over many years enable to create a reliable and sufficiently accurate methodology for measuring and evaluating the results. The results (Figure 4a, b) are just a representative view of measurements at a depth of 15 cm done by knife measuring equipment, processed with the Surfer 8 software in 2D view and in the 3D view.

a – 2D b – 3D

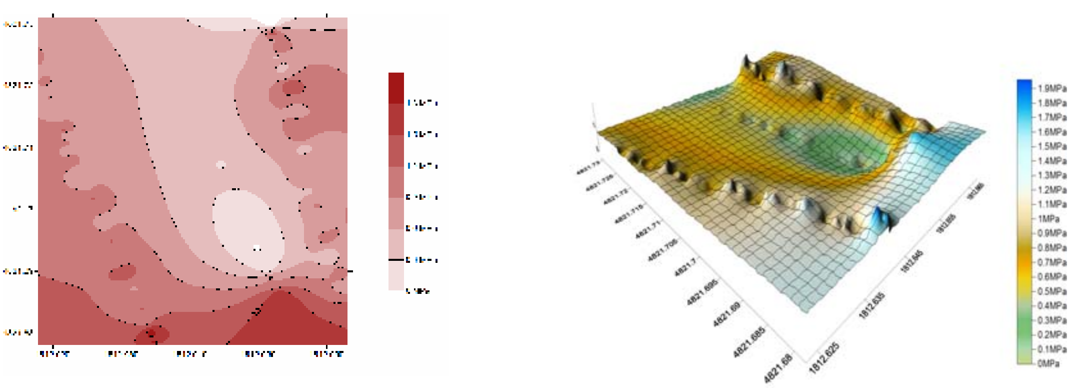


Figure 4. Soil compaction map, 2D, depth 15cm

Conditions for mechanisms work in the field are not defined by one variable. They require a comprehensive view of physical and mechanical properties, the state organization of soil particles, their size, grain size and shape, moisture and presence of organic matter. Continuity of particular location is determined by soil and terrain conditions. Terrain is often described by the occurrence and degree of inclination of obstacles or by terrain profile. Soil parameters to describe the response of soil under the load on wheel or tracks are used in conjunction with theoretical models formulated. Generally requires two types of information: deformation (compressibility of soil) vertical load (characterized by resistance) and the response of soil particles on the horizontal force components (characterized by soil shear strength). In agriculture, in farming, it is necessary to know the soil penetration resistance. With the measurement and experimental evaluation of the penetrometric resistance of the soil has got our department a lot of experience also with the use of own designed devices. Different approaches to monitoring soil parameters were published [3], [7], [18], [22] and others. The measuring principle is based on measuring the resistance against penetration into the soil. For the use of measurement methods for monitoring of soil load capacity the Bekkers theory was designed and experimentally verified using the new measurement system [23].

CONCLUSION

By urbanization of the country is now more than ever focused attention on nature and landscape protection. Related economic activities such as agriculture and forestry in this endeavor can achieve the best results when using the gentle power and technical means for the cultivation and harvesting (mining) activities. The problem of excessive volume changes of soil is a serious problem in connection with damage to the environment of plants, shear strength in dealing with slope stability and creating an optimal environment for root systems of plants. Important factors include the use of soil bearing capacity and the ability to transfer load and driving forces of the wheels on the base. The engineers must be focused on design of ground vehicles with minimum damage to soil structure and minimum impact on the soil surface layers. The knowledge of these laws were developed and further improved measurement systems that can help in the development, testing and use of modern mechanized techniques.

Need for active monitoring of soil compaction as the main indicator of changes in the working resistance of agricultural machinery is trying to be solved by many researchers. The basic principles of measurement are continuous and discontinuous measurements of compaction.

Research in this area has resulted in different constructive suggestions for reducing the compaction of soil by structural modifications of the chassis, to reducing the axial load of tires under cultivation, the use of twin, radial or terra tires, and use of track or half-tracks systems. Despite those solutions, mechanisms for soil treatment, protection and collection of crops will until they have tracks or tires affect the soil compaction, especially in extreme weather.

In this paper we have pointed out various aspects of damage to soil and methods and procedures for their measurement in field conditions. Their knowledge and the extent of their changes under different conditions can help to prevent their negative influence on soil in agriculture and forestry and to ensure effective measures to improve them.

ACKNOWLEDGEMENT

The paper was prepared with a financial support provided by the VEGA Agency within the projects: VEGA V-09-012-00 *Uplatnenie indikátorov hodnotenia vplyvu technológií obrábania pri priestorovej variabilite pôdnych vlastností* (Application of indicators for influence evaluation of cultivating technologies by spatial variability of soil properties).

REFERENCES

[1] Adamchuk, V.I. a i.: Application of a strain gauge array to estimate soil mechanical impedance on-the-go. In: Transactios of the ASAE, 44, 2001, č.6, s.1377-1383.

[2] Adamchuk, V.I. a i.: On.the-go soil sensors for precision agriculture. In: Computer and electronics in agriculture 44, 2004, s. 71-91.

[3] Adamchuk, V.I., Christensen, P.T.: Development of an instrumented blade system for mapping soil mechanical resistance represented as a second-order polynomial. In: Soil and Tillage Research, Vol. 95, 2007, No. 1, p. 76-78.

[4] Alimsyah, T. a i.: A Technique for Horizontal Measurement of Soil Mechanical Impedance. In: Transactios of the ASAE, roč. 33, 1990, č. 1, s.74-77.

[5] Bajla, J.: Penetrometrické merania pôdnych vlastností. Metódy, prístroje a interpretácia. (Monografia). 1. vyd.: Nitra, VES 1998, 112 s. ISBN 80-7137-543-8

[6] Bajla, J., Vargic, M., Tóth, J.: Hodnotenie mobilnej techniky a jej vplyvu na životné prostredie z pohľadu pôdnej mechaniky. In: Zborník medzin. ved. konferencie „Mobilné energetické prostriedky – hydraulika – Životné prostredie – Ergonómia mobilných strojov“, Zvolen 2007, s.7-15. ISBN 978-80-228-1750-9

[7] Chukwu, E., Bowers, C.G.: Instantaneous Multiple – Depth Soil Mechanical Impedance Sensing From a Moving Vehicle. In: Transactios of the ASAE, 48, 2005, č.3, s.885-894.

[8] Chung, S.O., Sudduth, K.A. a Hummel, J.W.: Design and Validation of an On-The-Go Soil Strength Profile Sensor. In: Transactios of the ASAE, roč. 49, 2005, č.1, s.5-14.

[9] Desbiolles, J.M.A. a i.: Prediction of Tillage Implement Draught using Cone Penetrometer Data. In: J. Agric. Engng Res.(1999) 73, 65-76.

[10] Dexter, A.R. a i.: A method for prediction of soil resistance. In: Soil and Tillage Research, Vol. 93, 2007, No. 4, p. 412-419.

[11] Diestel, H. a i.: Bodeneigenschaften. In: Forschungsbericht 2000, Fachbereiche Elektronik und Informatik- Agrarwissenschalten.

[12] Domsch, H. a i.: Evaluation of the soil penetration resistance along a transect to determine the loosening depth. In: Precision Agriculture, Vol. 7, 2006, p. 309-326.

[13] Godwin, R.J.- O´Dogherthy, M.J.: Integrated soil tillage force prediction models. In: J. of Terramechanics, roč. 44, 2007, č. 1, s. 3-14.

[14] Hall, H.E. – Raper, R.L.: Development and Concept Evaluation of an On-The-Go Soil Strenght Measurement System. In: Transactios of the ASAE, roč. 48, 2005, č. 2, s.469-477

[15] Hutl,G. a i.: Ein neues Messgerät zur Bestimmung des Bodenzustandes. In: Praktische Landtechnik, 122, 1990, 4, 10

[16] Isensee, E., Luth, H.G.: Kontinuierliche messung der bodendichte. In: Landtechnik, roč. 47, 1992, č. 9, s. 449-451.

[17] Kushwaha, R.L., Linke, C.: Draft-speed relationship of simple tillage tools at high operating speeds. In: Soil and Tillage Research, Vol. 39, 1996, No. 1, p. 61-73.

[18] Lammers, P. S. a i.: Einsatz eines Kombinationssensors zur kartierung des Bodenwider-standes und Bodenwassergehaltes. In: Landtechnik, roč. 62, 2007, č. 5, s. 330-331.

[19] Raper, R.L. a i.: A Tractor – Mounted Multiple – Probe Soil Cone Penetrometer. In: Applied Engineering in Agriculture, 15, 1999, č.4, s.287-290.

[20] Perumpral, J.V.: Cone penetrometer applications – A review. Transactios of the ASAE, 30, 1987, č.4, s.939-944.

[21] Siefken, R.J. a i.: Mapping Soil Mechanical Resistance with a Multiple Blade System. In: Applied Engineering in Agriculture, 21, 2004, č.1, s.15-23.

[22] Sun, Y. a i.: On-the-go measurement of soil water content and mechanical resistence by a combined horizontal penetrometer. In: Soil and Tillage Research 68, 2004, č.3, s. 286-295.

[23] Weissbach, M.: Flächenbonitur mit dem Horizontalpenetrometer. In: Landtechnik, roč. 53, 1998, č. 2, s.58-59.

[24] Wong, J.Y.: Theory of Ground Vehicles. 3-rd ed.: New York: Wiley, 2001, 528 s.

BIOMASS IN SERBIA – RESOURCES, BARRIERS AND POSSIBLE SOLUTIONS

Dragoljub Živković[1], Marko Mančić[1], Velimir Stefanović[1], Saša Pavlović[1]
[1] University in Niš, Faculty of Mechanical Engineering, Niš, Serbia
e–mail: markomancic@yahoo.com

Abstract: Biomass, accounting for 63% in the balance of renewable energy sources (RES), represents the most significant energy source in Serbia. Its total energy potential is estimated on 2,7 million toe, 1 million of which represents forestry and wood production industry residues, while 1,7 million toe are agricultural residues. This paper gives a review of energy potentials of various types of biomass. Also, some key characteristics of biomass were pointed out which should be improved in order for its consumption to become sustainable and a factor of development. Utilization of biomass is defined by the means of strategic framework represented by the enacted laws, development strategies in the energy sector and environment safety. On the way towards the membership in European Union Serbia must prepare itself to respect numerous directives of the European Commission in this field. The most significant reason for its insufficient use are nontechnical barriers. In order to utilize biomass, it is necessary to provide adequate consents, licenses and certificates. The procedure for acquiring licenses and consents needs simplification, while maintaining care about factors such as plant safety, energy and environment demand fulfilment etc. Biomass facilities are characterized by higher investment costs and lower exploitation costs compared to plants with the same rated power fired primarily by fossil fuels. In this paper, administrative, economical and financial barriers are analyzed and propositions for their overcoming are presented. This manuscript gives suggestions which should contribute to the removal of a number of non-technical barriers for the consumption of biomass.
Key words: biomass, renewable energy, resources and utilization, non technical barriers

INTRODUCTION

Biomass, as a renewable energy source is an organic substance of plant or animal origin (wood, straw, biodegradable agricultural residues, manure, and organic part of municipal waste). Biomass is used in combustion processes or converted in heat or power production systems, or systems for simultaneous heat and power production [1,2]. Apart from this, biomass is used for production of liquid and gas fuels – bio-ethanol, biodiesel and biogas.

As a country with vast arable land and forest areas, Serbia has a significant potential for biomass production. Biomass accounts for 63% of the total potential of renewable energy sources (RES) [3]. Forests cover around 30% of the territory, whereas 55% of the territory is arable land. Besides agricultural plant residues, there are large opportunities for growing energy crops which would not compete with food production.

The total energy potential of biomass in Serbia is estimated to be 2,7 million tons of equivalent oil (toe), and is composed of forest and wood production residues (around a million toe) and residues from crop farming, livestock, viniculture and primary fruit processing (around 1,7 million toe). Energy potential of biomass from livestock suitable for biogas production is estimated to be 42000toe.

Production of biogas from liquid manure is significant in the terms of both energy and environment. As a result of anaerobic digestion, apart from biogas, a liquid residue is obtained which is used as fertilizer. Due to a high fragmentation level of agricultural farms in the Republic of Serbia, the recommendation is to gather and treat manure for one plant collected from more farms.

A larger extent of biomass consumption is limited by numerous nontechnical barriers such as administrative, economical and financial restrictions and impediments. This paper gives suggestions aimed to contribute to deposition of a number of nontechnical barriers for biomass consumption.

RESOURCES OF BIOMASS IN SERBIA

Biomass utilization for energy purposes should be performed in a manner which does not affect any other possibility for its utilization (biomass as food, for example) (Table 1.). At the same time, biomass used for energy purposes should possess certain characteristics, in order to insure fulfilment

of energy, environment and other conditions. In order to avoid operational problems, it is necessary to define biomass sources suitable for production of heat and power, biogas and bio-fuel for transport, as well as criteria to be fulfilled. This is important for both concurrence with the sustainability criteria and prevention of competition with food production and food crops.
Biomass is mostly used for household heating. There are positive experiences with biomass utilization in large scale plants, but main obstacles are supply assurance and biomass expenses. Some companies make use of their own biomass. Thus, wood residues are used in forestry and wood manufacturing companies, and agricultural residues are used on farms for heat production. There are some examples of biomass trading, though without any long term supply contrasts. Also, biomass sale prices are not clearly defined and can vary on different locations and time periods.

Table 1. Energy potential of biomass

Biomass source	Potential (toe)
Wood biomass	1.527.678*
Wood for heating	1.150.000
Forest residues	163.760
Wood manufacturing residues	179.563
Wood biomass from trees outside forests	34.355
Agricultural biomass	1.670.240
Agricultural crop farming residues	1.023.000
Vinegar and fruit cultivation residues	605.000
Liquid manure (for biogas production)	42.240
Bio-fuels for transport	191.305
Total biomass without transport fuel	3.197.918
Total biomass with transport fuel	3.389.223

*Based on the latest research for wood biomass according to FAO methodology

Biomass incentive measures

The Republic of Serbia has set its goals for biomass utilization until 2012. and adopted measures for electricity production (Table 2.) [4].
“Feed in” tariff is a market price mechanism designed to provoke the use of energy acquired from renewable energy sources and to speed up the transition for their utilization. The introduction of beneficiary prices implies formation of higher prices at the state level for energy acquired from renewable energy sources, and forcing companies which produce energy from nonrenewable energy sources to buy a certain quantity of energy acquired form RES.

Table 2. Incentive tariff for electricity production

Biomass	c€/kWh
Installed capacity up to 500 kW	13,6
Installed capacity from 500 kW to 5 MW	13,845-0,489*P
Installed capacity from 5 MW to 10 MW	11,4
Biogas	**c€/kWh**
Installed capacity up to 200 kW	16
Installed capacity from 200 kW to 2 MW	16,444-2,222*P
Installed capacity from 2 MW to 10 MW	12

P – Installed capacity in MW

Bio-fuel production

Bio-ethanol: Ethanol production in the Republic of Serbia is based on molasses (around 50%) and grains (around 50%). Available amounts of molasses are not sufficient for current production demands: total capacities of existing sugar factories generate around 200.000 tons of molasses annually, 50.000 tons of which is utilized, whilst the residue of around 150.000 tons can be considered for utilization for additional purposes and bio-ethanol production.
For the production of 100.000 tons of bio-ethanol, 3330.000 tons of grain is needed, which represents about a third of the grain market surplus or just 2-4% of the total grain production.
As additional feedstock considered suitable for bio-ethanol production with potential in our country, sorghum, Jerusalem artichoke (topinambur) and potato can be sorted. It is estimated that there is 100.000 hectares of marginal land in the Republic of Serbia, which can be exploited for sorghum and Jerusalem artichoke cultivation, which is enough to produce three million tons of ethanol annually.
Biodiesel: In the Republic of Serbia, oilseed – sunflower, soya and oilseed rape, and cooking oil residues may be used as feedstock for biodiesel production. Total oilseed crop area is estimated to be around 668.000 ha, out of which 350.000 ha could be used for oilseed farming for biodiesel production. Average biodiesel production from oilseed plants that could be grown in the Republic of Serbia is shown in Table 3.
The consumption of cooking oil in the Republic of Serbia is around 16 liters per resident, leading to a conclusion that the amount of collected residue cooking oil suitable for biodiesel production could be around 10.000 tons annually.

Table 3. Average biodiesel production from oilseed feedstock

Oilseed	Average grain yield (t/ha)	Grain oil content (%)	Biodiesel production	
			(kg/ha)	(l/ha)
Sunflower	1,79	40	716	816
Soya	2,25	18	405	460
Oilseed rape	1,69	36	608	690

Depending on the type of oilseed cultivated, potential amounts of biodiesel which can be produced on the available area (350.000 ha) are shown in Table 4.

Table 4. Potential for biodiesel production

Sowing composition	Possible biodiesel production (t)
100 % oilseed rape	212.800
70 % oilseed rape + 30 % sunflower	224.140
50 % oilseed rape + 50 % sunflower	231.700
30 % oilseed rape + 70 % sunflower	239.260
100 % sunflower	250.600
100 % soya	141.750

Forestry energy potential

Forestry energy potential in Serbia and two districts in the south of Serbia, Jablanica and Pčinja districts, are shown in Table 5. The same table shows a comparison of forestry data for Montenegro and the Freiburg region (Baden-Wirtenberg, Germany). Based on the presented data it can be seen that the average volume of wood biomass in the forests of Serbia (166 m^3/ha) is 2,5 times smaller compared to the forests in Freiburg region (393 m^3/ha).

Annual increase in wood mass per hectare of wood in Serbia (4,0 m^3/ha) is more than 3 times smaller than the annual increment in Freiburg region (12,5 m^3/ha), whereas the planned annual forest logging per hectare in Serbia (2,0 m^3/ha) is almost 5 times smaller. Hence, with better forest management in Serbia, which is primarily a task for the "Srbija šume" company, and with better Government measures for the private forest owners, energy potential of forests in Serbia could be significantly larger.

Table 5. A comparison of forestry in Germany (Freiburg region), Montenegro and Serbia

		Freiburg region		**Montenegro**		**Serbia**		**Jablanica and Pčinja**	
		Total		**Total**		**Total**		**Total**	
Forest Area	In ha	102.733		620.890		2.252.400		272.000	
	In %	100%		100%		100%		100%	
		Total	**Per ha**	**Total**	**Per ha**	**Total**	**Per ha**	**Total**	**Per ha**
Volume	(m^3)	40.414.135	393	76.487.659	123	362.487.418	161	45.309.838	166
Increment	(m^3/a)	1.280.567	12,5	1.704.813	2,7	9.079.773	4,0	974.217	3,6
Planned Cutting Vol.	(m^3/a)	968.036	9,6	832.177	1,3	4.432.144	2,0	477,365	1,8
	Dry t	489.850	4,8	471.795	0,8	2.801.698	1,2	301.879	1,1
Maximum Potential	**MWh**	**2.491.692**	**24,3**	**2.357.243**	**3,8**	**13.813.426**	**6,1**	**1.488.307**	**5,5**
Relation	%	53%		47%		64%		65%	
Technical Potential	m^3/a	293.100	2,9	390.546	0,6	2.845.080	1,3	308.019	1,1
	Dry t	175.203	1,7	253.013	0,4	1.892.222	0,8	204.907	0,8
	MWh	**869.598**	**8,5**	**1.243.913**	**2,0**	**9.275.592**	**4,1**	**1.004.419**	**3,7**

METHODOLOGY FOR ESTIMATING POSSIBILITIS FOR BIOMASS UTILIZATION

Methodology for estimating possibilities for biomass utilization consists of administrative, economic and financial criteria.
The following criteria are used for estimating administrative measures:

- Clarity and simplicity for defining procedures for issuing licences;
- Precision level in defining responsibility of institutions;
- Information level found in local governments about the advantages of biomass utilization;
- Acceptability by the legally defined model for biomass utilization.

For estimating economic conditions, the following criteria are used:

- Prevalence of the resources;
- Possibilities for continuous supply of resources;
- Necessity for bio-fuel storage;
- Initial investment value and the price of bio-fuel;
- Rate of reduction of local and global pollution;
- Existing knowledge level about the advantages of using biomass in various levels, among various target groups;

Criteria for estimating financial conditions of biomass utilization are:

- Interest rates for investment loans;
- Costs of loan approval;
- Providing loan guarantees;
- Loan repayment schedules.

Application of the presented criteria has shown the existence of serious barriers for biomass utilization, which are classified in three groups: administrative, economic and financial barriers.

Besides presenting existing barriers, further text of this manuscript presents measures for their overcoming.

BARRIERS FOR BIOMASS UTILIZATION

Administrative barriers

In order to utilize biomass, it is necessary to provide certain consent, license and certificates. Building a facility for power production from renewable energy sources (RES) must be conducted according to the Republic of Serbia Planning and Construction Law.
Deficiencies which could be characterized as administrative barriers are:

- The procedure for license expenditure and consent for various types of plants is not well defined. There are numerous examples where procedures for different plants are being used for biomass as well. These procedures should be simple, with precisely defined responsibilities of the institutions on various levels, and constantly improved.
- Local government authorities as an authorized institution are not always informed about the advantages and disadvantages of using certain technologies in the field of bio-energy, leading to cautious approach and delay in the procedures for consent and authorization expenditure.

Current model for buying electricity is unacceptable for the investors, since according to the current law the trading contract with the Serbian power company (Elektroprivreda Srbije) cannot be signed before the construction has finished, the Occupancy license and the license for conducting energy activities have been acquired and the status of authorized manufacturer has been obtained.

Proposed measures for solving administrative barriers

The procedure for acquiring license and consent should be simplified, while factors such as plant safety, fulfilment of energy and environment demands etc. should be still taken into account.
Proposed measures for overcoming the administrative barriers are:

1. The contract for electricity trading should be made immediately after the location license has been provided, which would make a revision of the current model possible.
2. The obligation of buying the complete amount of energy produced should be regulated by Law, until the end of the exploitation life cycle, at market price.
3. Make signing the contract for connecting to the electric grid possible immediately after the location license has been acquired, instead of construction license.
4. Define incentives for providing a constant amount of biomass required for the efficient operation of a bio-energy plant.
5. Ministry should construct terms for incentives for the use of energy crops in the near future.

Economic barriers

Plants for biomass are characterized by greater investment costs and lower exploitation costs compared to plants with the same power rating which use fossil fuels as primary fuel. The reduced green house gas emission makes the biomass plant favourable over its fossil competition.
The consumption of bio-fuels for energy production purposes is accompanied by the following uncertainties:

- Unlike fossil fuels, bio-fuels are often widespread in small quantities on vast areas. This implies a need for a serious logistic support for providing sufficient biomass, and represents a significant economic barrier.
- The storage requirement, especially in urban areas where the storage costs are very high.
- The supply cost and continuity would be provided if biomass is product of some process (wood mill, joinery factory, etc.)
- Providing initial investment.
- Continuity of bio-fuel supply.
- Long term bio-fuel cost.

Proposed measures for solving economic barriers

Proposed measures for overcoming economic barriers are:

1. Start using the Kyoto protocol mechanisms, especially the Mechanism of pure development,
2. Promote “carbon credit” trade,
3. Educate the citizens about the positive ecological effects of biomass consumption and the utilization of other RES,
4. Finance the production of detailed studies about the potential of forest and agricultural biomass and inform expert public opinion, citizens and corporate subjects about real possibilities for starting a business in this sector,
5. Increase public investment in development of scientific research laboratories for biomass and other RES research,
6. Stimulate forming of laboratories accredited for issuing certificates about the quality of bio-fuel,
7. Organize educations on all levels for preparation of documentation about the utilization of foreign funds for improving energy efficiency and RES utilization,
8. Lower the tax for environment friendly fuels, to the extent of making them cheaper for the end user then the conventional fuels,
9. Lower the toll rates for the import of facilities and equipment used for biomass and other RES,
10. Lower the tax rate for biomass and other environment friendly energy sources compared to the conventional fuels,
11. Envisage a Fund for energy efficiency and RES by the new Energy Law,
12. Local government should establish criteria for municipal tax payment exclusion for investors in energy efficient residential or industrial objects, that utilize biomass and other RES to meet energy demands of these objects,
13. The Energy Law or The Law on Rational Energy Consumption should enforce an obligation for creating and submitting annual energy balances in industrial and public sector according to realized specific consumption, or make them subjected to tax obligations,
14. Introduce additional, significantly higher taxes for the use of fossil fuels,
15. Stimulate the banking sector to raise their offers of convenient loans for utilization of biomass and other RES, thus making the loans more accessible,
16. Raise government subventions for employers opening new job places for energy production from RES,
17. Make control of government forest logging more rigorous,
18. Envisage a formation of a Fund for crops suitable for the production of environment friendly fuels by the Agricultural Law.

Financial barriers

Biomass consumption for energy purposes demands investments in various phases during project realization: biomass production, production/supply of equipment for biomass preparation and conversion to bio-fuel, construction of bio-energy plants, promotion bio-energy sources utilization among citizens and so on. There are relieved loans in Serbia from international financial organizations, domestic development funds and banks, but their utilization brings along numerous problems. The state and the local governments do not offer sufficient financial stimulus for biomass consumption for energy purposes. Therefore, financial barriers represent a serious problem in biomass project realization.

Key financial barriers related to the use of loans are:

- Insufficient experience and knowledge for business plan creation,
- High interest rates, mostly indexed in euro, variable rates (Euribor),
- High fixed costs of loan payback approval and monitoring,
- Common problems with providing guarantee,
- Inadequate loan maturity, and so on.

Proposed measures for solving financial barriers

Recommendations for improving loan conditions are:

- State subventions,
- Founding microloan organizations on local municipality level,
- Founding local guarantee funds (by giving guarantee for loan payback the risk of insolvent not paying back the loan is reduced, loan appropriation is improved and interest rates are reduced, thus the loans become more available for entrepreneurs and Medium and Small Companies (MSCs)),
- Cooperation between local government and other parties: banks, associations, other municipalities, government supported etc. (Microloan organizations can be organized on municipality level whose budgets can provide micro loans for entrepreneurs and MSCs, which start biomass utilization related business in the municipality jurisdiction area).
- Introducing "incentive prices" for the consumption of bio-fuels (such incentives cannot be subjected for heat production, therefore a good solution would be introducing "green licenses" and obligatory quotas).

In order to promote biomass consumption for energy purposes, the Government could introduce various tax reliefs. Usual EU praxes is cutting down VAT for biomass sold as energy source; Lowering VAT rate for companies which use and/or produce energy by utilizing renewable energy sources or cogeneration; Lowering tax and fees for companies which manufacture equipment for pretreatment and utilization of biomass for energy purposes; Environment tax increase for fossil fuel utilization and so on.

Import/export abatements:

- Lowering tax and toll burdens for import materials and equipment required for biomass utilization,
- Fanatical abatements for export of biomass end products.

Financial abatements of municipalities and local government:

- Introduction of "environment taxes" on the local level, for carbon dioxide air pollution from fossil fuels.
- Subventions for replacing old coal fired boilers by new biomass fired boilers, in municipalities.
- Integration of biomass into public energy supply plan.

CONCLUSION

Biomass, accounting for 63% in the balance of RES, represents the most significant energy source in Serbia. Its total energy potential is estimated on 2,7 million toe, 1 million of which represents forestry and wood production industry residues, while 1,7 million toe are agricultural residues. The most significant reason for its insufficient use are nontechnical barriers. Methodology for estimating possibilities for biomass utilization consists of administrative, economic and financial criteria is proposed in this paper, and the solutions acquired by using this methodology are presented.
In order to utilize biomass, it is necessary to provide adequate consents, licenses and certificates. The procedure for acquiring licenses and consents needs simplification, while maintaining care about factors such as plant safety, energy and environment demand fulfilment etc. Biomass facilities are characterized by higher investment costs and lower exploitation costs compared to plants with the same power rating fired primarily by fossil fuels. In this paper, administrative, economical and financial barriers are analyzed and many propositions for their overcoming are presented.

ACKGNOWLEDGEMENT

This paper was realized within the framework of the national project "Research and Development of Energy and Environmentally Highly Effective Polygeneration Systems Based on Utilization of Renewable Energy Sources, III42006", 2011-2014, funded by the Serbian Ministry of Education and Science.

REFERENCES

[1] Van Den Broek R., Faaij A., Van Wijk A., Biomass Combustion For Power Generation, Biomass And Bioenergy, Vol. 11, No 4, pp. 271-281, 1996.
[2] Nussbaumer T., Biomass Combustion In Europe Overview On Technologies And Regulations, Verenum Switzerland, p. 97, 2008.
[3] Biomass Action Plan 2010 -2012, Government of Republic of Serbia, (Акциони план за биомасу 2010 – 2012, Vlada Републике Србије), p. 43., 2010.
[4] Ilić M., Grubor B., Tešić M., The State Of Biomass Energy In Serbia, Thermal Science, Vol. 8, No. 2, pp. 5-19, 2004.

MULTIFUNCTIONAL USE OF SOIL RESOURCES AND ITS INFLUENCE TO CROP PRODUCTION-PROTECTION AND RECOVERY

Vesna Kraišnik[1], Husnija Resulović[2], Esad Bukalo[2]
[1]University of East Sarajevo, Faculty of Agriculture, Republic of Srpska, Bosnia and Herzegovina
[2]Federal Institute of Agropedology Sarajevo, Bosnia and Herzegovina
e-mail: vesna.kraisnik@gmail.com

Abstract: In this paper we deal with four basic groups of consequences in the area of soil use which are: biological contamination, chemical contamination, anthropogenic soil degradation, physical destruction. Care of soil and its protection should always be present in all our actions and its protection should constantly be improved. Care of soil should also be brought to the same level as it has been done with other participants of eco-system.
Key words: biological contamination, chemical contamination, anthropogenic soil degradation, physical destruction

INTRODUCTION

Use of soil is in practice carried out in multifunctional manner, in other words, from the aspect of its ecological and technical functions. These two basic groups have tendencies for the same land area so the question emerges whether it is possible to harmonize relationship between two of them. As a result of use of soil from the aspect of its technical functions, soil suffers great consequences which vary from temporary exclusion from crop production to its permanent destruction. In this paper we deal with four basic groups of consequences in the area of soil use which are: biological contamination, chemical contamination, anthropogenic soil degradation, physical destruction. In the paper are also elaborated causes of unhealthy condition of soil as well as recovery. In Bosnia and Herzegovina losses in soil are 3000 ha per year and in states of ex-Yugoslavia those losses are about 15 000 ha, while entire world is deprived of 7 million ha of soil per year. This is a growing trend because demands for living areas, factories, roads, exploitation of materials etc. will still be present. Question is whether these losses could be reduced? There are no absolute measures but there are however relative measures. In this presentation we will mention some of those measures. In the past few years there have been so called technogenous soils created. These new creations are separated into separate class in the soil classification, so called technogenous soils.
In the paper we elaborate following topics:
- Causes and consequences of soil damage
- Indicators of unhealthy state of soil
- Measures of soil protection and recovery

CAUSES OF SOIL DAMAGE

Causes for soil damage can be observed from two aspects: its use from the standpoint of crop production and from the standpoint out of this domain.
In the area of soil use for **crop production** damages are a result of its irrational use, incorrect tillage, losses in organic matter, soil compaction, loss of structure etc.
In the area of soil use **out of domain of crop production**, causes are numerous and consequences are manifested in different manners. Consequences also vary from occurrence of small damages to the most severe cases were soil is totally lost as natural object.

CONSEQUENCES OF SOIL DAMAGE

As a result of large number of causes for soil damage, different consequences emerged. They can be divided into four groups:
-biological contamination of soil
-chemical contamination of soil
-anthropogenic degradation of soil
-physical destruction of soil.

Biological contamination (soil infection)

This problem started to be spoken of much later than its other manifestations.
What is soil infection?
This term covers addition of various parasites, viruses, fungi and bacteria into the soil. Their presence can have the following consequences:
-infection of farmers who perform their daily activities at the soil,
-desease of domestic animals which move and feed on such land areas,
-pollution of agricultural products grown on such farm land and therefore harmful effect to health of population which consumes products grown on that soil.

Research in this domain has not been sufficiently conducted in our country.
We will briefly mention some data regarding possibilities of their presence in the soil. Research conducted on parks, children's playgrounds in Sarajevo city area has shown significant presence of certain parasites such as viruses, bacteria, fungi etc.
What is the health status of the soil in the areas where recultivation is carried out in garbage dumps?
In any case, such study should involve experts in various areas (pedologists, veterinarians, microbiologists etc.). This issue is very contemporary because of large number of newly found infective diseases such as bird flu, brucellosis, swine flu etc. In any case, it is important to conduct research and have a follow-up of soil condition in our country in order to evade possible consequences on health of both human population and animals. It is also important to know how long can certain pathogens survive in the soil. In the following table is data about survival time for some parasites.

Table 1. Survival time for some microorganisms in liquid cowshed manure according to Tamasi

Microorganisms	Days of survival
Brucella spp.	1-100
Leptospira spp.	60
E. coli	120
Chlomaydia spp.	27
Classic swine influenza virus	5-40
E. Enteretidis	143

Chemical contamination of soil

This process implies addition of various harmful organic and anorganic matters into the soil, in various states of matter (solid, liquid and gas). In our country this area is fairly well researched. There are many causes for such contamination: heavy metals, organic pollutants, radionuclides, mineral fertilizers etc. Their presence is particularly risky from the standpoint of production of sanitarily safe food and therefore health of people. Some research has shown that chemical contamination is present mostly nearby traffic roads. Research directed to that area has shown that soil at the distance of 5-10-20-30-50m was still contaminated, which means that agricultural products were contaminated as well.

Table 2. Border values of heavy metals content in their total form

Metal	mg/kg of soil
Lead – Pb	100
Cadmium – Cd	3
Zinc – Zn	200
Copper – Cu	100
Cobalt – Co	60
Mercury – Hg	1
Manganese - Mn	850

Anthropogenic soil degradation

This process is soil damage in the function of its regular use in crop production. It is a result of its irrational use and it is manifested in deterioration of physical, biological and chemical properties of soil. Consequences can be formed in the following: structural damage, compaction, reduction in physiological soil depth, occurrence of surface and ridge erosion, landslides, loss of nutrients and general loss of fertility. It is necessary to do tillage on slopes and turn grassland into farmland. There can also be included changes in follow-up of damage after fire.
Protection measures are based on prevention of negative influences and damage recovery, humisation, great caution while tillage at slopes, strict control of turning grassland into farmland, tillage according to cultures planted, construction of protective wind shields and caution while adding protective agents for plants.
All the above mentioned requires constant follow-up in soil changes.

Physical destruction of soil (pedocide)

This process is the most severe attack on soil and its properties. Causes are numerous and consequences can lead to either permanent or contemporary exclusion of soil from crop production.
In the case of **temporary exclusion of soil from crop production** we can state the following causes: surface exploitation of raw materials (coal, iron ore, bauxite etc.), exploitation of gravel, and other exploitation sites, waste areas for different types of waste: communal, industrial (ash, coal dust, cinder), medical and pharmaceutical waste, metals, electric appliances etc. All these causes lead to temporary exclusion of soil from its ecological functions. Recovery measures are re-mediation and re-cultivation. All the re-cultivated areas as well as products obtained from that farm land have to be constantly controlled for health condition.
Permanent loss of soil is the most severe aspect of soil damage. It is manifested in total exclusion of soil from crop production, in other words, soil loses its primary function.
Regarding the size of affected areas we can point out following causes:
-construction of living areas
-industry
-roads
-water accumulations
-military objects
-airports etc.

Consequences of these causes are very significant, especially if they take place on the most valuable farm land with soil bonitet from I to III category. Annual soil losses to these causes only are 3000 ha in Bosnia and Herzegovina. Question is whether these losses can be reduced. We have to stress out that there are no absolute measures of protection because construction of all the above mentioned objects will be necessary in the future as well. What can we do? Basic concern is how to protect the most valuable soil. For this purpose it is necessary to have maps of soil value or bonitet maps. Use of

the most valuable soil for the above mentioned purposes should be prohibited by the law. Such objects should be located on less valuable soil categories.
Regarding the soil which is temporarily excluded from crop production, we can imply measures of re-mediation and re-cultivation and return them back o normal, regular production.

SOIL HEALTH STATE-INDICATORS OF ITS UNHEALTHY STATE

From the aspect of production of sanitary safe food it is important to know health condition of soil. We can state that it is conditio sine qua non for such production. Soils can be in healthy and unhealthy condition. Soils in unhealthy condition from the aspect of crop production are those with reduced or with no capacity for production of sanitarily safe food. What are the indicators of unhealthy condition of soil? Causes can be chemical, physical and biological.
In the following table is an overview of these indicators.

Table 3. Unhealthy condition of soil indicators

Visible causes	Causes obtained from analyses
1. stagnation in surface (rainfall) water	1. reduction in humus content
2. adverse structural state	2. acidification
3. intensive development of erosion (surface, ridge)	3. presence of heavy metals and organic pollutants
4. shallowness of physiologically active part of profile	4. reduction in soil resistance
5. compaction	5. reduction in soil fertility
6. reduction in soil watertightness	6.reduction in water retention
7. creation of crust	7.higher values of wilting point
8. shallow plant rooting	8. high values of soil mechanical resistence
9. ground water level	9. high pH values <27,3
10. landslides	

Within necessary measures it is important to pay special attention to the following:
-planning of rational use of land
-possession of relevant data and maps in the process of change of purpose for certain parcel
-increase of soil immunity, its defensive immunological mechanisms
-continuous control of soil health condition
-improvement of law regulations
Certain parcels demand application of special measures such as drainage and irrigation.

CONCLUSIONS

In this paper we examined ecological and technical functions of soil. Both of the functions have tendencies to the same parcel. We proposed possibilities for harmonization of their mutual relationship. Causes and consequences of soil damage are stated and four groups of consequences are pointed out: biological contamination, chemical contamination, anthropogenic degradation and physical destruction. Indicators of unhealthy condition of soil are also stated, as well as the measures for recovery of damaged soil.
Some of the necessary measures we propose for the damaged parcels would be:

- Intensified production on agricultural land,
- Evaluation of land especially in karst area and its inclusion in agricultural production,
- In the process of treatment of damaged soil it is necessary to pay special attention to protection of fertile layer, performing its separate disposal,
- Establishment of **special office of soil inspector** which would constantly monitor losses in soil not just quantitatively but also according to its quality,
- Possession of maps stating health condition of soil, especially from the aspect of biological and chemical contamination, for the purpose of sanitary safe food,
- Creation of maps of soil damage

- Involvement of active and potential water erosion state into the projects,
- Strict following of the law according change of purpose of land on inclined surfaces,
- Constant improvement in laws regarding soil protection.

Special measures for protection of land are: creation of maps of land value, maps of soil damage and maps of soil contamination. Special attention should be paid to continuous monitoring of soil health state follow-up. We have to keep in mind that land is non-renewable resource and that on the territory of Bosnia and Herzegovina there is small amount of quality soil (32%).
Care of soil and its protection should always be present in all our actions and its protection should constantly be improved. Care of soil should also be brought to the same level as it has been done with other participants of eco-system.
We would like to conclude with contemplation of an American scientist:
Land is your home land-preserving it means serving your country!

REFERENCES

[1] Benhabib, K., Marie-Odile Simonnot, Appert-Collin, J.C., Sardin, M., PAH desorption from contaminated soil samples, Pollutant dynamics and transfer risks, SUITMA, Nancy, 2003.
[2] Blum, W.E.H., Sustainable land use and environmental protection. Soil and water use relating to sustainable development and environmental protection. Acad.Sci. and arts of Bosnia and Herzegovina, Special publications, Vol. CIX, Sarajevo, pp. 61-69, 1999.
[3] Birkas, M., Soil condition assessment Environmentally, Sound adaptale tillage. Akadémiai Kiadó, Budapest, 2008.
[4] Csete, L., Agrienvironment protection and soiciety, Akademia Kiado, Budapest, 2004.
[5] Resulović, H., Causes and consequences of soil damages in Bosnia and Herzegovina-some experiences in soil protection, Bearing the costs of remediation: Polluter pays and owner pays principle, International Committee on Contaminated Land, pp. 155-160, 2001.
[6] Resulović, H., Čustović, H., Bukalo E., Vesna Kraišnik: Modern principles of analyzing damages and repairing destroyed soil in function of food production, Innovations in Crop and Vegetable Production, Preliminary reports, pp 16-17, Belgrade, 2011.
[7] Rossiter, D. G. Burghardt, W.: Classification of urban and industrial soils in the World Reference Base for soil resources (WRB), SUITMA, Nancy, 2003.
[8] Varallyay, G., Degradation processes of soils-A global overview, Pollution processes in Agri-environment, pp. 91-13, Budapest, 2004.

OVERVIEW OF RELEVANT INFORMATION ON THE USE AND PRODUCTION OF BIODIESEL

Zoran Carkic[1], Jörg Lükert[1], Dragana Dimitrijević[2], Slavica Prvulović[2], Dragiša Tolmač[2], Jasna Tolmač[2]

[1]PETKUS Technologie GmbH, Röberstrasse 8, D-99848 Wutha-Farnroda, Deutschland
[2]University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
e-mail: zorancarkic@gmail.com, dragisatolmac@gmail.com

Abstract: This work represents a review of biodiesel production in the world. European Union (EU) policy and aims are to reduce increased emission of gases, CO_2 in particular, which cause greenhouse effect due to increase in demand and use of fossil fuels. Studies which are made for biodiesel, show that the total energy balance is positive. Regulations and aims directed to increase in production of biodiesel are also shown as well as possibilities for obtaining and use of this ecological fuel. Questions of energy, due to unequal distribution of power and different resources and reserves in the world, have long been beyond the state borders. For sustainable economic development depends on the sufficient amount of energy, and increased use of energy sources is inevitable. Growing needs in energy, as well as the significant changes that occurred and occur in the world energy market and increasing the impact of energy production and consumption on the environment, contributed to that energy is now considered globally due to their interdependence. On this basis, the paper presents the following: Global production of biodiesel, Existing / required production capacity of biodiesel in the EU, and some aspects related to environmental protection in the event of replacement of mineral fuels biodiesel.
Key words biodiesel, production, utilization

INTRODUCTION

Because of a lower supplies of fossil energy sources in the present time, a growing interest in other energy sources is expressed. Such energy sources are alternative energy sources, or renewable energy sources. This group consists of energy sources: wind energy, sun energy, waterpower, geothermal energy, wave energy and energy obtained from biomass.

The most important energy of 20. century was oil. In the world's primary energy consumption oil has participated with about 35%, coal with about 24%, gas with about 18%, renewable energy with about 17% and nuclear energy with about 6% (Prvulović, et al., 2009).

Consumption of energy in the world is growing by the day despite a series of measures to be taken in order to energy conservation in all areas of human activity. According to BP Statistical Review of World Energy 2008, the world energy consumption in 2007 is around 11,000 million tons of oil equivalent. According to the forecast, the total world energy consumption by 2020. year is going to grow for close to 50%, and up to 2060. year is going to grow for about 3 times.

It is well known that transport almost completely dependent on fossil fuels. Demand for energy is growing continuously, as well as dependence on imported energy, which contributes to the development of the renewable energy sector. All efforts are focused to find such a fuel that would be tailored to existing structures engines, and at the same time meets the additional criteria related to regenerationing and ecology, as well as reliability of using.

Wider appliance of liquid fossil fuels has caused research and development and oil processing and are the reason why the world's capacity were continuously spread. (Mushrush et al., 2001).

Advances in technology and scientific knowledge contributed to the development of renewable energy sector, and oil still remains the main source of energy production and consumption, which grows from day to day. However, oil reserves are not eternal, and the world industry deals with all the serious search for alternative types of fuel, which could one day replace oil.

One of the most important renewable energy sources, if not the most important is biomass as for amount of energy periodically renewed and the relatively small cost of production, and collection. The great advantage of biomass is reflected in obtaining ecological alternative fuels, as one of the possible

solutions more imposing is biodiesel, fuel that origins on plant processing and waste oils. (Encinar et al., 2002; Tolmač, et al., 2005).
For sustainable economic development depends on the sufficient amount of energy, and increased use of energy sources is inevitable. Questions of energy, due to unequal distribution of power and different resources and reserves in the world, have long been beyond the state borders. Growing needs in energy, as well as the significant changes that occurred and occur in the world energy market and increasing the impact of energy production and consumption on the environment, contributed to that energy is now considered globally due to their interdependence, (Tešić, et al., 2009). Accessibility and security of energy supply for all countries of the importance of life, because it is impossible to create the minimum economic and social progress without power. Energy will have more importance, because the need for energy is constantly increasing, due to increasing population, and due to an increase in the level and standards of life in all countries of the world. According to the evaluation of all the leading associations, renewable of energy in the XXI century will be the significant growth.

PRODUCTION AND USE OF BIODIESEL

The desire for progress and development of existing technology of getting biodiesel has led many countries in the world to discovering new raw materials from which it is possible to get this ecological fuel. In addition to the basic raw material for obtaining biodiesel worldwide are used : palm oil, coconut, sugar cane and wood jatrofa, vegetable (Al-Widian et al., 2002; Tolmač et al., 2009) . All these advances in the development of technology production of biodiesel carry with them some difficulties. Because of seizing working areas, ie. growing plant culture to obtain a higher degree of biodiesel, in the world, notably in the eastern countries of the world, there is a problem of lack of surface for planting wheat and other crops that are necessary factor of human life. (Brkić et al., 2005). Using food crops to produce biodiesel is increasing the world food problem. According to FAO there are more than 1,02 billion hungry people. For these reasons, the production of biodiesel has a limiting factor. (Prvulović et al., 2009). Biodiesel is an environmentally friendly alternative liquid fuel that can be used in any diesel engine without modification. There has been renewed interest in the use of vegetable oils for making biodiesel due to less pollution and its renewable nature in contrast to conventional petroleum diesel fuel. (Demirbas, 2008).
In 2007. year total production in the world amounted to seven million tons of biodiesel, which is a approximately 2.9 million tons produced Germany, as shown in Figure 1.
In Europe, produces more than 80% of world production of biodiesel, with high annual growth rates of production and processing capacity. Existing and planned production and growth capacity of plants for biodiesel production in EU countries are shown in Fig. 2.

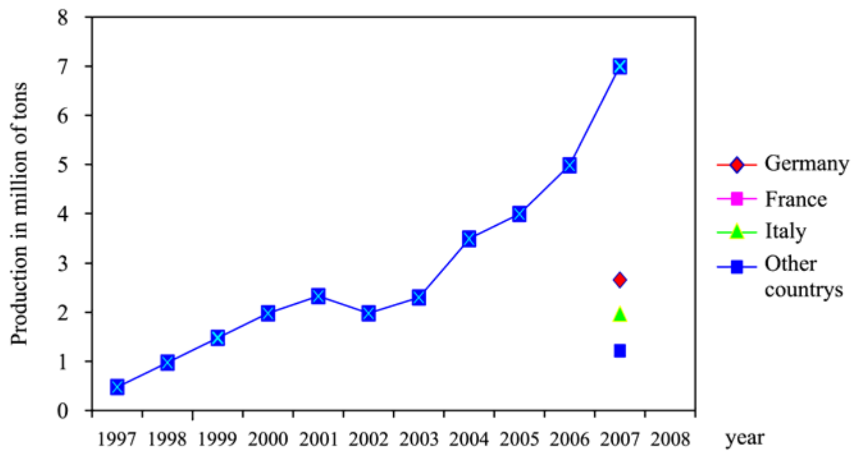


Figure 1. Global production of biodiesel

Biodiesel started to be widely produced in the early 1990-s and since then production has been increasing steadily. The global biodiesel industry is among the fastest-growing markets the chemical industry has ever seen. World capacity, production, and consumption of biodiesel grew on average by 32% per year during 2000-2005, and the industry looks set for even faster growth rates 115% per year for capacity, and 101% per year for demand in the years to 2008 and beyond, Fig. 2.

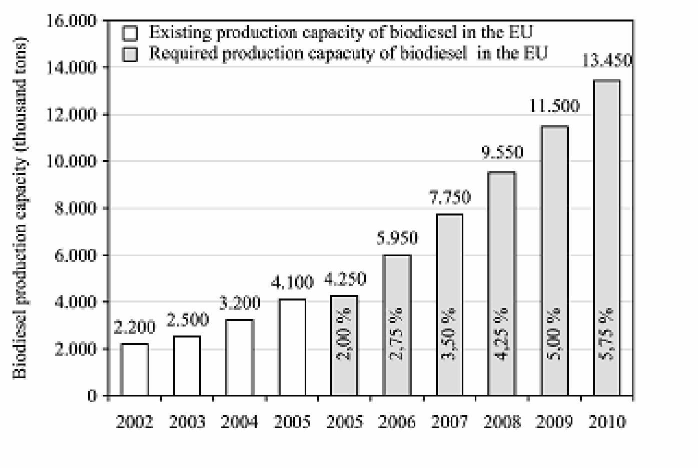


Figure 2. Existing required production capacity of biodiesel in the EU

Germany, the largest biodiesel market, has excluded biofuels from taxation altogether. The main characteristic of Germany is to market 100% pure biodiesel, which is on sale in Germany at over 1500 public filling stations (Balat, 2009).

The European Union is on the third rank of biofuel production world wide, behind Brazil and the United States. In Europe, Germany is the largest, and France the second largest producer of biofuels. Most biofuels in commercial production in Europe today are based on sugar beet, wheat and rapeseed, which are converted to bioethanol / ETBE and biodiesel. The European Commission has set as a goal that by the end of 2005. year, 2% of the energy used in transportation shall be biofuels. The use of biofuels is then to grow by 0.75% annually. The ambition is to have 5.75% biofuels in transportation by 2010. (Balat, 2007).

The European strategy is that, share of consumption of bio-fuels is growing at the rate of 0.75% per annum. According to EU directives 2003/30/EC reference value set goals (calculated on the basis of energy content of the total petrol and diesel) is: 2% to 31. december 2005. and 5.75% to 31. december 2010.

Interest in biodiesel production is rapidly increased in the last 5 years. The first amount of commercially made biodiesel has emerged in the EU in early 1990's, but it’s estimated growth at the EU level, in the last few years has reached 35% annually.

Initiators of significant investment in increasement of production capacity in the EU, especially in Germany, which caused the development of biodiesel in the EU.

Complete assessment of the energy balance of fuel cycle includes not only the energy content of biodiesel and energy is spent in the production, but also energy that is absorbed welcome by all the necessary process to reach the final product.

Amounts of emissions are becoming a growing problem of industrial developed countries. It is known that engines with internal combustion are big air pollutants. According to different authors, from (68 to 85)% of total air pollution, causing engines with internal combustion. Car Exhaust gases contain about 200 different substances, of which a particularly toxic can be distinguished as follows: CO2, CO, NOx, CH, Pb and its compounds (Furman et al., 1995).

Using biodiesel instead of mineral diesel it is reduce emissions of hydrocarbons. When using biodiesel instead the mineral diesel in combustion engines and it is reduces emissions of solid particles. Unlike mineral diesel sulfur and its compounds in the biodiesel are contains only in trace. Application of biodiesel in terms of carbon dioxide (CO2) is a neutral, which means that the combustion of biodiesel liberates the same amount CO2 as the plant absorbed during photosynthesis. However, in the

production chain of biodiesel, it is used mineral diesel also, in the stage of production and transport of plants-raw material for biodiesel. Therefore, reducing emissions of carbon dioxide is not completely, but only 78.3%. Biodiesel is biodegradable. Studies have shown that biodiesel can break down to 98% flow for 21 days, while the mineral diesel decompose only 50% in the same period (Leung et al. 2005). This can reduce the risk of pollution of soil and surface and groundwater. It is this feature of biodiesel justifies its wider use in nature reserves and national parks, and in agricultural areas. Using pure biodiesel instead of mineral diesel emission prevents 2.8 kg CO_2 equivalent per kilogram of biodiesel (IFEU, 2005). According the projected substitution from 29 000 t, mineral diesel with biodiesel, which is 2% of diesel consumption in Serbia, according to (Bašić et al. 2007), to prevent emissions of greenhouse gases in the equivalent quantity of 80,00 tonnes of CO_2. Looking cumulatively for the period 2007-2010. amount of preventing emissions of greenhouse gases would be equivalent to approximately 650.000 tons of CO_2 (Fig. 3)
Based on laboratory tests of biodiesel as a motor fuel, (Best, 2006; Nikolić, 2002) it is found that biodiesel does not damage the parts of diesel engines. On the contrary, its high capacity for lubrication, compared to mineral diesel, causing less wear clips, sealing rings, cylinder walls and precision parts of pumps for fuel injection. Increased emissions of gases that participate in the greenhouse effect (mainly due to increased demand and use of fossil fuels) and their impact on global climate is the reason for the moves that try to reduce the emission of these gases, especially CO_2.

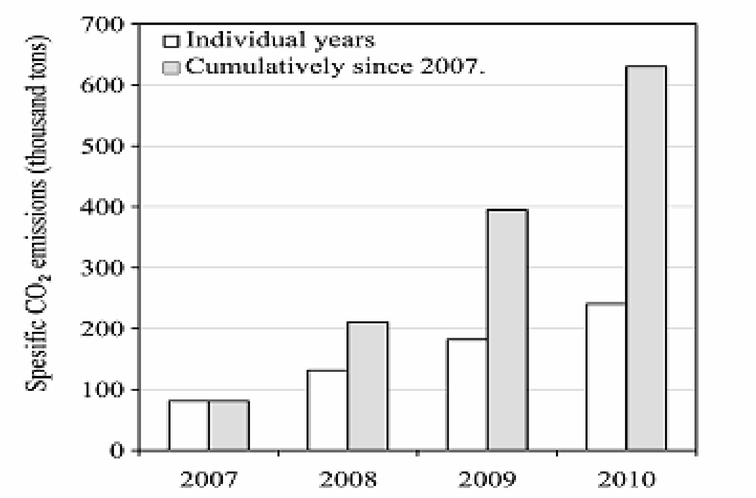


Figure 3. Prevented emissions of greenhouse gases in the case of substitution of mineral diesel with biodiesel

In the context of the conference in Riu and Kyoto protocol, the EU pledged to reduce the total emission of gases with greenhouse effect, where a large share of CO_2, 8% by 2012. year in a comparison with 1990. year.

RESULTS AND DISCUSSION

In Europe, biodiesel is most used in transportation, agriculture, forestry and construction and due to their bio-degradability characteristic and less emission of harmful gases in a comparison to the classic fuel (Hawkis et al., 1982).
Germany is world champion in the production of eco-fuels. The factory "Horen industries, in the German city Freiburg will soon begin production of biodiesel generation. As raw materials, in addition to traditional biomass, will be used agricultural wastes-stem, straw and pulverous straw. Until now, for the production of biodiesel only crop of family agricultural was suitable. The authors of this new technology called BTL (Biomass to Liquid) enable the processing of whole plants, as well as straw and pulverous straw. Production of biodiesel is more economic
and in majority environmental than earlier types because the whole plant processes in biomass, not just the fruit. In this way, with one hectare oilseed rape we can get 3 300 liters of biodiesel, while the

standard technology gets two times less amount of fuel. (Brkić et al., 2005; Encinar et al., 2002; Prvulović et al., 2008).
Obstacle to the wider introduction of alternative energy sources makes his undurability, because bio-fuel quickly loses its quality and becomes a cause premature of engine fatigue. To the rapid deterioration of the biological product oxygen contributes, which is his ingredient.
Brazil has developed a new diesel combined with vegetable oil, which will drastically reduce the need for the country to import diesel.
India at the same time hope that they will achieve success in the production of biofuel from wood jatrofa, for which breeding government of the country already allocated 40 million hectares of land. In Delhi, they hope that the fuel made of jatrofa, for five years will be able to replace 20 percent of Indian consumption of oil (Balat, 2009).
Document on renewable energy sources adopted in 1997. year , meets us in order to achieve a sustainable energy system in the EU. The aim was to duplicate (with 6% to 12%) share of renewable energy sources in total energy consumption in the EU by 2010. year.
Within the sector, which used the final form of energy transport sector is the most important, first because of its share in final consumption (over 30% of the total energy consumption) and secondly, due to its almost complete dependence on liquid fossil fuels. Transport policy is the priority area in improving energy efficiency. Road traffic is of particular importance because it is responsible for 84% of total CO_2 emissions from the transport sector.

CONCLUSION

Production and use of biodiesel is a trend that is very present in the whole of Europe and in the world. The use of biodiesel is very important and is present in energetics and ecology.
Technically, the undeniable fact is that the sources of fossil fuel are still limited. Liquid fuels for starting the engines and all kinds of mobile systems are in that measure applied in practice that is totally unrealistic to expect any quick preorentiation to other fuels. Investment in research and exploitation of new oil sites from year to year are increasing, and therefore the price, of liquid fossil fuels grows. A special problem is to provide a safe supply of oil from the region with rich deposits.
The alternative is biodiesel, which has the possibility to be mixed with fossil diesel in all segments. It can be used in engines without special intervention on the engine. In addition to the fact that biodiesel made from renewable raw materials (plant oils), as well as minor differences in the energy potential of fuel it is clear that this is the right solution for a transitional period until other forms of energy operationise and adequately adapt to the new engine design.
It is generally known fact that the use of liquid fossil fuels contributes to the accumulating carbon dioxide in the atmosphere, which is the cause of the occurrence of greenhouse effect. This is one of the most important negative effects of the use of fossil fuels.
Biodiesel in the economic sense has significant advantages. Degradability in water and soil is relatively fast and complete. In car exhaust gases there are much less harmful substances. From the standpoint of carbon dioxide, biodiesel is neutral, because all the amount of biodiesel combustion that overhangs in the atmosphere engines throughout photosynthesis in plants from which is again re-produced biodiesel.

REFERENCES

[1] Arslan R. 2007. Agricultural and Economic Potential of Biodiesel in Turkey. Energy Sources, Part B: Economics, Planning, and Policy 2:305-310.
[2] Al-Widian M.I., and Al-Shyoukh A.O. 2002. Experimental evaluation of the transesterification of waste palm oil into biodiesel, Bioresource Tecnology 85: 253-256.

[3] Balat M. 2007. An Overview of Biofuels and Policies in the European Union, Energy Sources, Part B: Economics, Planning, and Policy 2: 167 – 181.
[4] Balat M. 2009. Prospects for Worldwide Biodiesel Market Development, Energy Sources, Part B: Economics, Planning, and Policy 4: 48 – 58.
[5] Bašic D, Tešic M, Kiš F, and Janković V. 2007. Possibilities of production and use of biodiesel in the region Vojvodina – Serbia. Faculty of Technical Sciences, Novi Sad.
[6] Best G. 2006. Alternative energy crops for agricultural machinery biofuels – focus on biodiesel. Agricultural Engineering International: the CIGR E journal 8.
[7] Brkić M. 2005. Ecological significance of biodiesel - Biodiesel and ecological alternative liquid fuel. Faculty of Agriculture, Novi Sad .
[8] Brkić M, Skala D, Mulić R, Marić M. 2005. Technology production of biodiesel - Biodiesel and ecological alternative to liquid fuel. Contemporary Agricultural Engineering 30: 73-105.
[9] Canakci M, and Van Gerpen J.H. 2003. Comparison of Engine Performance and Emissions for Petroleum Diesel Fuel. Transactions of the American Society of Agricultural Engineers 46: 937-944.
[10] Demirbas A. 2008. The Importance of Bioethanol and Biodiesel from Biomass. Energy Sources, Part B: Economics, Planning, and Policy 3: 177 – 185.
[11] 11.Encinar J.M, Gonzalez J.F, Rodriguez, J.J, Tejedor A. 2002. Biodiesel fuels from vegetables Oils: Transesterification of Cynara cardunculus L. oils with ethanol. Energy & Fuels 19: 443-450.
[12] FAO, 2009. http://www.fao.org/hunger/en/
[13] Furman T, Nikolic R, Oparnica S, Popovic Z, Brkic M, Veresbaranji I. Keckes I, and Macvanin N. 1995. Biodiesel production and use, Faculty of Agriculture. Institute for Agricultural Technology, Novi Sad, Serbia.
[14] IFEU, 2005. Biodiesel initiatives in Germany, Final report, Germany, Heidelberg, p.24.
[15] Hawkins C. S, and J. Fuls. 1982. Comparative combustion studies on various plant oil bio-diesels and the long term effects of an ethyl bio-diesel on compression-ignition engine. Proceedings International Conference on plaint oils as fuels. American Society of Agricultural Engineers 4-82: 184-187.
[16] Leung D.Y.C. et al. 2006. Degradation of biodiesel under different storage conditions, Bioresource Technology 97: 250-256.
[17] Mushrush G.W, Beal E.J, Spencer G, Wynne J.H, Lloyd C.L, Hughes J.M, Wall C.L, and Hardy D.R. 2001. An environmentally benign soybean derived fuel as a blending stock or replacement for home heating oil. Journal of Environmental Science and Health 36: 613-622.
[18] Nikolić M. 2002. Biodiesel as alternative fuel in the engines. Faculty of Agriculture, Novi Sad.
[19] Peterson C.L, Reece D.L, Hammond B.J, Thompson J.C, and Beck S, 1995. Commercialization of Idaho biodiesel (HYSEE) from ethanol and waste vegetable oil. ASAE Paper No. 956738. ASAE, St. Joseph, MI.
[20] Prvulović S, Tolmač D, and Radovanović Lj. 2008. Analysis of investing input effect in corn product industry. Contemporary Agricultural Engineering 34:13-18.
[21] Prvulović S, Tolmač D, Radovanović Lj, and Blagojević Z. 2009. Analysis of state in biodiesel production in Serbia. Research and design in commerce & industry 23: 61-66.
[22] Prvulović S, Tolmač D, and Blagojević Z. 2009. Global energy perspectives. Energetic Technologies 2: 9-16.
[23] Tolmač D, and Prvulović S. 2005. Design industrial biotechnology processes, Energetic Technologies 4: 9-11.
[24] Tolmač D, Prvulović S, Štrbac N, and Radovanović Lj. 2009. Material and energy balance of biodiesel production. Contemporary Agricultural Engineering 35:185-190.
[25] Tešić M, Kiš F, Janković V. 2009. Suggested strategy for wide-scale introduction of biodiesel in Serbia. Contemporary Agricultural Engineering 35: (3) 207-213.

SUPERCRITICAL FLUID EXTRACTION – PERSPECTIVE OF NEW TECHNOLOGY

Snežana Filip[1], Kiril Lisičkov[2], Nina Đapić[1]
[1]University of Novi Sad, Technical faculty "Mihajlo Pupin" Zrenjanin, Serbia
[2]Faculty of Technology and Metallurgy – Skopje , Macedonia
e-mail: zana@tfzr.uns.ac.rs

Abstract: This article review some of the perspectiv of supercritical extraction. In the past decade, SFE has been applied successfully to the extraction of a variety of organic compounds from herbs and other plants. Today, this technique is used in many areas. In the future SFE is used for extraction food, drugs but also very interesting application of the SFE technique is in the environmental area, for extraction or clean up of pesticides from natural products.
Key words: supercritical fluid extraction, natural products.

INTRODUCTION

In the 21st century, the mission of chemical engineering is to promote innovative technologies that reduce or eliminate the use or generation of hazardous materials in the design and manufacture of chemical products. The sustainable use of renewable resources, complying with consumer health and environmental requirements, motivates the design, optimization, and application of green benign processes. Supercritical fluid extraction (SFE) is a typical example of a novel technology for the ecologically compatible production of natural substances of high industrial potential from renewable resources such as vegetable matrices that finds extended industrial application.
The high solvatation power of supercritical fluids (SF) was first reported over a century ago [1]. Demonstration of SFE technology for industrial applications was reported by Zosel at the Max Planck Institute for Kohlemforschung in 1969 [2]. Initially, the experiments with SC-CO_2 extraction of natural products were conducted in a limited number of laboratories, most intensively in Germany [2] and in Russia [3]. Since then, many laboratories in different countries have been equipped with SFE units and extensive research has been done in the extraction of flavours, spices, essential oils, and other substances from herbs and plants. The first pilot and full-scale plants were built for SC-CO_2 extraction of caffeine from coffee beans and tea leaves, the extraction of acids from hops giving taste to bear, and the extraction of taste and flavour compounds from spice. The number and capacity of industrial units for supercritical extraction and the variety of extracted substances are increasing, and today more than 200 industrial plants are operating all over the world [4]. The two most important commercial applications of SFE in the food industry still remain hop extraction and coffee decaffeination [5]; however, the production of extracts rich in biologically active substances as antioxidants, lipid-soluble vitamins, and others is fast increasing. Small-scale SFE for analytical application was developed in the midle-1980s in response to the desire to reduce the use of organic solvents in the laboratory environment [6].
Today, SFE has become an acceptable extraction technique used in many areas. The most important application area is still extraction of natural products from plant materials. Although the focus of the research in SCF applications is moving nowadays to new areas, such as particle design, chemical reactions in supercritical solvents, polymer treatment with SCF, and fractionation of liquid natural products as edible oils. Concerns about the cost and environmental dangers of waste disposal, and the emission of hazardous solvents into the atmosphere motivate the design and application of a green technology such as SFE [7].

PHISICAL AND CHEMICAL CHARACTERISTIC OF CO_2 AS EXTRACTION FLUID

A supercritical fluid (SF) is a substance above its critical pressure and temperature (Table 1). Its properties range between those of liquid and gas (Figure1). SF is characterized by a high density, near the density of liquid, which is convenient for dissolution of their power. Diffusivity of SF is large and glows diffusivity of gases, while their viscosity is low and close to the viscosity of gases, which allows them to ease penetration into material and its dissolution.

CO_2 is the most commonly used supercritical fluid, has a moderately low critical pressure and quite a low critical temperature (Pc=73,8 bar, Tc=31,1°C). Mild extraction conditions are suitable for extracting high-value thermolabile compounds. The solvating power of the fluid can be manipulated by changing pressure (P) and/or temperature (T); therefore, it may achieve a remarkably high selectivity [8]. Solutes dissolved in supercritical CO_2 can be easily separated by depressurization, so the residue of solvent is not detected. Carbon dioxide is non-flammable, non-explosive, cheap, and easily accessible in high purity.

SFE uses no or significantly less environmentally hostile organic solvents. A SFE method may need no or only a few milliliters of an organic solvent while a typical Liquid-Solid extraction method would require tens to hundreds of milliliters. In large scale SFE processes, the fluid, usually CO_2, can be recycled or reused thus minimizes waste generation. SFE can be applied to systems of different scales, for instance, from analytical scale (less than a gram to a few grams of samples), to preparative scale (several hundred grams of samples) [9], to pilot plant scale (kilograms of samples) [8] and up to large industrial scale (tons of raw materials, such as SFE of coffee beans). To also dissolve more polar substances, supercritical carbon dioxide is usually modified by addition of small amounts of polar liquids, such as methanol, ethanol, water, and others.

Table 1. The fluids critical points

Fluid	Critical temperature [°C]	Critical pressure [bar]
ethylene	9.3	50.4
carbon dioxide	31.3	73.8
ethane	32.3	48.8
nitric oxide	36.5	72.7
propilen	91.9	46.2
propane	96.7	42.5
ammonia	132.5	112.8
hexane	234.2	30.3
water	374.2	220.5

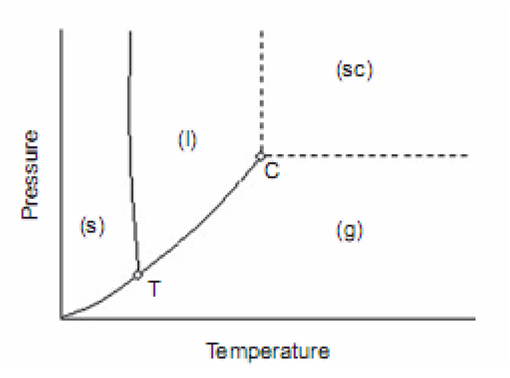


Figure 1. Phase diagram with ternary point (T), critical point (C) and soil (s), liquid (l), gaseous (g) and supercritical (sc) state.

THE PROCESS AND THE EQUIPMENT

High-pressure extraction can be used for the separation of both solid (Figure 2a) and liquid raw substances (Figure 2b). The extraction is usually carried out as a semi-continuous process. Plant material, usually dry and disintegrated, is charged into an extraction vessel of cylindrical shape to obtain a fixed bed of particles. Liquid CO_2 flows from collecting vessel (D) to pump (P), which compresses it to required extraction pressure and transfers it to heat exchanger (E1), where it is heated to the extraction temperature and transferred to the extraction vessel or column (C). The substances to be extracted are dissolved in the CO_2 as they pass through the extraction vessel or column. The CO_2, laden with the dissolved substances, is then fed to separator (S). By adjusting the pressure and/or temperature, the dissolving power of the CO_2 in the separator is reduced, thus causing the extracts to be precipitated. This may take place in several stages, allowing extract fractions of different qualities to be obtained. The gaseous CO_2 from the separator is liquefied in a refrigerated condenser and collected in collecting vessel (D). The use of several extraction vessels for the extraction of substances in the solid state permits virtually semi-continuous operation. More separation stages are often used to achieve a partial fractionation of the extract [10, 11].

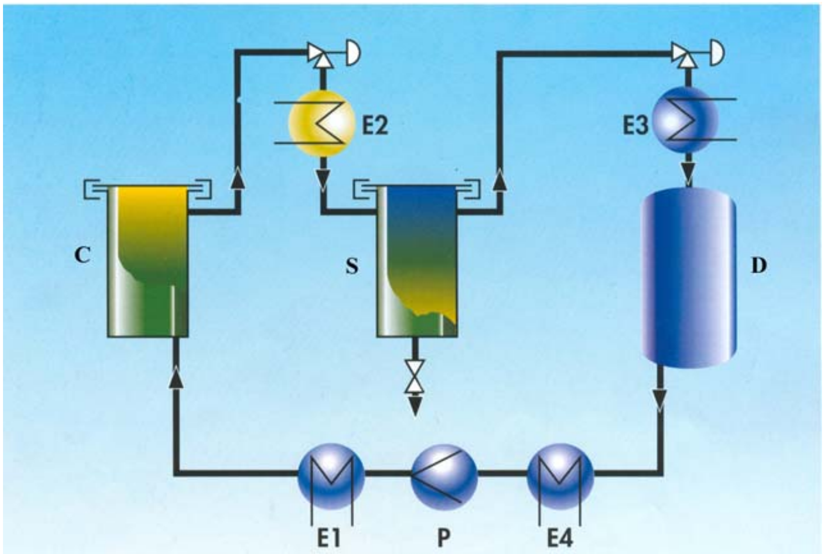


Figure 2a. Process diagram of an extraction system for solid materials [12].

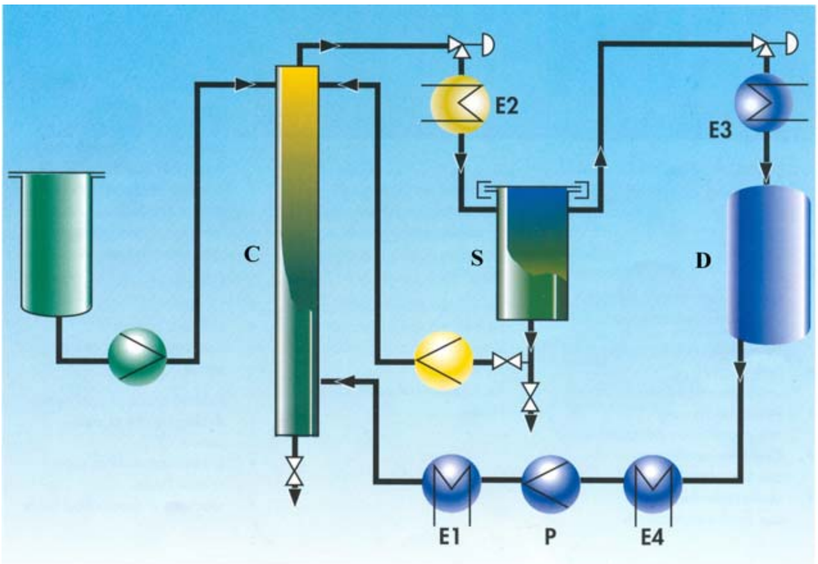


Figure 2b. Process diagram of an extraction system for liquid [12].

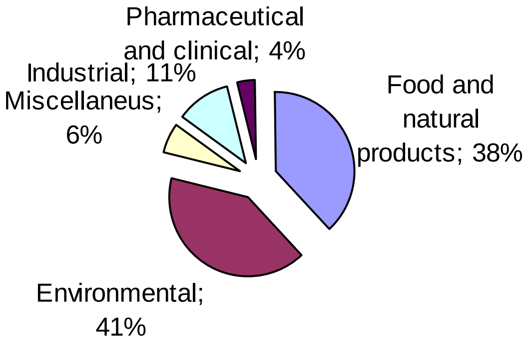
The typical volume of extractors is from 0.1 to 2 dm^3 on the laboratory scale and from 2 to 5 dm^3 on the pilot scale. In micro- and small-scale extraction, the CO_2 flow rate is low and therefore the

equipment does not require solvent recycle – CO_2 can be expanded to ambient pressure in the separator and vented.
When the SFE plant is equipped with several separators in series, fractionation of the extracts is possible, operating the separators at different pressures and temperatures (Figure 3). The scope of this operation is to induce the selective precipitation of different compound families as a function of their different saturation conditions in the solvent. This procedure has often been applied in the SFE of essential oils to separate them from coextracted cuticular waxes [13].
High capital costs of SFE equipment are usually mentioned among the drawbacks of the process. On the other hand, the operating costs are usually lower than those of conventional extraction. Thus, many large-scale units for the SFE of solid natural materials, mainly for food ingredients and phytopharmaceuticals, are operated worldwide and are economically competitive [14].

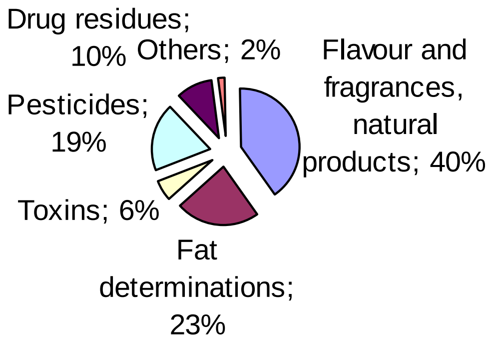
Figure 3. Industrial equipmentwith 3 extractors (500L each), 2 separators (375L each) and 1 separator with 175L. Extraction pressure 440 bar (UHDE) [12].

APPLICATIONS OF SUPERCRITICAL FLUID EXTRACTION

SFE is the most commonly used techniques in food and pharmaceutical industry. Extraction in food industry is carried out of isolation high valuables substances such as fats and oils. Total fat content cholesterol [15], fatty acid composition [16], triglycerides, and phospholipids [17] can be determined by using SFE methods. The extraction of total fat is usually carried out at high pressure (350 - 700 bar) and temperatures between 60 and 80°C. The extraction of oil from seed using SC-CO_2 is interesting on the industrial [18] and analytical scale.
In the beginning, analytical-scale SFE was recommended for application to non-polar, medium molecular-weight compounds. Supercritical fluids are able to extract a wide range of analytes including utterly non-polar, polar and even ionic compounds of widely variable molecular weights.
Figure 4A shows the distribution of SFE methods among major fields of analysis. The percentage of each portion of the pie was calculated from the number of publications recorded in Analytical Abstracts from January 1980 to December 1995. More than 40% of SFE methods are devoted to environmental analysis, followed by 38% concerning food and natural product analysis. Industrial, biomedical and other applications account for 11, 4 and 6%, respectively. While environmental analysis is the widest field of application for SFE, industrial, food and biomedical uses of this separation technique follow close behind [19].



A)



B)

Figure 4. Distribution of SFE applications among major field of analysis [19]

In Figure 4B, the portion of SFE applications to food and natural products is broken down into the isolation of harmful compounds such as drugs, pesticides and toxins, the determination of fats, and the extraction of natural products from plant materials. Extraction of natural products, flavors and fragrances from seeds, vegetables and plants using SC-CO_2 account for about one-half of all SFE applications in food analysis. Determinations of lipids by SFE-based methods are continuously expanding and account for 23%. On the other hand, SFE is less extensively used for isolating analytes such as pesticides, drugs or toxins from samples [19].

The great features of SFE are always in field of the extraction natural products from plant materials. Although preparative SFE has attracted most attention in the area of food and fragrance applications, analytical-scale SFE is gaining increasing acceptance for this purpose. Some of these compounds, including alkaloids, diterpenes and sesquiterpene lactones, are of pharmacological significance; others are of interest to food analysis and the industry. The new development in SFE is in the fractionation of products, dyeing of fibers, treatment of contaminated soils, production of powders in micro and submicro range.

REFERENCES

[1] J.B. Hannay, J. Hogarth, Proc. R. Soc. London A 29,324, (1879).
[2] K. Zosel, Ger. Pat. 1, 493, 190, (1969).
[3] Pekhov AV, Ponomarenko IJ, Prokopchuk AF. Patent USSR No. 167798, (1965).
[4] Perrut M. Proc. 1st Iberoamerican Conf. on Supercritical Fluids, Iguassu Falls, Brazil, (2007).
[5] del Valle JM, Aguilera JM. Review: High pressure CO_2 extraction. Fundamentals and applications in the food industry. Food. Sci. Technol. Int., 5: 1 – 24, (1999).
[6] King JW. Analytical-process supercritical fluid extraction: a synergistic combination for solving analytical and laboratory scale problems. Trends Anal. Chem.; 14: 474–481, (1995).
[7] Sovová H. and Stateva RP. Supercritical fluid extraction from vegetable materials. Rev. Chem. Eng. 27: 79–156, (2011).
[8] Reverchon E., Donsi G., Osseo L.S., Ind. Eng. Chem. Res. 32, 2721, (1993).
[9] Fuh M.R.S., Pan W.H.,. Chuo C.M, Am. Lab. 27, 36, (1995).
[10] Brunner G., Stofftrennung mit überkritischen Gasen (Gasextraktion). Chem. Ing. Tech., 59: 12 – 22, (1987).
[11] Reverchon E., Supercritical fluid extraction and fractionation of essential oils and related products. J. Supercrit. Fluids, 10:1 – 37, (1997).
[12] UHDE Hochdrucktechnik (1996).
[13] Reverchon E., De Marco I. Supercritical fluid extraction and fractionation of natural matter. J Supercrit Fluids, 38: 146 – 166, (2006).

[14] Sovová H., Stateva R., Supercritical fluid extraction from vegetable materials. Rev Chem Eng 27, 79–156, (2011).
[15] Lembke P., Engelhardt H., Chromatographia 35:509-516, (1993).
[16] Artz W.E., Sauer R.M., J. Am. Oil. Chem. Soc. 69:309-313, (1992)
[17] Temelli F., J. Food. Sci. 57:440-442, 457, (1992).
[18] Reverchon E., Sesti Osseo L., J. Am. Oil. Chem. Soc. 71:1007-1012, (1994).
[19] M. Valcarcel, M.T. Tena, Applications of supercritical fluid extraction in food analysis, Fresenius J. Anal. Chem., 358: 561-573, (1997).

SESSION 2: Engineering Environmental Protection and Safety at Work

THE EVOLVING REFINERY AND RISK ANALYSIS

James G. Speight[1], Ljiljana Radovanovic[2], Dragana Glušac[2]
[1]CD&W Inc., Laramie, Wyoming 82070, USA
[2]University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
e-mail: jamessp8@aol.com

Abstract: During the next 50 years, the future of petroleum refinery will be focus on process modification with some new innovations coming on-stream. The industry will move predictably on to (1) deep conversion of heavy feedstocks, (2) higher hydrocracking and hydrotreating capacity, and (3) more efficient processes. A major trend in the refining industry market demand for refined products will be in synthesizing fuels from simple basic reactants (e.g. synthesis gas) when it becomes uneconomical to produce super clean transportation fuels through conventional refining processes. Gasification of residua and incorporation of Fischer-Tropsch processes will be more highly integrated into refineries, which will offer the advantage of high quality products.
Key words: refinery, risk analysis

INTRODUCTION

Petroleum refining technology is experiencing its great innovation driven by the increasing supply of heavy oils with decreasing quality and the fast increases in the demand for clean and ultra-clean vehicle fuels and petrochemical raw materials. As feedstocks to refineries change to heavier crude oils, there must be an accompanying change in refinery technology. This means a movement from conventional means of refining heavy feedstocks using (typically) coking technologies to more innovative processes (including hydrogen management) that will produce the ultimate amounts liquid fuels from the feedstock and maintain emissions within environmental compliance (Penning, 2001; Davis and Patel, 2004; Speight, 2008, 2011).
High conversion refineries will move to gasification of feedstocks for the development of alternative fuels and to enhance equipment usage. A major trend in the refining industry market demand for refined products will be in synthesizing fuels from simple basic reactants (e.g. synthesis gas) when it becomes uneconomical to produce super clean transportation fuels through conventional refining processes. Fischer-Tropsch plants together with IGCC systems will be integrated with or even into refineries, which will offer the advantage of high quality products (Stanislaus et al., 200).

REFINERY CONFIGURATIONS

A petroleum refinery is an industrial processing plant that is collection of integrated process units (Speight and Ozum, 2002; Hsu and Robinson, 2006; Speight, 2007, 2008, 2011). The crude oil feedstock is typically a blend of two or more crude oils, often with heavy oil or even tar sand bitumen blended in to a maximum amount. With the depletion of known crude oil reserves, refining companies have to seek petroleum in places other than the usual sources of supply.
Hydrocarbon-based energy is important and energy prices have had an important effect on economic performance because energy is used directly and indirectly in the production of all goods and services and a decrease in the rate of increase in energy availability will have serious economic impacts.

Petroleum Refinery

In recent years, the *average quality* of crude oil has become has deteriorated and continues to do so as more heavy oil and tar sand bitumen are being sent to refineries (Speight, 2007, 2008, 2011). This has caused the nature of crude oil refining has been changed considerably. Indeed, the declining reserves of lighter crude oil have resulted in an increasing need to develop options to desulfurize and upgrade the heavy feedstocks, specifically heavy oil and bitumen. This has resulted in a variety of process options that specialise in sulfur removal during refining.

In addition, the general trend throughout refining has been to produce more products from each barrel of petroleum and to process those products in different ways to meet the product specifications for use in modern engines. Overall, the demand for gasoline has rapidly expanded and demand has also developed for gas oils and fuels for domestic central heating, and fuel oil for power generation, as well as for light distillates and other inputs, derived from crude oil, for the petrochemical industries.

Therefore, refineries need to be constantly adapted and upgraded to remain viable and responsive to ever changing patterns of crude supply and product market demands. As a result, refineries have been introducing increasingly complex and expensive processes to gain higher yields of lower boiling products from the higher boiling fractions and residua.

Changes in the characteristics of conventional crude oil can be exogenously specified and will trigger changes in refinery configurations and corresponding investments. The future crude slate is expected to consist of larger fractions of both heavier, sourer crudes and extra-light inputs, such as natural gas liquids. There will also be a shift towards bitumen, such as Canadian oil sands and Venezuelan heavy oil. These changes will require investment in upgrading, either at field level to process tar sand bitumen and oil shale into synthetic crude oil shale either at a field site or at the refinery level.

A change in energy resources requires a very substantial increase in upgrading capacity. Where this upgrading capacity will be built is likely to be strongly influenced by greenhouse gas policy. In fact, the petroleum and petrochemicals industries are is coming under increasing pressure not only to compete effectively with global competitors utilizing more advantaged hydrocarbon feedstocks but also to ensure that its processes and products comply with increasingly stringent environmental legislation.

There is also the need for a refinery to be able to accommodate *opportunity crude oils* and/or *high acid crude oils*, which are often *dirty* and need cleaning before refining by removal of undesirable constituents such as high-sulfur, high-nitrogen, and high-aromatics (such as polynuclear aromatic) components. A controlled visbreaking treatment would *clean up* such crude oils by removing these undesirable constituents (which, if not removed, would cause problems further down the refinery sequence) as coke or sediment.

In addition to taking preventative measure for the refinery to process these high-margin crude oils without serious deleterious effects on the equipment, refiners will need to develop programs for detailed and immediate feedstock evaluation so that they can understand the qualities of a crude oil very quickly and it can be valued appropriately. There is also the need to assess the potential impact of contaminants, like metals or acidity, in crudes so that the feedstock can be correctly valued and management of the crude processing can be planned.

Gasification Refinery

A gasification refinery would have, as the center piece, gasification technology as is the case of the Sasol refinery in South Africa (Couvaras, 1997). The refinery would produce *synthesis gas* (from the carbonaceous feedstock) from which liquid fuels would be manufactured using the Fischer-Tropsch synthesis technology.

In fact, gasification to produce synthesis gas can proceed from any carbonaceous material, including biomass. Inorganic components of the feedstock, such as metals and minerals, are trapped in an inert and environmentally safe form as char, which may have use as a fertilizer. Biomass gasification is therefore one of the most technically and economically convincing energy possibilities for a potentially carbon neutral economy.

The manufacture of gas mixtures of carbon monoxide and hydrogen has been an important part of chemical technology for about a century. Originally, such mixtures were obtained by the reaction of steam with incandescent coke and were known as *water gas*. Eventually, steam reforming processes, in which steam is reacted with natural gas (methane) or petroleum naphtha over a nickel catalyst, found wide application for the production of synthesis gas.

A modified version of steam reforming known as autothermal reforming, which is a combination of partial oxidation near the reactor inlet with conventional steam reforming further along the reactor, improves the overall reactor efficiency and increases the flexibility of the process. Partial oxidation processes using oxygen instead of steam also found wide application for synthesis gas manufacture, with the special feature that they could utilize low-value feedstocks such as heavy petroleum residua.

In recent years, catalytic partial oxidation employing very short reaction times (milliseconds) at high temperatures (850 to 1000^{o}C) is providing still another approach to synthesis gas manufacture (Speight, 2008, 2011.

As petroleum supplies decrease, the desirability of producing gas from other carbonaceous feedstocks will increase, especially in those areas where natural gas is in short supply. It is also anticipated that costs of natural gas will increase, allowing coal gasification to compete as an economically viable process (Speight, 2013).

The conversion of the gaseous products of gasification processes to synthesis gas, a mixture of hydrogen (H_2) and carbon monoxide (CO), in a ratio appropriate to the application, needs additional steps, after purification. The product gases - carbon monoxide, carbon dioxide, hydrogen, methane, and nitrogen - can be used as fuels or as raw materials for chemical or fertilizer manufacture.

THE FUTURE REFINERY

Over the past three decades, the refining industry has been challenged by changing feedstocks and product slate. In the near future, the refining industry will become increasingly flexible with improved technologies and improved catalysts (Speight, 2011).

However, even the *tried and true processes* will see changes and ensuing risks as they evolve. The *distillation units* will continue to be the mainstay of petroleum refining and the main short-term developments are in improved integration through the use of heat recovery technology and integration of different distillation units (i.e., atmospheric distillation unit and the vacuum distillation unit). In the long-term, the major developments are the integration of different distillation columns into one reactor (e.g. dividing-wall column) or the development of alternative processing routes allowing for combination of conversion and distillation (such as reactive distillation). Alternative processes to distillation will also include membranes and technologies such as freeze concentration.

Thermal processes will also evolve and become more efficient. While the current processes may not see much change in terms of reactor vessel configuration, there will be changes to the reactor internals and to the nature of the catalysts. For example, the *tried and true coking processes* will remain the mainstay of refineries coping with an influx of heavy oil and bitumen, but other process options will be used.

For example, visbreaking (or even hydrovisbreaking – i.e., visbreaking in an atmosphere of hydrogen or in the presence of a hydrogen donor material) the long ignored step-child of the refining industry may see a surge in use as a pretreatment process. Management of the process to produce a liquid product that has been freed of the high potential for coke deposition (by taking the process parameters into the region where sediment forms) either in the absence or presence of (for example) a metal oxide scavenger could be valuable ally to catalyst cracking or hydrocracking units.

In the integration of refining and petrochemical businesses, new technologies based on the traditional fluid catalytic cracking process will be of increased interests to refiners because of their potential to meet the increasing demand for light olefins. Meanwhile, hydrocracking, due to its flexibility, will take the central position in the integration of refining and petrochemical businesses in 21st century

Scavenger additives such as metal oxides may also see a surge in use. As a simple example, a metal oxide (such as calcium oxide) has the ability to react with sulfur-containing feedstock to produce a hydrocarbon (and calcium sulfide):

$$\text{Feedstock[S]} + CaO \rightarrow \text{hydrocarbon product} + CaS + H_2O$$

Propane has been used extensively in deasphalting heavy feedstocks, especially in the preparation of high quality lubricating oils and feedstocks for catalytic cracking units. The use of propane has necessitated elaborate solvent cooling systems utilizing cold water, which is a relatively expensive cooling agent. In order to circumvent such technology, future units will use solvent systems that will allow operation at elevated temperatures relative to conventional propane deasphalting temperatures, thereby permitting easy heat exchange. Furthermore, as a means of energy reduction for the process, in future deasphalting units the conventional solvent recovery scheme will be retrofitted with supercritical solvent recovery scheme to reap benefits of higher energy efficiency. Other improvements will include variations in the extraction column internals.

For example, the three major properties, which influence the design of extraction column, are interfacial tension, viscosity and density of phases. Solvent deasphalting extraction column is characterized by low interfacial tension, high viscosities of asphaltene phase, and a density difference between the phases. Extension of these property correlations for solvent deasphalting applications will be suitably validated and corrections made where necessary to improve extraction performance and yields of the products.

Other areas of future process modification will be in the extractor tower internals, studies with higher molecular weight solvent, accurate estimation of physical properties of mix stream, studies in combination with other processes and firming up design tools for supercritical solvent recovery configuration.

In the long-term, new desulfurization technologies or evolution of the older technologies will reduce the need for hydrogen. At the same time, refineries are constantly faced with challenges to reduce air pollution and other energy related issues. Thus, traditional end-of-pipe air emission-control technologies will lead to increased energy use and decreasing energy efficiency in the refinery. The petroleum refining industry will face many other challenges – climate change, new developments in automotive technology and biotechnology – which are poised to affect the future structure of refineries.

In addition, the most common approaches to upgrading hydrotreaters for clean-fuels production will continue to be: (1) developing higher-activity and more resilient catalysts, (2) replacing reactor internals for increased efficiency, (3) adding reactor capacity to accommodate heavy feedstocks and increase gasoline-diesel production, (4) increasing hydrogen partial pressure, (5) process design and hardware that are more specialized and focus on process schemes that effectively reduce hydrogen consumption.

For heavy oil upgrading, hydrotreating technology and hydrocracking technology will be the processes of choice. For cleaner transportation fuel production, the main task is the desulfurization of gasoline and diesel. With the advent of various techniques, such as adsorption and biodesulfurization, the future development will be still centralized on hydrodesulfurization techniques.

In fact, hydrocracking will continue to be an indispensable processing technology to modern petroleum refining and petrochemical industry due to its flexibility to feedstocks and product scheme, and high quality products. Particularly, high quality naphtha, jet fuel, diesel and lube base oil can be produced through this technology. The hydrocracker provides a better balance of gasoline and distillates, improves gasoline yield, octane quality, and can supplement the fluid catalytic cracker to upgrade heavy feedstocks. In the hydrocracker, light fuel oil is converted into lighter products under a high hydrogen pressure and over a hot catalyst bed – the main products are naphtha, jet fuel, and diesel oil.

Catalyst development will be key to the modification of processes and the development of new ones to make environmentally acceptable fuels (Rostrup-Nielsen, 2004). Conversion of crude oil is expected to remain the principal source of motor fuels for another 30 to 50 years but it is likely that the production of fuel additives in large quantities along with conversion of natural gas will become significant (Sousa-Aguiar et al., 2005). Although crude oil conversion is expected to remain the principal source of fuels and petrochemicals in the future, natural gas reserves are emerging, and will continue to emerge, as a major hydrocarbon resource. This trend has already started to result in a shift toward use of natural gas (methane) as a significant feedstock for chemicals and for fuels as well. As a result, deployment of technology for direct and indirect conversion of methane will probably displace much of the current production of

The *panacea* (rather than a *Pandora's box*) for a variety of feedstock could well be the *gasification refinery*. This type of refinery approaches that of a petrochemical complex, capable of supplying the traditional refined products, but also meeting much more severe specifications, and petrochemical intermediates such as olefins, aromatics, hydrogen and methanol.

The typical refinery in the year 2030 will be located at an existing refinery site because economic and environmental considerations will make it difficult and uneconomical to build a new refinery at another site. Many existing refining process may still be in use but they will be more efficient and more technologically advanced and perhaps even rebuilt (reactors having been replaced on a scheduled or as needed basis) rather than retrofitted. However, energy efficiency and high risk will still be a primary concern, as refiners seek to combat the inevitable increasing cost of crude oil and refinery operating expenses.

Process unit and refinery economics/operations computer models will be optimized, with integration into plant operations via process computer controls to reduce risk. Alternate fuels for power generation will continue to push crude processing toward higher value products, such as transportation fuels and chemicals. Otherwise heavy crude oils and tar sand bitumen that are considered uneconomical to transport to a refinery will be partially refined at their source to facilitate transport; and there will be a new emphasis on partial or full upgrading in situ during recovery operations.

Other challenges and risks facing the refining industry include its capital-intensive nature and dealing with the disruptions to business operations that are inherent in industry. It is imperative for refiners to raise their operations to new levels of performance. Merely extending current performance incrementally will fail to meet most company's performance goals.

RISK ANALYSIS

In the framework of refinery analysis is necessary to examine each processing component to determine potential types of technical and economic failure. All the different types of risk must be calculated using appropriate models. It is also necessary for the analysis to take into account the possibility that different refinery components (process units) may fail in different ways and maintenance costs associated with unit withdrawal from on-stream performance must be evaluated with the conditional probability of certain types of failures that certain types of failure may increase overall the risk.

In many cases, the overall course of events must be taken into consideration. For example, in all cases it must be possible to assess the financial and mechanical damage and the ensuing consequences and the quantification for each individual case. After determining the size and consequence of failure probability of a unit and its individual components, the appropriate risk must be calculated. For this purpose, the risk should be presented in the form of a *risk matrix* with the ability to determine whether or not the risks are acceptable in terms of set criteria.

Thus to reduce the risk, it is necessary to establish the effects of optimizing each process unit with the associated maintenance measures in terms of risk reduction with the costs of their implementation.

REFERENCES

[1] Couvaras, G. 1997. Sasol's Slurry Phase Distillate Process and Future Applications. Proceedings. Monetizing Stranded Gas Reserves Conference, Houston, December 1997.

[2] Davis, R.A., and Patel, N.M. 2004. Refinery Hydrogen Management. Petroleum Technology Quarterly, Spring: 29-35.

[3] Hsu, C.S., and Robinson, P.R. 2006. Practical Advances in Petroleum Processing, Volumes 1 and 2. Springer, New York.

[4] Penning, R.T. 2001. Petroleum Refining: A Look at The Future. Hydrocarbon Processing, 80(2): 45-46.

[5] Rostrup-Nielsen, J.R. 2004. Fuels and Energy for the Future: The Role of Catalysis. Catalysis Reviews, 46(3&4):247 – 270.

[6] Sousa-Aguiar, E.F., Appel, L.G., and Mota, C. 2005. Natural gas chemical transformations: The path to refining in the future. Catalysis Today, 10(1): 3-7.

[7] Stanislaus, A., Qabazard, H., and Absi-Halabi, M.. 2000. Refinery of the Future. Proceedings. 16th World Petroleum Congress, Calgary, Canada. June 11 – 15.

[8] Speight, J.G., and Ozum, B. 2002. Petroleum Refining Processes. Marcel Dekker Inc., New York.

[9] Speight, J.G. 2007. The Chemistry and Technology of Petroleum, 4th Edition. CRC Press, Taylor & Francis Group, Boca Raton, Florida.

[10] Speight, J.G. 2008. Handbook of Synthetic Fuels, McGraw-Hill, New York.

[11] Speight, J.G. 2011. The Refinery of the Future. Gulf Professional Publishing, Elsevier, Oxford, United Kingdom.

[12] Speight, J.G. 2013. The Chemistry and Technology of Coal 3rd Edition. . CRC Press, Taylor & Francis Group, Boca Raton, Florida.

SOME EXPERIENCES FROM RISK ASSESSMENT AT "HEALTHY" FOOD PRODUCTION

Vangelce Mitrevski, Tale Geramitcioski, Vladimir Mijakovski, Monika Lutovska
University St.Kliment Ohridski, Faculty of Technical Sciences, Bitola, FYR Macedonia
e-mail: vangelce.mitrevski@uklo.edu.mk

Abstract: In this paper some experiences in risk assessment of workplaces in company Vitalia Skopje are described. On the basis of results obtained by processing of prepared check list, and results from the measurements of microclimate parameters, physical and chemical hazards, the identification of present risks and hazards were done. The risk assessment was performed using the software package LatiPRO. After defining the level of risk, measures for prevention, reduction and elimination of risks at workplaces where increased risk was found, were recommended.
Key words: occupational risk assessment, risks, hazards.

INTRODUCTION

Safety and health at work is a very important part for every employer, regardless of the scope of works of the company. This segment of labour in Republic of Macedonia is regulated from the year 2007 when the Law on Safety and Health at Work [1], was adopted. The essence of the Law on Safety and Health at Work is the protection of workers based on the application of preventive measures, in order to create a safer and healthier workplace. Particular attention must be dedicated to the risk assessment. Risk assessment for each workplace, as well as developing and implementing the concept of safety is the initial declaration and the basic step in the process of risk management for workplaces and work environment. They must be developed in accordance with the Law on Safety and Health at Work [1] and on the basis of the Rulebook on the manner of making safety statement, its contents and the information on which the risk assessment [2], should be based.
VITALIA Nikola Ltd, Skopje is a healthy food production and trading company with a general purpose to supply the domestic and foreign markets with natural, great tasting, nutritional products of excellent quality, prepared according to the traditional recipes that fit today's healthy lifestyle.
Food production process is carried out in:

- **facility for automatic and manual packing** - where the mixture of granular material is prepared in a mixer according to previously approved recipe. The mixtures are then transported via conveyor to a vertical multihead packer. Manufactured products pass through metal detector are packed afterwards
- **facility for the production of crispy muesli** - in which it was carried out the preparation of the liquid phase in a three mixers, as well as the preparation of the dry phase in horizontal mixer. Followed by the process of mixing of two stages and discharges in mixtures feeder that is allocated to inox elevated track that enters in the furnace. In the furnace mixtures is baked, then cooled and the end passes through the grinder
- **facility for the production of cereal-bars** – that starts with preparation of the liquid phase in the mixer. Dry components and liquid phase are mixed in horizontal blender and complete mixture is transported with elevated roll to a press for the formation of cereal-bars. Thus, formed cereal-bars through system of elevated rolls are transported to the chocolate equipment. Then the cooling and packaging processes follow
- **thermal halls for the production of jams and compotes** - where admission and washing of fresh fruits is done as first step. Afterwards, seeds, leaves and handles are subsequently extracted from the fruit and it undergoes the process of cutting into pieces. Fruits and other components digest into inox pots, after which follows the filling in glass jars and storage.
- **facility for expansion** - cereals are prepared according to previously approved recipe and are exposed to a pressure of 10 bar and high-temperature in the expander
- **facility for extrusion** - cereals are prepared and extruded in the extruder at a high temperature.

In this paper, the process of risk assessment in the workplace, at the healthy food company Vitalia Nikola ltd, Skopje, as well as measures to prevent, reduce and eliminate risks at workplaces where increased risk is defined, are described.

RISK ASSESSEMENT

A risk assessment under the Law on health and safety at work, is defined as systematic recording and evaluation of risk factors (risks and hazards) in the working process, which can cause occupational injury, illness or damage to health, and identifying possibility, ways to prevent, reduce or eliminate the risk. The basic purpose of identifying the risk factors is the identification of all possible dangers and hazards, without omittin any risk.
The risk assessment at workplaces during production of healthy food in the factory VITALIA Nikola Ltd, Skopje has been realized in several phases:
The **first phase** includes:

- Adoption of a written decision by the employer and development of a plan for the implementation of risk assessment
- Engaging authorized institutions to carry out professional activities for safety at work or entrepreneur who has authorization-license for carrying out activities related to safety at work
- Forming a team to perform the risk assessment
- Informing the employers about the activities.

The **second phase** is related to:

- Recording and analyzing the organization of work
- General information of the employer
- Description of the technological and working process
- Description of the tools of labour and its grouping
- Description of the resources and personal protective equipment at work
- Screening and analyzing the work organization (systematization and grouping of workplaces)
- Recognition and identification of dangers and hazards at workplace and work environment
- Establishing the list of hazards
- Risk assessment to the dangers and hazards and
- Determining the ways and measures for eliminating, reducing and preventing risk.

The **third phase** consists of processing and analyzing the results

- Defined on the basis of the priority list of dangers and hazards, the level of risk for each work position is being determined and a plan with proposed measures to eliminate, reduce or prevent the risk is being prepared.

Forth phase:

- Making conclusion, priorities for eliminating of the risk.

For identification of risk factors (dangers and hazards), at work place and work environment, there are different tools and techniques, such as:

- Advanced tools and techniques
- Measurements of microclimate, physical, chemical and biological hazards
- Onsite inspection
- Interview with the employees
- Regular and periodical review of work equipment.

In 2011 from the authorized persons of Faculty of Technical Sciences in Bitola, risk assessment for all workplaces in the factory for production of healthy food VITALIA Nikola Ltd, Skopje [3,4], was performed. A survey was conducted with the employees in which they were asked to describe their daily activities and to indicate any dangers and hazards observed during performing of their daily activities. For identification of the dangers and hazards in the work environment on people's health, measurements of microclimate conditions and physical and chemical hazards [5], have been conducted.

RESULTS AND DISCUSSION

The risk assessment, identification and determination of present dangers and hazards has been made for workplaces in the hall for automatic and manual packing, in the hall for production of crispy muesli and hall for production of cereal bars . In Table 1, the values of the conducted measurements of the microclimate conditions (temperature, relative humidity and velocity of air circulation), physical hazards (lighting and noise) and chemical hazards (dust of vegetable or animal origin without SiO_2 toxic substances), are given.

The measurements of microclimate and physical hazards are made with calibrated instrument, product of METREL Slovenia. For measuring of the dust the concentration, calibrated instrument, product of TURNKEY UK is used.

From table 1, one can note that the microclimate conditions (temperature and relative humidity of air, as well as velocity of air circulation) are in the allowable limits for the summer period of measurements, except for the workplaces in the plant where cereal bars are produced (workplace - mixer, line formation - mixer, press, chocolate coating, thermal oven and packing, as well as in the warehouse for finished products). The allowed limits for the summer period are: t = 15÷28 ^oC, □ = 40÷60%, v = 0.7 m/s. The results of the conducted measurements show that the measured values are in the limits of the allowed values according to MKS.U.C9.100 standards (150÷300 Lx for production line and 80÷150 Lx for warehouse). The measured values of level of noise in all workplaces are in the allowed limits, according to the exposure limit values (87 dB), defined by the Rulebook for safety and health at work for the employees exposed to a risk of noise [6]. Except for the facility for the production of crispy muesli- machine for producing crispy muesli, where the value is 90.60 dB and is the upper limit value. It can be noted that the measured values of concentration of dust at all workplaces are under allowed limits, according to MKS 8 BO 001/71 standard (3 mg/ m^3 for respirable and 10 mg/m^3 for TSP).

For the listed workplaces, the following dangers are identified:

- Mechanical dangers from the use of work equipment
- Mechanical dangers due to machines not equipped with protective devices
- Mechanical dangers due to working on a conveyor belt
- Mechanical dangers that can happen due to insufficient safety of spinning and moving parts
- Dangers due to movement on uneven, damaged and slippery floor
- Mechanical dangers by means of internal transport and moving parts of the machine or equipment
- Dangers from work on height-platforms
- Biological hazards due to direct contact with rough material of herbal origin
- Hazards that occur by use of hazardous materials in the production, transport, operating, packing, stockpiling or crushing
- Dangers caused by lack of equipment for raising payload heavier than 11 kg or 25÷50 kg, or improper towing, pushing or lifting
- Dangers due to new physiological condition of the body-prolonged sitting/standing
- Dangers related to work organization-work in shifts or night work
- Dangers due to work near sources of heat (steam or hot water).

Table 1. The measurement value on microclimatic conditions, physical and chemical hazard

Workplaces	Microclimatic conditions			Physical hazard		Chemical hazard
	Measurement value			Measurement value		Measurement value
	Air temperature t [°C]	Air hymidity φ [%]	Air velocity v [m/s]	Lighting [Lx]	Noise [dB]	Dust [mg/m³]
FAP-machine for packing powdered materials	17.00	42.70	< 0.05	160	73.90	0.03
FAP-machine for packing of large materials	17.30	42.50	< 0.05	169	74.20	0.07
FAP-packing	17.60	41.20	< 0.05	234	83.90	0.07
FAM-packing	18.30	40.00	< 0.05	172	74.80	0.09
FPCM-machine for producing crispy muesli	15.30	41.20	< 0.05	151	**90.60**	0.15
FPCM-mixer	21.10	**35.50**	< 0.05	210	66.80	0.21
FPCP-mixer forming line	23.40	**32.30**	0.15	226	68.70	0.09
FPCP-press forming line	23.30	**33.70**	0.07	250	85.50	0.09
FPCP-chocolate coating line	23.30	**32.70**	< 0.05	243	73.30	0.18
FPCP-thermo oven forming line	23.60	**31.00**	0.16	282	72.30	0.03
FPCP-packing	23.50	**31.50**	< 0.05	282	66.50	0.07
Warehouse	15.00	**36.60**	0.16	282	72.30	0.07

FAP - facility for automatic packing, **FAM** - facility for manual packing, **FPCM** - facility for the production of crispy muesli, **FPCP** - facility for the production of cereal bar

For conducting the risk assessment, processing and analyzing ″LatiPRO″ software package [7], is used. For estimating the values the following formula is used:

$$RISK = TP \times UI \times VP \times BO$$

Where the parameters indicate: TP-weight of potential injury, UI- frequency of exposure to dangers, VP-probability of injury and BO-number of exposed people.
For defining the TP factor - weight of potential injury multi criteria scale with 7 levels, is used.

Weight of potential injury	Values of TP factor
Scratches, bruises etc.	0.1
Cuts, lacerations etc.	0.5
Temporary minor illness, minor broken bones etc.	2.0
Temporary serious illness, major broken bones etc.	4.0
Permanent illness, loss of an eye, sense of hearing, limbs etc.	6.0
Serious permanent illness, loss of sight, limbs etc.	10.0
Fatal injuries-mortal income	15.0

For defining the UI factor - frequency of exposure to dangers multi criteria scale with 6 levels, is used.

Frequency of exposure to dangers	Values of UI factor
Once a year	0.5
Once a month	1.0
Once a week	1.5
Once a day	2.5
Each hour	4.0
Continuously	5.0

For defining the VP factor - probability of injury multi criteria scale with 8 levels, is used.

Probability of injury	Values of VP factor
Almost impossible, only under exceptional circumstances	0.33
Highly unlikely, but possible	1.0
Unlikely, although it can happen	1.5
It can happen but it is unusual	2.0
There is a real chance to happen	5.0
Possible, not surprisingly	8.0
Probably, should be expected to happen	10.0
Surely, there will be no doubt	15.0

For defining the BO factor-number of exposed people, a scale with 5 levels, is used.

Number of exposed people	Values of BO factor
1÷2	1.0
3÷7	2.0
8÷15	4.0
16÷50	8.0
50 and more	12.0

By multiplying of the values of previously defined factors we obtain the total value of the estimated risk, and it is categorized according to the values shown in the next table:

Risk category	RISK = TP × UI × VP × BO
NEGLIGIBLE RISK does not require any action to reduce the risk	0÷5
LOW RISK low risk to safety and health at work	6÷50
MODERATE RISK there is a risk, it is necessary to determine the extent of its reduction	51÷250
HIGH RISK significant risk, determine the measures required to reduce it	251÷500
UNACCEPTABLE RISK work at such risk is unacceptable	> 500

In Table 2 are given the workplaces at which the assessment is carried out and the workplaces that are determined as work places with increased risk.

Table 2. Workplaces for which risk assessment is done

Worker in the hall for automatic packing						
Total risk	Negligible risk	Low risk	Moderate risk	High risk	Unacceptable risk	**Max risk**
21	0	20	1	0	0	**60.00**
Worker in the hall for manual packing						
Total risks	Negligible risk	Low risk	Moderate risk	High risk	Unacceptable risk	**Max risk**
18	0	15	3	0	0	**60.00**
Worker in the hall for production of crunchy muesli- mixer						
Total risks	Negligible risk	Low risk	Moderate risk	High risk	Unacceptable risk	**Max risk**
24	0	18	6	0	0	**200.00**
Worker in the hall for production of crunchy muesli-oven for baking crunchy muesli						
Total risks	Negligible risk	Low risk	Moderate risk	High risk	Unacceptable risk	**Max risk**
23	0	15	8	0	0	**160.00**
Worker in the hall for production of cereal bars-mixer/and preparation of the liquid phase and ready mix						
Total risks	Negligible risk	Low risk	Moderate risk	High risk	Unacceptable risk	**Max risk**
24	0	16	8	0	0	**160.00**
Worker in the hall for production of cereal bars- line for forming cereal bars and packaging						
Total risks	Negligible risk	Low risk	Moderate risk	High risk	Unacceptable risk	**Max risk**
23	0	16	7	0	0	**100.00**

The analysis of the identified hazards and potential harms, as well as the values of the estimated risks in accordance with the methodology - worker on a mixer in the halls for the production of crispy muesli shows that the possibility of injury caused by lack of equipment for lifting loads heavier than 25 ÷ 50 kg, or caused by inappropriate pulling, pushing and lifting, is with the maximum value of 200. While the conducted analysis of identified hazards and potential harms at the workplace-worker on a oven for baking crispy muesli shows that the physical dangers from working on the installations and aggregates that generate noise, have the maximum risk factor of 160. In the plant for production of cereal-bars, the workplace - worker on a mixer for preparation of liquid phase and mix has risk factor with maximum value of 160 due to lack of equipment for lifting load heavier than 20 kg. The hazards that arise from the new physiological condition of the body in the process of packaging – at the workplace worker on a forming line of cereal-bars and packaging has the highest risk factor of 100, while the risk value of 60 in the hall for automatic and manual packaging refers to hazards related to work organization such as overtime work, working in shifts and night work. For reducing and eliminating the highest risk, as well as the other risks, on the listed workplaces, collective and individual protective measures are stipulated. They mainly refer to:

- Implementation of health and safety measures at work when lifting and transferring cargo, with short breaks during work. Active breaks from 3 to 5 minutes for every hour of work
- If the worker in the work zone is retained longer than the allowed time for noise exposure, the use of personal protective equipment for protection of the sense of hearing (ear plugs and ear protectors) is mandatory. Periodical measurements of physical dangers-level of noise are obligatory.
- It is not recommendable to exceed the eight-hour working day. Breaks during the work, shift rotation, training employees of safety and health at work are also obligatory.

CONCLUSION

The paper shows the risk assessment for workplaces in production facilities of the company for healthy food production Vitalia Ltd - Skopje. Based on the analysed results from the prepared questionnaires and based on the results of the measurements of microclimate, physical and chemical hazards, present dangers and hazards in the plant of automatic and manual packing, plant for production crunchy muesli and plant for the production of cereal-bars, are identified. The maximum risk is obtained for the workplace - worker on a mixer in the plant for production crunchy muesli. Based on the risk assessment measures for minimizing/eliminating of dangers and hazards at workplace, employee training has been done and proposed implementation of organizational, technological and personal protection measures, are proposed.

REFERENCES

[1] Zakon o bezbednosti i zdravlju na radu (Službeni glasnik R.M. br.92/2007).
[2] Pravilnik o načinu izrade izjave za bezbednost, njen sadržaj, kao i podaci na osnovu kojih treba da se bazira procena rizika (Službeni glasnik R.M. br.2/2009).
[3] Mitrevski, V., Geramitcioski, T., Mijakovski, V., Lutovska, M., Procenka rizika u Vitalia Ltd, Tehnički fakultet Bitola, 2011.
[4] Mitrevski, V, Geramitcioski, T., Mijakovski, V., Lutovska, M., Koncept izjave za bezbednost u Vitalia Ltd, Tehnički fakultet Bitola, 2011.
[5] Mijakovski, V., Mitrevski, V, Geramitcioski, T., Lutovska, M., Izveštaj izvršenih merenja mikroklimatskih i fizičkih štetnosti u Vitalia Ltd, Tehnički fakultet Bitola, 2011.
[6] Pravilnik o bezbednosti i zdravlju pri radu zaposlenih izloženih na rizik buke (Službeni glasnik R.M. br.21/2008).
[7] www.latipro.net

USE OF ALUMINIUM IN THE PRODUCTION OF CARS

Radoje Vujadinović[1], Uroš Karadžić[1]
[1]Faculty of Mechanical Engineering, Podgorica, Montenegro
e-mail: uros.karadzic@ac.me

Abstract: In order to solve ecological problems caused by the emissions of exhaust gasses from cars, one of ways is the use of aluminium in a car industry. By the use of aluminium in the manufacturing of cars, the lighter structure is obtained which results in a smaller fuel consumption and, therefore, smaller emission of exhaust gasses. Beside the ecological improvement, a better security of cars in case of collision is achieved by the use of aluminium in the production of cars, and better driving characteristics are visible and they are mirrored in the improvement of acceleration and shortening the trace of braking. The characteristics of aluminium and its alloys that found their use in a car industry are presented in this paper. The commercially-technological aspects of prospects of use of some aluminum alloy types are also presented.
Key words: ecology, car industry, aluminium

INTRODUCTION

More and more pronounced ecological problems on the Earth planet to which cars significantly contribute forced the leading world economies to set significantly more rigorous standards for car manufacturers related to the gas emissions from cars which they produce. The strategy aiming to achieve smaller engine sizes and, therefore, the reduction of fuel consumption and the emission of dangerous gasses is called downsizing. The downsizing of engine sizes also leads to the decreasing a chassis and all its parts. Beside an engine size, a car mass can also be reduced by the decrease of a chassis mass and some car components (seats, car interior...). This is achieved by the replacement of some steel parts with aluminium alloys, and also by the use of various composite materials and plastics in the manufacturing process of other car components. Modern cars with chassis parts made of aluminium alloys can be lighter up to 24% and the fuel consumption is smaller up to 2L by 100 km.
The reduction of a car weight leads to the reduction of fuel consumption meaning the reduction of exhaust gasses. The car weight reduction of 10% has an average fuel saving of about 8% as a consequence. In cars, each kilogram of inbuilt aluminium replaces in average about 2 kilograms of steel.
The basic concepts of car safety are based on the idea that the impact energy in a collision be absorbed by a chassis and by passengers and to prevent the penetration of some parts of a car into passenger cabin. The very fact that by the replacement of a steel kilogram with an aluminium kilogram gives two or more times stronger structure indicates the possibilities of installation of additional construction elements for the increase of safety and that this still stays in the area of a reduced car weight. Also, aluminium can approximately absorb two times more of an impact energy than steel. Namely, aluminium elements which are designed in such a way that during a collision behave in previously defined manner, i.e. which absorb a high part of an impact energy in all circumstances, can be inbuilt.
The introduction of aluminium structures enabled the introduction of new constructional solutions that have essentially improved driving characteristics. First of all, this had been used and developed for race cars, and many similar solutions are visible in passenger cars or various trucks. First of all, here emerge improved characteristics of stiffness, vibration reduction, noise etc. The weight reduction directly influences the acceleration rise and the shortening of braking trace.

CHARACTERISTICS OF ALUMINIUM

Aluminium is third most present element in the earth crust, behind oxygen and silica–(8.07%). Pure aluminium is soft and of limited strength. By the alloying with Cu, Mg, Si, Mn and Zn, it attains the characteristic that makes it convenient for use in many industrial branches. Aluminium belongs to the group of light metals (specific mass 2.7 g/cm^3) and belongs to the group of low-strength materials-soft, flexible. The melting temperature of aluminium is 660°C. It has a high electrical and heat

conductivity. It also has a high corrosion resistance because a homogenous layer of aluminium oxide is formed what protects aluminium from further influences.
The characteristics of technically pure aluminium in annealing state are, conventional flow stress $R_{p0,}$=24 N/mm^2, tensile strength R_m=69 N/mm^2, elongation $A_{5,65}$=42%, hardness HBS=19 and elasticity module E=70000 N/mm^2. Cold deformed aluminium (deformation degree75%) has an increased hardness but also reduced flexibility: R_{p02}=124 N/mm^2, tensile strength R_m=13 N/mm^2, elongation $A_{5,65}$=6%, hardness HBS=35.
Aluminium alloys are most frequently used in the industry, and depending on hardness (admixture Fe, Cu, Zn, Si and other metals), there are several kinds of aluminium –Al 99.80 where admixtures occupy 0.2%, and 99.7, 99.5 where the admixtures occupy 0.03 and 0.05% respectively. Aluminium can be alloyed with a bigger number of elements. Mn, Mg, Si, Cu and Zn.

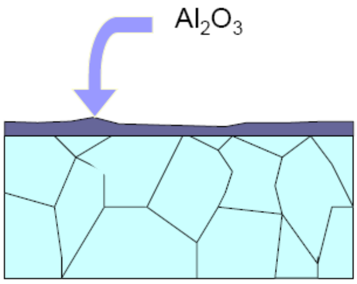


Figure 1. Protective oxide aluminium layer

The resistance to corrosion of aluminium is achieved by forming of protective oxide layer Al_2O_3 at an ambient temperature. This layer reaches the depth of 0.1 μm (anodising 10 μm). This oxide makes Al stabile in the air and sea water. The cleaner aluminium the higher resistance to corrosion. However, it does not resist neither to hydroxides (NaOH, KOH) nor to acids of halogen elements (HCl, HF).
As has already been mentioned, aluminium can be alloyed with a bigger number of elements Mn, Mg, Si, Cu and Zn and all the alloys can be divided into two basic groups: aluminium alloys for the plastic processing and alloys for casting. There are subgroups–alloys that are not thermally processed (strengthening by dissolution, deforming and dispersion), alloys that are thermally processed (strengthening by thermal precipitation). They can be divided according to the number of added elements into double, triple and complex.

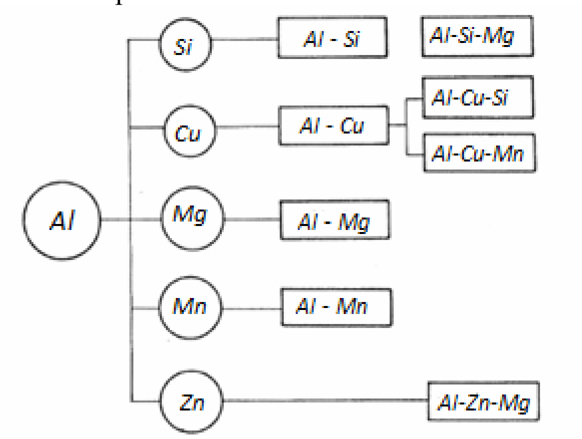


Figure 2. Aluminium alloys

Aluminium alloys for processing by deforming- Most frequent alloying element for these alloys are Mn, Mg, Cu, Zn and Ni.
Manganese (Mn) increases a strength, machine ability by deforming, recrystallisation temperature, resistance to corrosion and limits grain rise in solution during solution annealing.
Magnesium (Mg) increases power and resistance to corrosion.

Cuprum (Cu) and Zinc (Zn) strengthens the alloy but deteriorates the machinability by a deforming and resistance to corrosion.
Nickel (Ni) positively affects mechanical properties, especially at higher temperatures and resistance to corrosion.

TYPES OF ALUMINIUM ALLOYS THAT ARE USED FOR PRODUCTION OF AUTO – CHASSIS PARTS

In the history of use of Al alloys for the fabrication of some parts or entire chassis, in majority of car producers both in America and Europe, during the initial developmental phase, alloys 2036 based on Cu and 5182 based on Magnesium had a dominant role. By the use of these alloys, the demanded stiffness of a chassis was achieved by the embedding of sheet metal with an increased thickness in relation to the steel in a range of 20% to 40%. Alloy 2036 which is prone to aging (strengthens by aging) was used for the fabrication of external chassis elements , while the alloy 5182, because of characteristic surface texture due to Lunder's deformation, was more directed to the fabrication of internal chassis parts. By the comparison with the alloy 2036, the alloy 5182 strengthens by a cold deformation and effect of dissolution strengthening mechanism. One important difference in behavior during the baking of a coloured chassis stems from this difference. Namely, at a higher temperature on which the baking is executed (around 200 °C), hardness of AlMg alloys decreases, and, for 2036, due to precipitation strengthening, fairly bigger hardness can be achieved. However, the combination of mentioned alloys is very inconvenient from the standpoint of secondary treatment in sense of a waste due to cuprum present in an alloy 2036. In searching for an alloy which would be compatible in waste with the 5000 series, the alloys from the family 6000 based on AlMgSi were selected. The alloys from this series are also characteristic by the absence of Lunder's deformation, high strength after aging and by good weld ability. Main disadvantages are small ductility (possibility of shaping) and the occurrence of a specific surface with „reefs" parallel to the rolling direction due to a specific texture.

COMMERCIALY-TECHNOLOGICAL ASPECTS OF PROSPECTS OF USE OF ALUMINUM ALLOY TYPES

In USA, the researching-commercial producer association was formed during 1990s (three companies which produce rolled products: ARCO (Aluminium Inc. Century Aluminium and Commonwealth Aluminium), users (Ford Motor Company established a group USAMP-American partnership for car materials) and certain governmental expert groups (Department of Ministry for Energy USA, American engineer association, research centre and development of technologies etc.), under the name ALCARTM (1) , which needed to estimate the prospects of needs for aluminium sheet metal in car chassis.
After the comprehensive analyse based on a mark of leading commercial-expert institution, the mentioned group derived the following conclusions:

a) Future needs in sense of making car chassis lighter will be in a continual rise.
b) Thermally machineable alloys of 6000 series are superior in sense of mechanical properties and the quality of surface. However, their production is much more demanding–it is necessary to have a modern equipment and technology for a continual thermal processing which is these days available only to big companies that essentially influence the final price.
c) The expert analyses of costs of thermally machineable (6000) and thermally non-machineable alloys (5000) taking into account all the elements of quality, showed that investment costs and variable costs of production, AL-Mg alloys form 6000 series should be at least 10% cheaper than alloys of 6000 series.
d) The difference in the price of material in favour of Al-Mg alloys will enable fast and more prevalent use of aluminium in car structures.

The successful use of alloys from 5000 series instead of alloys from 6000 series can be expected in the area of structural car components, internal and external chassis components. According to given estimations, use of 6000 series alloys will be reasonable in a smaller number of positions in cars. The production of alloys of 6000 series will mostly be a privilege of big companies having a necessary equipment, and they will further have an important place for a sophisticated structures such as planes, space aircrafts etc.

CONCLUSION

A car mass is a very important factor influencing the fuel consumption. This aspect affects the resistances and forces that are to be overcome, and which are directly confronted to the movement of a car. A smaller car mass lead to a smaller fuel consumption. According to this, car manufacturers tend to reduce a mass of car chassis. They do it in a manner that they use aluminium and its alloys instead of iron and its alloys. They use plastics and composite materials with which they make some parts of a chassis and interior of a car. Not only a chassis is lighter but also it is stronger and better absorbs impacts. On the other side, the reduction of a certain chassis mass and car engine opens a possibility of embedding of additional safety systems, reinforcement of a chassis etc.

With regard to the limit of reserves of crude oil, strict demands prescribed by leading countries in the world in relation to the emission of dangerous gasses, trend to offer a buyer more economical car, all measures influence the reduction of an entire car mass and smaller fuel consumption, still will be a main goal of leading car manufacturers and leader in the development of car industry.

REFERENCES

[1] S.K. Das, H.W. Hayden, G.B. Barthold, *Development of Non-Heat-Treatable Automotive Aluminium Sheet Alloys*, Materials Science Forum-Trans Tech Publications, Switzerland, 331-337(2000)

[2] J.M. Story, G.W.Jarvis, H.R. Zonke, S.J. Murtha, “Issues and Trends in Automotive Aluminium Sheet Forming”, Alcoa, *SAE Paper No930277* (1993).

[3] Božidar Nikolić, Danilo Nikolić, Radoje Vujadinović, *Motorna vozila I*, DANU, Podgorica 2006.

[4] Bataković Mirjana – *Uticaj mase vozila na potrošnju goriva* - Diplomski rad: Mašinski fakultet, Podgorica, 2012. godine.

[5] Primena aluminijuma u automobilskoj industriji (http://mfkg.kg.ac.rs/centri-fakulteta/centar-zavirtuelnuproizvodnju/download/SZnanja/AlMgVC/1.%20Primena%20aluminijuma%20u%20automobilskoj%20industriji.pdf);

[6] http://www.drivealuminum.org

IMPROVING SAFETY AND HEALTH AT WORK THROUGH A STANDARD OHSAS 18001

Biljana Gemović[1]
[1]The Higher Education Technical School in Novi Sad, Serbia
e-mail: gemovic@vtsns.edu.rs

Abstract: Introduction of OHSAS 18001:2007 into an organization enables complying with international standards of safety and health at work (OSH). Maintaining and improving of OSH enables a better quality of life and material well-being of employees in the organization. The paper presents results of the research that includes the impact of the implemented quality system ISO 9001 and OHSAS standards on the current state of OHS in the company, and the application of measures provided to eliminate or reduce risk and verify the efficacy of the measures. The aim is to contribute to forming a better OHS system in Serbia through the implementation of quality standards.
Key words: OHSAS, risk reduction, implemented measures

INTRODUCTION

A man spends a significant part of their life in the workplace. Work is a necessity and a prerequisite for ensuring one's existence, but also a constant challenge for the health and safety of individuals and society as a whole. A man works to create and earn, fulfill their professional goals, and to progress and improve. In addition, the primary goal of each worker should be the preservation of health during the working life, both physical and mental, to be able to live freely and long enjoying the fruits of their labor.

A healthy, safe, capable and motivated worker is not just an individual goal; it is also a state and social priority. The institutions, laws, regulations, companies and individuals who are directly involved in achieving this goal consist a system of health and safety at work (OSH) of a country.

The goal of the OSH system is to prevent occupational injuries, occupational diseases and other illnesses related to work, and to improve working conditions, which can be achieved through risk management.

Risk management involves a series of arranged, logically related activities aimed at achieving the goals - based on the assessment of risk, to identify and establish measures to reduce risk, provide continuous monitoring and improvement of safety and health at work, as standard OHSAS 18001: 2007 enables..

OHSAS 18001 - MOTIVATION AND BENEFITS

OHSAS 18001 is an industry standard for the implementation and certification of management systems regarding safety and health of employees, created due to the need for ensuring safety in the working environment.

OHSAS 18001 certification protects the company from unnecessary fees, provides more favorable contracts with insurance companies, improves the relationship with national authorities, increases worker productivity by reducing injuries, and therefore sick leaves. During the certification, special attention is paid to determine the degree of hazard in the workplace, and establish protective measures for its reduction or elimination.

OHSAS 18001 has been successfully implemented in all industries, in manufacturing industries and in all companies in the service sector. OHSAS 18001 standard contains criteria for assessing the safety management system at work for all companies, regardless of the type of activity and size of the company [4].

A company certified according to OHSAS 18001 standard awakens great trust with customers, suppliers, employees, government institutions and investors. By the certification in accordance with OHSAS 18001 a company also meets the criteria of EKAS guideline 6508. The elements of OHSAS 18001 can be combined or integrated with the standards ISO 9001:2008 and ISO 14001:2005 and structured as a comprehensive management system, i.e. OHSAS 18001 should be applied as a standard that corresponds to the standard ISO 9001:2008.

The management system of health and safety OHSAS 18001 represents a set of norms including the following areas of the organization:

- Risk management through planning measures, their implementation and proactive action,
- Legal and other requirements,
- Protection measures and personal protective equipment,
- Human resources, roles, tasks, responsibilities and powers,
- Qualifications, expertise and awareness of the importance of protection,
- Teamwork (communication, participation and consultation),
- Operational control,
- Readiness to respond in emergencies, and
- Measurement of results, recording of the condition and improvements.

The paper discusses OSH aspects in small, medium and large enterprises (SMEs) in the Republic of Serbia, and businesses that have or do not have certified quality standards.

SMEs are a key factor in the development of Serbian economy. Over 100,000 companies and over 200,000 employers make up 99% of total registered enterprises employing 60% of the workforce and account for 50% of the gross domestic product. Big businesses include major enterprises in the area of public companies and from a large number of manufacturing industries, and as such they certainly should not be ignored

Small and medium enterprises in Serbia, as well as throughout South Eastern Europe, are a key factor of economic development and drivers of the structural economic reforms [1].

RESEARCH OBJECTIVE

The objective of this research was to show that by the use of "Integrated Management System" (IMS) the introduction of OHSAS leads to the systematization of safety activities and process improvement. The awareness of OSH risks is strengthened, legal requirements in terms of safety at work are met, and an open information policy on the development of work safety and protection is led. Products and processes are systematically examined, and the measures are established, implemented, monitored and evaluated.

The overall objective of the paper is to promote the introduction of quality standards primarily in the observed IMS, which means raising employee morale, less dissatisfaction, lower insurance premiums, and increased credibility and image of the company.

The implementation of the first primary research objective is conditioned by the realization of the following subgoals:

- improve the protection of life, health and safety of people, animals and plants and the environment,
- improve the quality of products, processes and services, and determine their purpose, unification, compatibility and interchangeability,
- provide a uniform technical basis,
- develop and improve the production and trade of goods, provide works or services through the development of internationally harmonized standards and related documents to obtain the rational use of labor, materials and energy, and
- promote the international trade by preventing or eliminating unnecessary technical barriers.

The research includes the impact of the implemented quality system ISO 9001, ISO 14001 and OHSAS on:

- the current state of OSH in the company,
- the implementation of prescribed measures to reduce risk, and
- the check of effectiveness of measures implemented to reduce risks in the workplace and working environment.

The aim of the paper is to contribute to forming a better system of health and safety at work in our country, and to a quality education system with respect to its values.

Rationale of the research needs

Based on the Resolution on safety, hygiene and health at work of the Council of the European Community from June 1989, The Directive of EEC Council 89/391/ECC was adopted on the introduction of measures to encourage improvements in safety and health at work [7]. This Directive of a general nature is applicable to all branches of activity and provides that each state has the ability to adapt the recommendations and risk assessment methodologies to national legislation. The Directive defines the responsibilities of the employer and promotes the development of a culture of prevention.

Safety and health at work is a very important part of work in every employer, regardless of the type of activity. This segment of work is regulated in Serbia in November 2005, when the Parliament adopted a new Law on Safety and Health at Work. This law is a system law, not a specialist one, and follows other system laws, such as the Labour Law, the Company Law, the Law on Private Entrepreneurs, and the Law on Pension and Disability Insurance. The Law on Safety and Health at Work includes not only safety but also health, social welfare, and it is primarily based on the principle of prevention and accountability in order to create conditions for conducting business activities in a safe and healthy workplace. Now the focus of the activity of all participants in this area is on the events before and not after the occurrence of occupational injuries, illnesses or damage to the health of employees. The essence of the Law on Safety and Health at Work is the protection of workers based on the application of preventive measures, all aimed at creating a safer and healthier workplace.

Preparation of the document on risk assessment is the initial and basic step in the process of risk management in the workplace and in the working environment. This is an obligation on the basis of the OSH Law and according to the Regulations on the procedure for risk assessment in the workplace [1].

Risk management involves a series of arranged, logically related activities aimed at achieving the set goal. The risk management objective is to, based on the assessment of risk, determine and establish measures to reduce risk, provide continuous monitoring and improvement of safety and health at work. The introduction of OHSAS 18001:2007 into an organization enables the management of safety and health at work. This control is a continuous and dynamic process of problem solving regarding the scope of the organization and applied technologies, aimed at achieving security goals, and thus to improve the health of all employees.

OHSAS 18001:2007 introduction into an organization enables the alignment of the existing good practices with international standards of safety and health at work. Maintaining and improving safety and health enables a better quality of life and material well-being of employees in the organization and all other interested parties.

Concerning the results of previous practice in the subject area, certain problems are identified, since few companies have implemented the requirements of ISO 9001, ISO 14001, and especially OHSAS 18001.

As a country aspiring to join the European Union, the Republic of Serbia is obliged to accept the standards and practices of the European Union, including the recognition and promotion of corporate social responsibility, and its contribution to social harmonization and sustainable competitiveness and development.

Standardization is the process of establishing provisions for common and repeated use in connection with existing or future needs. The application of standards in Serbia is voluntary. The compliance with standards becomes mandatory for a manufacturer only if the contract between the producer/supplier and the buyer calls for a standard, or a technical regulation.

The goals of Serbian standardization should be realized through the Serbian Institute for Standardization, established under the Law on Standardization as an independent non-profit organization. There are 20 registered companies in Serbia that have been licensed as certification bodies, and quality certificates are necessary when a company:

- is market-oriented and committed to its own development,
- has products or services for export,
- intends to participate in national and international tenders, and
- wants to meet and exceed the needs and expectations of customers and partners.

SETTING THE HYPOTHESIS AND RESTRICTIONS

Based on information gathered about the current state of OSH in companies from the experimental sample and the control sample, and on their analysis, the main hypotheses was set as follows:

"It is possible to improve the OSH system in organizations using an integrated system of management quality."

The main hypothesis is supported by the following sub-hypothesis:

- It is possible to improve the system of OSH in a work organization by developing its own procedures in respect of preventive and corrective measures, and
- It is possible to contribute to the improvement of OSH in organizations by applying measures to reduce risks in the workplace and in the working environment.

The proposed implementation of IMS represents a prerequisite for the success of the organization in the future. This includes the use of integrated quality management system ISO 9001, ISO 14001 referring to the environmental protection, and in case of hazardous working conditions also the application of ISO 18001.

Organizations that have separately adopted all or some of the existing systems should take into account the possibility of creating their IMS system from these systems. The integration brings the possibility of substantial improvement of business efficiency and the quality of products and/or services, and improves procedures related to environmental and health and safety protection. It also helps the organization to clearly define the objectives and business strategy, encourages innovation and creativity, and so on.

Finally, no system of preventive measures, which is usually required by ISO 9001 and OHSAS 18001 standards, can be established unless it is previously determined through a risk analysis what these measures should refer to.

INVESTIGATION RESULTS

Characteristics of the sample

The study included a total of 90 companies from Serbia dealing with production or non-production activities (Figure 1), and 90 respondents – OSH persons from these companies in the experimental group, and 100 representatives in the control group, i.e. entities that are on the hierarchical and organizational scheme of the public company that was selected as a control sample in charge of a bigger or smaller number of employees in terms of OSH.

When selecting the companies of the experimental group, it was taken into account to equitably distribute enterprises by type of activity (productive/non-productive), and to include in the sample companies from all industries and companies of different sizes (small, medium and large).

The public company engaged in the transmission and distribution of electricity in Serbia has six regional offices and about 1,350 employees. All subjects from these regional units composed the control sample (100 respondents).

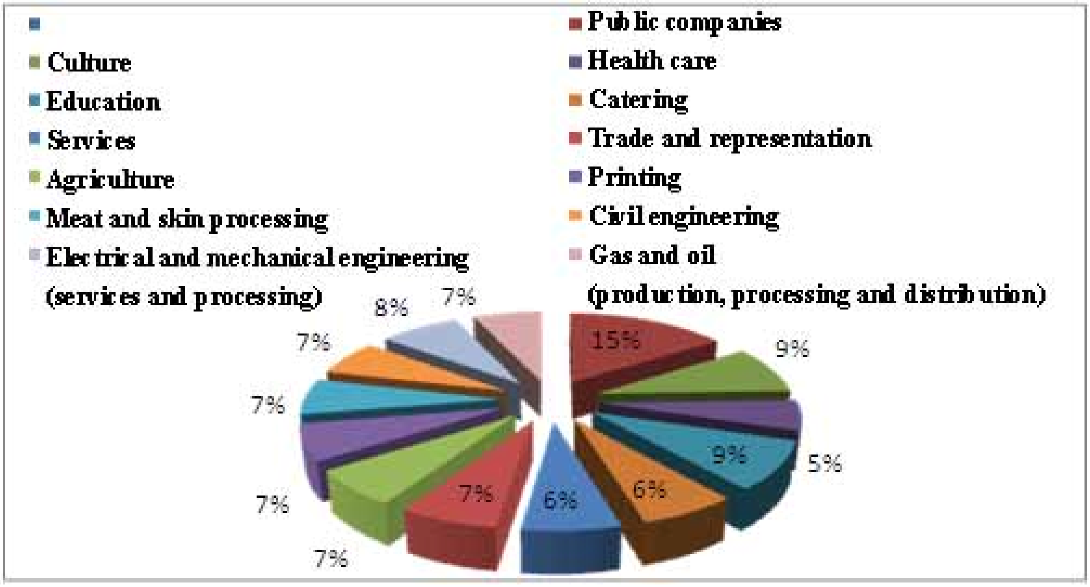


Figure 1 – Representation of different activities in the experimental sample

Companies from the experimental sample are classified according to certified quality standards and are divided into three subgroups, Table 1.

The first group consists of companies that have certified quality standard ISO 9001 and/or ISO 14001 and/or OHSAS. The second group includes companies that have certified some other standard of quality. In the observed sample these are standards ISO 12 647 (criteria related to the printing industry and printing techniques), ISO 17025 (general requirements for competence of testing laboratories and calibration laboratories), SRPS EN 45011:1990 (general criteria for certification of organizations working on certification of products), and the HACCP system (for hazard analysis and management of processes in the critical control points). The third group represents companies that have no certified quality standards.

For this sample division a statistical analysis was performed of responses to questions relevant to verify the main hypothesis and sub-hypothesis, using appropriate statistical techniques. This division of the sample is caused by the main topic of the research – risk management as an element of the integrated system of enterprise management.

Table 1 - Grouping of companies from the sample according to number of certificates

Activity type	Certified quality standard							
	ISO 9001	**OHSAS 18001**	**ISO 14001**	**ISO 17025**	**45011**	**HACCP**	**ISO 12647**	**None**
Production	19	4	3	0	0	10	2	13
Non-production	8	3	1	2	1	0	0	19
Total company number	27	7	4	2	1	11	2	32

In addition to this division the experimental sample was further divided according to the type of company activity into two subgroups:
• production activity, and
• non-production activity.

Methods and techniques of research

The study was conducted from April 2010 to May 2012. According to the type of research, it is operational. This research focuses on studying the situation in the field of health and safety at work in Serbia.

Research methods used in this paper are the following:

– *existing practice analysis method* for the analysis of the current situation in OSH and events in the period from 2005 to May 2012,

– *method of theoretical analysis* for the study of current theoretical knowledge in the OSH field in Serbia,

– *descriptive method* for collecting data on the state of OSH, i.e. gathering views of respondents on the state of BZR in their companies, and

– *data processing method* – In the processing and statistical analysis of the collected data at the stage of descriptive statistics were used measures of the average (central tendency) and the corresponding measures of variability (dispersion): arithmetic mean and standard deviation, median and mode. The data were analyzed by the statistical program SPSS 8.5.

Research techniques applied in this research include the following actions:

– *systematic observation* – observing the situation in OSH in Serbia from 2005 to May 2012, and

– *survey* – obtaining opinions by the OSH persons as representatives of their companies and professionals in this area, conducted from May 2010 till the end of April 2012.

Research Tools

The survey was conducted by written collection of data on attitudes and opinions of a representative sample of respondents using questionnaires. For testing of the hypotheses were used:
– parametric statistical test (Student's t-test), and

– non-parametric tests χ2 (Pearson's chi-squared test) to determine statistically significant differences of results in the control and experimental groups.
The data were analyzed by the statistical program SPSS 8.5. Research topics of health and safety at work are grouped into several groups of questions and provide a basis for testing the hypothesis and sub-hypotheses. Selected statistical procedures were designed to confirm or refute the hypotheses [1].

Statistical analysis and analysis of general characteristics of the observed sample

Table 2 and Figure 2 show the distribution of activities in the experimental sample into two subgroups of companies, I (1) and II (2), which have/have not certified quality standards. This sample comprises 33 companies with at least one quality standard certified (hereinafter when referred to certified quality standards it is considered that there is at least one certified standard of quality), and 53 companies that have no certified quality standards.

Table 2 – Statistical analysis of results of companies with/without certified quality standards concerning their activities

		Standard		Total
		1.00	2.00	
Activity	1	23	14	37
	2	10	39	49
Total		33	53	86

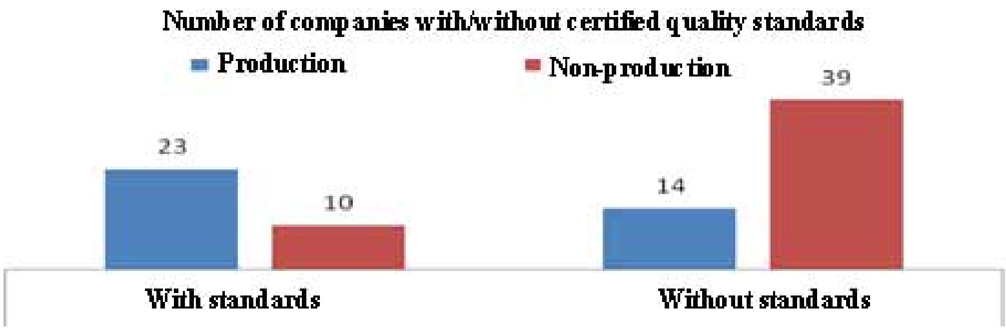


Figure 2 – Companies with/without certified quality standards concerning their activities

Descriptive results of the investigation

The following tables and graphs present the results for the experimental sample and the control sample. Answers to the question ***Has the Risk Assessment Act regarding the workplace (WP) and the working environment (WE) been made?*** are shown in Table 3, while in Table 4 there are answers to the question ***When was the Risk Assessment Act made?***

Table 3 – Responses to the question: Has the Risk Assessment Act been made?

Has the Risk Assessment Act on WP and WE been made?		
	Percentage	***Number of companies***
Yes	80%	68
No	20%	17
No answer		1

Table 4 – Responses to the question: When was the Risk Assessment Act made?

When was the Risk Assessment Act on WP and WE made?						
	200.	***2007***	***2008***	***2009***	***2010***	***2011***
Number of companies	3	13	29	12	6	1
Participation (%)	4.7	20.3	45.3	18.7	9.4	1.6

In Figure 3 are the answers of the experimental sample to the question ***Who did the risk assessment?***

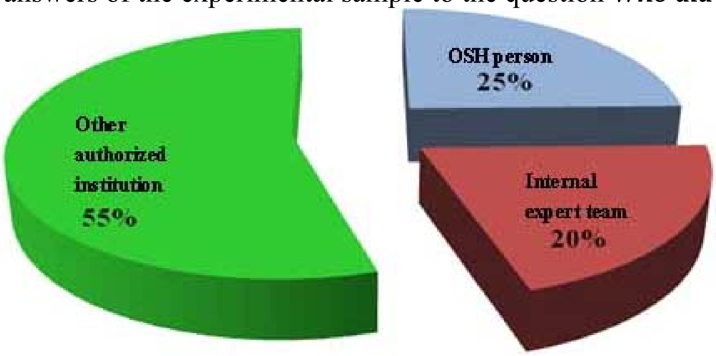


Figure 3 – Responses to the question: Who did the risk assessment? – for the experimental sample

Figure 4 presents answers to the question ***Was the Act revised?*** regarding the experimental sample.

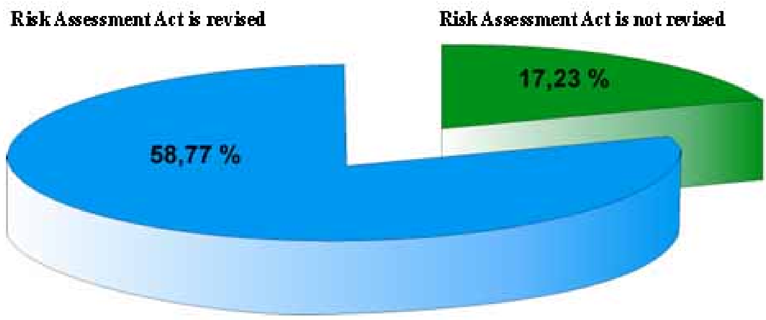


Figure 4 – Responses to the question: Was the Act revised? – for the experimental sample

The first revision was conducted in May 2009. That year there were two revisions of the Act on the risk assessment of WP and the WE, in 2010 there were seven revisions, and in 2011 four.

Responses to the question ***Do you implement measures prescribed by the Risk Assessment Act?*** are shown in Table 5 [1].

Table 5 – Responses to the question: Do you implement the prescribed measures? – for the experimental sample

Do you implement the prescribed measures?				
	Experimental sample		*Control sample*	
	Number of companies	*%*	*Number of companies*	*%*
Yes	25	35.7	50	61
No	4	5.7		
Partially	41	58.6	32	39

Responses to the question ***Is the effectiveness of the implemented measures checked?*** are shown in Table 6

Table 6 – Responses to the question: Is the effectiveness of the implemented measures checked?

Is the effectiveness of the implemented measures checked?				
	Experimental sample		*Control sample*	
	Number of companies	*%*	*Number of companies*	*%*
Yes	20	28.6		
No	17	24.3		
Occasionally	33	47.1		100

Statistical processing and analysis of data

Table 7 and Figure 4 show the results obtained by the applying statistical analysis of the chi-squared test criterion. The criterion of the check was to test the efficacy of measures for risk reduction. N – degrees of freedom is 2 (answers offered to the respondents are: *yes* – (parameter) 1, *no* – 2, and *occasionally* – 3; therefore, N = 3 – 1).

Table 7 – The results of statistical analysis of the chi-squared test criterion

Efficacy check	*Value*	*Freedom degrees*	*Significance level*
Pearson's $\chi 2$ test	8.496	2	0.014

The resulting value of the test statistics is 8.466, and the corresponding significance level is 0.014 (as it is less than 0.05, the probability is considered to be acceptably small).
From this it can be concluded that companies with certified quality standards attach greater importance to the efficiency of measures implemented to reduce risks. The quality standards ISO 9001, ISO 14001 and OHSAS state the need to constantly improve, review and verify the efficacy of the system – which is confirmed by this.
Table 8 and Figure 5 show the results obtained by applying statistical analysis of the chi-squared test criterion. The criterion of the check is the implementation of measures to reduce risks that are prescribed by the Risk Assessment Act concerning the workplace and the working environment.

Table 8 – The results of statistical analysis of the chi-squared test criterion

Measure implementation	*Value*	*Freedom degrees*	*Significance level*
Pearson's $\chi 2$ test	3.892	1	0.049

The resulting value of the test statistics is 3.892, and the corresponding significance level is 0.049. The correlation obtained at random is acceptably small, and connections in the population might exist, i.e. the obtained results are results that are marginally significant, meaning that a larger sample would probably be more significant [1].

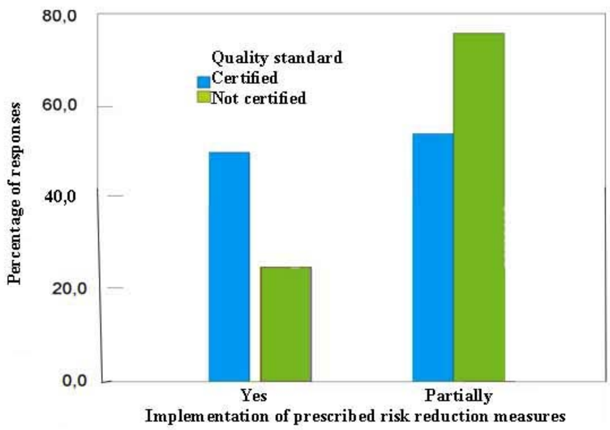


Figure 5 – The results of statistical analysis of the chi-squared test criterion

Control sample – check of the sub-hypothesis on measure implementation

Table 9 shows the results obtained through the statistical analysis of Pearson's chi-squared test criterion for the application of measures to reduce risk in the control sample and the companies that have certified quality standards. The obtained value of significance level is greater than 0.05, which in this case is desired because we do not want significant differences between the control sample and the companies that have the quality certificate.

Table 9 – The results of statistical analysis of the chi-squared test criterion

Measure implementation	*Value*	*Freedom degrees*	*Significance level*
Pearson's $\chi 2$ test	1.459	1	0.227

On the basis of the presented results of the conducted research and statistical processing of the data it can conclude that the set sub-hypotheses have been confirmed, which consequently results in the confirmation of the general hypothesis:
"It is possible to improve the OSH system in organizations using an integrated system of management quality."

CONCLUSION

The protecting of the most valuable resource – the employed is an imperative for the organization, especially the protection in terms of health and safety in the workplace. The dynamics of business requires a proactive approach to occupational health and safety of employees during the work that will identify risks, eliminate them or through a preventive action reduce the likelihood of their occurrence to an acceptable level.
The standard OHSAS 18001 promotes a safe and healthy working environment and with its clear definition of technical standards setting a framework, helps organizations to, in accordance with the laws, manage the risks to health and safety of employees, removing them or reducing to acceptable levels.

REFERENCES

[1] Biljana Gemović, Ph.D. thesis, Faculty of Technical Sciences, Novi Sad, 2011
[2] Biljana Gemović, OHSAS – implementation of a joint IMS, specific elements and procedures, Kopaonik 2010
[3] ***: Regulations on the risk assessment procedure in the workplace and in the working environment ("Official Gazette of RS", No.72/06 and 84/06)
[4] ***: SRPS OHSAS 18001:2008., System of Occupational Health and Safety –Requirements
[5] ***: SRPS OHSAS 18002:2008 Management System of Occupational Health and Safety – Guidelines for Implementation
[6] www.pks.rs/PrivredauSrbiji/Kvalitet.aspx
[7] COSHH (The Control of Subltances Hazardous to Health Regulations 2002)

REVIEW INFORMATION ABOUT THE RECYCLING OF TIRES

Dragiša Tolmač[1], Dimitar G. Petrov[2], Slavica Prvulović[1], Dragana Dimitrijević[1], Jasna Tolmač[1]
[1]University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
[2]Technical University, Sofia, Bulgaria
e-mail: tolmac@tfzr.uns.ac.rs, dimgog@abv.bg; dimgog@tu-plovdiv.bg, prvulovicslavica@yahoo.com

Abstract: Recycling as an activity for extracting economic profit and for achieving reduction of pollution is considered. It is shown that recycling as a manufacturing process: creates less air pollution and water compared to that of primary production, saves storage space; creates new jobs in companies engaged in the collection, production and distribution of recyclable materials while saving significant resources and protect the environment. Basic technology for tire recycling is considered in this work. Schemes of technological lines for recycling tires, schemes of machine for extracting of the steel wires from tires and schemes of machines for cutting tires - 45,632 are displayed with basic information about them.
Keywords: Recycling, tires, machinery

INTRODUCTION

It is estimated that currently in the Republic of Serbia there are in use around 1.6 million cars, with an average age between 16 and 17 years. Serbia wills soon faces the problems connected with the amount of approximately 1.6 million tons of waste materials of various kinds, among which there are hazardous substances. Generation of automotive waste takes place successively, because of the dynamic renewal of the fleet of motor vehicles, and of course, generating waste takes place in the exploitation or maintaining of the cars. In any case, there are a very large quantity of waste, utilization of which would be better to be planned in the optimal way.
In Serbia there are not enough regulation systems for creating conditions for the development of recycling of the cars. The result is a weak development of the industry. World experience shows that material recycling is one of the most dynamic developing industries in the developed countries.
In order to ensure effective recycling of motor vehicles is necessary to create an appropriate legal framework and basic infrastructure requirements, which would undoubtedly contribute to its development by attracting investments and establishment of technological resources in accordance with the regulations. Also, the introduction of system solutions in the field of the automobile recycling contributes to the renewal of the motor fleet, consequently reduces emissions of harmful substances, increases road safety and saves energy and raw material resources.
At the present time in Serbia can be told that there are a deficit of the organization in the field of recycling of metals with the exception of collection and recycling of metal stuff (selection, cutting and crushing).

NEW RECYCLING TECHNOLOGIES

The procedure is 100% environmental friendly, i.e. no adverse impact on the environment. This recycling process creates no waste, no further substance, everything is usable, and it is extremely important that there are no environmental pollutions (of air, water or soil) accompanying the process. The studies showed that this mechanical recycling process is much better to the environment than combustion for energy purposes, because of the nature of the combustion process. The mechanical recycling process here is realised through the fragmenting of tires up to the rubber granules, which enter the cycle of re-use for preserve natural resources. Solving the problem of accumulated waste from tires at the same time has benefits not only for environmental, but for saving energy and resources. In Figure 1, is shown technology scheme recycling of tires, in Figure 2, are shown some technical data of the machine for extraction of wire, and in Figure 3, is shown the machine for cutting tires - Schredder.

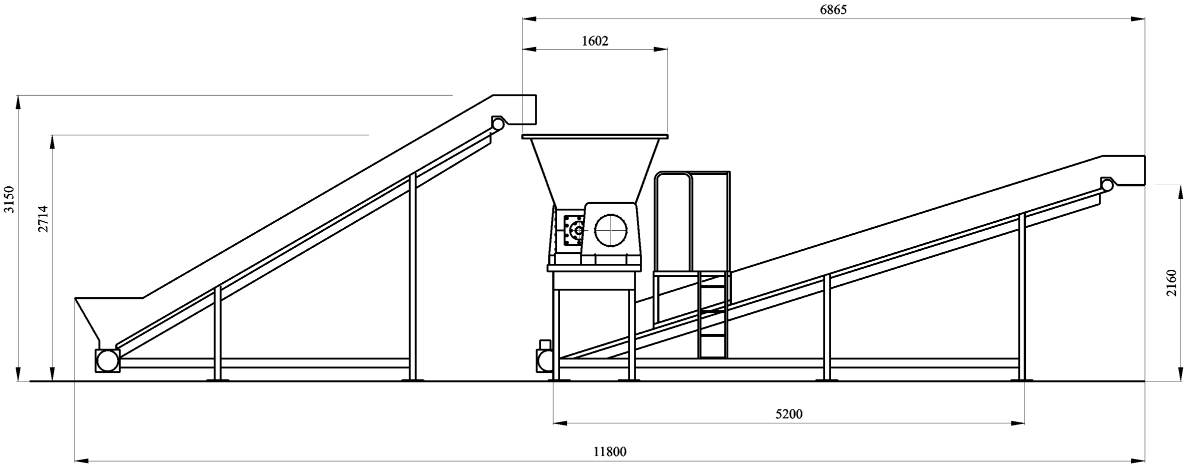
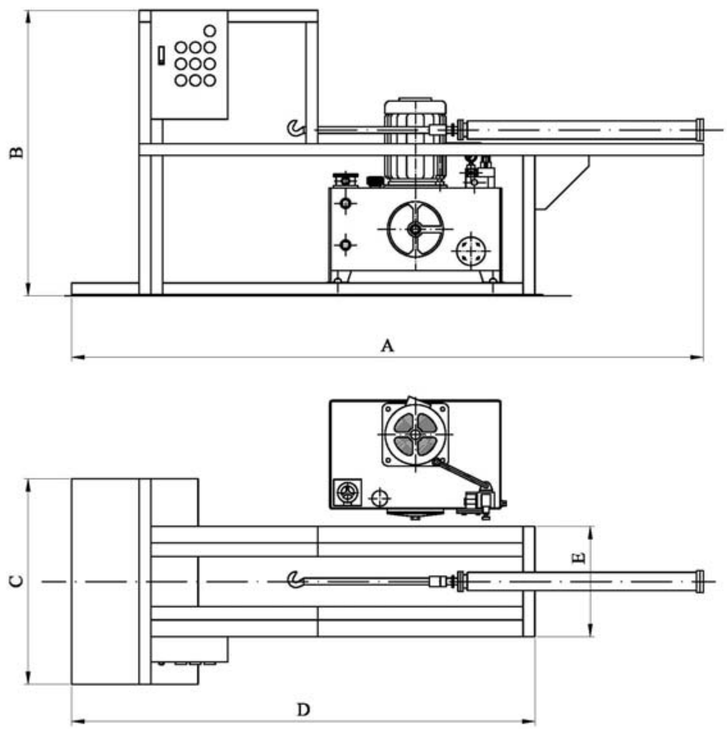
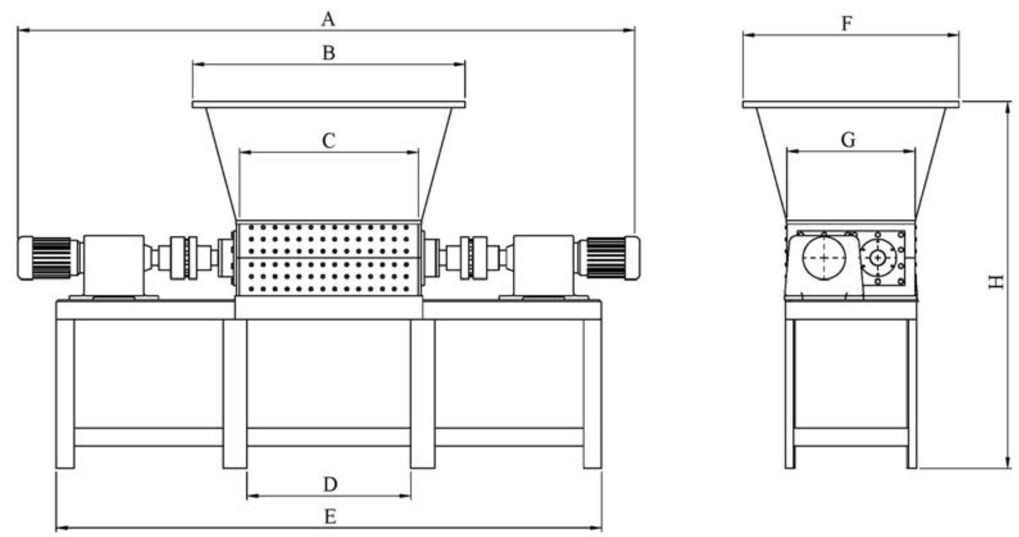


Figure 1. Technological scheme of recycling tires



Model no.	PTH-1200	PTH 800
Maximum pressure (MPa)	15	15
Maximum tire diameter (mm)	1200	800
Capacity (pcs / h)	15	60
Engine power (kW)	18.5	11
Weight (kg)	2500	2300

Figure 2. Machine for removing wires



Model	PT 7.5	PT 22	PT 37	PT 45
Engine power (kW)	7.5 + 7.5	22 + 22	37 + 37	45 + 45
Total weight (kg)	3.000	6.300	12.500	13.700
Capacity (kg / h)	500	1.200	2.000	2.500

Figure 3. Shredder - a machine for cutting tires

The feedstock for recycling consists of tires of cars, lorries, buses, commercial and other vehicles that had passed their life because of wear or damage, and its can no longer be used for the purpose they were intended. The tires of working machines, whose dimensions are larger than these, can also be processed, but it is necessary of pre-cutting.

The primary products of the recycling process are the rubber granules, and this process is often called granulation. The standard size of the granules ranges from 1 mm to 4 mm. The size of the granule is determined by settings on the equipment and it is possible to produce granules with various dimensions as stated above. The obtained clean granulate is 99.9%, i.e. rubber granulate is purified and has no more than 0.1% of its weight of components from steel and textiles which are released in the process of recycling of the worn tires. Here is obtained that the mass of the granules is from 55% to 65% by weight of front tire.

The secondary products of the recycling of tires are short steel wires separated from rest of material, which have from 25% to 30% of weight of the tire. The separation of these short pieces of the tire's steel wires, which are caused by the cutting and further fragmentation of the tires during the process is performed by a magnet.

The tertiary products of the recycling process are textile fibres and they makes up about 10% of the weight of the tire. The separation of textile fibres is accomplished by means of the powerful air flow. The air filtration systems (aspirators) consist from the bag filter and subsystem of self-cleaning filters. The quality (up to 10mg/m^3 dust) of discharged into atmosphere air is in accordance with current EU regulations.

This process of granulation represents a mechanical tire processing - cutting. During the process of cutting, which is carried out at several stages, the size of fragments gradually decreases to the final size of granules. The fragmentation and the separation of the steel wires and textile fibres included in the composition of the tire from each other and from the primary product (rubber granules) also takes place in the process. The separation of components is performed under the influence of magnetic field and of air flow.

The electricity is the main and virtually the only source of energy that this process uses. To performing the process there is no need of chemical reagents or thermal reactions. This way there are no any unwanted by-products in this processing. Simply put, the tires are to be separated into its component parts (rubber, steel and textiles) without are affected physical and chemical properties of the constituent elements themselves.

CONCLUSION

Republic of Serbia is also facing the problem of utilization of used motor vehicles. For now, their recycling is done sporadically, in an unorganized way and incidentally. The way to overcome this situation is the adoption of adequate legislation and implementation of integrated and sustainable model of recycling of vehicles at the end of their life cycle.

The recycling operators should be deployed on the territory of Serbia, so that the citizens to be can submit their old cars to the nearest recycling centre, which will issue a certificate on the basis of which they can avail from benefits when buying a new car. This approach will encourage everyone to participate in the recycling of batteries, waste oil, antifreeze, glass, plastic and everything from which is built one car. For that it is necessary to invest a total of around 20 million Euros

REFERENCES

[1] Arsovski, S., Milivojevic, J., Grubor, S., Simon Arsic, A, Tonic, N. The influence of model of integrated and sustainable recycling of motor vehicles at the end of the life cycle of the level of employment in Serbia, Quality, no. 11-12, 2010.
[2] Aleksic, A., Bian, S., Tonic, N., Grubor, S. Resilience of ELV Dismantling centers, the National Conference on Quality - FQ, p.105-111, 2011.
[3] Afgan, N.H., Hovanov, N., Andre, P.M. Sustainable Management Organization With Passenger Car Example of Sustainability Assessment, International Journal for Quality Research, Vol. 3, no.2, 2009.
[4] Guise, S., Bosdorf, Z., Goldmann, D. Life Cycle Assessment of End-of-Life Vehicle Treatment, VOLKSWAGEN AG, 2005.
[5] Gareth, C., Shahin, R. Cost models for Increased Value Recovery from End-of-Life Vehicles, The Centre for Sustainable Manufacturing and Reuse / Recycling Rate translation, 2006.
[6] Hempfl, C. The commercialization of recyclable materials and recycling waste in USAID, 2010. [7] Jovanovic, Z., Haase, H., Ziems, D. Development phases of waste management in the German-speaking countries and challenges for Serbia's EU membership ambitions. Ekolat 2008, Soko Banja, 2008.
[8] Junbeum K, Junghan, B. Braden, A. Recycling Systems and Management of Endof-Life Vehicles (¨ vs), A Center for Sustainable Engineering Education Module, October 23rd. 2007.
[9] Kozic, A., Sudarević, D. Access to recycling of motor vehicles, the Association for Quality and Standardization of Serbia, the Festival of quality, 32 National Conference on Quality, Kragujevac, 19-21. May. 2005.
[10] Krstic, M., Marjanovic, Z., Brzaković, R. Management and lifecycle emissions of vehicles, the Association for Quality and Standardization of Serbia, the Festival of Quality, 2 National conference on quality of life, Kragujevac, 8-11. May, 2007.
[11] Milivojevic, J., Grubor, S., Simon, A. The development of an integrated and sustainable recycling system of motor vehicles at the end of the life cycle in Serbia, 3 National conference on quality of life, quality festival, Kragujevac, 2008.
[12] Milivojevic, J., Grubor, S., Simon, A. Sustainable integrated system of recycling of motor vehicles during the life cycle, the First National Conference on recycling of motor vehicles in 2009, Ecka, 06. November, 2009.
[13] Milivojevic, J., Bian, S., Djordjevic, M. The current system's approach to recycling of motor vehicles at the end of the life cycle of Serbia, Faculty of Mechanical Engineering Kragujevac, Zastava vehicles, 2010.
[14] Medic, D. Analysis of the economic potential of the market of used cars in Serbia, Technical Faculty "Mihajlo Pupin", Zrenjanin, 2011.
[15] Pavlovic, M., Tolmac, D., et al. Sustainable development of technologies and equipment for the recycling of motor vehicles, the Ministry of Science and Technology of the RS. SRO: Technical faculty "Mihajlo Pupin", Zrenjanin, (2011-2014.), No. Project: 035033.
[16] Pavlovic, M. Directions for the Development of Recycling of used cars in Serbia, the Association for the recycling of motor vehicles of Serbia, Belgrade, 2009.

[17] Pavlovic, M., Subaru, N. Environmental logistics, Technical faculty "Mihajlo Pupin", Zrenjanin, 2006.
[18] Djordjevic, M., Kokic, M. Management feasibility study of recycling of used materials cars, Project Management and Entrepreneurship, Proceedings of the page. 72-76, Zlatibor, 9-12, May, 2004.
[19] Kozic, A., Sudarević, D. Access to recycling of motor vehicles, FESTIVAL OF QUALITY, May, 2005.
[20] Tadic, D., Bian, S., Stefanovic, M., Aleksic, A. A Fuzzy AHP and TOPSIS for ELV Dismantling selection, International Journal for Quality Research, Vol. 4, No.2, 2010.
[21] Tsuji, A. Recyclability Index for Automobiles, A Thesis Presented to the Faculty of California Polytechnic State University, In Partial Fulfillment of the Requirements for the Degree Master of Science in Civil and Environmental Engineering, 2006.
[22] Tolmač, D., Prvulović, S., Dimitrijević, D. : Some aspects of recycling automobile tires, ECO Urban Conference, Technical Faculty "Mihajlo Pupin", Zrenjanin, 2011.

IMPROVEMENT OF THE WOOD BIOMASS HEATING SYSTEM CONTROL

Saša Prodanović[1], Srđan Vasković[1], Zoran Radović[2]
[1] University of East Sarajevo, Faculty of Mechanical Engineering, East Sarajevo
[2]Hydropower plant Mesići, Rogatica
e-mail: elsing123@yahoo.com , srdjan_vaskovic@yahoo.com, z.radovic83@gmail.com

Abstract: A significant quantity of wood remains as a waste from primary and secondary processing in wood industry. This biomass can be used for the energy purposes. There belong: lappet, bark, scrap and sawdust. Wood cutting residues and energy forests grown specifically for energy purposes are also resources of wood bio-fuels. In order to enable easier handling, transportation and firing of scattered and unequal wood residues, those residues have to be chopped to appropriate size. Such a form of chopped wood is named chips.
Wood chips is very suitable as a fuel for automated heating systems. A high percentage of moisture in the fresh chips is sufficient reason for occurrence of technical problems during fuel combustion. Moisture content in the fuel and necessary thermal load can vary in a wide range.
This paper explores wood biomass heating system control, which utilizes wood chips as a fuel. The feeding of fuel into the boiler is made using a screw conveyor. Combined CO / λ control of exhaust gases in the chimney gives the best results in terms of combustion control and CO emission reductions. The main goal of this survey is optimization of combustion process using control based on moisture measurement in scattered wood chips as a disturbance, with already widespread control system by output (temperature in heated room) using information about concentration of CO and O in exhausted gases. Significant contribution of this research is increasing of entire heating system robustness in terms of fuel moisture.
Proposed control strategy for this thermo-energetic system has been presented as a structural diagram of process control.
Key words: heating system, wood chips, moisture compensation, automatic control.

INTRODUCTION

The use of biomass for production heat and electricity will be increasing in the coming days. Because biomass is a renewable energy source available in significant quantities and environmentally acceptable for CO2 emissions. Because of energy dependence on fossil fuels, biomass is one way to reduce it, with use biomass as domestic resources for energy. Residues from logging, wood processing at sawmill, and various other scrap wood can be use as a fuel for combustion and energy production. Scattered and disparate wood residues and waste must be processed and chopped to acceptable size for suitable handling, feeding and transport. Wood chips is very suitable for automated fuel heating systems. For production chopping wood residues and wood chips we can use special machines, which can be moving or stationary. The energy requirements for chipping of raw material are between 2 and 5 kWh per ton of wood chips [1]. This is less than about 0.5% of heat which is related in wood. This information refers to the freshly cut wood (about 50% moisture content) because the dryer wood requires more energy for chopping. Dimensions for wood chips are in the range of 1 cm to 10 cm in length and a width of up to 4 cm. Commercially wood chips is divided by size into three categories [1]:
- Finely chopped to the length less than 3 cm
- Medium chopped with length up to 5 cm
- Coarsely chopped to the length up to 10 cm.

The advantage of using wood chips versus firewood is in the automatic operation of combustion and significantly lower emissions, due to control systems for automatic fuel delivery. The main disadvantage of wood chips is in its preparation and storage, but also moisture content in wood chips. Wood chips shown in Fig. 1.

Figure 1. Wood chips

CONTROL STRATEGY FOR HEATING SYSTEM

Wood chips automatic bolier

Conventional wood chips automatic boiler is controlled based on information of outlet gases and room temperature, as shown figure 2.

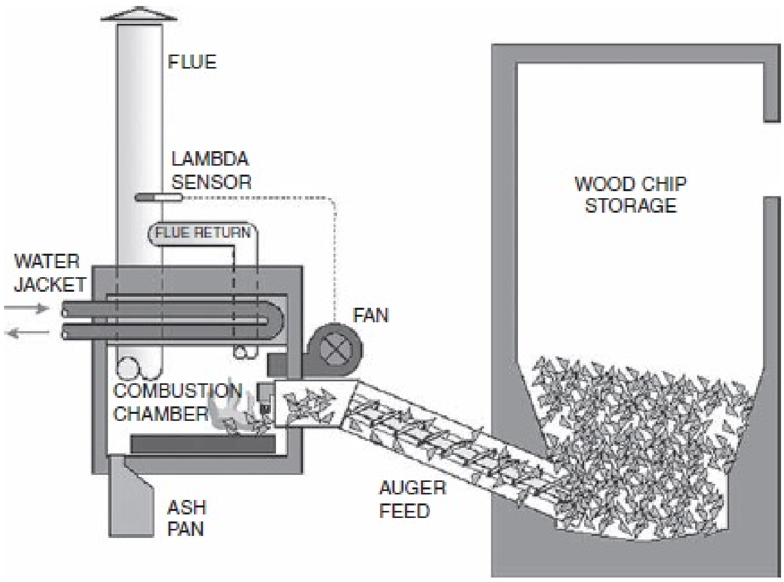


Figure 2. Wood chips automatic boiler [2]

Structural diagram of control system for wood chips boiler

New sugested strategy for automatic control of wood chips boiler is shown in figure 3.
Here ventilation depends on: oxygen sensor, CO sensor (in the chimney) and content of moisture (in the doser). In this way, control the combustion process has been enabled. Energy produced in the combustion process depends on the moisture content in the wood chips. By measuring the moisture content in the wood chips obtains the information from which will depend on the fuel feed rate on the grid and inlet air. Also, fuel feed rate depends on the heat load of the boiler, that is caused by the desired temperature in the house which is heated. Modulation range of equipment for regulating the amount of fuel and air is from 0 to 100% [3]. So for this type of control is not required as an independent source of heat.

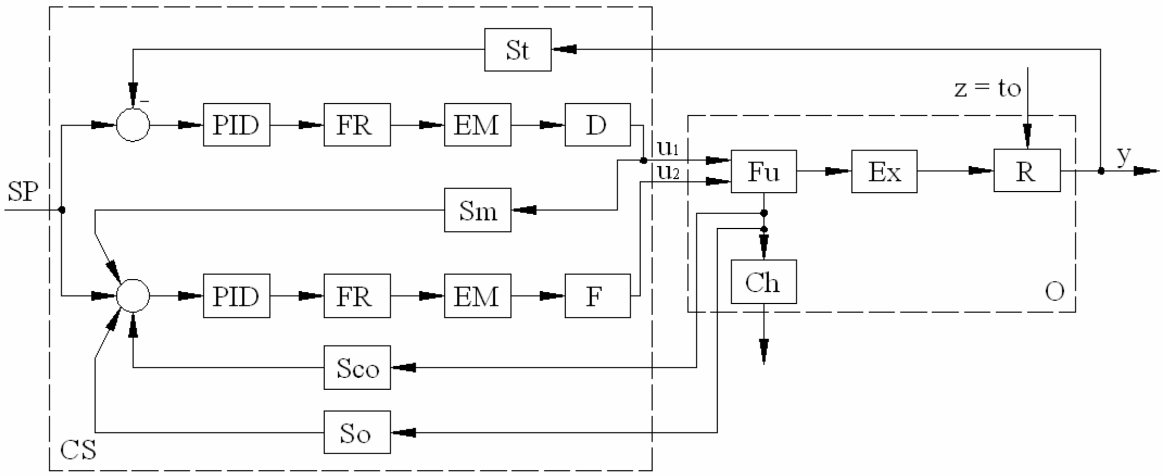


Figure 3. Structural diagram of wood biomass heating control system [4]

Hence, this improvements is enabled by controlling spead of fan depends on chips moisture in order to obtain approptiate quantity of air. This access prevents chips agglomeration in the furnace. Therefore, when chips with higher value of moisture come into furnace, control system should introduce more air in it, to enhance combustion.
According to last description of plant for wood chips, we have provided a schematic diagram of power plant in the form of a structural diagram in figure 3.

Ecological aspects

Wood chips as a fuel has advantages in terms of ecology. It is suitable for heating in automated plants and thus provides a significant increase in the efficiency of the plant. The application of automatic control system in the plant biomass-burning is of multiple importance. Primarily to increase energy efficiency and reduce CO and other emissions.

CONCLUSION

New strategy for wood biomass heating system control have been suggested. This strategy is characterized by taking into account moisture in fuel, in order to compensate it and in that way enhance combustion process. This is new modern achievement to increasing of energy efficiency of these systems.

REFERENCES

[1] Planing and installing bioenergy systems: a guide for installers, architects and engineers, German Solar Society (DGS) and Ecofys, 2005
[2] Lorenzini, G., Biserni, C., Flacco, G., Solar Thermal and Biomass Energy, WIT Press, Southampton, Boston, 2010.
[3] Mitic, D., Stankovic, M., Protic, M., Biomass for heat energy, Nis, 2009. (in Serbian)
[4] Milojkovic, B., Grujic Lj., Automatic control, Faculty of machanical engineering Belgrade, 1990.

ECO- INNOVATION AND ENVIRONMENTAL MANAGEMENT IN SMEs IN EU

Milica Stanković[1], Dragana Drinić[1] , Nikolina Krneta[1]
[1]Higher School of Professional Business Studies, Novi Sad, Serbia
e-mail: milica.stankovic.vps@gmail.com, dragana.vps@gmail.com,nikolinak.vps@gmail.com

Abstract: Eco innovations include new production processes, new products, new services, new methods of business management which use will prevent or significantly decrease the environmental risk, pollution or any other negative impact of using resources during the entire product life cycle. In the European Union there are 23 million SMEs, which account for 99% of all enterprises in the EU, so it can be concluded that small and medium-sized enterprises present the basis of the economic system. On the other hand, SMEs cause enormous environmental pollution. Therefore it's necessary to provide an adequate program to support eco-innovations in order to boost the competitiveness of SMEs and provide better access to finance.
Key words: environmental management, EU, eco innovations, SMEs, environmental burdens

INTRODUCTION

Intensification of the global environmental situation - warming, ozone layer depletion, desertification - is a result of the deterioration of the ecological situation in different countries and regions. The man has finally realized that a different attitude toward the environment is actually a further survival strategy. Small and medium-sized enterprises are the main and the most important factor in securing the success of business and initiating overall economic development. With a major goal to achieve efficient and effective utilization of potential of small and medium enterprises in the single European market, it is necessary to encourage eco-innovation in order to reduce the impact on the environment. Enterprise Europe Network, as the largest European network of business support, offers help to SMEs in the European Union since their position of the base of the economic system. Although SMEs are crucial engine for economic growth and employment in European Union, they are hardly aware of their negative impact on the environment as well as their liabilities linked with mentioned issue. There is vide range of reasons for difficult adoption of eco-innovations in SMEs, such as a luck of funds within enterprises, uncertain market demand, existing regulations, a lack of qualified personnel, technological capabilities and other obstacles. In order to help SMEs in overcoming mentioned obstacles, the Environmental Compliance Assistance Programme (ECAP) provides a plan for implementing the legislations and minimizing the SMEs environmental impact.

THE IMPORTANCE OF ENVIRONMENTAL MANAGEMENT IN SMEs IN EU

SMEs are the backbone of the European economy and their contribution is essential for achieving the EU goals for sustainable growth. SMEs are defined as enterprises which employ fewer than 250 employees and which have an annual turnover not exceeding €50 million, and/or a balance sheet total not exceeding €43 million. They are categorised into three groups: micro (0-9 employees), small (10-49 employees) and medium (50-249 employees) sized enterprises. There are 23 million SMEs in the EU, which represent about 99% of all EU enterprises. The impact of SMEs on the environment is significant. Micro enterprises account for almost 93%, 6% are small enterprises and less than 1% are medium sized enterprises. SMEs are active in a range of sectors across the EU economy: 22.2% in producer services; 20.4% in personal services; 20% in retail distribution; 11.9% in manufacturing; 11.6% in construction; 8.1% in wholesale trade; 5.5% in transport and communication; and 0.2% in extraction and energy. SMEs are far from being a homogenous group. However, they have many features in common, and encounter similar problems in relation to environmental compliance and performance.

In March 2010, the European Commission published its strategy for smart, sustainable and inclusive growth entitled Europe 2020. The strategy emphasizes three priorities: Smart growth: developing an economy based on knowledge and innovation; Sustainable growth: promoting a more resource-efficient, greener and more competitive economy and inclusive growth. [1] SMEs contribute about 64% of industrial pollution in Europe. Up to 24% of SMEs actively engage in actions to reduce their environmental impact. It is very important to emphasize that 0.4% of SMEs use a certified Environmental Management System (EMAS, ISO 14001 or other systems). In 2009, about 3,500 private companies and public organisations had implemented an EMAS system. The distribution varies across countries. In 12 countries less than 10 SME companies has an EMAS registration, 9 countries has less than 100 SME companies has an EMAS registration. Austria had 194 EMAS registered SME companies, Italy 901, Spain 922 and Germany 944 SME companies. One of the major challenges for SMEs is to reduce their impact on the environment. SMEs are in a more difficult position than large companies in the case of achieving environmental objectives. Simplified administration would facilitate the realization of these goals. Investment in environmental solutions is a priority for SMEs with a high environmental impact. [2]

The importance of protecting the environment is an issue that has emerged as an imperative and a crucial question of modern society. An Environmental Management System (EMS) helps organizations to achieve their-performance related to environmental protection. The best known international standards for EMS are the ISO 14001 series and the EMAS. The Eco-Management and Audit Scheme is a voluntary instrument established by the EU. It creates a standard way for organisations to measure their environmental performances and work to improve them. The benefits of EMAS are that companies have recognised proof of their credentials as environmentally friendly and socially responsible organisations. They can benefit from resource savings and it can provide a catalyst for innovation. Companies wanting to qualify for EMAS must review the environmental impacts of their activities, products and services. They then set up a management system with fixed objectives and must conduct regular environmental audits and produce statements of environmental performance. ISO 14001 is another international standard for environmental management. ISO 14001 has been more successful with more than 50,000 ISO 14001 certified companies worldwide in 2006. Apart from ISO 14001 and EMAS, there are a number of different national or regional schemes such as “123 environment “ in France, “Bayrisches Umweltsiegel” in Germany, “Ecoprofit” and “Green Key”.

Most of the SMEs consider that they are only indirectly concerned by environmental issues. In fact, the great majority of employees in SMEs do not see the environmental burden created by their enterprises. It can be argued that 80% of all 22.2 million SMEs in the Member States of the European Union are only concerned by two environmental issues, energy savings and waste recycling. The main features that influence the way SMEs deal with environmental issues are: [3]

- Small external pressure to behave in a more environmentally friendly way.
- Low internal motivation for most entrepreneurs in SMEs to behave in a more environmentally way. Moreover, the environmental costs of SMEs make up a small part of the total costs (on average 3 to 5%) of the total cost.
- SMEs are generally not well informed about the advantages and disadvantages of relevant environmental technologies.

Environmental Compliance Assistance Programme (ECAP)

Small and medium-sized enterprises (SMEs) find it harder to comply with environmental legislation than larger companies. SMEs are often not aware of their environmental impacts and liabilities. The European Commission proposed an Environmental Compliance Assistance Programme (ECAP). ECAP will make it easier for SMEs to comply with their environmental requirements and to improve their environmental performance. There are a number of areas where action is being taken: minimising the administrative burden on companies, helping SMEs integrate environmental concerns into their businesses, supporting regional and national networks, improving communication, providing funding. [4] It is necessary to highlight the importance of environmental protection in SMEs, because it is one of the preconditions for companies increasing their competitiveness. In a large number of SMEs there is a problem lack of awareness and knowledge about environmental problems and potential benefits that can be achieved through effective environmental management. [5]

The Environmental Compliance Assistance Programme proposed by the Commission is a set of measures that aim to help SMEs minimise the environmental impact of their activities and to facilitate

compliance with existing legislation. The Programme intends to reduce the burden of compliance by designing instruments and policies to integrate environmental concerns into the core of SME activities. Funding for the Programme's measures will come from LIFE+ funds (€5 million for 2007-13) with additional funds to be made available through the Competitiveness and Innovation framework Programme (CIP) and the Structural Funds. [6] The main objective of ECAP is helping SMEs comply with environmental requirements in order to improve their environmental performance. The protection of the environment and a more sustainable use of energy are often still perceived as a series of bureaucratic burdens imposed by public authorities. There is a lack of proactive attitude in this field. One of the biggest problems is the concept of rationalization of energy that is not systematically integrated into business decision-making. It should be noted that in most cases SMEs are not aware of their impact on the environment and do not have the expertise to manage such issues. [7]
SMEs are often not aware of their environmental impact. SMEs can benefit from the economic opportunities presented by addressing environmental performance and embracing opportunities for ecoinnovation. The European Commission presents an Environmental Compliance Assistance Programme for SMEs (ECAP-SME) in 2006. SMEs are an important engine for economic growth and employment throughout the European Union. SMEs are also an important contributor to environmental pollution. The lack of resources can lead to the SME being risk-averse and less willing to invest in new environmental technologies. Environmental Compliance Assistance Programme improves compliance, environmental performance and support eco-innovation in SMEs. There are already a large number of initiatives in place in the EU which seek to help SMEs comply with legislative requirements and improve their environmental performance. In some Member States, such as Belgium, the Netherlands, Austria, the UK, Germany and Spain, there are already a number of national and regional initiatives in place which offer environmental compliance support to SMEs. In other countries, support is available for SMEs, but it is not necessarily related to environmental compliance. [8] Adopted in October 2007, the Environmental Compliance Assistance Programme (ECAP) provides a framework to help small and medium-sized companies implement European environmental legislation and minimise the environmental impacts of their activities. Actions are planned for: [9]

- Better regulation in the design and implementation of policies to minimise the administrative burden of compliance on SMEs.
- Developing more accessible environmental management schemes to integrate environmental concerns into SMEs' core business activities in a coherent and cost-eff ective way.
- Focused financial assistance to promote and support initiatives for improving SMEs' environmental performance.
- Improved communication and targeted information.

Although almost all SMEs are taking action for a more efficient use of resources, there is still a lot of room for improvement. SMEs need advice and assistance on how to put in place actions such as saving energy, minimising waste, recycling, saving materials, etc. SMEs have to be able to comply with environmental regulations. The Environmental Compliance and Assistance Programme for SMEs (ECAP) aims at enhancing the compliance of SMEs with environmental legislation. [10]

ECO INOVATIONS

Small and medium-sized enterprises are an integral part of European economy and play an important role in area of environmental protection. Many companies are unaware of the impact they have on the environment. SMEs also tend to believe that they are complying with legislation. Under such circumstances the activities of SMEs may pose significant health and safety risks to workers as well as a threat to the environment. It is important to emphasize the importance of adopting eco-innovation to provide the following benefits: cost-savings on energy, access to a network and business opportunities. [11] SMEs could lose also out on the economic benefits presented by better environmental management and eco-innovation. SMEs face specific barriers hindering the adoption of environmental technologies and specific measures which should be developed to promote their adoption by SMEs. Adoptinion of environmental technologies will contribute to a better environment in Europe. Environmental Technology Action Plan (ETAP), adopted by the European Commission in 2004, is very important for environmental management. ETAP aims to exploit the full potential of environmental technologies to reduce pressures on natural resources, improve the quality of life and stimulate economic growth. SMEs dominate in almost all sectors of the economy. Most of these companies (about 80%) are mainly concerned by only two environmental issues: energy savings and waste recycling.

Barriers to the adoption of environmental technologies are the following:

- *Most SMEs do not consider environmental issues to be important*- There is lack of internal and external incentives to act in a more environmentally friendly manner since only a limited number of SMEs have been able to take advantage of the growing concern for the environment to obtain a competitive advantage. Public campaigns to raise awareness about environmental management among entrepreneurs in SMEs may also have an important role.
- *Most SMEs are not aware of the importance of environmental technologies and government policies to encourage such technology*- SMEs do not have information about modern technologies and the costs and benefits obtained by its use. They trust in the opinion of their professional surroundings regarding the adoption of environmental technologies, which often have the same lack of information about potential environmental technologies. Actions focussing on the professional surroundings, such as trade associations or equipment suppliers, may be more effective in regards to the adoption of environmental technologies, than actions which try to influence the entrepreneur himself directly.
- *Costs and risks*- The basic perception of SMEs in relation to environmental technologies are the costs and risks associated to them. Very important barriers are major financial outlays for the purchase of new technology and the lack of adequately trained personnel with sufficient knowledge about the installation and operation of new technology.

It is worthto mention three key determinants or drivers of the environmental innovativeness of European SMEs which correspond closely to the three barriers. There is a dynamic interaction between dimensions: environmental orientation, business competence and network involvement.

- *Environmental orientation*- The adoption of environmental innovations is embedded in the SMEs' business strategic decision-making. Companies have established an environmental management with a pro-active policy which goes beyond compliance with legislation.
- *Business competence*- The companies have the capacity to establish an internal adoption processes and to develop cooperative relations with external resources.
- *Network involvement*- The network relations of a firm influence the adoption of environmental innovations in every stage. The company's networks can be divided into the business network, the knowledge network and the regulatory network.

The environmental behaviour of SMEs, either through adopting environmental technologies or through implementing environmental management measures, in essence occurs via external pressure or via internal motivation. There is a need for SME-tailored measures to stimulate the adoption of environmental technologies. Generally, about 90% of each sector consists of micro and small enterprises. Environmental Technologies Action Plan (ETAP) indicated the following barriers to the adoption of eco-innovation:

- *Economic barriers*, such as the higher cost of investments in environmental technologies because of their perceived risk, the size of the initial investment or the complexity of switching from traditional to environmental technologies;
- *Legislative barriers*, when legislation is unclear or too detailed, while good legislation can stimulate environmental technologies;
- *Insufficient research efforts*, coupled with inappropriate functioning of the research system in European countries and weaknesses in information and training;
- *Inadequate availability of risk capit*al to move from the drawing board to the production line;
- *Lack of market demand* from the public sector, as well as from consumers. [11]

Just over a third of companies reported that less than 10% of their innovation investments in the past five years were related to eco-innovation. A quarter estimated that this share was between 10% and 29%. A minority (6%) of managers said that more than 50% of the innovation investments made by their company in the past five years were related to eco-innovation. Many companies in all countries had made eco-innovation investments in the past five years; however, a minority reported that the share of innovation investments related to eco-innovation was 30% or more. In just six countries, more

than a fifth of respondents estimated that they had reached this level: Sweden (21%), Greece (22%), Austria (23%), Cyprus and Luxembourg (both 24%) and Poland (30%). Roughly 3 in 10 companies in the EU had introduced a new or significantly improved eco-innovative production process or method in the past two years, while roughly a quarter had introduced a new or significantly improved eco-innovative organisational method. A similar proportion had introduced a new or significantly improved eco-innovative product or service on the market.
It is important to emphasize that 32% of medium-sized companies had introduced a new or significantly improved eco-innovative organisational method in the past two years and 41% said the same for a new or significantly improved production method or process; the corresponding figures for small companies were 22% and 26%. Among companies that had introduced at least one type of eco-innovation in the past two years, the largest number (42%) said that such eco-innovation had led to a reduction in material use of between 5% and 19% per unit of output, while roughly a third (34%) of respondents estimated that the reduction in material use had been less than 5% per unit of output.
The most common barriers to the adoption of eco-innovation in SMEs are the following:

- More than a third of managers in SMEs say that a lack of funds within their enterprise is a very serious barrier.
- Two-thirds of managers in SMEs say that the uncertain demand from the market was a barrier to a faster uptake of eco-innovation in their company.
- Existing regulations and structures are very serious barriers for 25% SMEs in EU.
- Technical and technological lock-ins and market dominated by established companies are barriers to a faster uptake of eco-innovation in SMEs.
- A lack of qualified personnel and technological capabilities in SMEs is very serious barrier.
- Limited access to external information and knowledge is a barrier to introducing eco-innovations in SMEs.

The drivers for a faster uptake of eco-innovation in SMEs are following:

- One in two SMEs consider **current high energy prices** to be a *very important* driver to accelerate eco-innovation uptake and development in their company and a similar proportion say the same about the **expected *future* increases in energy prices**.
- More than 45% managers say that having **good business partners** could be a *very important driver* of accelerated eco-innovation development
- **Securing or increasing existing market share** and **access to existing subsidies and fiscal incentives** are a *very important* driver of eco-innovation developments in about 40% of SMEs.
- C**urrent high material prices** are a *very important* driver of eco-innovation uptake in SMEs. [13]

Considering the significant impact of SMEs on the environment it is important to analyse the process of adoption of environmental technologies in this sector. Different studies have to a certain extent covered this issue, describing a not promising picture of the average SME and its quest for environmental technology.

CONCLUSION

Based on the increasingly pronounced environmental demands in terms of improving the quality of environment and life quality as well, modern enterprises are forced to harmonize their activities according to the requirements of sustainable, inclusive and smart growth. Nowadays, environmentally responsible business does not mean just simply compliance with applicable legislation, it becomes imperative for all business segments. SMEs that seek to maintain and improve their market position have to identify and integrate the environmental requirements in all levels of their business functions. What is more, the development of modern enterprises in developed countries can not be imagined without the recognition of the concept of sustainable, inclusive and smart growth which can be implemented only by using the appropriate eco-innovations.

REFERENCES

[1] (SMEs and the environment in the European Union- Main report: http://ec.europa.eu/enterprise/policies/sme/business-environment/files/main_report_en.pdf
[2] (European Commission Enterprise and Industry: http://ec.europa.eu/enterprise/policies/sme/business-environment/environmental-challenge/index_en.htm)
[3] (Ruud Hoevenagel, Guido Brummelkamp, Anna Peytcheva and Rob van der Horst, Promoting Environmental Technologies in SMEs: Barriers and Measures, Luxembourg: Office for Official Publications of the European Communities, European Communities, 2007)
[4] (European Commission Environment: http://ec.europa.eu/environment/sme/een/een_en.htm)
[5] (The Environmental Compliance Assistance Programme (ECAP) for SMEs: http://www.smefit.eu/IMG/pdf/ECAP_17042008_IB_UEAPME_-_Bedo.pdf)
[6] (European Commission Enterprise and Industry: http://ec.europa.eu/enterprise/policies/sme/business-environment/environmental-challenge/index_en.htm
[7] (First assessment of the Environmental Compliance Assistance Programme for SMEs (ECAP):http://ec.europa.eu/environment/sme/pdf/First%20assessemnt%20of%20the%20ECAP%20for%20SMEs.pdf
[8] STR 2-52 (ENVIRONMENTAL COMPLIANCE ASSISTANCE FOR SMES: ANALYSIS OF SPECIFIC INITIATIVES AT NATIONAL AND LOCAL LEVEL AND IDENTIFICATION OF BEST PRACTICES- Final Report, 2006, Claire Monkhouse, David Wilkinson, Martina Herodes, Peter Hjerp, Institute for European Environmental Policy
[9] (ECAP- Newsletter: http://ec.europa.eu/environment/sme/pdf/newsletter_11_01_en.pdf
[10] (UEAPME: http://www.ueapme.com/IMG/pdf/UEAPME_input_for_2nd_HL_Meeting_July2012.pdf
[11] (Small, clean and competitive, A programme to help small and medium-sized enterprises comply with environmental legislation: http://ec.europa.eu/environment/sme/pdf/doc_908_en.pdf
[12] STR 8-20 (Ruud Hoevenagel, Guido Brummelkamp, Anna Peytcheva and Rob van der Horst, Promoting Environmental Technologies in SMEs: Barriers and Measures Luxembourg: Office for Official Publications of the European Communities © European Communities, 2007
[13] Attitudes of European entrepreneurs towards eco-innovation- Summary: http://ec.europa.eu/public_opinion/flash/fl_315_sum_en.pdf

SESSION 3: Manufacturing Technologies and Materials

DEVELOPMENT OF TECHNOLOGIES FOR PRODUCING SPECIAL COATED ELECTRODES BASED ON DOMESTIC RAW MATERIALS

Nikola Bajić[1], Slobodan Stojadinović[2], Jasmina Pekez[2], Mihailo Mrdak[3], Zoran Karastojkovic[4], Zoran Radosavljevic[1]
[1] Reasearch and Development Center , IHIS Techno experts d.o.o, Belgrade, Serbia
[2]University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
[3] Reasearch and Development Center, IMTEL Communication a.d., Belgrade, Serbia
[4]Advanced Technical School for Vocational Studies, Belgrade, Serbia
e-mail: ihis@eunet.rs

Abstract : This paper presents the results of mastering of technological procedure of producing special electrodes designed for arc welding. The special coated electrode is a new product, which compared to traditional electrodes has a core of a flux-cored rod cut from cored wire made from steel strips. Mastering of the new product is based on domestic raw materials, steel strips for making the electrode core and nonmetallic components for the electrode coating.
The designed technological process for producing special electrodes is accomplished through two separate technological lines of which one is intended for production of cored wire with a thick steel jacket and the second line is designed for final production of classic and special coated electrodes with a core of flux-cored wire.
Key words: The special coated electrode, cored wire, manual arc welding process

INTRODUCTION

Of all welding fillers coated electrodes in scope of application are the leader. This is explained by the simplicity of the welding process, good and easy handling and a homogeneous composition of the welded seams. Good techno-economic indicators achieved using various metallurgical qualities of coated electrodes are connected to the knowledge of metallurgical and technical characteristics, as well as other features [1].

The coated electrode consists of a metal core to which, with the appropriate technological process, a coating was applied. The electrode coating consists of milled powders which should provide the basic requirements: stable arc burning; good formation of weld metal; creating a weld metal of appropriate chemical composition and without defects; calm and steady arc melting of the metal core and of the coating in the welding process; a minimum loss of electrode material due to burning off and splatter; high productivity of welding; easy removal of the slag crust from the surface of the weld metal; sufficient amount of slag to cover the weld metal; retaining of physical-chemical and welding-technological properties of welding electrodes during long-term storage; minimal toxicity in the process of welding and electrode manufacturing [3-6].

Also, the coating of the electrodes is expected to ensure special requirements also:

- Getting the designed weld shape (deep penetration, smooth transition of weld metal, the ability to perform the process in all spatial positions);
- The possibility of controlling the welding process with a selected method;
- Producing a weld metal with special properties (high strength, plasticity, corrosion resistance and fire-resistance).

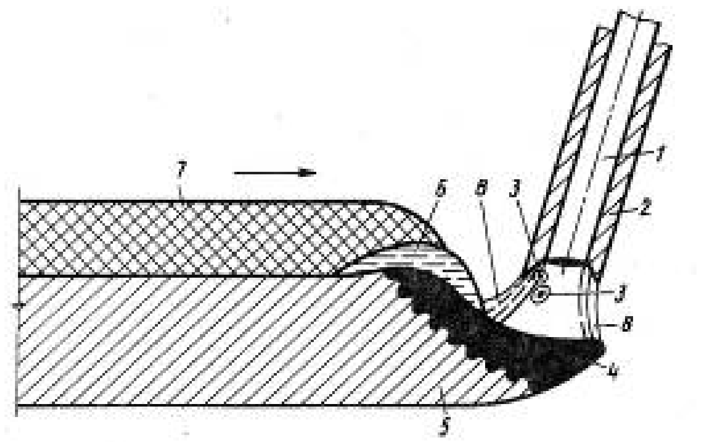
This paper presents the results of experimental work on mastering of technology of manufacturing of a standard coated electrode with a core made of solid steel wire and special coated electrodes with a core made of flux-cored wire.

MATERIAL AND METHODS

Coated electrodes for manual arc welding

To meet the high-quality of transfer of weld metal, certain ingredients are introduced into the coating and form: slag, gases, fusibility, alloying, stabilization, bonding. One of the basic functions of the coating is to protect the weld pool and the weld metal from the influence of atmospheric gases. Heating and melting of the electrode coating flows down the sides of its inner layer (Fig.1), leading to the formation of a funnel at the end of the melting electrode. The result is formation of gases and vapors which in a continuous flow protect the weld pool from the atmosphere.

This contributes to a significant reduction of partial pressure of oxygen and nitrogen in the fusion zone. Separating from the electrode tip drops of liquid molten metal are passing through an electric arc, covered with a thin layer of slag which flows from the tip of the electrode forming a protective coating on the surface of the weld metal [1].



1 - metal core; 2 - coating; 3 - drops of liquid metal, which pass through the electric arc; 4- liquid metal pool; 5 - crystallized weld metal part; 6 - liquid slag on the welding pool; 7 - solidified slag; 8 - gas shielding of molten metal, the arrow shows welding direction.

Figure 1. Scheme of welding with a coated electrode (cross-section) with a core of solid rod [1].

The appearance of the cross section of classical coated electrodes with a core of solid steel wire is given in the diagram, Figure 2 (a) and the cross-section appearance of a special coated electrode with a core made of cut rods from flux-cored wires shown in the diagram, Figure 2 (b).

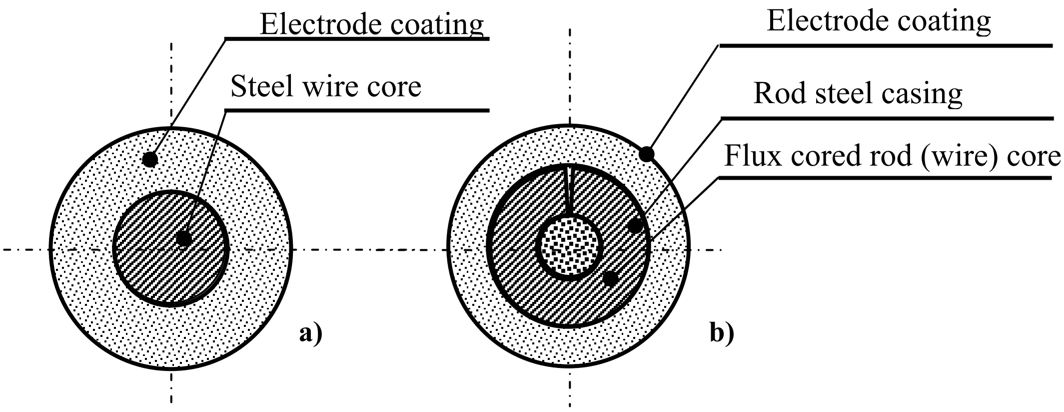


Figure 2. Drawing of coated electrodes a) classic coated electrode b) special coated electrode

The method of alloying of the weld metal during welding with a coated electrode may vary. According to literature the best way of alloying the weld metal in terms of uniformity of the chemical composition is through the core of the electrode. Whereas the alloying elements come from the solid metal core or metal powders that are in the cored rods made from flux-cored wire [4-6].

RESULTS AND DISCUSSION

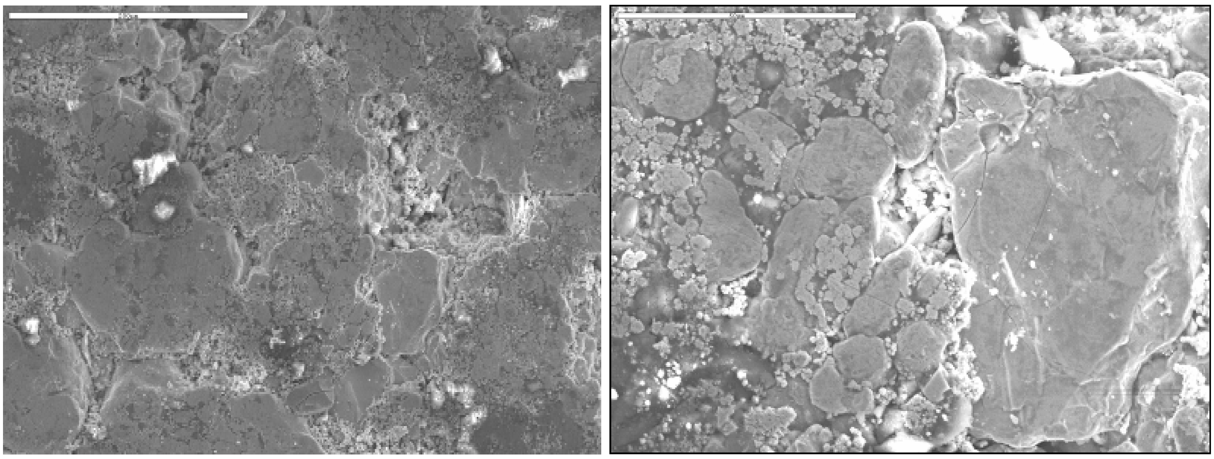
Experimental work

The experimental part includes creating a coated electrode with a core of solid and flux-cored wire.
For the experimental work selected was a low-carbon wire 2.0; 2.5 and 3.25mm in diameter, the chemical composition of 0.10% C, 0.03% Si, and 0.6% Mn. Both solid and flux-cored wire were straightened and cut on a machine to a standard length rod of 250mm (2.0 and 2.5mm in diameter) and the 3.25mm diameter wire was cut to a standard length of 350mm.
To create flux-cored wire steel strip was purchased, quality Č.0147 (JUS C.B4.016) from Iron Works, Smederevo and the longitudinal cutting of a 0.8 mm thick steel strip to a width of 10 mm was performed on a slitter at the "Metalpromet" Company - Gornji Milanovac, Table 1.

Table 1. Mark and chemical composition of the steel strip

Steel mark		Chemical composition, % (Manufacturers Catalogue)				
JUS	DIN	C	Mn	P	S	Al
Č.0147	Q_{ST} 13	0.10	0.45	0.03	0.03	0.02

After weighing and compiling of the core homogenization of the dry mixture is done in a W mixer, subsequently drying the formed powder mixture in the chamber dryer.
To prevent spilling of core of the flux-cored wire chosen were low hydrophobic compounds whose molecules consist of carbon, hydrogen and oxygen, whose share in the core is only a fraction of percentage and during combustion in an electric arc only gaseous products are produced [2].
After homogenization mixing samples were taken for metallographic testing. Testing of core samples from flux-cored wire was done on the SEM microscope of the Institute Vinca, and the appearance of samples of pressed filler is shown in Figure 2. Appearance of filler microstructure after pressing into tablets can be seen in micrographs with various magnification, Figure 3a (magnification 250x) and Figure 3b (magnification 1000x).



a) b)
Figure 3. SEM, microstructure of filler after pressing into tablets (a, b)

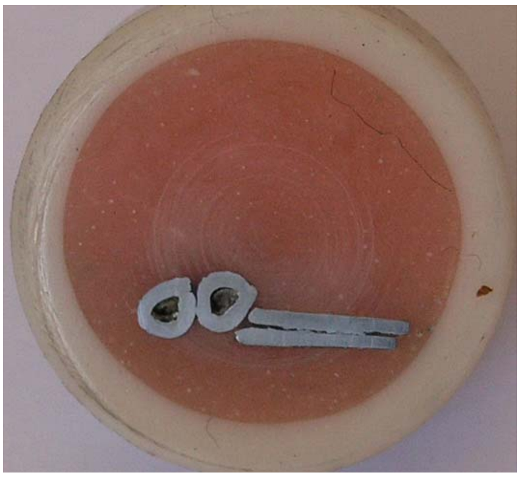
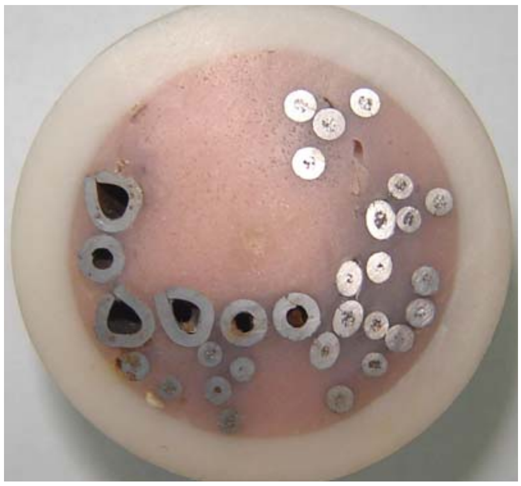
Production of flux-cored wire was done on the line for strip calibration and flux-cored wire production developed and performed in the IHIS Research and Development Center-Belgrade, Figure 4a, appearance of obtained flux-cored wire in Figure 4b.


a) b)

Figure 4. Layout of experimental line (a) for production of flux-cored wire (b)

However, due to the uneven longitudinal joint of the bent edges of the narrow steel strip, during the attempt of drawing resulted in damage or cutting through the traction matrix which is why it was necessary to change the profile of the working final cylinders on the line for filling and forming of wire after which were achieved the desired effects of improving the proper closing of the ends of the strip and thus improving the damage to the flux-cored wire during drawing in the plastic processing stage.

The appearance of cross-sectional samples of steel strips of 0.8mm x 10mm and flux-cored wires at profiling stages and after filling and closing at 4.0 mm in diameter can be seen in the micrograph Figure 5 (a, b), and Figure 5b shows cross-section of flux-cored wire with various degrees of reduction in the drawing phase.

a) b)

Figure 5. Appearance of cross section of narrow steel strip and formed flux-cored wire (R = 1:2)

Drawing of flux-cored wire was done from a diameter of 4.0 mm to a diameter of standard electrodes 3.25; 2.5 and 2.0 mm, and the appearance of samples of drawn wire can be seen in Figure 6 (a, b). Straightening and cutting of solid and flux-cored wires was performed in the company SINEX CO d.o.o. Belgrade on a straightening and cutting machine to the diameter of 2.0 and 2.5 mm to a standard length of rods of 250 mm, and 3.25 mm diameter wire to a length of 350 mm.

a)

b)

Figure 6. Appearance of flux-cored wire after drawing (ASCO VIDAK-Futog)

Production of cored electrodes was performed on the experimental line for coating in the IHIS Research and Development Center-Belgrade, Figure 7. Appearance of the produced samples of coated rutile and basic electrodes with a core of solid and flux-cored steel wire can be seen in Figure 8.

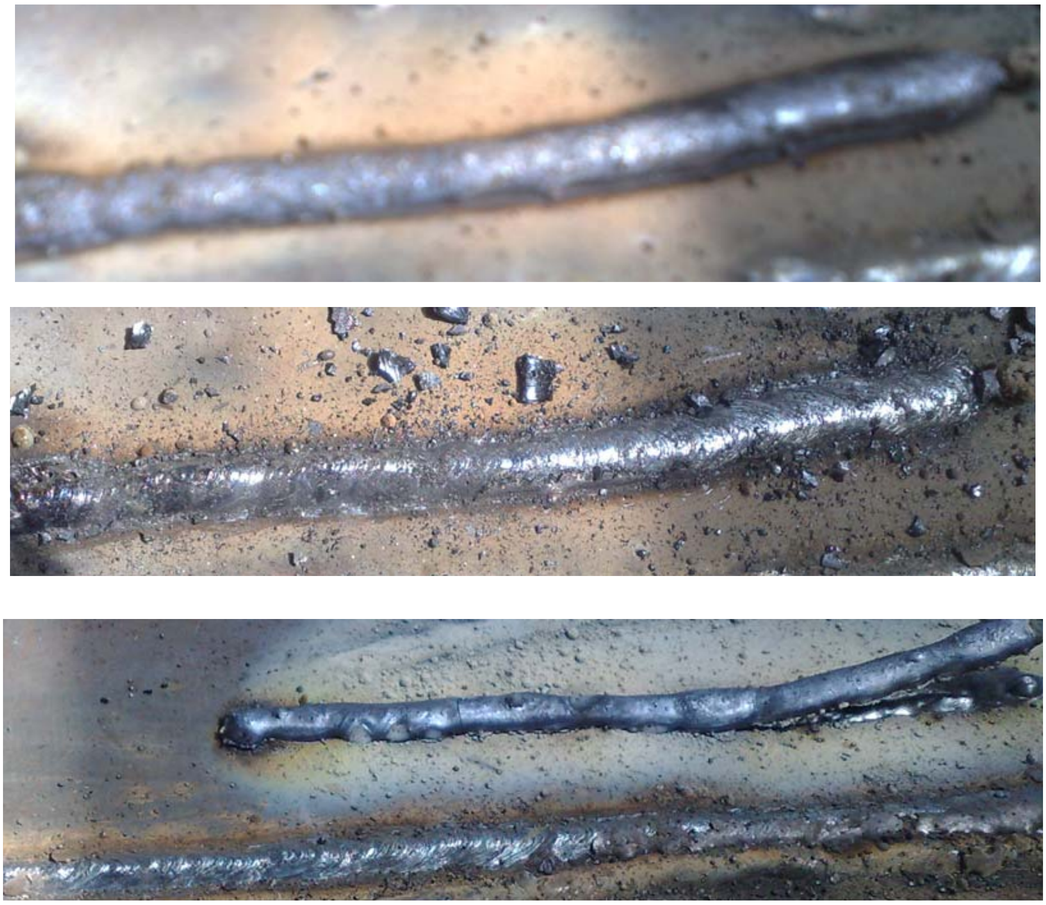
Figure 7. Layout of the experimental line for production of coated electrodes

Figure 8. Appearance experimentally produced coated electrode with a core of solid and flux-cored steel wire

Test welding with produced electrodes with solid and flux-cored wires was performed in the Welding Laboratory at the IHIS Research and Development Center, Belgrade, Figure 9. The first results related to the welding properties of rutile and basic electrodes are very encouraging. Observed was easy establishing of the arc, easily separating slag from the metal surface, and the appearance of the produced seam, Figure 10 (a, b, c, d) is without pores and inclusions and that should be subject to further development and research in the IHIS Research and Development Center [7].

a)

Figure 9.. Experimental welding using the E- process



b)

c)

d)

Figure 10. Appearance of trial surfacing with experimentally produced electrodes (a, b, c, d, e)

RESULTS AND DISCUSSION

The designed technology of making special coated electrodes requires a very long path from the development of flux-cored wires for welding with a thick metal casing as a basis for further research. The realistic basis for the production of flux-cored welding wire are domestic raw materials in the form of steel strips produced in the steelworks Smederevo which are treated with a higher degree of processing up to the final product. Production of flux-cored wire, designed for welding with the MIG/MAG process, the EPP process in several metallurgical qualities, represents a basis for further

development of a new product in the form of a special coated electrode designed for welding and surfacing of low carbon, alloyed and high alloyed steels.
Based on the results of research of the domestic market apart from acquiring steel strips and wire a significant part of the basic powdered materials (minerals, binders, plasticizers), that constitute the composition of the coating are available in the domestic market, such as: fluorite, marble, granite, dolomite, mica, feldspar, kaolin talc, bentonite, limestone, alignate, cellulose, etc.
There is a realistic basis for exploring other local raw materials that are not listed, however judging by their chemical composition they could be used to produce coatings.
A special interest present minerals of domestic origin, such as basalt, boron minerals, then secondary materials such as fly ash (TEPP) converter slag, fly-dust, oxides of iron (steel mills) and other which have to go through the phase of study and experimental research.

CONCLUSIONS

Based on the results of comparative analysis of the welding properties of special coated electrodes compared to the classic ones perceived are certain advantages in terms of:

- facilitating the welding process control;
- quality of slag formation and separation from the weld metal;
- stable arc management.

Also, it is expected that with the special alloyed electrodes achieved is a uniform chemical composition along the length of the weld metal and a lower oxidation loss of alloying elements than with the classic coated electrode where the alloying elements are present in the coating.

ACKNOWLEDGEMENTS

This work is supported by the Serbian Ministry of Science and Technological Development (project number TR34016 & TR 35002).

REFERENCES

[1] N.N. Potapov, D. N. Baranov, O. S. Kakovkin, D. B. Vitman i dr.: „Svaročnie provoloki i elektrodi“, ISBN 5-217-01236-8., Moskva, Mašinostrenie, 1993.
[2] V.M. Karpenko, I.A.Rjabcev, L.J. Galuško.: „Primenie niskomolekularnih hidrofobnih soedinenij dlja predotvrašćenija prosipanja i uvlažnenija šihti poroškobih provolok“ AVTOMATIČESKAJA SVARKA, 1993, No 7 (484).
[3] Rosado Tobias, Almeida Pedro, Pires Inês, Miranda Rosa, Quintino Luísa,: “Inovations in ARC Welding” Zavarivanje i zavarene konstrukcije, vol. 56, br. 1, str. 23-36, 2011.
[4] Ilić Vera, Antić Milica,: “Celulozne elektrode” Zavarivanje i zavarene konstrukcije, vol. 56, br. 4, str. 171-173, 2011.
[5] Blečić Ž., Blečić D., Čabarkapa D., Martinović D,: “Raspodjela legirajućih elemenata u strukturnim komponentama šava niskolegiranih čelika u funkciji baziciteta obloge” Zavarivanje i zavarene konstrukcije, vol. 55, br. 2, str. 75-79, 2010.
[6] Yurioka, N. „Nauka i tehnologija zavarivanja i spajanja u 20-om veku i perspektive za 21. vek - konstrukcijski čelici i njihovo zavarivanje“. Zavarivanje i zavarene konstrukcije,2001.,vol. 46, br. 3, str. 123-128.
[7] Nikola Bajić, B. Petrovski, B. Bogdanović, M. Rakin “Development of a device for semi-industrial production of cored filer wires“, Inženjerstvo, materijali i menadžment u procesnoj industriji, Jahorina- Republika Srpska, oktobar 2009, IT47, str.280-283

DEGRADATION OF TCE IN COLUMN EXPERIMENTS WITH MICROSCALE ZEROVALENT IRON

Milica Velimirović[1,2], Simons, Q.[1], Bastiaens, L.[1]
[1] Flemish Institute for Technological Research (VITO), Mol, Belgium
[2] University of Antwerp, Department of Bio-Engineering, Antwerp, Belgium
e-mail: milica.velimirovic@vito.be

Abstract: Microscale zerovalent iron (mZVI) particles are less expensive compared to nanoscale zerovalent iron particles and are becoming more popular for the degradation of chlorinated ethenes. Smalle ranged micro-scale irons are injectable and can as such be used for creating an in-situ reactive zones. The present study focuses on the remediation of trichloroethene (TCE) by mZVI particles. Batch tests were performed to determine minimal required doses of mZVI for TCE removal. After fourteen days of experiment the lowest concentration of examined mZVI (1 g/kg aquifer) was capable for 100% TCE removal. In a next step, column experiments were performed to evaluate degradation of TCE by mZVI under in situ conditions with continuous flow. Three aquifer containing columns were set-up under different conditions. Degradation intermediates cDCE, VC, 1,1 DCA as well as end products ethene and ethane were analyzed. An efficient degradation of TCE by mZVI was observed, which was in line with the reaction rate of TCE derived via batch experiments. On the basis of the results from the batch and column degradation studies, the examined mZVI was selected for a more detailed characterization and evaluation for in-situ remediation applications.
Key words: microscale zerovalent iron, TCE degradation, column study

INTRODUCTION

Last decades remediation of groundwater polluted with chlorinated aliphatic hydrocarbons (CAHs) has been studied by many research groups in the world. CAHs represent a class of dense non-aqueous-phase liquid (DNAPL) contaminants in groundwater and soil. DNAPLs are one of the major environmental problems in the industrialized countries because they are difficult to remediate [1]. Chlorinated aliphatic hydrocarbons such as perchlorethylene (PCE), trichloroethylene (TCE), cis-dichloroethylene (cDCE) and 1,1,1 trichloroethane (111-TCA) were mainly used in dry cleaning and metal degreasing processes and represent the most frequently detected groundwater contaminants in industrialized countries [2]. One of the reasons why research in this field is very active, is that remediation of a site contaminated by CAHs is a difficult and time consuming process [3].
The use of granular zerovalent iron for in-situ remediation of groundwater contaminated with chlorinated solvents is a proven technology [4, 5, 6]. Up to now, ZVI has been mostly emplaced into the subsurface in granular form to create permeable reactive barriers comprising for instance funnel and gate systems [6], restricting the application to the plume area. The last years microscale [7] and also nano-sized (< 100 nm) (bi)metallic particles [8] are gaining increasing interest as these materials have been found to be more reactive towards a variety of pollutants including also chlorinated ethenes [9] and chlorinated ethanes [10]. In contrast with granular, micro/nano iron particles are injectable and more mobile in the subsurface [11]. This implies that these fine particles can migrate to some extent in the subsurface along with the groundwater. Up to now, however, it remains difficult to predict and verify the injection radius.
Although applications of injectable zerovalent iron particles are already available on the market, there are still major uncertainties about the application. Most research is focused on nanoparticles because of their extreme reactivity. It concerns mainly laboratory scale tests, although during the last years the number of field applications increased [12, 13]. In comparison with nano-sized particles, microscale zerovalent iron particles are less expensive, more stable, do have a longer lifetime and pose less risk for human health. On the other hand, they are less reactive and their distribution in the subsurface during the injection needs attention.
The general aim of this study was (1) to evaluate minimal concentration of mZVI required for an efficient remediation of TCE and (2) to investigate degradation of TCE by mZVI iron simulating in situ conditions under continuous flow.

MATERIAL AND METHODS

Materials

The reactive micrometer-sized zerovalent iron particles used in this study were obtained from Höganäs (Sweden) with particle size distribution (D_{50}) less than 58 µm.
The aquifer material and groundwater that was used for lab-scale experiments was sampled from Belgian site where later on a pilot test was planned.

Batch dechlorination experiments

Batch experiments were performed to study minimal concentration of mZVI required for efficient remediation of TCE . Batch tests were prepared in a 160 ml glass vials with butyl/PFTE grey septum containing different concentrations of examined mZVI being 1, 5, 10, 25 and 50 g mZVI per kg of aquifer and 45 g of soil and 25 g of groundwater polluted by TCE (~ 0.5 ppm), leaving a 85 ml headspace.
The experiments were set up under anaerobic conditions and in triplicate, and were incubated (shaking) at groundwater temperature (12°C). Analyses were performed at different time points: at the beginning, and after 14, 28, 49 and 105 days. Control conditions were set up following the same procedure but in the absence of mZVI particles. Also a poisoned control was included.

Lab scale column dechlorination experiments

The lab scale column tests were set up with representative groundwater and aquifer material from a Belgian site. Three flow through plexiglas columns were set up at controlled flow and temperature conditions (12°C). The first column system was completely filled with a mixture of aquifer material and filter sand. The second system contained the same filling material amended with 25 g/kg of mZVI. Dead control (DC) was made for the system consisting only aquifer material.
The column systems were fed with real groundwater polluted by TCE (~ 0.5 ppm). Dead control was additionally supplied with formaldehyde. Groundwater was applied to the columns at a flow rate of 17 mL/day using a Watson Marlov 205s peristaltic pump corresponding to hydraulic retention times of 17.2 (Blank - DC), 13.2 (Blank) and 8.4 (mZVI) days. In time, influent and effluent samples were regularly taken for contaminant analysis.
Experimental set-up is shown in Fig. 1. Characteristics of the columns used for groundwater remediation are presented in Table 1.

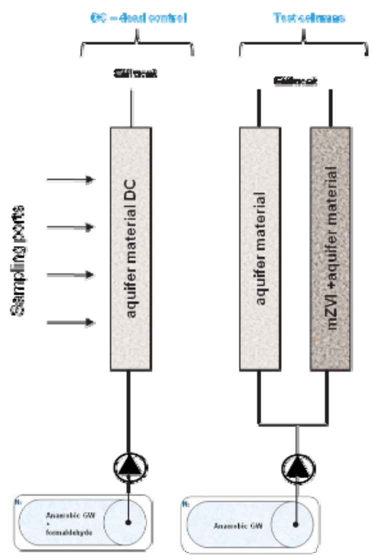


Figure 1. Column experiment set-up.

Table 1. Characteristics of the columns used for CAHs remediation.

Characteristic	Blanc (DC)	Blanc	mZVI
Solid weight (g)	1034	1121	1051
Iron concentration(g/kg)	-	-	25
Pore volume (mL)	292	224	143

Chemical analyses

Concentrations of CAHs, ethene, ethane and acetylene were determined via headspace measurements using a Varian GC-FID (CP-3800) equipped with a Rt-U plot column for the detection of ethene, ethane and acetylene or a split-splitless injector followed by a Rt-X column (Restek) and a DB-1 column (J&W Scientific) for analysis of CAHs.

RESULTS AND DISCUSSION

Batch experiments

Lab scale reactivity tests were performed to determine the required dose of examined mZVI in an aquifer matrix to efficiently remove TCE. According to the presented data (Fig. 2), the examined microscale particles are efficient in TCE removal. After fourteen days of experiment the lowest concentration of examined mZVI was capable for TCE removal of 100 % from initial concentration. Based on data of the dose tests, the minimal required concentrations of mZVI needed for efficient remediation of the TCE is 1 g of mZVI per kg of aquifer material used in batch degradation test. Since 1g of mZVI per kg of aquifer was not efficient in removal of other pollutants being cDCE and 1,1DCE (data now shown), higher concentration of mZVI iron has been used in column experiments.

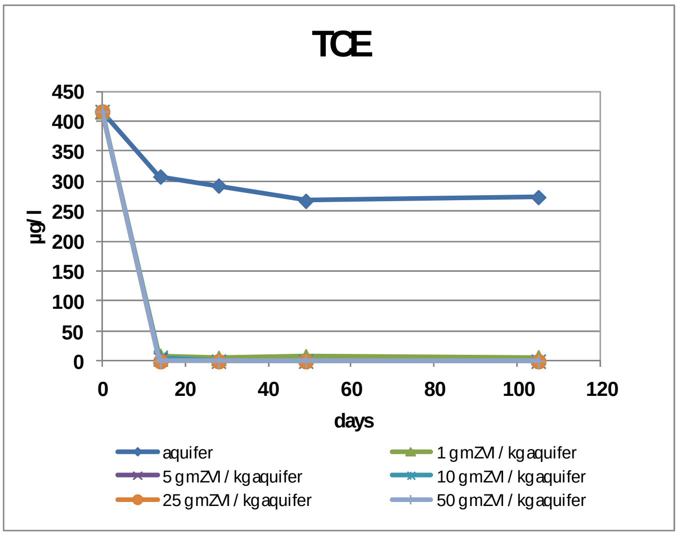


Figure 2. Evaluation of the TCE concentrations with time (days)

Column experiments

Column experiments have been started to simulate in situ dynamic conditions and estimate the iron reactivity towards TCE under these conditions. Normalized TCE concentration values in column experiments with and without mZVI are shown in Fig. 3. Measured TCE concentrations in influent and effluent of control columns show sorption of TCE by aquifer material at the beginning of experiment. Later, no biodegradation potential of aquifer material was observed. In the presence of

mZVI, TCE was completely degraded. The final degradation products were mainly ethane and ethane. Significant concentrations of VC and CA have not been observed.
Fig. 4 shows the ORP and pH values measured in the effluent after 110 days. As expected, the presence of mZVI in the columns resulted in more reducing conditions (decreased ORP values) and slightly increased pH values. The changes are less pronounced than observed in the batch degradation experiments previously reported [14], explicable by the buffering properties of the aquifer material and the continuous operation mode.

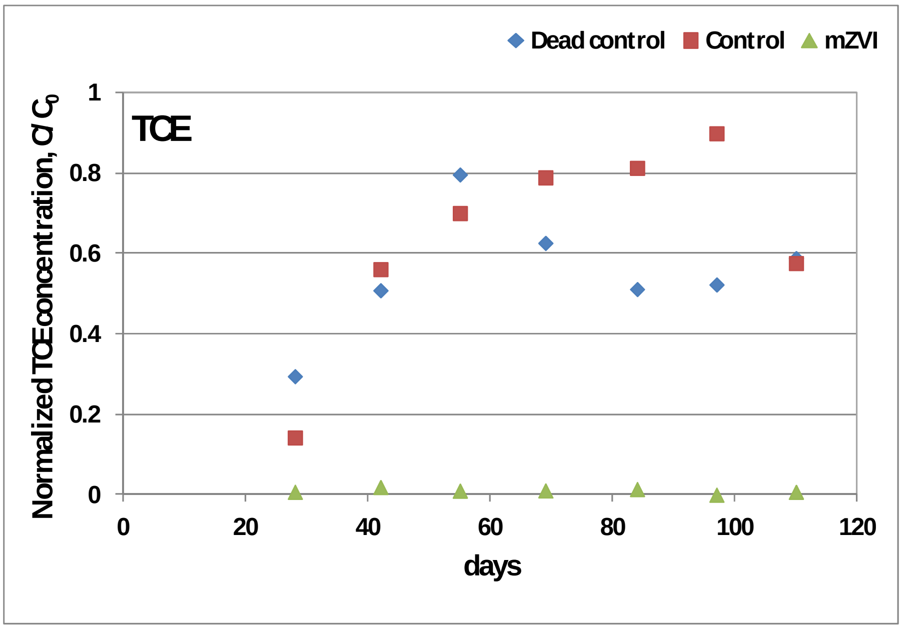


Figure 3. Normalized TCE concentration in column experiments (effluent).

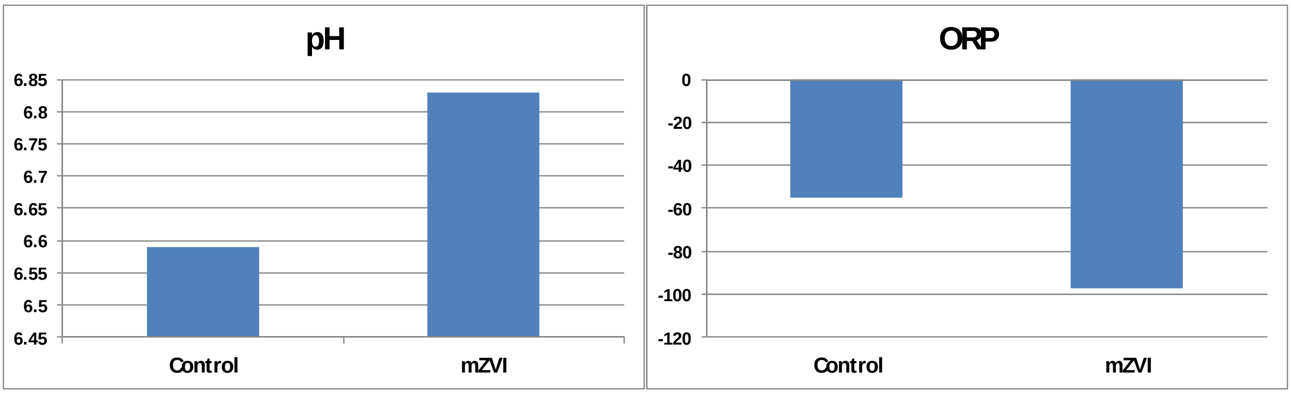


Figure 4. pH and ORP values measured after 110 days (effluent).

CONCLUSION

The present study was designed to investigate minimal concentration of mZVI required for efficient remediation of TCE. Moreover, TCE degradation by mZVI under continuous flow system was studied. Batch degradation tests suggest that examined mZVI is effective in degradation of TCE and has a great potential for remediation of contaminated sites.
Preliminary results of a column study demonstrated that under conditions, more closely to the real field conditions, mZVI was capable for efficient TCE degradation. Experiments are still ongoing to deduce the effect of mZVI on the bacterial community in soil.

Finally, a pilot test in the field has been performed. Approximately 100 kg of the examined zerovalent iron particles were stabilized by guar gum and injected into a test zone mainly polluted by TCE, 1,1DCA and 1,1,1-TCA.

ACKNOWLEDGMENTS

This research was conducted in the framework of the European Union project AQUAREHAB (FP7 - Grant Agreement Nr. 226565).

REFERENCES

[1] Wang, W., Zhou, M., Jin, Z. and Li, T. : Reactivity characteristics of poly(methyl methacrylate) coated nanoscale iron particles for trichloroethylene remediation, Journal of Hazardous Materials, Vol. 173, pp.724–730, 2010.

[2] Prommer, H., Aziz, L.H., Bolano, N., Taubals, H. and Schuth, C. : Modeling of geochemical and isotopic changes in a column experiment for degradation of TCE by zero-valent iron, Journal of Contaminant Hydrology, Vol. 97, pp.13-26, 2008.

[3] Haest, P.J., Springael, D. and Smolders, E. : Dechlorination kinetics of TCE at toxic TCE concentrations: Assessment of different models. Water Research, Vol. 44, pp.331-339, 2010.

[4] Matheson, L.J. and Tratnyek, P.G. : Reductive dehalogenation of chlorinated methanes by iron metal. Environmental Science and Technology, Vol. 28, pp.2045-2053, 1994.

[5] Gavaskar, A., Gupta, N. Sass, B. Janosy, R. and Hicks, J.: Design guidance for application of permeable reactive barriers for groundwater remediation. Battelle Press, Columbus, Ohio, 2000.

[6] Gillham, R.W. : In-situ Treatment of groundwater: Metal-enhanced degradation of chlorinated Organic Contaminants, In: M.M. Aral (ed.), Advances in groundwater Pollution Control and Remediation, Kluwer Academic Publishers, pp.249-274, 1996.

[7] Choe, S., Chang, Y.-Y., Hwang, K.-Y. and Khim, J. : Kinetics of reductive denitrification by nanoscale zero-valent iron. Chemosphere, Vol. 41, pp.1307-1311, 2000.

[8] Liu, Y., Majetich, S.A., Titon, R.D., Sholl, D.S. and Lowry, G.V. : TCE dechlorination rates, pathways, and efficiency of nanoscale iron particles with different properties. Environmental Science and Technology, Vol. 39, pp.1338-1345, 2005.

[9] Lien, H.-L. and Zhang, W.-X. : Nanoscale iron particles for complete reduction of chlorinated ethenes. Colloids and surfaces A, Vol. 191, pp.97-105, 2001.

[10] Fennelly, J.P. and Roberts, A.L. : Reaction of 1,1,1-trichloroethanes with zerovalent metals and bimetallic reductants. Environmental Science and Technology, Vol. 32, pp.1980-1988, 1998.

[11] Elliott, D.W. and Zhang. W.-X. : Proceedings groundwater Quality: remediation and protection, pp.28-30, 2002.

[12] O'Hara, S., Krug, T., Major, D., Quinn, J., Geiger, C., Clausen, C. and Yoon, W.-S. S. : Performance evaluation of dehalogenation of DNAPLs using emulsified zero-valent inron. Proceedings Conference on Remediation of chlorinated and recalcitrant Compounds (Monterey, 2004) Ed. Gavaskar & Chen. Paper 2E-05, 2004.

[13] Zhang, W. : Nanoscale iron particles for environmental remediation: An overview. Journal of Nanoparticle Research Vol. 5, pp.323 – 332, 2003.

[14] Velimirovic, M., Simos, Q., Bastiaens, L. : Remediation of CAHs with Guar Gum Stabilized Microscale Zerovalent Iron. Proceedings of the 1st European Symposium Remediation Technologies and their Integration in Water Management, pp. 15-19, 2012.

THE INFLUENCE OF POWDERS CLADDED WITH ELECTRIC CHARGES ON THE OHMIC RESISTANCE OF THE LAYERS THAT ARE DEPOSITED BY METALLIZATION

Roata Ionut Claudiu[1], Iovanas Radu[1], Iovanas Daniela Maria[1]
[1]Transilvania University of Brasov, Romanian
e-mail:r.i.claudiu@gmail.com

Abstract: In this paper is presented the influence of the voltage on the ohmic resistance of the layers that are deposited using the method of recondition with flame and powders cladded with electric charges. The metallizing system with CastDyn DS 8000 flame and Proxon 21021 powder was used in order to obtain the necessary samples
Key words:powders, electric charge, recondition thermal spraying

INTRODUCTION

The experimental researches were performed on several tests obtained by the process of metallization (spraying) with flame and powder using the standard metallization module SSM 10 of the Castodyn DS 8000 system of oxyacetylenical flame spraying.

GENERAL CONSIDERATIONS REGARDING THE TECHNOLOGY OF METALLIZATION WITH FLAME AND POWDERS CLADDED WITH ELECTRIC CHARGES

The process of powders cladding with electric charges

If the metallizing pistol and the piece placed at a certain distance are connected to a higher voltage power source, an electric field is developed between the two bodies.
Any body that is placed near another body which is loaded with electric loads is loaded itself. [1]
In order to obtain a deposit by spraying in optimal conditions, the powder must capture a big load when passing through the electric field. The loaded particle can lose partially or even totally the electric charge that was accumulated, in the distance between the pistol and the piece.
In this sense, the shape of the particles is important; the spherical particles can keep the charge easier than the particles with irregular shape.[2]Beside the density of the current, an ion circulation appears, and generates a current that has the sense of displacement from the anode to the cathode, due to the positive particles.[3]The principle of the experimental assembly for the achievement of layers deposited by spraying with flame and powders cladded with electric charges is presented in figure 1.

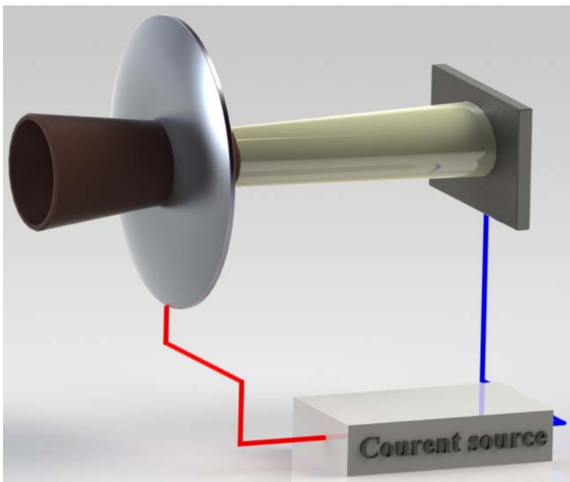


Figure 1. Diagram of the electric field generation unit.

Supply voltage of the device Ud = 230 [V] CA
Electric field voltage U = 0 – 70 [V] CC

The technological process of recondition by metallization with flame and powders cladded with electric charges.

Powders from the Proxon 2100 series, namely ProXon 21021 and the OLC 45 (AISI 1045 – EN8) base material were used for these experiments.
The main technological recommendations for the standard metallization module *SSM 10*in the case of cylindrical surfaces that will be cold sprayed are the following:

- performing the surface preparation.
- choosing the optimal spraying distance during the process (generallyrangesbetween 100-200[mm]). If the spraying distance is too short, an overheating of the surface is produced and, consequently, this fact may lead to exfoliation and burning of the deposited material. If the spraying distance is too long, it may lead to the increase of porosity and decreasing the liability, embedding a large amount of cold particles in the deposited material.
- the best quality of the deposit will be obtained when the sprayed metal jet is projected perpendicularly on the metallization surface. When de 45^0 angle of the surface is overrun, an inadequate deposit is obtained, with low adhesion and accentuated porosity by the so called shadow effect.[4]

The processing operation of the samples (turningand threading), that are necessary in the process of cladding by thermal spraying were performed on an universal lathe with the parameters described in table 1.
This processing operation is not recommended to be used in the case of deposits with a thickness less than 0,5 [mm].

Table 1. Parameters used in turning and exterior threading of the samples.

Exterior turning		Exterior threading			Step thread [mm]
Number of turns [turns/min]	Feed [mm/turn]	Number of turns [turns/min]	Feed [mm]/rot]	Cutting depth [mm]	
160	0,125	150	0,5	0,35	0,7

Table 2. Chemical composition of the filler material used in the process of metallization with flame and powder

Test labelling	Powder type	Chemical composition [%]						
		Ni	Al	B	Fe	Cr	Si	C
P1 – P4	ProXon 21021	93,45	5	0,8	0,34	0,18	0,15	0,08

Table 3. Parameters of depositing process by spraying (metallization) with flame and powder regime

Test	Powder	Number of turns [turns/min]	Feed speed [m/min]	Oxygen pressure [bar]	Acetylene pressure[bar]	Metallizing speed [mm]	U [V]	Tp [^{0}C]
P1	ProXon 21021	127	0.38	4	0,7	100	0	60
P2	ProXon 21021	127	0.38	4	0,7	100	30	60
P3	ProXon 21021	127	0.38	4	0,7	100	50	60
P4	ProXon 21021	127	0.38	4	0,7	100	70	60

Determination of ohmic and adherence resistance of the layers deposited by metallization with flame and powders cladded with electric charges in direct current.

Ohmic resistance – ***Ohm's law*** **–** on a section of the circuit the intensity of the electric current is equal with the ratio between the voltage applied on the edges of the section and the intensity of the electric current that crosses the section.

$$I = \frac{U}{R} \quad (1)$$

$$\frac{U_1}{I_1} = \frac{U_2}{I_3} = \frac{U_3}{I_3} = const \Rightarrow \frac{U}{I} = const \Rightarrow R = \frac{U}{I} \quad (2)$$

Intensity of the current – is the scalarphysical size equal with the charge that crosses the section of a conductor for a second.

$$I = \frac{Q}{\Delta t} \Rightarrow 1A = \frac{1C}{1S} \quad [I]_{S.I.} = 1A(amper) \quad I = \frac{N \cdot e}{\Delta t} \quad (3)$$

- By convention the sense of the electric current is from (+) to (-) in the exterior circuit.
- Irrespective of the type of mobile charge carriers, the electric current has the sense of electric filed intensity.

Based on Ohm's law $R = \frac{U}{I}[\Omega]$ a rack was developed in order to measure this resistance and is presented in figure 1 that respects the following considerations:

- The intensity of the voltage is measured by using the ammeter that is always connected in series with the circuit elements on which the intensity is determined
- U does not have a determined value , namely it depends on the structure of the exterior
- The voltmeter measures the voltage and it is connected in parallel with the circuit element that is determined.

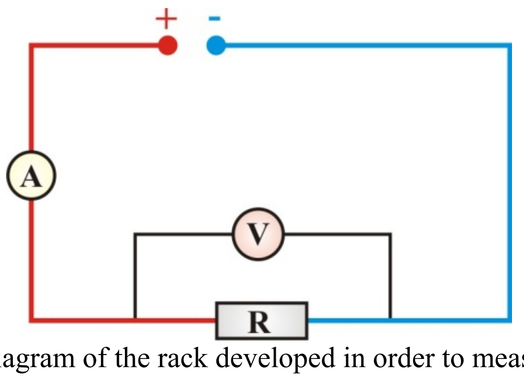
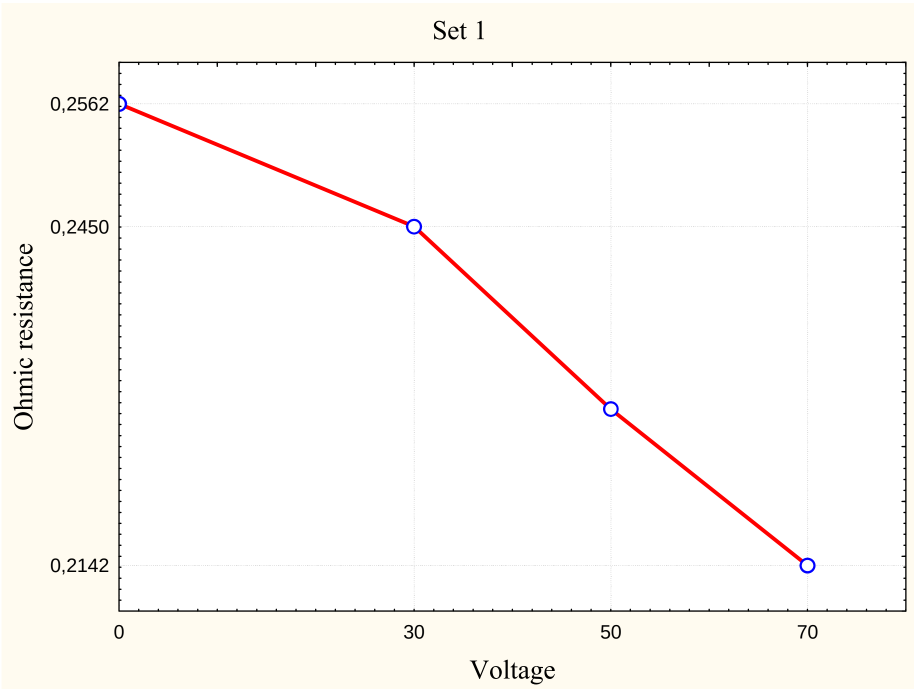


Figure 2. Electric schematic diagram of the rack developed in order to measure the ohmic resistance.

Figure 3. Rack developed for ohmic resistance measurement.

Table 4. The results of ohmic resistance measurement.

Results	P1 0 [V]	P2 30 [V]	P3 50 [V]	P4 70 [V]
U	1,44	1,36	1,27	1,21
I	5,62	5,55	5,56	5,65
R_1=U/I	**0,256228**	**0,245045**	**0,228417**	**0,214159**
U	1,43	1,35	1,26	1,2
I	5,61	5,54	5,55	5,64
R_2=U/I	**0,255008**	**0,243785**	**0,227123**	**0,212854**



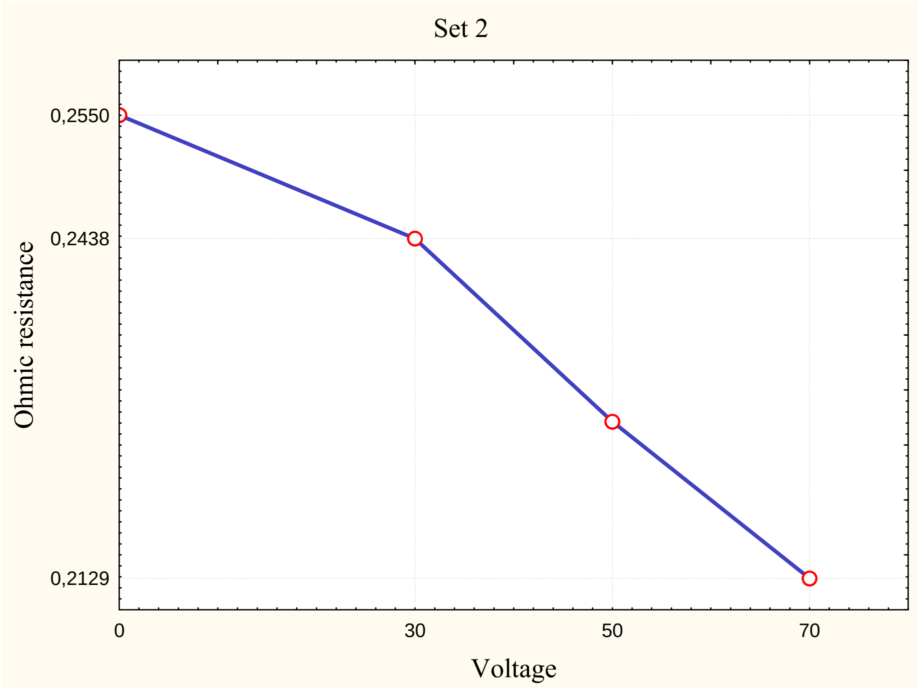


Figure 4. Graphical representation of the ohmic resistance analysis

P1 test

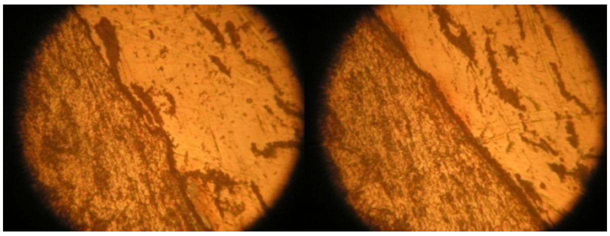


Figure 5. Micrograph of the interface between the base material and the deposit obtained by metallization, for the **P1 test** (100x) – Nital attack 2%

Observations:
The base materialpresents a ferrite - perlite structure**.**
The layer deposited by metallization highlights the presence of embedded carbides with polyhedral morphology. A less compact aspect can be observed and also some successive deposits and frequent discontinuities of pores and inclusions type.
The interfacewith the base material is inappropriate presenting some areas with particles and detachment accumulations.

P2 test

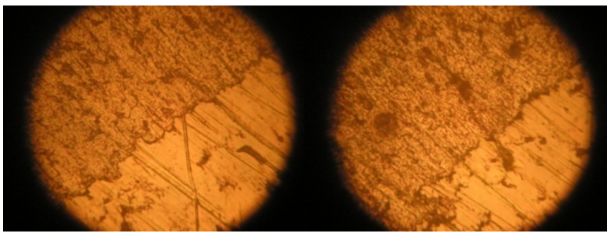


Figure 6. Micrograph of the interface between the base material and the deposit obtained by metallization, for the **P2 test** (100x) – Nital attack 2%

Observations:
The base material presents a ferrite - perlite structure**.**

The layer deposited by metallization highlights the presence of embedded carbides with polyhedral morphology. A compact aspect can be observed and also some successive deposits and rare discontinuities of pores and inclusions type.
The interface with the base material is good, without detachments and pores are visible at the interface level.

P3 test

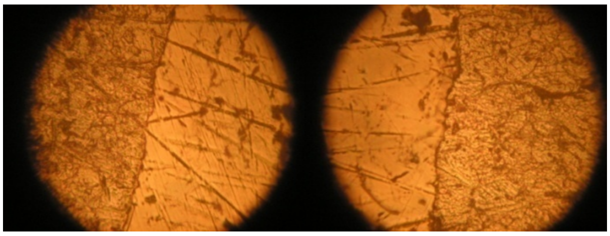


Figure 7. Micrograph of the interface between the base material and the deposit obtained by metallization, for the **P3 test** (100x) – Nital attack 2%

Observations:
The base material presents a ferrite - perlite structure**.**
The layer deposited by metallization highlights the presence of embedded carbides with polyhedral morphology. A compact aspect can be observed and also some successive deposits and rare discontinuities of pores and inclusions type.
The interface with the base material is good, without detachments

P4 test

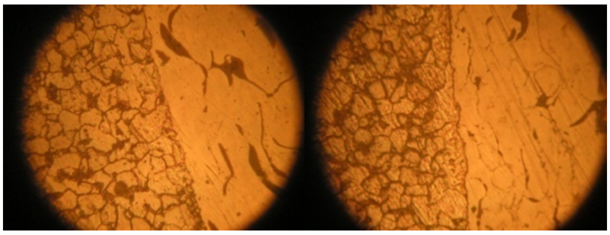


Figure 8. Micrograph of the interface between the base material and the deposit obtained by metallization, for the **P4 test** (100x) – Nital attack 2%

Observations:
The base material presents a ferrite - perlite structure**.**
The layer deposited by metallization highlights the presence of embedded carbides with polyhedral morphology. A compact aspect can be observed and also some successive deposits and rare discontinuities of pores and inclusions type.
The interface with the base material is good, without detachments and the screwed aspect that results from mechanical working is visible.

RESULTS AND DISCUSSION

By comparing the results of ohmic resistance in case of samples P2, P3, P4 with P1 (classic case) it can be noticed a decrease of the deposited layers ohmic resistance for the samples where the powder used for the process of metallization was cladded with electric charges.

CONCLUSION

- By powder cladding with electric charge, the adhesion is improved by increasing the speed and by performing several microweldings between the basic material and the deposit material.
- The technological recommendations concerning the process of recondition by metallization with flame and powder had been exposed.

- After performing the tests, adecrease of the ohmic resistance was observed in the case of sample no. 2, 3 and 4, in which was used a powder cladded with electric charge.
- After performing the analysis, it can be concluded that the metallic powder cladding with electric charge improve the qualities of the deposited layers, using the following parameters: metallization distance = 100 [mm], U = 70 [V].

ACKNOWLEDGEMENT

This paper is supported by the Sectoral Operational Programme Human Resources Development (SOP HRD), financed from the European Social Fund and the Romanian Government under the project number ID59323

REFERENCES

[1] Andreescu, F., Trif, N., Andreescu, B., Elemente de electronică cu aplicațiiînsudură, TomII, Vol.V, Edit.LuxLibris, Braşov, 2004.
[2] Andreescu, F., Serban, L., Physical phenomenon taking place during metal coating using electrically charged metallic particles, Proceedings of Internationl Conference n Materials Science and Engineering, BRAMAT 2007, 02.2007 Brasov, ISSN 1223 – 9631.
[3] Antoniu,Ion S., Bazeleelectrotehnicii, vol.I, Ed. DidacticăşiPedagogică, Bucureşti,1974
[4] Iovănaş, R., Iovănaş, D. M., Recondiționareaşiremaniereaproduselorsudate, ISBN973-635-416-2, EdituraUniversității,,Transilvania'', Braşov, 2006.

SHEET METAL DESIGN AND PRODUCTION IMPROVEMENTS BY USING SOLIDWORKS

Branislav Vorgic[1], Habil Mulaji[1]
[1]Ramadi Kitchen Industries L.L.C., Dubai, United Arab Emirates
e-mail: vorgic.branislav@gmail.com, web page: www.ramadigroup.com

Abstract: This paper presents a view of improvement of production, development rate of technical documentation and quality of preparation of individual parts for making the final product in the process of sheet metal production within the company Ramadi Kitchen Industries L.L.C. by using the SolidWorks software for 3D modeling which can automatically flatten sheet metal design and document it for manufacturing; includes bend compensation to ensure proper blank sizing for manufacturing.
Key words: Sheet metal, SolidWorks, Production

INTRODUCTION

Today sheet metal is one of the most important semi finished products used in the steel industry and many products are made with sheet metal components. These products can be simple components requiring simple fabrication steps while others may involve very complicated processes requiring several steps to fabricate. For the complicated parts the time to market from conceptualization stage can be significantly shortened at various levels from design to manufacturing by understanding the product, its features and implications of the features.
It is widely accepted that about 70 percent of the final product cost is determined during the design stage. Systems that automatically provide inputs on manufacturing guidelines to designers during the initial design process that lower costs and reduce cycle times have proven highly effective in achieving their goals.
The sheet metal industry is largely an empirical industry. The design and process planning of sheet metal products need human involvement more than other areas of manufacturing industry. Design of complex parts are based heavily on human experience. In the design stage, if some of the design considerations are ignored, the cost of production may increase rapidly.
To prevent modification attempts of the initial design from becoming a trial and error process, some knowledge-based assistance is necessary. If the traditional knowledge gained from years of experience is integrated into a solid modeler, it will provide valuable input to the designer. The designer can then attempt changes while adhering to the functional requirements of the design for achieving easier manufacture and reduced costs at the same time.

MODELLING

The drawing of the sheet metal part serves as the basis for the NC program. Simple, flat parts are easy to create using the sheet metal design module of the SolidWorks software, as shown in Figure 1.

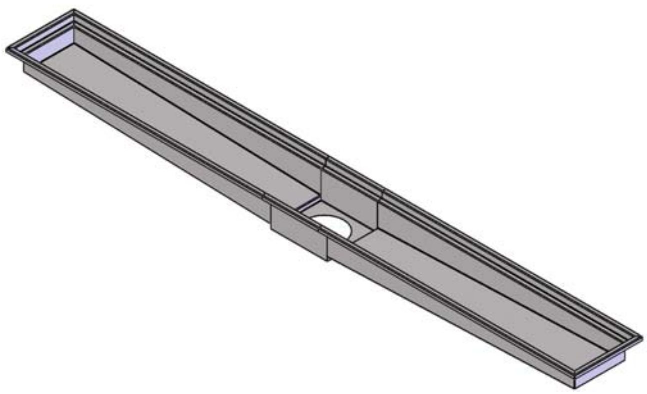


Fig. 1 Model of the Final product in SolidWorks

Complicated sheet metal parts has a multiple bends or bends that are at difficult angles. Bends are preformed in different angles and in four main directions up, down, to the right and to the left. SolidWorks offers visualization of the finished part and thus helping the operator. When a (3D) sheet metal part modeling is finished, the model is then unfolded in order to gain the initial blank needed for sequent operations. Part is then saved as a sheet metal pattern which produces a 2D drawing with bend lines and degrees. (figure 2) Part is then transferred in Lantek software in IGES format for punching operations. After punching operations are finished the bending operations take place.
Different sequences are possible for producing the bend lines. The main goal of process planning is to determine an executable bend sequence and to select tools to use for each bend line and the punch displacements. Bend sequence can be researched and displayed with this software. Two-dimensional or three-dimensional views show the operator which bending operation needs to be performed and what happens to the part as it is bent. The bending sequence should ensure that all bending processes can be completed without destroying previous bends or causing collisions between the tool, work piece, and machine.

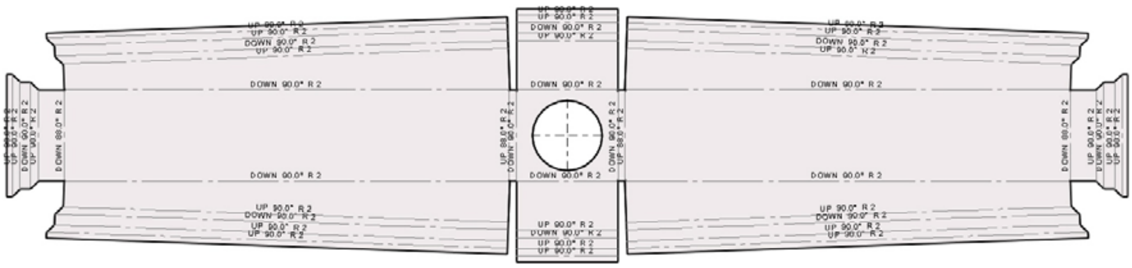


Fig. 2 2D drawing with bend lines

SolidWorks also allows creation of complex products with connection of multiple parts such as cabinets and counters. An optimum bending sequence is the one that enables the fastest possible processing of the part. SolidWorks offers 3-D mechanical design software that helps engineers speed up product development. Suggested bending sequence depends on the tool shape, especially its maximum nest height, care should be taken for collision detection after each bend.

PROGRAMMING

The programming software has to make a lot of decisions when defining the machining operation. The first step in the manufacture of sheet metal parts is always flat processing, during which one or more parts are made from a sheet. The model was made in SolidWorks than transferred in DXF format into Lantek software. The programmer uses the programming software to specify the location of each part on the sheet. This process is known as “nesting” and for given product Lantek software was used. Then the programmer indicates the required quantity for each part. The nesting program then calculates the optimum sheet layout, taking into account manufacturing specifications such as the distance between two parts. Lantek was used for creation of the NC program, this is a programming system for punching and combination of laser/punching machining.
Import of 2D or 3D data is possible for IGES, DXF of MI standard interfaces. Program performs on automatic analyses of the drawing, it closes open contours, deletes superimposed drawing elements and smoothens contours transition, clarifies inner and outer contours, defines single hole processing, it also defines special tools. Optimal nesting selection of sheet parts was also done with the Lantek optimal sheet utilization. The choice is to divide parts on sheet into sectors of optimal size in rows, columns etc. in order to nesta maximum number of parts with minimum material waste.
For Bending important factors for calculation of tool selection are the tensile strength of the material, the bend length, the bent angle, and the tool dimensions. With knowledge of the tonnage, the programmer or operator can determine whether the press capacity of the press brake will be sufficient and which tools will be able to withstand the loads produced by the bending operation. The die width,

however, affects the bend radius. So it is not only the question of tonnage. The programmer specifies the type of material, dimensions (of the tool, the die and the work piece), and bending specifications. The programmer then retrieves the remaining data on the material and tool properties from a database, suggests tools that can be used, and calculates the press force or tonnage. The parameters obtained in this way are optimally configured to the machine and tools. The programmer can use various software's in order to calculate the bending sequence. A bending plan and simulation allows the programmer to check that everything works smoothly.

IMPROVEMENTS

Some of the improvement over the old method of work where we used AutoCAD as the basic software package for making production and technical documentations are reflected in the time reduction of making technical documentation and reduce the possible occurrence of a wasted materials which is the annual amounts up to 23% less of used materials.

After the analysis of time usage for preparation of particular technical documentation with all details related to the subject on Figure 3. we can see on chart (Figure 4.) that the acceleration in the process of preparation documentation by using SolidWorks software. We reduced the time from 217 minutes in total to 85 minutes, That is almost 60% for this particular model.

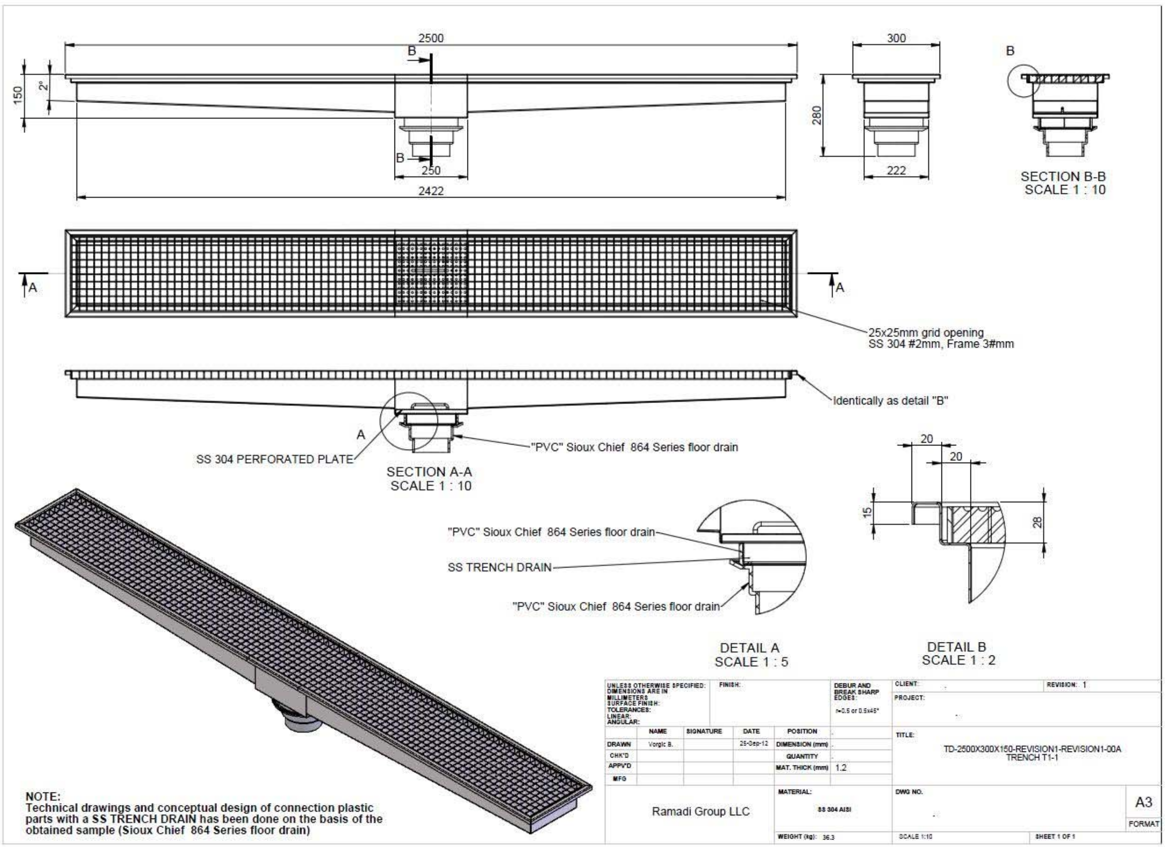


Fig. 3 3D workshop drawing of trench drain

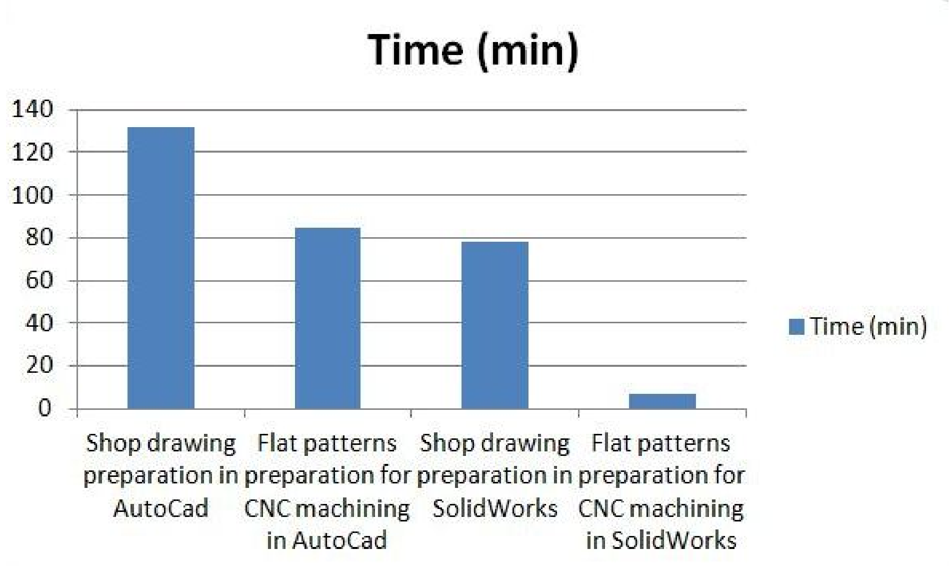


Fig. 4 Technical drawing preparation time consumption - SolidWorks vs. AutoCad

Analysis of the sales of waste materials in the company Ramadi Kitchen Industries LLC, at the quarterly level, during 2010 and 2011, only after a year of use SolidWorks software results are obvious. The waste materials is reduced from 7.86t (2010) to 6.05 t (2011) as shown on the chart Figure 5. which would represent a total decrease of 23% compared to the previous year where we did not used SolidWorks for making of technical documentation.

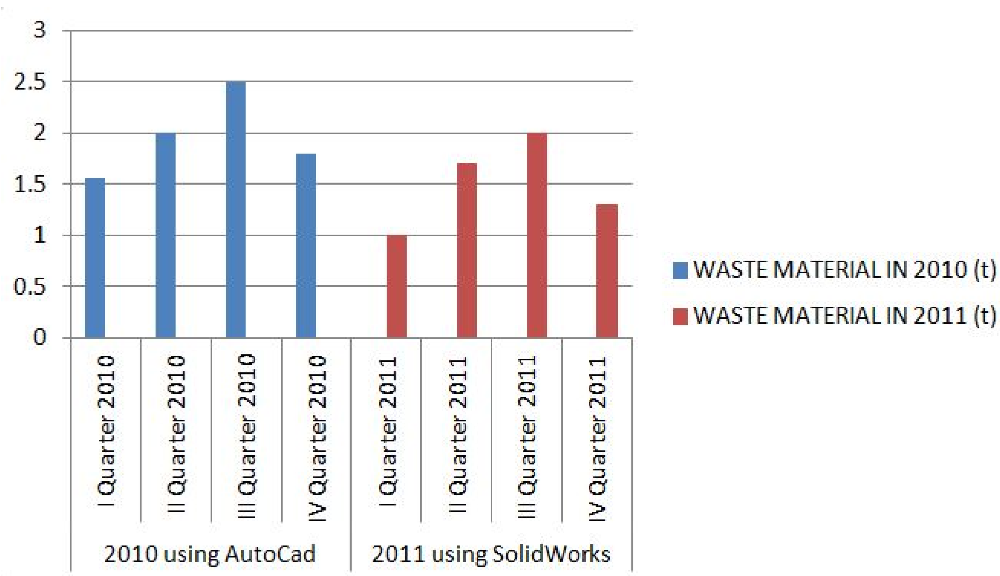


Fig. 5 Analysis of waste material sales - waste quantities submitted to recycling company

CONCLUSION

SolidWorks has special features for sheet metal modelling, the Sheet Metal modules allows modeling automatically these parts, sampling the process and making it more productive.
Computer-aided design (CAD) was used for converting the initial idea of a product into a detailed engineering design in order to communicate design information.
Computer-aided engineering (CAE) was used in order to conduct optimization analyses on the model such as bend allowance, material behavior, spring-back etc. in order to select the optimal values for

design parameters. Prior to the manufacturing process was simulated with SolidWorks and Lantek to visualize the manufacturing process.
Computer-aided manufacturing (CAM) was used for converting engineering designs into finished products, creation of a process plans and elimination of possible bend errors.
CAD, CAE and CAM capable software's SolidWorks and Lantek ware used to eliminate redundant design, increase the efficiency of equipment, reduce waste and scrap, decrease the time required to design and make a product, and improve the ability of the factory to pro-duce high quality products.

REFERENCES

[1] Matt Lombard, SolidWorks® 2010 Bible, Published by Wiley Publishing, Inc., Indianapolis, Indiana, 2010.
[2] M. Pan, Y. Rao: An integrated knowledge based system for sheet metal cutting–punching combination processing, Knowledge-Based Systems, 2009.
[3] Donovan, James Ryan, A computer-aided cost estimating system for sheet metal parts, phd Thesis, Industrial and Manufacturing Engineering, University of Rhode Island, 1992.
[4] © Lantek . Sheet Metal Solutions, http://www.lanteksms.com/uk/home.asp
[5] ©2012 Dassault Systèmes SolidWorks Corp., http://www.solidworks.com/
[6] Branislav V., Ramadi Kitchen Industries L.L.C., internal technical documentation "Tranch Drain" SolidWorks drawing, 2012.
[7] Branislav V., Ramadi Kitchen Industries L.L.C., Internal company documentation " Drawing preparation time consumption analysis " and " Material waste analysis", 2012.

WELDABILITY OF THE MICRO ALLOYED STEELS AS A FUNCTION ON THE COLD AND HOT CRACKING APPEARANCE

Slobodan Stojadinović[1], Nikola Bajić[2], Jasmina Pekez[1]
[1]University of Novi Sad Technical Faculty "Mihajlo Pupin, Zrenjanin, Serbia
[2] IHIS Research and Development Center, Belgrade, Serbia
e-mail: jpekez@yahoo.com

Abstract: In this work are given the testing results of mechanical properties and welded joints microstructure of micro alloyed steel, as well as its sensitivity to cold and hot cracking appearance. Obtained results show that steel has good resistance to cold and hot cracking appearance, especially at low temperatures, and welded joints have a very good combination of mechanical-technological properties.
Key words: micro alloyed steed welding, mechanical properties of welded joints, cold and hot crackings, microstructure.

INTRODUCTION

Process of welding can be observed as termodeformational cyclus, or cuclus of local thermal treatment of metal, which happens very fast, on wide specter of temperatures, from room temperature to testing temperature, at simultanious influence of plastic deformation of various sizes. A significant influence is made by method and process of welding, base metal characteristics, thickness and rigidity of joint and other factors.
Safety of welded, as of any other construction, is determined by the choice of material, level of stress (inner or outer) as by the quality of it's manufacturing. Total safety of welded construction depends on local safety. On every welded construction there are critical places, from: aspect of chosen and built in materials, point of design and calculation of construction, and finaly, point of technology of manufacturing of construction [1-2] .

LABORATORY TESTINGS

Chosing the base and additional material
Base material for welding is X-65 steel (label by API-5L standard), in shape of hot rolled steel sheets, 9.5mm and 14.5mm thick. Chemical composition of X-65 steel is given in table 1.

Table 1. Chemical composition of X-65 steel

Sample	Elements (%)										
	C	Si	Mn	P	S	Cu	Ni	Cr	Al	Nb	V
1.	0,066	0,179	1,440	0,015	0,006	0,068	0,025	0,034	0,031	0,039	0,066
2.	0,067	0,201	1,490	0,013	0,007	0,080	0,025	0,025	0,028	0,039	0,065

Table 2. Mechanical properies and characteristics of X-65 steel samples.

Sample	Thickness (mm)	Mechanical properties			
		Yield point Re (MPa)	Ultimate tensile strength, Rm (MPa)	A_5, (%)	Toughness, KV(J), na -20^{0}C
1.	9,5	531	619	35	112
2.	14,5	473	569	43	97

Welding of samples of microalloyed X-65 steel was done with coated wire, which's characteristics are given in table 3.

Table 3. Chemical composition and mechanical properties of weld of used wire

Wire	.Chemical composition (%)				Mechanical properties			
	C	Si	Mn	Ni	Re (MPa)	Rm (MPa)	A_5 (%)	Toughness, (J)
E53BNi «ELVAKO»	0,06	0,50	0,90	1,10	> 400	570 - 650	> 22	> 47, na – 40 ^{0}C

For steel sensitivity to cold cracks occurance TEKKEN method was used (Y-test), and for steel sensitivity to hot cracks FISKO method was used. Welding was performed with arc (REL method), coated wire, ϕ 3,25 (tab. 3).
Experimental welding was performed with two levels of introduced heat, who's quantity is defined by energethic conditions (current, voltage, heating speed).
Namely, shape and dimensions of molten bath depend on energy input during welding, conditions of crystalization, content and distribution of leftover gases, width of HAZ, it's structural state, re-distribution of microalloying elements in metal and HAZ, as the deformation level, that folow the welding process.
Optimization of metal seam structure (dominant presence of acerose ferrite) and heat affected zone (narrow overheated zone in which dissolution of carbide, nitride, carbonitride deposits occures, and grain growth) is achieved by limiting the temperature between two passes to 200^{0}C max and adequate cooling speed in temperature interval 800-500^{0}C ($\Delta t_{8/5}$).
Welding parameters of technological tests for determening weldability and sensitivity of X-65 steel to hot and cold cracks occurance is shown in table 4.

Table 4. Basic information on energetic parameters of experimental welding of X-65 sample steel

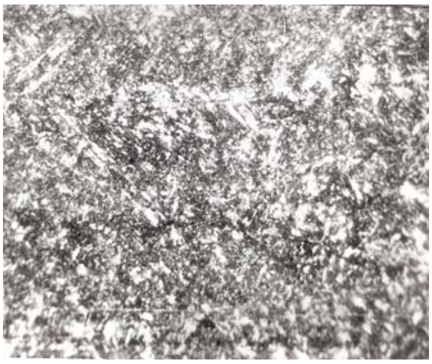
Sample	Thickness (mm)	Wire E53BNi, ϕ (mm)	Voltage (V)	Speed (cm/min)	Current (A)	Nomber of passes	Linear energy (kJ/cm)
1.	9,5	3,25	25 to 26	13,33 to 33,00	113 to 125	10	6,09 to 10,15
2.	14,5	3,25	25 to 27	14,44 to 25,32	107 to 125	10	7,03 to 13,36

Mechanical - technological tests of welded joints were done in complience to JUS C. T3054 (ultimate tensile strenfth), and JUS C. T3051 (toughness).
Test results are given in table 5.

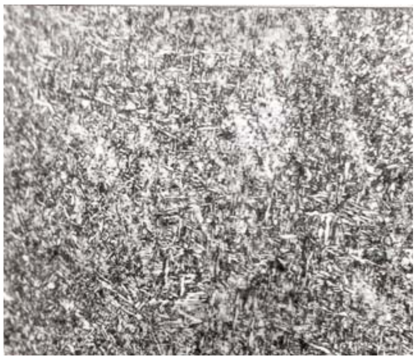
Table 5. Mechanical - technological properties of weld (average value)

Base material	Additional material	Sample	Ultimate tensile strength, Rm (MPa)	A_5 (%)	Toughness, KV (J)	T (^{0}C)
Steel (X - 65)	E53BNi	1	560	25	167 86 35 14	+20 -20 -40 -60
		2	580	18	177 145 78 19	+20 -20 -40 -60

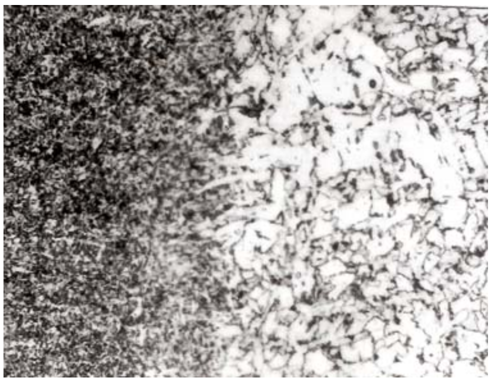
Metalographical tests were made on samples that were taken from seam („clean metal weld“), place of joining of HAZ and base (BM) and HAZ itself.
Metalographical tests were done on samples, that were taken from welded seam ("pure welded seam metal"), HAZ, and the spot where HAZ and base metal meet (BM) picture 3 a, b and c.
On picture 3 transcrystalization zone of weld is shown (picture 3a) which continues as HAZ with acerose Widmannstalten structure (picture 3b). Then it's an area of non completed pre-crystalization (temperature range between Ac_3 and Ac_1), and on a few milimeters from HAZ there is structurally not changed material (picture 3c).



a) welded joints



b) ZUT



c) BM-ZUT

Figure 1. The appearance of microstructures welded joints of steel X65, thickness 9.5 mm executed with electrode *E 53 BNi* [5]

On Fig. 1a seam structure of welded joint is shown. In normalized zone of seam composition consists of low grain ferrite. On Fig. 1b structure in HAZ area is shown, which consists of ferrite, less fine. Fig. 1c shows the structure on line: base metal – HAZ.

RESULTS AND DISCUSSION

Based on calculated values for Cekv. And HCS (formulas 1 and 2), for microalloyed steel X-65 (table 6), we can conclude that mentioned steel has no tendency to cold or hot cracks occurance.

Table 6. Cekv and HCS for X-65 steel

Sample	Carbon content (%)	Cekv. (%)	HCS
1.	0,066	0,33	0,47
2.	0,067	0,34	0,42

We should mention that with selfreducing of Cekv. Value (lowering the carbon and Mn content) transformation temperature (γ/α) increases, which leads to growth of ferrite grains, and endangers reaching the Rm required minimum. This problem is overcome by adding Nb whuch refines grain, and is not in Cekv. Formula. Also, by adding V+Nb high ultimate tensile strength is achieved.
Based on obtained values for ultimate tensile strength and impact tenacity (table 5), we can conclude that a good combination of mechanical-technological characteristics of welded joints has been achieved, while results of better quality were obtrained for X-65 steel 14.5mm thick. Namely, sample breaking, 14.5mm thick occured in base material (not in HAZ, as with 9.5mm sample), which can be explained by, on one side lower width of HAZ, and on another, by better mechanical properties of seam (table 5), relative to mechanical properties of base material (table 2).
Based on pictures analysis of microstructure we can see that normalized structure and weld and HAZ consist of fine grain ferrite crystals, while the primary structure is of acerose and polygonal ferrite.
Results of cold and hot cracks ocurance sensitivity of X-65 microalloyed steel tests show that mentioned steel has no tendency to occurance of cracks of these types. Namely, using metalographical analysis of X-65 steel, using TEKKEN method, as based on calculated Cekv. Value (table 3), it;s concluded that mentioned steel has no temdency towards cold cracks occurance, while calculated HCS values (table 6) also show that X-65 steel is not sensitive to hot cracks occurance.

CONCLUSION

Based on set research goal, performed tests and obtrained results we can conclude:
1. Microalloyed X-65 steel has good weldability, especialy on lower temperatures (-20 do – 60 ^{0}C).
2. Welded joints have a good combination of mechanical – technological properties
3. Steel has, also a good tenability to as cold so hot cracks occurance.

REFERENCES

[1] Hrivnjak, I. Weldability of steel, Belgrade, 1982.
[2] Semijan, V. i dr., theory of steel weldability, Welding Institute, ENERGOINVEST, Sarajevo, 1989.
[3] Kasatin, B. S. i dr., Mikrostruktura i svojstva svarnih jedinenij v niskolegirovanih stalej, Avtomat svarka. No 2, 1987,
[4] Radović, A., Metalurgical and technological parameters of weldability, International Conference, ZMUI, Vranje, 1985.
[5] Bajić, N., S. Stojadinović i dr., Research and development of optimal calibration of steel ribbons, composition of filler and technological method of producing activated filled wire for welding, Department Of Science and Environmental Protection, area: Technological development, EB 6756B, Institute for Chemical Sources of Electricity – IHIS, Zemun, 2005 – 2008.
[6] Bajić, N. i dr., Weldability testing and brittle fracture tndency of microalloyed and special steel, SARTID, Welding Center, Smederevo, 2000.
[7] Stojadinović, S., S. Vobornik, Min. Met. Quarter, 27(3)125, 1991.

CORROSION BEHAVIOUR OF AN Al-Zn-Mg-Cu ALLOY AFTER DIFFERENT HEAT TREATMENTS

Ana Alil[1], Bore Jegdić, Biljana Bobić, Marko Ristić
[1]Institute Goša, Milana Rakića 35, Belgrade, Serbia
e-mail: ana.alil@institutgosa.rs

Abstract: The variation of factors such as the amount of alloying elements in solid solution, thermal and thermo-mechanical treatments changes the corrosion tendency in the Al-Zn-Mg-Cu alloy. The measurements of electrical conductivity enabled the estimation of the structural state of the alloy, i.e. the type and the degree of precipitation.The corrosion behaviour was examined through three electrochemical methods($E_{corr.}$, polarization measurements, EIS).The measurement of corrosion potentials ($E_{corr.}$) gave information about the distribution of the alloying elements between the solid solution and the precipitation phases. The polarization measurements have shown a more positive value of pitting potential ($E_{pit.}$) and a greater resistance to corrosionfor the two-step aged alloy. The electrochemical impedance spectroscopy (EIS) has also shown that the two-step aged alloy has better corrosion propertiescompared to the one-step aged alloy.The fracture mechanics (FM) method wasused for SCC testing and hasshown that the alloy after two-step precipitation hardening is significantly more resistant to SCC. The obtained results enable a greaterinsight into the effects of both heat treatment and alloying elements, primarily copper, on the corrosion resistance of the alloy.
Key words: aluminium alloys, electrochemical methods, fracture mechanics,stress corrosion cracking

INTRODUCTION

Even the Al-Zn-Mg-Cu alloys have maximum strength; they are prone to localized types of corrosion and also to stress corrosion cracking (SCC). However, the tendency of these alloys to corrode changes depending on the content of alloying elements as well as on mechanical, thermal and thermo-mechanical treatments [1-4]. The precipitation hardening of the 7000 series Al-alloys takes place through the segregation of GP zones that are transformed through the intermediate η' phase into the equilibrium phase $MgZn_2$[5-8]. The maximum strength is achieved where there is a mixture of GP zones and η' precipitatesin the structure. But, in the state of maximum strength the alloy is prone to SCC. Stress corrosion cracking is a time-dependent process that occurs under the influence of residual or imposed tensile stress and specific corrosion environment. Localized corrosion (intergranular, pitting) usually proceeds to the SCC. For SCC to occur, the following conditions have to be fulfilled: the alloy is prone to SCC, the alloy is in a specific corrosion environment and the value of tensile stress is higher than the threshold value [2]. According to fracture mechanics (FM), the third condition is defined so that the coefficient of the stress intensity on the crack tip K_I is higher than some critical value K_{ISCC} [3]. The addition of copper in these alloys increase the volume fraction of the hardening precipitates. It was found that copper is incorporated in the GP zones, making them more stable even at higher temperatures [5, 9, 10]. In addition, copper atoms replace zinc atoms in the hardening precipitate η' ($MgZn_2$), particularly at temperatures above 150 °C [10], making the precipitate nobler. All this provide conditions for the increased resistance of these alloys to SCC. The electrochemical and corrosion characteristics of the alloy in the state after one and after a two-stage aging process were investigated in this paper.

EXPERIMENTAL PART

Material

The chemical composition of the tested alloy is given in Table 1.

Table 1. Chemical composition of the Al-Zn-Mg-Cu alloy (wt. %):

Zn	Mg	Cu	Mn	Cr	Zr	Al
7.2	2.15	1.46	0.28	0.16	0.12	Rest

The heat treatment of the samples was performed according to two different regimes: 1) homogenization annealing at 460°C/1h, quenching in water at room temperature, then precipitation hardening at 120°C/24h (one-stage aging, indicated in this paper with TA), 2) homogenization annealing at 460°C/1h, quenching in water at room temperature, precipitation hardening at 100°C/5h, and then at 160°C/5h (two-stage aging, indicated in this paper with TB).

Measurements of electrical resistivity

The method of measurement is described in ASTM B193 standard. Electrical resistivity was measured on the TA and TB samples by a microohmmeter in accordance with the manufacturer's instructions. The value of the measured electrical resistivity (ρ) was recalculated into electrical conductivity (($\chi=1/\rho$), as well as into the IACS% factor, using the equation:

$$IACS = \frac{\chi}{\chi_{Cu}} \cdot 100\% \qquad (1)$$

where χ is the value of the electrical conductivity of the tested alloy and χ_{Cu} is the electrical conductivity of pure copper (58.34 MS m^{-1}).

Corrosion potential measurements

Corrosion potential measurements were performed on the TA and TB samples. The samples (working electrodes) were degreased by ethanol and then placed in the electrochemical cell with a saturated calomel electrode (SCE) as a reference electrode. The measurements were performed in the 3.5 wt. % NaCl solution. The changes in the corrosion potential were monitored at room temperature, in the presence of atmospheric air, during 60 min.

Polarisation measurements

The cathodic and anodic polarization curves of the TA and TB samples were obtained using the GAMRY Reference 600 Potentiostat / Galvanostat / ZRA in deaerated 3.5 wt. % NaCl at room temperature. A three-electrode cell arrangement was used in the experiments. The working electrode was the sample, placed in a special holder, whilethe counter electrode was a platinum mesh with a surface area considerably greater than that of the working electrode. The reference electrode was the SCE. A potential sweep rate of 0.5 mV s^{-1} was applied after the constant open circuit potential was established (up to 30 min).

Electrochemical impedance spectroscopy measurements

For electrochemical impedance spectroscopy (EIS) measurements, the TA and TB samples were exposed to 3.5 wt. % NaCl for 48 h, anda three-electrode cell arrangement was used as in the polarization measurements. The EIS data were obtained at the open-circuit potential using the GAMRY Reference 600 potentiostat / galvanostat / ZRA. The impedance measurements were carried out over a frequency range of 100 kHz to 10 mHz using the 10 mV amplitude of sinusoidal voltage. The impedance spectra were analyzed using the GAMRY Elchem Analyst fitting procedure.

Fracture mechanics (FM) method

A bolt-loaded double-cantilever-beam (DCB) test specimen was chosen for testing SCC by the FM methodology. The samples were cut in the S-L orientation since aluminium alloys are most sensitive to SCC at this orientation. The starting value of the K_{I0} was calculated on the basis of the measured value of the crack length (a), the sample half-height (H) and the given size of the crack opening on the line of the load (V_Y), according to the following equation [ISO 7539-6]:

$$K_{I0} = \frac{E \cdot V_Y \cdot H \cdot \sqrt{3H\left(a+0,6H\right)^2 + H^3}}{4\left[\left(a+0,6H\right)^3 + H^2 a\right]} \qquad (2)$$

The starting crack was formed mechanically on the sample and the crack length was precisely measured. The increase of the crack length was measured microscopically in the next 150 days. The diagram of time dependence of the crack length is used for calculating and drawing the diagram of the crack growth rate dependence on the K_I. The real value of the stress intensity and the real value of the stress intensity when the crack practically stops, K_{ISCC}, were calculated (equ.2). In addition, SCC tests at different temperatures were done in a 3.5 wt. % NaCl solution. The length of the crack was measured during the time and the $v_{pl}$was calculated for every chosen temperature.

RESULTS AND DISCUSSION

The tested Al-Zn-Mg-Cu alloy, aged according to the TA and TB regimes, is characterized with an appropriate structure, mechanical properties, corrosion resistance, electrical conductivity and electrochemical properties. Based on these indicators, the tendency of the alloy to SCC and to localized corrosion was evaluated.

Electrical conductivity

The electrical resistivity and the recalculated values of electrical conductivity and the IACS% factor for TA and TB state of the tested aluminium alloy are shown in Table 2.

Table 2. Electrical resistivity and the recalculated values of electrical conductivity and the IACS factor after homogenization annealing (T0), one-stage (TA) and two-stage (TB) aging.

Thermal State	ρ (nΩ m)	χ (MS m-1)	IACS (%)
T0	5.82	17.20	29.65
TA	5.30	18.88	32.56
TB	4.75	21.06	36.71

The obtained results have shown that the TB sample has larger conductivity than the TA sample and the T0sample. A supersaturated solid solution with a high concentration of vacancies was obtained after quenching. Fields of elastic strains around vacancies cause dissipation of electrons, so lower values of conductivity are obtained. During aging, the clusters of zinc are formed at first, followed by the GP zones which grow gradually and transform themselves into the half-coherent phase η'. Elastic strains around the GP zones and the η' phase caused more electron dissipation. With appearance of the stabile η phase during two-stage aging, elastic strains decrease, and the alloy conductivity increases.

Electrochemical properties

In the test solution, at a constant temperature, the corrosion potential value of the tested aluminium alloy depends on the content of the alloying elements in the solid solution [11]. The results presented in Fig.1 show that the corrosion potential has a higher value after two-stage (TB), than after one-stage aging (TA). This can be related to the kinetics of the precipitation hardening. The alloy in the TA thermal state has a larger concentration of zinc (more negative) in the solid solution, which results in a more negative value of the corrosion potential (E_{corr} = -795 mV). In the case of the TB thermal state (partially over-aged state), the enlargement of the straightening precipitates occurs at the expense of impoverishment of the solid solution in zinc, magnesium and copper. In this case, the solid solution has a more positive corrosion potential (E_{corr} = -775 mV) due to depletion in zinc and magnesium. The formed precipitates after two-stage aging have become more electrically positive than the precipitates after one-stage aging. The atoms of aluminium and copper are incorporated in ($MgZn_2$), replacing to some extent the atoms of zinc and forming $Mg(AlCuZn)_2$.

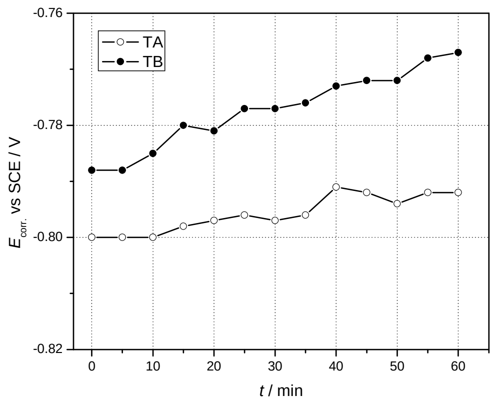


Figure 1. Time dependence of E_{corr} of the aluminium alloy in the TA and TB state.

The polarization curves of aluminium alloy after one-stage and two-stage aging are shown in Fig.2. It can be seen that the sample TB has a more positive value of the pitting potential (E_{pit} = -775 mV) with regard to the sample TA (E_{pit} = -800 mV). Also, the value of the corrosion current density for the alloy in the TB state is lower than for the alloy in the TA state, whereas the anodic and cathodic curves are shifted to the lower current density for the alloy in the TB state.

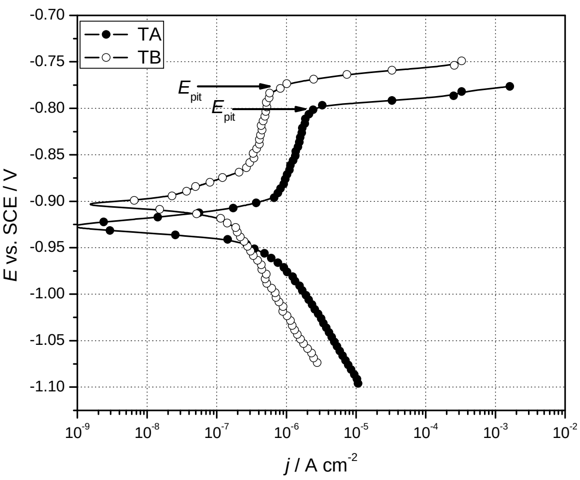


Figure 2. Polarisation diagrams of the aluminium alloy in the TA and TB states in deaerated 3.5 % NaCl at room temperature.

In the 7000 series alloys, pitting occurs due to the local dissolution of the matrix or to the dissolution of intermetallic compounds [13]. The explanation for the alloy's behaviour after two-stage aging lies in the fact that the difference in the electrode potentials between the intermetallic compounds and the solid solution has been decreased as well as the electrode potential difference between the precipitates and the solid solution. It was noticed that two pitting potentials exist,with the appearance of the second pitting potential at current densities higher than 1 mA cm^{-2} [12, 13]. The Nyquist complex plane plots of aluminium alloys in TA and TB state obtained by the EIS measurements are shown in Fig.3. The alloys in both thermal states show almost ideal Nyquist semicircle after one hour in 3.5 wt. % NaCl. The polarization resistance, R_p, of the alloy in the TA state is lower (which corresponds to a higher corrosion rate) with regard to R_p of the TB state (Table 3). After 24 h, a so-called Warburg's diffusion tail has appeared on the Nyquist diagram for the TA sample. A similar diffusion tail has appeared for the TB sample, also, after 48 h. However, the value of R_p was higher for the TB sample that corresponds to a lower corrosion rate.At the surface of the tested samples a layer of dark corrosion products has been formed, probably consisting of $Al(OH)_3$. A significant increase in the double layer capacitance capacitance (C_{dl}) and a decrease in the polarization resistance (R_p) with time indicate lower corrosion characteristics of the alloy after one-stage aging (Table 3).

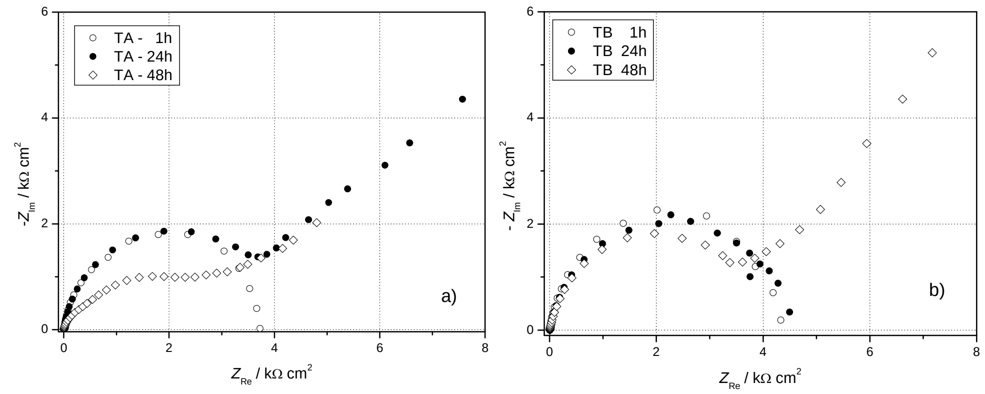


Figure 3. Nyquist plots of the aluminium alloys in 3.5 wt.% NaCl at room temperature after a) one-stage aging (TA), b) two-stage aging (TB).

Table 3. The values of corrosion potential, E_{corr}, double layer capacitance, C_{dl}, polarization resistance, R_p and pitting potential, E_{pit} after one-stage aging (TA) and two-stage aging (TB).

t (h)	Thermal State TA			
	E_{corr} (mV)	C_{dl} (μF cm^{-2})	R_p (kΩ cm^2)	E_{pit} (mV)
1	-795	12.5	3.86	-800
24	-775	22.7	4.18	-
48	-750	118.2	2.84	-
	Thermal State TB			
1	-770	7.9	4.33	-775
24	-755	28.7	4.56	-
48	-740	28.9	4.06	-

Fracture mechanics (FM) method

The main advantage of the FM method is getting quantitative data about alloy susceptibility to SCC (K_{ISCC}, $v = da/dt$). A diagram of dependence of the stress corrosion crack rate on the K_I is given in Fig.4. When the K_I is smaller than the K_{ISCC}, there is no growth of the stress corrosion crack or the growth rate is too small that can be neglected. In the first stadium (I), the crack growth rate strongly depends on the K_I. In the second stadium (II), the crack growth rate does not depend on the K_I. The influence of the alloy heat treatment is significant and it reflects in shifting the level of the second stadium to higher or lower values (Fig.4). In the third stadium (III), v increases fast until the critical value K_{IC} is reached, when it comes to a quasi-static fracture. It can be seen (Fig.4 and Table 4) that the alloy is more resistant to SCC after two-step aging (TB). The difference in SCC resistance is reflected on the v_{pl} value. The value of the v_{pl} is lower for more than one order of magnitude in the TB case. The maximum strength of the alloy (TA state) is obtained when GP zones and η' precipitates are present in a structure. Local plastic deformation at the tip of the stress corrosion crack causes mainly planar slipping when dislocations cut GP zones and smaller particles of the η' phase. It comes to the accumulation of dislocations at the grain boundaries at the crack tip, which causes increase in local stress, so that SCC starts at lower external stress [5,7].

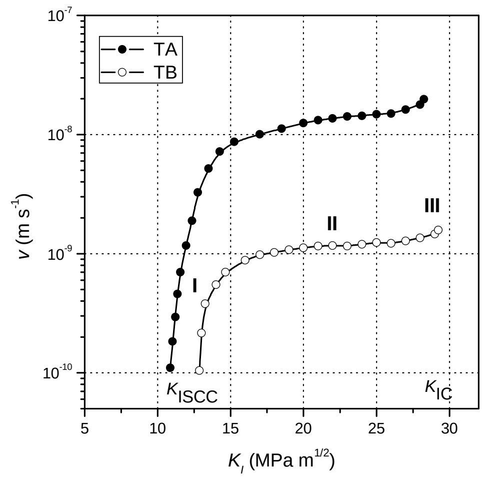


Figure 4. Influence of the heat treatment regime on the log v - $K_I$dependence.

Table 4. Results of the SCC testing by the FM method.

Therma l State	K_{I0} (MPa m$^{1/2}$)	K_{ISCC} (MPa m$^{1/2}$)	v_{pl} (m s-1)
TA	28.25	10.87	14.4 10^{-9}
TB	29.25	12.87	1.16 10^{-9}

In the TB case, a great number of GP zones is created in the first stage, at a lower temperature (100°C). The smaller particles (of the η' phase) precipitate on the GP zones during the second stage of aging (160°C) and then, they are partially transformed into the stable ηphase. In this case, the local plastic deformation at the crack tip is homogeneous (so-called turbulent slipping). Dislocations cannot succeed in cutting the particles of the stable ηphase and are uniformly distributed inside the grains. There is no local increase in stress at the grain boundaries and that creates favorable conditions for higher resistance to SCC [5, 7].

Addition of copper affects in the electrochemical characteristics of the alloy structural constituents. In the Al-Zn-Mg alloys, the ηphase precipitated on the grain boundary is anodic compared to the grain itself (which is covered with a passive film). These conditions are favourable for intergranular corrosion and SCC to occur. In the tested alloy, copper atoms enter into the solid solution and into the precipitates, making them nobler [9]. The precipitates on the grain boundaries are dissolved slower, and the cathodic reaction (hydrogen ion reduction) becomes more difficult [5, 9]. Copper has influence on mechanism of plastic deformation (slipping) and on electrochemical characteristics of the matrix and the precipitates. All this contributes to the increased SCC resistance.

The influence of the test solution temperature on the v_{pl} is shown in Figure 5. The exponential increase of the v_{pl} with the increase in temperature can be noticed, which is expressed by the following equation:

$$v = v_0 \exp(-E_a/RT) \qquad (3)$$

where$E_a$is the apparent activation energy of the process that controls the v_{pl}.

If the previous equation is logarithmed, a linear dependence between the logarithm of the v_{pl} and the reciprocal value of the temperature is gained.

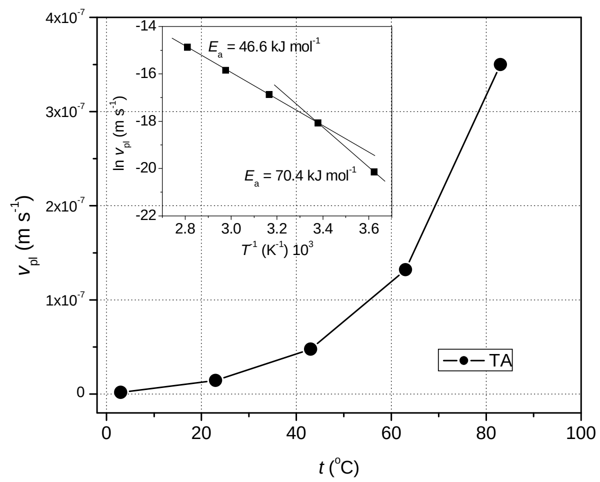


Figure 5.v_{pl}dependence of temperature during SCC testing (TA state).

The dependence of the v_{pl} on the reciprocal value of the temperature is shown in the insert in Fig.5. The apparent activation energy of the process that controls the v_{pl} is obtainedfrom the slope. There are two values of the apparent activation energy. One value (E_a = 46.6 kJmol^{-1}) refers to the temperature interval from 23 to 83^{o}C, while the other value (E_a = 70.4 kJmol^{-1}) refers to the lower testing temperatures, from 3 to 23^{o}C. These values correspond to different processes that control the v_{pl}. It was proposed that the crack propagation v_{pl} at temperatures above ~ 40^{o}C is associated with aluminium hydride formation (E_a ~ 35 kJmol^{-1}). The decomposition of aluminium hydride within the crack-tip region leads to significantly enhanced local entry of hydrogen, which facilitates the observed increase of v_{pl}, independent of the copper content. The crack propagation v_{pl} at temperatures below ~ 40^{o}C is dependent on the availability of hydrogen generated via the electrochemical process.

CONCLUSIONS

The corrosion resistance of a high strength Al-Zn-Mg-Cu alloywas tested. The alloy was subjected to the standard one-step aging process as well as to a two-step aging process. The measurements of electrical conductivity enabled the estimation of the structural state of the alloy, i.e. the type and the degree of precipitation. The resistance to the localized types of corrosion depends on the presence of different phases developed during the aging process. The value of the corrosion potential depends on the distribution of the alloying elements (Zn, Mg, Cu) in the solid solution and in the precipitated phases such as the $Mg(AlCuZn)_2$ phase. The alloy in the TB state has more positive corrosion potential, compared to the TA state. The polarization measurements have shown that the anodic and cathodic polarization curves of the alloy in the TB state were shifted to the lower values of the current density, and a more positive value of the pitting potential was achieved. The results of electrochemical impedance spectroscopy indicated better corrosion characteristics (higher values of polarization resistance and lower values of double layer capacitance) of the two-stage aged alloy compared to the one-stage aged alloy.
The results obtained with the FM method have a quantitative character. The value of K_{ISCC} is higher, and the v_{pl} is lower for more than one order of magnitude for the two-step aged alloy. The explanation for the processes that take place at the crack tip during SCC of the alloy in the TA and TB states and copper influence is proposed. In the case of real SCC danger in exploitation, the value of the K_{ISCC} should be used in the calculation of the allowed stress, instead of the K_{IC}. For the calculation of the construction work life, the stress corrosion crack growth rate should be applied.Two values of apparent activation energies have been obtained. One value (E_a = 46.6 kJmol^{-1}) refers to the temperature interval from 23 to 83^{o}C, while the other value (E_a = 70.4 kJmol^{-1}) refers to the lower temperatures, from 3 to 23^{o}C. The most likely processes that control the v_{pl} at lower and higher temperatures were suggested. All the results presented enable a deeper insight into different forms of localized corrosion of the aluminium alloys after one- and a two-step aging.

ACKNOWLEDGEMENT

This work was co-financed from the Ministry of Education of the Republic of Serbia (project No. TR 34028 and TR 34018).

REFERENCES

[1] Jones, R. H., Stress-Corrosion Cracking, in Corrosion: Fundamentals, Testing, and Protection, Vol 13A, ASM Handbook, ASM International, 2003, p 346–366
[2] Landolt, D., Corrosion and Surface Chemistry of Metals, Lausanne, Switzerland, 2007.
[3] Brown, B. F., Stress Corrosion Cracking Control Measures, NACE, monograph 156, Ohio, 1977.
[4] Moran, J., Effects of Metallurgical Variables on the Corrosion of Aluminum Alloys, in Corrosion: Fundamentals, Testing, and Protection, Vol 13A, ASM Handbook, ASM International, 2003, pp. 275–278
[5] Fontana, M. G. and Staehle, R.W., Advances in Corrosion Science and Technology, vol. 2, vol. 3 and vol. 7, Plenum Press, New York, 1972, 1973 and 1980 (Russian translation).
[6] Bobby, M., Kannan, P., BALA, S., RAJA, V. S., Stress corrosion cracking (SCC) of aluminium alloys, in Stress corrosion cracking, Theory and practice, Edited by: Raja, V. S. and Shoji, T., Oxford, Cambridge, Philadelphia, New Delhi, 2011, pp. 307-340.
[7] Sinjavskij, V. S., Valjkov, V. D., Kalinin, V. D., Korrozijaizaschitaaljuminijevihsplavov, Moskva, Metalurgija, 1986.
[8] Jegdić, B., "Behavior of Stress Corrosion Crack in a High-Strength Aluminum Alloys Structure", Scientific-Technical Review, LIII (2003) 19-24.
[9] Summerson, T. J. and Sprowls, D. O., Corrosion Behavior of Aluminum Alloys, Vol. III, Conference Proceedings, Aluminum Alloys-Physical and Mechanical Properties, Ed. Starke E. A. and Sanders, T. H., Virginia, June 1986, pp. 1576-1662.
[10] Hatch, J.E., Aluminum: Properties and Physical Metallurgy, American Society for Metals, 1984.
[11] Mondolfo, L. F., Aluminum Alloys: Structure and Properties, Butterworths, 1976.
[12] Burleigh, T. D., "The Postulated Mechanisms for Stress Corrosion Cracking of Aluminum Alloys, A Review of the Literature" 1980-1989, Corrosion, 47 (1991) 89-97.
[13] Andreatta, F., Terryn, H., de Wit, J. H. W., "Corrosion behaviour of different tempers of AA7075 aluminium alloy", ElectrochimicaActa 49 (2004) 2851–2862.

COMPARATIVE ANALYSIS OF THE FORMABILITY OF THE TWO LOW-CARBONCOLD-ROLLED STEEL SHEET

Gorde Ivanoska[1], Jovan Lazarev[2], Jasmina Caloska[2]
[1]SOU "Riste Risteski-Ričko" Prilep, R. Macedonia
[2]Mechanical Engineering, Skopje, R. Macedonia
e-mail: gordeiv@yahoo.com, jovan.lazarev@mf.edu.mk, jasmina@mf.edu.mk

Abstract: The paper presents the research results of formability of the two low-carbon steel sheets DC03 and DC04. The investigation is realized based of the analysis of mechanical characteristics of materials, coefficient of anisotropy, hardening coefficient, and forming limit curve. At the end is made comparative analysis of the formability of both sheets DC03 and DC04 based on the evaluated parameters.
Key words: formability, deformability, mechanical characteristics, r-value, hardening coefficient (exponent) n

INTRODUCTION - FORMABILITY OF COLD ROLLED STEEL SHEET

Formability of cold rolled steel sheet for deep drawing is defined as ability of the material to deform in sufficient size and in certain ways, specifically its deformability. Formability of the material by deep drawing, on lot of factors such as: chemical composition, the structure of the material, the quality of the surface geometry of the work piece, the asset and how lubrication etc..
Low-carbon steel sheets have good formability with deep drawing and as such are usually applied for this kind of processing. In their chemical composition they need to contain up to 0.12% C, 0.35% Mn and up to 0,30% Si. Sulfur and phosphorus content is limited to 0.05%.
Formability by deep drawing particular importance is state of the internal structure of the material. Steel materials with the same chemical composition, depending on the structure, may have essential differences in mechanical properties, and hence different formability deep drawing. For a steel sheet to have good formability with deep drawing, it is the procedure of its receipt to ensure:

- same chemical composition in the whole volume;
- smaller inhomogeneity arising from the presence of gaseous elements;
- less metallic includes;
- *Cementitious* to be secreted into ball shape and evenly distributed weight ferrites, not in the form of perlite tiles, because in that case it will have unfavorably affect on formability by deep drawing.

The quality of the surface of the sheet metal in the way of its production and has a major impact on the formability by deep drawing. By deep drawing can only be processed sheets and tapes whose surfaces are completely clean of metal oxides.
Based on the overall findings for behavior of sheets in deforming process can be divided in several important characteristics of the material that has a direct influence on its ability to plastic deformation. They are:

- Ultimate strength and Yield strength and their attitude ReH/Rm,
- degree of relative deformation at break d, and maximum steady deformation φ_m,
- shape of the curve of work- hardening and hardening coefficient – *n*-Value;
- coefficient of normal anisotropy – *r*-Value.

The method of determination of all these parameters is simple and is done by elongation the sample based on the usual exponential approximation curve of hardening:

$$\sigma_s = B.\varphi^n \qquad (1.1)$$

If we select two points sufficiently distant from one anotheron on curve of work- hardening (fig.1.1), and successful presentation by equation (1.1):

$\sigma_1 = C \cdot \varphi_1^n$ and $\sigma_2 = C \cdot \varphi_2^n$

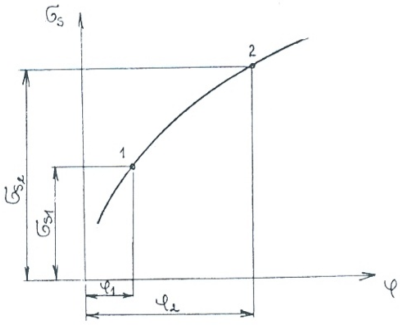


Figure 1.1 Determination of the exponent *n*

we get the expression for the calculation the hardening coefficient – *n*-Value:

$$n = \frac{\log\frac{\sigma_2}{\sigma_1}}{\log\frac{\varphi_2}{\varphi_1}} = \frac{\log\frac{\sigma_{T2}(1+\varepsilon_2)}{\sigma_{T1}(1+\varepsilon_1)}}{\log\frac{\ln(1+\varepsilon_2)}{\ln(1+\varepsilon_1)}} = \frac{\log\frac{F_2 l_2}{F_1 l_1}}{\log\frac{\log\frac{l_2}{l_0}}{\log\frac{l_1}{l_0}}} \qquad (1.2)$$

The hardening coefficient *n,* values for the low-carbon steel sheet typically ranges between 0,2 and 0,3. Materials with higher values of *n* are better with plastic deformation processing.
According to oriented division of low-carbon steel sheet therefore the value of the exponent *n*, that therefore what is the hardening influence on formability, we have:

1) $n = 0{,}16 \div 0{,}19$- very bad formability,
2) $n = 0{,}19 \div 0{,}21$–low formability,
3) $n = 0{,}21 \div 0{,}23$ - good (mean) formability,
4) $n = 0{,}23 \div 0{,}25$–very good,
5) $n > 0{,}25$ - very good (excellent) formability,

The coefficient of normal anisotropy is the ratio of logarithmic deformations after the width and thickness of the sample examined tin.

$$r = \ln\frac{\varphi b}{\varphi s} = \frac{\log\frac{b}{b_0}}{\log\frac{L_0 \cdot b_0}{L \cdot b}} \qquad (1.3)$$

The coefficient of normal anisotropy for sheets which is used in processing for plastic deformation change in the range of 0,2 to 2,7. For forming operations, is better sheet which have values of normal anisotropy coefficient greater than 1. Given that by definition the coefficient *r* is the ratio of logarithmic deformations in breadth and thickness, if *r* >1, then sheet metal will further deform in width and less in thickness, which ensures a higher degree of deformation before the occurrence of localized deformation and breakage material. Conversely, if the value of *r* <1 then sheet metal will further deform in thickness and less in width and will soon appear localized deformation and tearing of the material. Sheets that have a value of the ratio *r* = 1 are isotropy.
According to oriented division of low-carbon steel sheet therefore the value of *r*-value, that is therefore what the impact of the formability, we have:

1) $r = 0{,}5 \div 1$-very bad formability,
2) $r = 1 \div 1{,}2$ -low formability,
3) $r = 1{,}2 \div 1{,}5$ - good formability,
4) $r = 1{,}5 \div 1{,}8$ - very good formability,
5) $r > 1{,}8$ - excellent formability,

Besides these features in this paper are tested also curve of work-hardening and Forming-limit diagram known as the Keeler-Goodwin-t diagram, and made a comparison between the two materials DC03 and DC04. This diagram is one of the most practical methods for assessing the possibility of making complex parts with the deep drawing and stability of the process of deep drawing. Knowing

the sizes of the main deformation in the plane of the sheet metal *φ1* and *φ2* in the dangerous intersection (critical point), obtained by measuring the axes of the ellipses from deforme circles measuring network and the calculation of deformations can be checked border deformability tinplate viewed operation in terms of the emergence of local deformation or breakage.
Forming-limit diagram (FLD) divides the diagram into two departments: the area under FLD which represents the area of successful, stable plastic processing and FLD area over which an area of unstable plastic processing, i.e. area where the tearing of the material occurs in the dangerous intersection.

EKSPERIMENTAL RESULTS

Are investigated two sheets: DC03 and DC04, with a thickness of 1,0 *mm*. Survey made standard specimens with a width of 20 *mm* and 60 *mm* measuring length in three routes: 0^0, $45^0$and 90^0 in relation to the direction of rolling (fig.2.1).

Figure 2.1. Standard test specimens cut in three directions

For down -forming-limit diagram are madespecial test specimens as fig. 2.2.

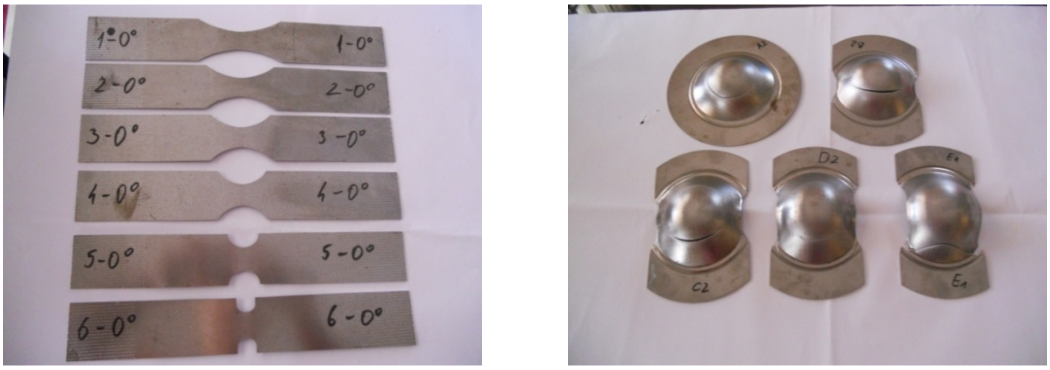


Figure 2.2. Specimens to determine the DGD

The specimens are cut with 3 axial laser L1Xe SALVAGNINI (fig.2.3) and the surface is done measuring network in the form of a circle with a diameter 5 *mm*.

Figure 2.3. Laser cutting and applying measurement network

The tests were conducted on the latest machine SHIMADZU equipped with a camera and that can be read directly the values of mechanical characteristics as *r*-Value and *n* –Value.

Results and analysis of results

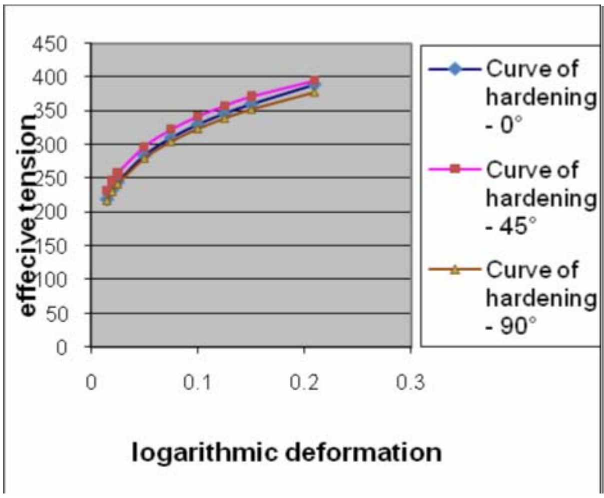
In Table 2.1 are the results of tests of mechanical characteristics and *r* and *n*-values for sheets DC03 and DC04. For each direction tested three specimens in the table included mean values according to the following:

$$r = \frac{1}{4}(r_0 + 2r_{45} + r_{90})$$

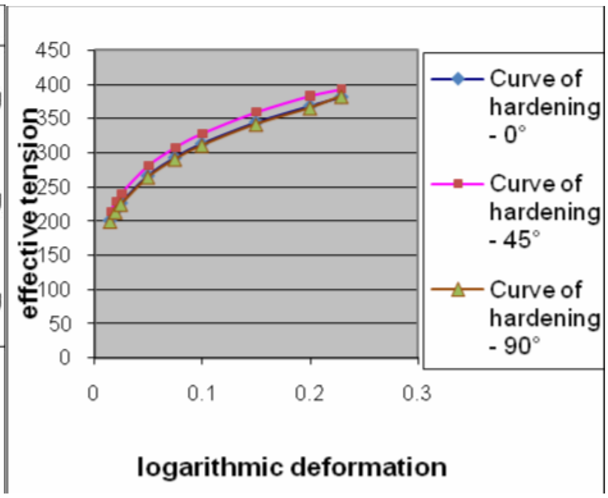
Table 2.1 Comparable values between DC03 and DC04 for thickness of 1*mm*

Ordinal number	Material	Yield strength	Ultimate strength	Relation of strenghtes	Modulus of work hardening	Coefficient of normal anisotropy	relative deformation
		ReH [N/mm²]	Rm[N/mm²]	ReH/Rm	n	r	ε_m
1	**DC03**	193.8001	316.4836	0.61233	0.2078025	0.9899983	0.214686
2	**DC04**	181.98285	307.1715	0.5923481	0.2287775	1.167115	0.243706

For both materials are assessed curves of hardening (fig.2.4).



a) material DC03



б) material DC04

Figure 2.4 Curves of hardening

Forming-limit diagram is determined by two types of samples fig.2.2 for the two materials separately, which is done measuring networkwith using a laser. The left part of the diagram is draw based on samples that tested the tensile (fig. 2.2 left), and the right of the diagram where you need two positive deformations are determined by test samples - round clips at yield of spherical extractor (fig. 2.2. right).
Logarithmic deformations measured axes of the ellipses are calculated by the equations:

$$\varphi_1 = \ln (d_1/d_0), \quad \varphi_2 = \ln (d_2/d_0)$$

where is: d_0–network diameter of a circle, d_1 and d_2, diameters smaller and larger ellipse measuring network after deforming.
Forming-limit diagram (FLD) is shown on fig. 2.5 for both types of sheet, DC03 and DC04. The upper curves represent measured values of broken ellipses, while the lower curves are the maximum uniform elongation at maximum curve.

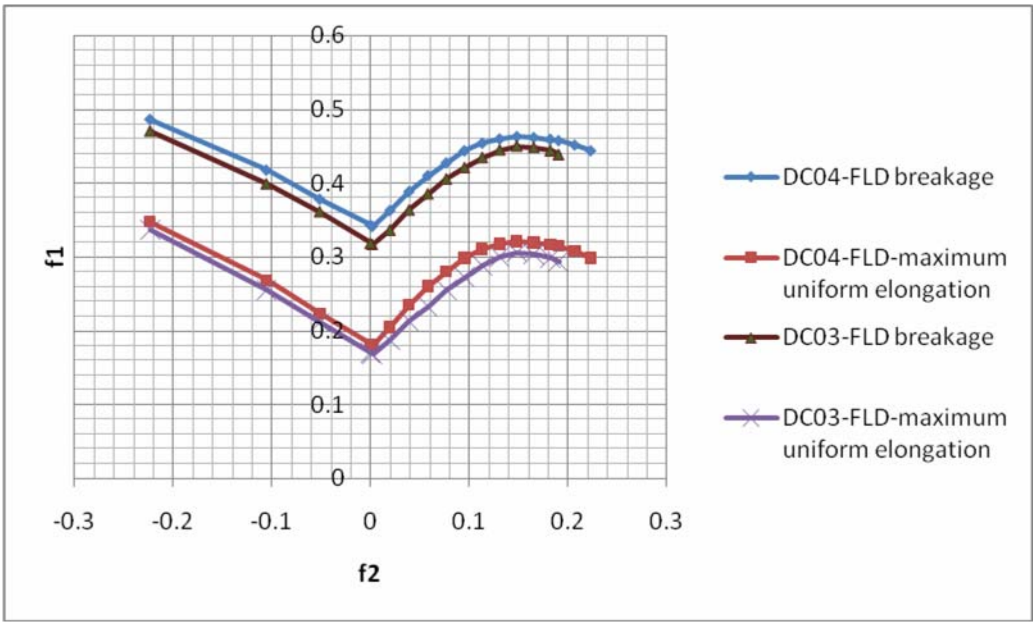


Figure 2.5. Forming-limit diagram for DC03 and DC04

From the diagrams it is evident that the material DC03 shows weaker plasticity in compared to the DC04.

CONCLUSION

If we analyze the reseived values of the mechanical characteristics of the two materials, we can observe that relation R_{eH}/R_m for DC03 moves from 0.60 to 0.65, while the DC04 from 0.57 to 0.60. The sheet metal forming process it is necessary this coefficient to be <0.65, so better plasticity shows the DC04.

The coefficient of work-hardening *n* moves from 0.19 to 0.21 for DC03, while the DC04 from 0.22 to 0.24, indicating that these materials belong to the group of materials well strengthen the process of deep drawing, where DC04 better strengthens in compared to the DC03.

The coefficient for normal anisotropy *r* ranges from 0.83 to 1.3 for DC03, and from 0.85 to 1.6 for DC04. For good processing by deep drawing, it is necessary this coefficient to be higher, as in the case of DC04.

Forming-limit diagram (FLD) shows the limits to what extent can be deformed the sheet metal without danger of tearing, as well as the limits at which the material destroys. Lower values of this diagram show low plasticity the sheet metal. DC04 shows the higher plasticity compared to the DC03.

Based of all comparative analyses as the leas conclusion we can say that the material DC04 is better for sheet metal forming by deep drawing then DC03, wich detected better formability.

REFERENCES

[1] G. Ivanoska. Research the workability of low-carbon cold rolled steel sheet, Magisterial work, Faculty of Mechanical Engineering Skopje, 2012

[2] J. Lazarev, J. Caloska, G. Ivanoska. Research the workability of low-carbon cold rolled steel sheet, KODIP 2012,Budva, 26-29.06.2012

[3] J. lazarev, V. Strezov. Processing Machinery and deformation, Ss. Cyril and Methodius, Skopje, 2005

[4] S. Cvetkov. Numerical and experimental methods for optimal technological process of extracting basket with friction clutches for motor vehicles, Doctoral Dissertation, Mechanical Engineering, 2011.

SESSION 4: Maintenance

AN INVESTIGATION ON THE LOADING DURABILITY OF POLYMERIC GEAR WHEELS WITH VACUUM DEPOSITED COATINGS

Dimitar G. Petrov[1], Petar Hr. Shindov[1], Dimitar N. Dimitrov[1], Petar L. Dimitrov[1].
[1]Technical University-Sofia, branch Plovdiv, Bulgaria
e-mail: dimgog@abv.bg, p_shindov@mail.bg, ddimitrov_tu@abv.bg, petar1dimitrov@abv.bg

Abstract: A technology of vacuum deposition of the thin layers shaped wear-resisting coatings on teeth's working face flanks of polymeric gears was developed. The laboratory tests showed positive influence of vacuum deposited wear-resisting coatings for improving of strength of teeth against fatigue fractures. This is because of the fact that coatings reduce the influence of micro defects on the face flanks of teeth. These coatings reduce the wear of gears as well.
Key words: polymeric gear, vacuum deposited coating, wear and load durability.

INTRODUCTION

The use of polymer gears is widely spread in many industries and applications because of their most beneficial properties – low cost; light weight and low inertia; capability to absorb shock and vibration; noiselessness; tolerances often less critical than for metal gears; ability to operate under dry unlubricated conditions; etc [1]. However, when using polymer gears (comparatively with metal gears) should be taken into account such their shortcomings as greater thermal expansion and contraction, lower strength parameters concerning broken teeth from bending fatigue, lower contact resistance of the tooth flanks, greater absorption moisture, etc. In scientific publications have been reported on various damages in polymer gears (heat-related wear and pitting), while [2] the most common failures are due to wear. There are examinations the various parameters influencing the wear on the plastic gears - the roughness of the side surfaces of steel gears rotating polymer [3], the introduction of politetraflouroetilen (PTFE) as an internal lubricant [4], the introduction of structural measures [5] with conflicting results. A well-known approach to increase contact load and wear resistance of the steel gears is the appropriate treatment of lateral surface of the teeth (eg, nitriding, cementation). In the polymer gears this approach can be implemented as proposed in [6], using a metal rim. Another method is tested by applying coatings of solid lubricants [7] - the experiments show improved functional characteristics of polymer gears with PTFE coatings, especially evident for polymer gears made of polyamide (PA).
In this work are presented the experimental results of the comparative study on the effectiveness of the application of coatings by depositing titanium nitride (widely known is the use of TiN to create wear-resistant coatings) on the lateral surface of the working teeth polymer gears using vacuum technology to improve of their total load capacity.

USED MATERIALS AND TECHNOLOGIES

Basic engineering plastics used to produce gears nowadays are polyamide (PA 66), polyacetal (POM) and PolyEtherEtherKetone (PEEK). PEEK [8] offers among the polymers some of the highest mechanical strength and wear resistance, working up to 260 ° C, resistance to chemicals, but it's too expensive. PA and POM combine acceptable load capacity, relatively low coefficient of friction and a low price. So it was decided to use the two relatively inexpensive materials – PA 66 and POM. Their main drawback, however (especially POM) is a relatively low temperature of continuous operation – from 100 to 110°C. These temperatures limit the coating deposition using vacuum technology in view of the inevitably heating of the substrate on which the coating is deposited. Along with the risk of thermal deformation and melting, there is a problem with the release of moisture and volatile vapor, which deteriorate adhesion at the deposition of thin layers of wear-resistant coatings (titanium nitride - TiN).

Our studies have shown that the problem is technologically surmountable by lying of layer of special varnish for "sealing" the polymer surface and by means of the application of interrupted deposition processes through switching on and off consecutively the electric arc in the process of cathodic arc deposition. The accepted technology consists of the following steps:
1. Cleaning, pre-treatment with surface active agents and drying of polymer gears.
2. Plasma chemical modification of the surface with reactive gas O_2 - ion treatment in glow discharge.
3. A spraying of thin layer of varnish with thickness 20-40 μm (company "EWERT LAK", Strelcha, Bulgaria). The lacquer layer is used to create a smooth trouble-free surface and a protective barrier against diffusion.
4. Drying of the applied varnish layer at 180°C. The varnish layer with thickness 20-40 μm (density 1.65 g/cm^3) is resistant to temperatures up to 240°C, which is higher than the heat resistance of polymers POM and PA. The high firing temperature (180°C), however, lead to irreversible thermal deformation of the polymeric gears from the POM, so they were excluded from further experiments.
5. Vacuum arc deposition of TiN (density 5.44 g/cm^3) switched on and off (2-3 hours) - the resulting coating thickness for this experiment was ~ 1μm.

GEAR WHEELS, TEST RIG AND EXPERIMENTAL CONDITIONS

The studied polymer gear wheels were made by PA 66 (density 1.14 g/cm3) by means of the gear cutting. The gears have similar geometrical parameters - number of teeth z = 30, module m = 2 mm, width of the tooth crown b = 18 mm, profile angle of pitch circle α_w = 20° and steel insertion – fig. 1. It has been studied two couples of gears - one uncoated and one coated (under-layer of varnish, which has been covered with another layer of TiN by means of the cathodic arc deposition).

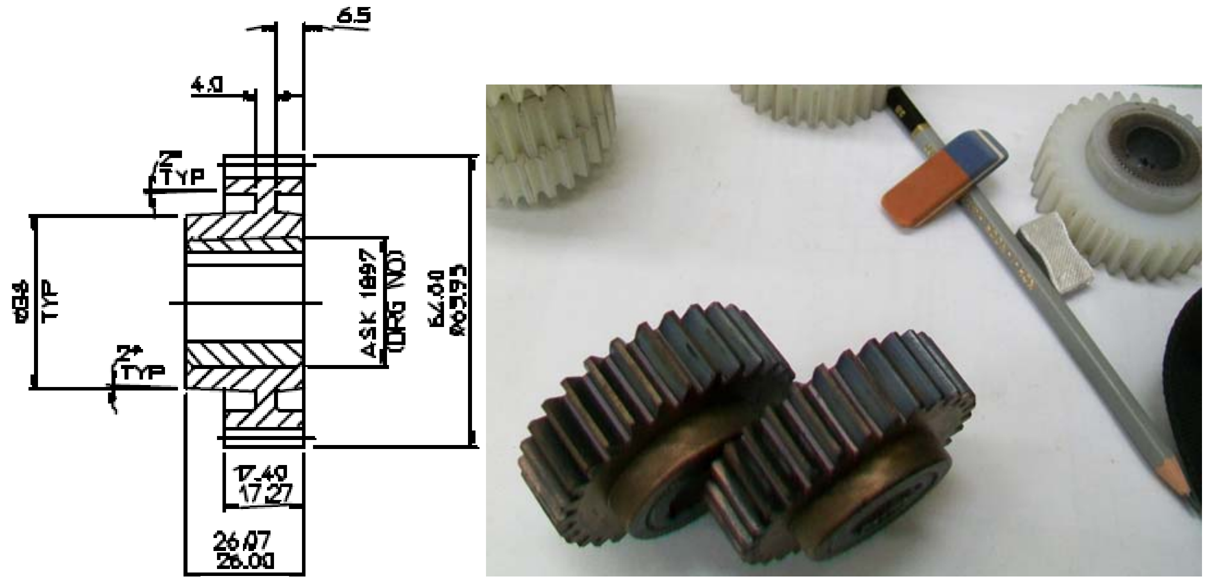


Figure 1. Sketch and photo of polymeric gears

The scheme of the test rig used for the tests and its photo is shown on fig. 2. It is a closed loop rig designed specifically for testing polymer gears and is described in [2,9]. One gearbox (Master Gearbox) contains identical metal gears, which do not require replacement, while the polymer test gear pair forms the opposing set. The power to drive the arrangement is that which is needed to overcome the gear sliding and bearing losses in the system. When the motor is switched on the reactive forces between the test gears balance the externally applied torque and the bearing block and loading arm are maintained in balance. When using a closed loop system the torque is normally wound-in but for plastic gears wear and tooth deformations would mean that the torque would change (reduce) with time. Using a pivot block and load arm to load the gears ensured that the test gears were subjected to a constant load throughout the test. As the test gear wear, the bearing block rotates about the pivot.

Quite large rotations are allowed, and, because of this and the associated differential movement, the closed loop drive shafts are free to slide axially and are fitted with universal joints. Temperature in the mesh point was measured using non-contacting infra-red thermocouple and the data stored on a computer. A cut-off switch is fitted to switch off the motor and terminate data logging in the event of tooth fracture.

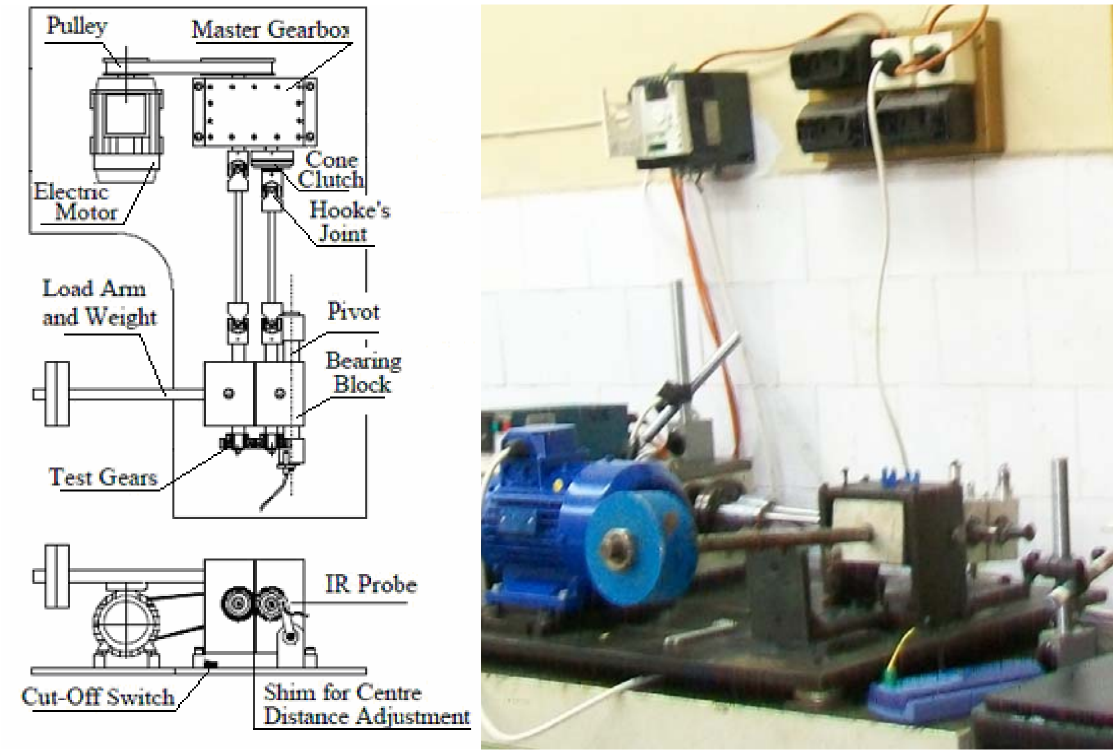


Figure 2. The scheme and photo of the test rig

The gears tested were loaded to a torque of 8.5 Nm, running at 1000 revs/min in unlubricated conditions of running up to reaching 2 million cycles or when one or two of pair have been broken. The achieving of 2 million cycles was realizing in 2 days of continuous running.

RESULTS

The wear was measured by measuring the weight loss after a number of cycles. The gears were removed each time the weighing took place. A non-running control gear was mounted on the pivot block assembly and the weight of this gear was measured so that any moisture either absorbed or released from the polymeric (PA 66) gears could be added or subtracted from the test gear measurements. The precise analog analytical balance for measurement of mass was used. The wear was measured by measuring the mass loss after a number of cycles. The wear is shown on fig.3 by the percentage relative mass loss *R%* calculated by means of the formula:

$$R\%_i = \frac{\left(\dfrac{Q_i}{Q_0}.P_0 - P_i\right)}{P_0}.100\% \qquad (1)$$

Where: P_0 - original gear mass; P_i – current gear mass; Q_0 - original control gear mass; Q_0 - current control gear mass; $R\%_i$ – current relative mass loss.
The measured temperature in the point of meshing (Fig. 4) at running of the gear showed directly proportional relationship between the intensity of wear and the released heat.

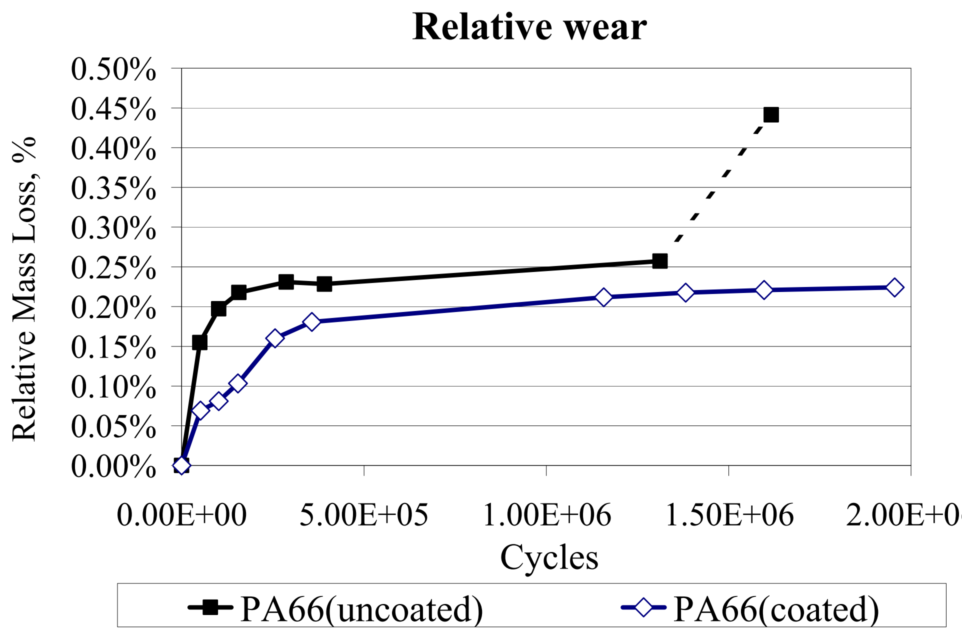


Figure 3. Relative mass loss of two identical (coated or uncoated) polymer gear wheels (nylon PA66)

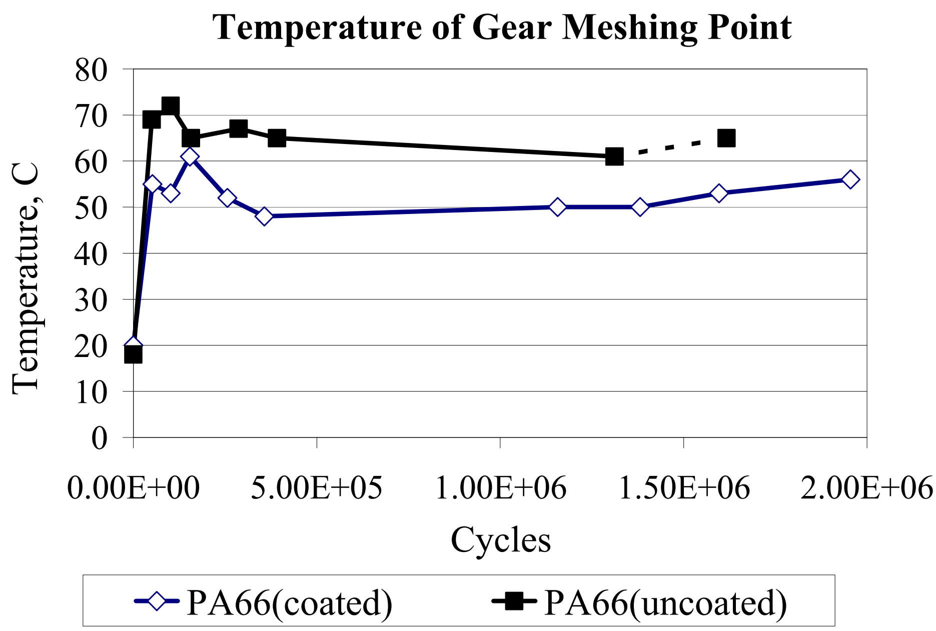


Figure 4. Temperature at meshing point gear of two identical (coated or uncoated) polymer gear wheels (nylon PA66)

In addition in uncoated gear pair beside of more intensified wear is registered difference in distribution of the wear among different teeth in each wheel (Fig. 5) and difference in the wear of the two different wheels from the pair with uncoated wheels. The result is an uneven weakening of various teeth; developing cracks and broken teeth (Fig. 6) at the gear without wear-resisting coating. The fracture from fatigue of the gear without coating has been occured in less than 1.6 million cycles, while the gear with coating continued to work without any noticeable wear and there were no cracks in teeth to nearly 2 million cycles.

Figure 5. Difference in distribution of the wear among different teeth in each wheel

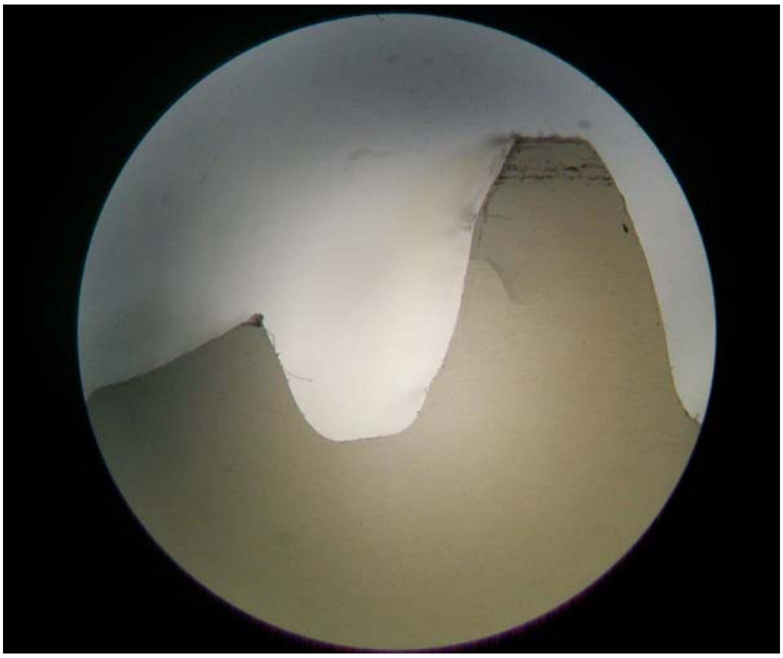


Figure 6. Cracks and broken teeth

SOME CONCLUSIONS

The experiments show that the double-layer protective coatings on the flanks of the teeth of the tested polymeric (nylon PA66) gears not only reduce wear but also reduces the effect of all micro-cracks, ulcers and roughness on the surface all of which could become nucleuses for development of cracks in the teeth. The coating provides uniformity in the strength characteristics as of the teeth in the each of the gear wheels as well of the two meshing wheels of the gear together. Thus, the application of wear-resistant double-layered coating on the tested technology for vacuum deposition of coatings, primarily increases the strength against breakage of the studied polymer gears, increases at least one and a half the life of gears and also reduces wear of their teeth.

REFERENCES

[1] http://plastics.dupont.com/plastics/pdflit/americas/markets/gears.pdf
[2] K. Mao. *The performance of dry running non-metallic gears*. PhD thesis, Birmingham University, 1993.
[3] S. Akkurt. *On the effect of surface roughness on wear of acetal-metal gear pairs*. Wear 184, pp 107-109, 1995.
[4] M. Rao, C. J. Hooke, S. N. Kukureka, P. Liao and Y. K. Chen. *The effect of PTFE on the friction and wear behavior of polymers in rolling-sliding contact*. Polymer Engineering and Science, Vol. 38, No. 12, pp 1946-1958, 1998.
[5] Hayrettin Duzcukoglu, PA 66 spur gear durability improvement with tooth width modification, Materials and Design 30 (2009), pp1060–1067
[6] Dimitar Petrov, Georgi Dinev, "Model investigations on different original designs of nonmetal tooth gears with sheet iron bandage", Proceeding of the DEMI'2005 – 7th International Conference On Accomplishments In Electro And Mechanical Industries, Banja Luka University, Faculty of Mechanical Engineering, Banja Luka, 27 - 28 .05. 2005, pp.83 -88.
[7] Dimitar Petrov, Karl Dearn, Doug Walton, Richard Bancs, Some experimental results concerning the influence of surface coatings from solid lubricants on the wear of polymeric gears, Journal of the Technical University Sofia, branch Plovdiv, Fundamental Sciences and Applications", Vol. 16, 2011, International Conference Engineering, Technologies and Systems - TechSys 2011, Plovdiv, Bulgaria.
[8] http://www.tregaltd.com/img/svoistvaCOLOR.pdf
[9] A.B.Cropper, The failure mode analysis of plastic gears, PhD thesis, Birmingham University, 2003.

SUSTAINABLE DEVELOPMENT AND MAINTENANCE AS A LOGISTICS

Miodrag Bulatović
Academician IACG & IAS, Center for Quality, Faculty of Mechanical Engineering,
University of Montenegro, Montenegro
bulatovm@ac.me

Abstract: Way of solving the problem of sustainable development has a global character. In the sphere of global character sustainable development provides a brief overview of the industrial policy of sustainable development policies. Industrial processes and logistics of the process, the maintenance process before all the elements have a broad base of activities that impact on the sustainable development. Integrated standards and their application in order to achieve the quality of life are an important condition for sustainable development.
Key words: sustainable development, health, industrial processes, logistics, maintenance, environmental aspects.

CONCEPT AND SIGNIFICANCE OF SUSTAINABLE DEVELOPMENT

The concept of sustainable development is most often associated with environmental protection, social development planning, environmental, economic and political issues (Fig. 1)
The concept of sustainable development is a new development concept, a new strategy and philosophy of social development.

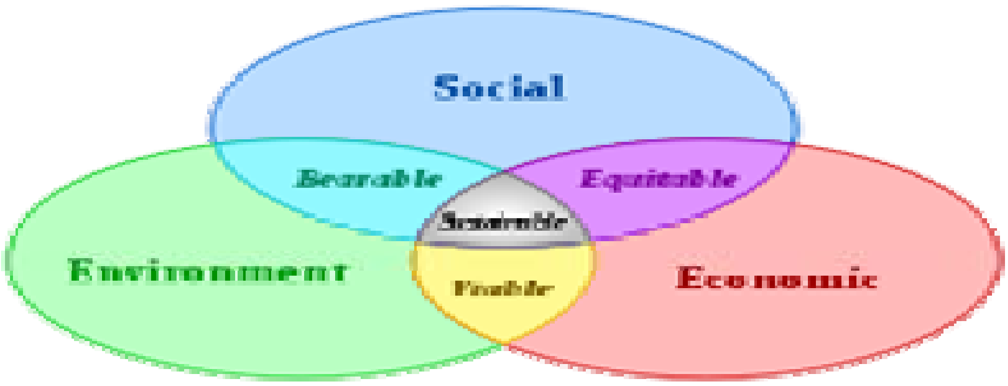


Figure 1. Spectrum impact on sustainability - sustainability as a cross-section of influential factors

Sustainable development combines concern for wildlife on the planet Earth and preserving the capacity of natural systems (natural resources) with social and environmental challenges, in front of every society, country and humanity as a whole.
News concept of sustainable development in particular contributes to the challenges that come with the vulnerability of the environment. Some of these challenges are: global warming, ozone layer depletion, "greenhouse effect", deforestation, conversion of arable land into deserts, acid rains, and the extinction of animal and plant species.
The very concept of "sustainable development" is relatively new, but the ideas contained in it we can find it in the past. So, for example, in the late 18th, English economist Malthus argued that there is a mismatch between population growth and rising living resources.

DEFINITION OF SUSTAINABLE DEVELOPMENT

There is no single definition of the concept of sustainable development.

However, there is agreement on the need to introduce the concept and awareness of the reasons for its creation.

The most commonly quoted definition of sustainable development is in the report „Our Common Future", compiled by the World Commission on Environment and Development (the Brundtland Commission) 1987., "Sustainable development is development that meets the needs of the present, and that does not prejudice the ability of future generations to meet their own needs."

According to the second definition of "sustainable development is a balance between resource consumption and the ability of natural systems to meet the needs of future generations."

A comprehensive definition of sustainable development is: "Sustainable development is an integral economic, technological, social and cultural development, in line with the need to protect and improve the environment, which allows current and future generations to meet their needs and improve quality of life".

Some authors instead of the term "sustainable development"prefer to talk about the concept of "sustainability" and the term "sustainable development" reserved only for specific development activities.

Basic Principles of Sustainability

- Intergenerational equity, in the sense that the current generation should not diminish the chances for the development of future generations;
- The precautionary principle in environmental conditions global uncertainty;
- The principle of conservation of natural resources with minimal damage to the environment;
- Prevention of pollution at the source;
- The principle that the polluter pays, through internalization of ecological costs through charges, fees and permits;
- Using the best available technology;
- Prevention and Elimination of creating unnecessary waste;
- Solution and control of waste that cannot be recycled for further use;
- Inclusion of environmental analysis and assessment, in any decision-making in the economy
- Integrated Product Lifecycle;
- Compliance with environmental and ecological space;

Sustainable society can be regarded as the society that:

- Recognizes that economic growth has its limits and that they are certain resource capacity in the region;
- Evaluated cultural diversity;
- Fosters respect for all forms of life and encourages diversity of wildlife;
- The values a broader system of social sustainability through education;
- Should hire experts for the environment when making any development decisions;
- Make plans balanced development, respecting the social, health, economic and environmental needs;
- Use of local resources and capacities of the long-term best;
- Uses renewable and reliable sources of energy;
- Minimize environmental damage;
- Strengthen the activities in which materials are recycled;

SUSTAINABLE DEVELOPMENT AND LAWS OF THERMODYNAMICS

The first law of thermodynamics says that the total amount of matter and energy in a closed system remains the same as it has direct impact on the occurrence of pollution[3].

Pollution is not only the result of a selfish and short-sighted behavior of people, but the inevitable companion of economic activity.

Before humanity can only be imperative to set the pace of environmental pollution to be optimal, that complies with a renewable natural equilibrium with the principle of economic efficiency.

The second law of thermodynamics says that in isolated systems, the amount of useful energy and matter decreases over time.
This law, known as the law of entropy, has far-reaching significance.
The notion of entropy is related to the level of organization of matter and energy
What is the organization of matter and energy is higher, the higher their usefulness, the entropy is lower
The opposite is true, as the lower levels of the organization, the higher the entropy, the utility is lower.
To make matter and energy were biologically and economically useful, must be organized into structured forms.
The law itself says that in an isolated system, entropy increases over time, and the declining level of the organization.
The basic message is that the law of entropy, in fact, condemns civilization on the decline, when all stocks highly organized matter-energy and low entropy, spend
The only thing that humanity can make rational action is to postpone the moment, and that the pace of increase in entropy on earth is it slower.

MAINTENANCE - GENERAL LOGISTICS WORK FOR SUSTAINABILITY

Steady growth in industrial production and manufacturing systems (Fig. 2) in developed countries has led to a tightening of environmental protection, the use of energy and natural resources, and waste disposal

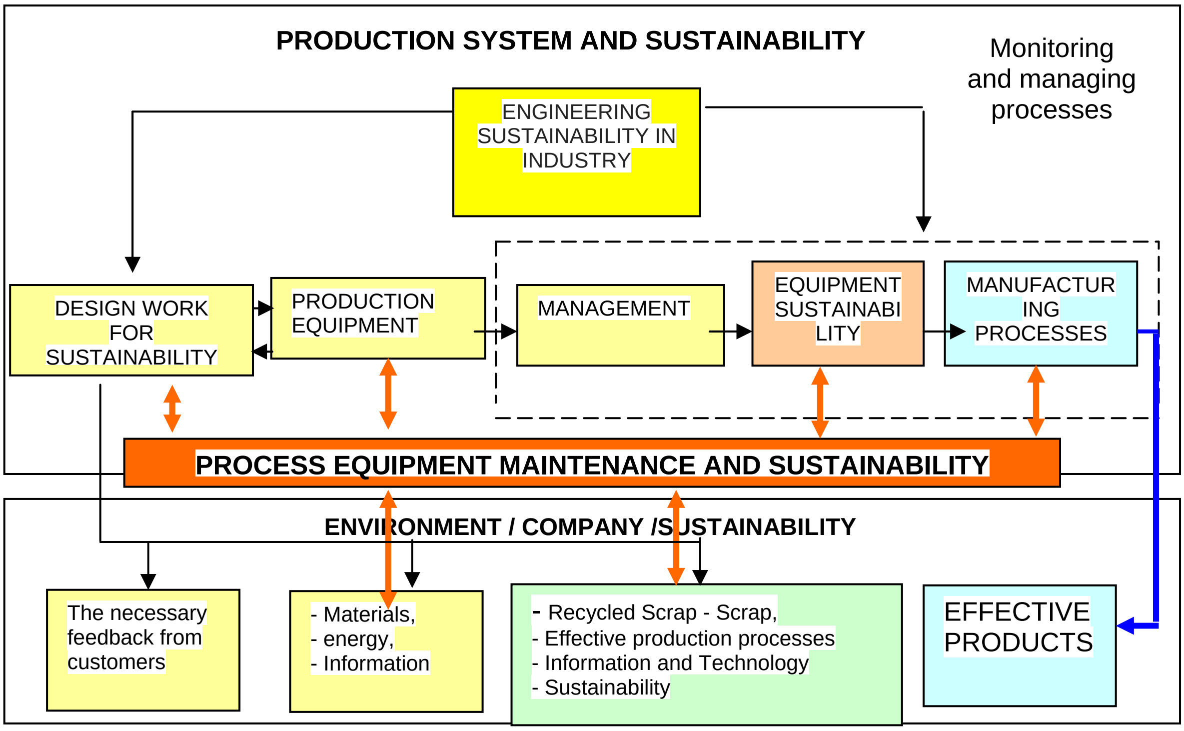


Figure 2. The functional structure of the production system

The current trend is to manage the process has full verified and evaluated according to the requirements of standard ISO 9000, ISO14000, ISO18000, ISO22000, and more
From this point of view it is necessary to monitor the crucial process in maintaining the focus on their performance, such as: washing and cleaning machinery and equipment, lubrication and oil change, monitoring and diagnostics, security checks, replacement of machinery and equipment, the possibility of monitoring and assessment, effectiveness analysis, internal and external maintenance planning, spare parts control, restoration of damaged parts, check-ups and more.

Maintenance a basic logistics in industrial systems in terms of their ability to work, and in terms of meeting the requirements of environmental protection and sustainable development in general.
Maintenance a multidisciplinary set of indirect (preparatory) and direct (executive) activities to predict, prevent and eliminate failure of machinery and equipment in order to achieve an optimal level of effectiveness of the system.

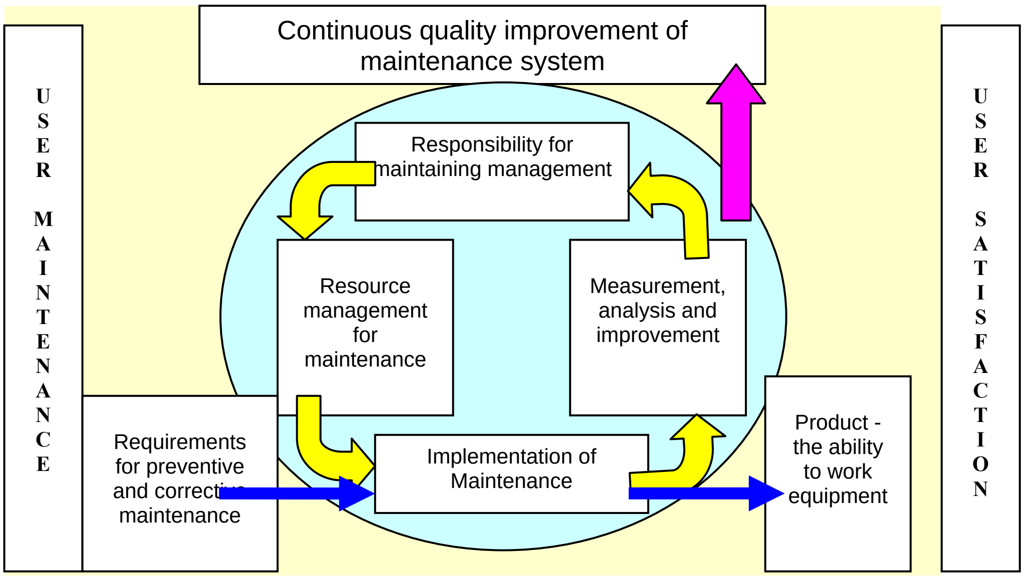


Figure 3. The process model in maintenance quality management requirements

Maintenance as a process model (Figure 3) acne is caused by the multiple roles that each of them has its place in the standard ISO 9000 and in the standard ISO 14000, and in terms of sustainability[1]:

a. **Maintenance as the main activity of production**

When the process is the maintenance of main production activity of then results in a final product companies.
Then maintenance has a fundamental responsibility to protect the environment and sustainability.

b. **Maintenance production activities as logistics companies**

Then participate in the maintenance of environmental protection with dual responsibility:

- secondary - when its function prevents the technological equipment that threatens the environment (piping, pumps, motors, gearboxes, crushers, mills, furnaces and many others) and
- *primary* - when its function in the technological system maintains operational equipment that prevents pollution (filters, sedimentation tanks, separators, collectors, filters, etc.).

c. **Maintenance its own production and development functions**

Then maintain a fundamental role in protecting the environment as a potential producer of equipment for environmental protection as its servicer.

d. **Leaning of such basic services.**

In this case it appears as a maintenance repairman and takes a secondary role in protecting the environment.
The primary role of user equipment for environmental protection.

CONCEPT AND DEFINITION OF CLEANER PRODUCTION

Cleaner production is a preventive approach
This approach aims to meet human needs without endangering lives or the integrity of ecosystems.
The main goal of cleaner production (Fig. 4) is to focus on the prevention or reduction of waste and inefficient use of energy and resources.

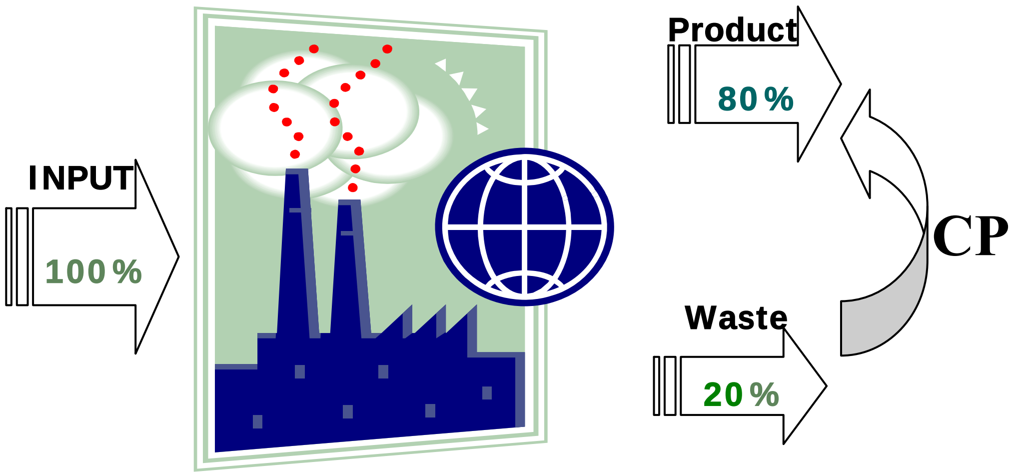


Figure 4. Terms of cleaner production

In fact, cleaner production can be written as:

- Reduce the amount of waste, or avoiding the production of the same;
- More efficient use of energy and resources;
- Production of environmentally friendly products and services;
- Produce smaller amounts of waste, lower costs and higher profits;

CONCLUSION

Sustainable development is a process of change in which the exploitation of resources, the orientation of technical development and related activities in a particular mutual compliance, which increases the possibility of meeting the needs and expectations of current and future generations
Sustainable development seeks to create a better world, putting the balance of social, economic and environmental factors.
Strategy for sustainable development of the EU has a significant impact on policy-making at all levels of development, requires an integrated and balanced approach that maximizes integration important economic, social and environmental aspects.
Steady growth in industrial production in developed countries has led to a tightening of environmental protection, the use of energy and natural resources, and waste disposal, where the logistics of manufacturing systems is a set of actions that implements the requirements of sustainable development.
Maintenance functions has an impact, especially as a significant logistics of manufacturing processes, on a wide range of environmental aspects of internal character (immediate impact in the narrow area of its operations) and external activities (direct and indirect influence in the wider environment), depending on whether the maintenance logistics or the main production process of the company.

REFERENCES

[1] Bulatović M., Funkcija održavanja procesa u upravljanju zaštitom životne sredine (Maintaining the process of environmental management), Svjetski dan kvaliteta 2003, Beograd 2003.
[2] Publikacije: Poslovni svijet u održivom razvoju 2002. god., Svjetski poslovi savjet za održivi razvoj, (www.gesi.org).
[3] Pešić, R., Održivi razvoj, Ekonomika životne sredine i prirodnih resursa, Tema 1, 2009.
[4] WEB areas: www.bbnet.org.yu/bdnet/development/htm,

THE DEVELOPMENT OF THE ELECTRIC BRAKE MODEL ON STAND FOR TESTING THE RELIABILITY OF AGRICULTURAL CARDAN SHAFTS

Aleksandar Ašonja[1], Živoslav Adamović[2], Radojka Gligorić[3], Aleksandar Pastukhov[4], Danilo Mikić[1]
[1]The Serbian Academic Center, Novi Sad, Serbia
[2] University of Novi Sad, Technical Faculty "Mihajlo Pupin" Zrenjanin, Serbia
[3] University of Novi Sad, Faculty of Agricultural, Novi Sad, Serbia
[4]Agricultural Academy named after "V. Gorin", Faculty of Engineering Belgorod Region, Belgorod, Russia
e-mail: aleksandar.asonja@gmail.com

Abstract: This paper presents a developed model of the electric brake for testing the reliability of agricultural cardan shafts. The aim of this study was to allow testing of all types of agricultural cardan shafts and other mechanical power transmission by projecting the electric brake on the stand. The electric brake on the stand is used to simulate the loads during reliability tests of agricultural cardan shafts. The total power of electric brake is 6 kW, and the load itself, which allows the brakes can be regulated in the range of 0-6 kW.
This paper will describe in details the work of electric brake and all its components, especially the most important part of DC load control system.
Key words: the electric brake, the cardan shaft, the stand, the reliability

INTRODUCTION

There are a large number of different construction of laboratory stands for testing the reliability of cardan shafts today. All laboratory stands can be divided into two groups: devices that work on the principle of closed flow power, and devices that work on the principle of an open flow of power [3]. The laboratory stands of American company MTS and German company Schenck ate the best known in the market [8]. For devices that work on the principle of closed flow power the main feature is the low power, needed for drive and very complex system with a large number of working elements, while at devices that operate on the principle of open flow forces the main attributes is a great power needed for drive and great deal of heat to all of the braking system relieves [9].
For all laboratory tables the brake mechanisms are in use, that can be, electrical, hydraulic etc. The simplest solution for testing the reliability of the agricultural cardan shaft for laboratory stand was definitely mechanical brakes, but given the time of the study and the amount of heat that develops between the rotor and the brake pads, respectively, continuing need for cooling mechanism and the replacement of brake pads, dropped from the design and implementation of this type of brake [4, 7].

MATERIAL AND METHODS

Electric brake model, "EK" type 3/28 is projected and manufactured for the purpose of testing the reliability of mechanical power transmission in laboratory-test stand, model: "ANA", type: 23-26-26-04, which is primarily intended for reliability testing of agricultural cardan shaft, however, it can be used to test other cardan shafts and other mechanical power transmission. By appropriate adaptation of foreign elements, it is possible to set up on laboratory stand any power transmitter and perform the required tests (diagnostic, tribological, efficiency, durability, etc.). [6].

RESULTS AND DISCUSSION

The developed model of laboratory stand on which is installed electric brake EK 6/28, is shown in figure 1 with a closed protective fence, in fig.2 with open protective fence.
By adaptation of elements for connection to a driving machine with one hand and electric brake on the other hand, it is possible on laboratory stand, except agricultural cardan shaft, perform tests and other types of power transmission (chain, belt gear, box, friction, etc.)., of course, with the limit of transmitter dimensions and with fulfill the range of loads.

Figure 1. The laboratory stand with a closed protective fence

Figure 2. The laboratory stand with a open protective fence

The basic elements of the laboratory stand (fig.3), to which is installed electric brakes are: 1 steel construction (base) of laboratory stand, 2 main electrical control box with power supply and electric load control system, 3 drive (electric motor) 4 gears on the drive belt area, 5 bearing units on the first additional shaft, 6 the first auxiliary shaft, 7 batteries, 8 the laboratory cardan shaft, 9 DC generator, 10 reservoir units on the second auxiliary shaft 11 second auxiliary shaft, 12 belt conveyors at brake part, 13 regulation system load, 14 manual control of the generator excitation DC and 15 control lamp excitation DC generator. On the schematic drawing, there is omitted the protection system stand and system with mobile stop button because of simplicity of showing [1].

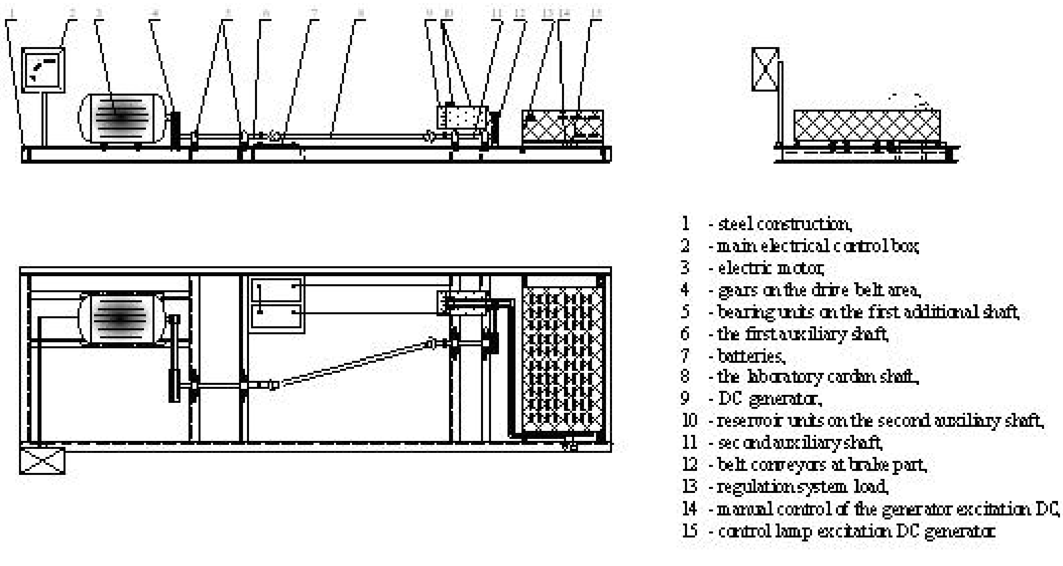


Figure 3. The schematic view of the laboratory stand - "ANA" for testing the reliability of cardan shaft

Electric brake model "EC", type 6/28 is designed for the use of test reliability of cardan shaft on a laboratory stand, consisted of: an DC generator (180 A, 28 V, Bosch), a system for controlling the load of 0-6 kW and two consumers (60 A battery 24 V). Electrical scheme of elements connection on electromagnetic brake on the laboratory stand is shown in fig.4 [2].

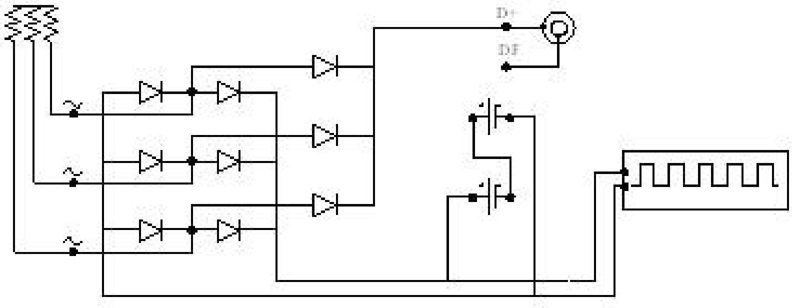


Figure 4. The electrical scheme of electromagnetic brake on laboratory stand

For the purposes of regulation of the electrical load brake, respectively, on the DC, was projected a system for the regulation of DC load of 0-6 kW, 28 V so-called "DC Load Bank", specially for this examinations, fig.5. Rheostats installed on a system for the regulation of the load consists of three clay pipes, which are located on each tube separately by 2 kW load (1 kW + 1 kW). On load control system to control the voltage and current values are set digital DC voltmeter 0-50 V and 0-200 A DC ammeter. The aim of this presentation values of voltage and current is accurately settings of desired strength at the end of the shaft and its calculation through equation 2. Dimensions of the device for controlling DC loads are 700x450x250 mm and a weight of 22 kg. The device was fabricated for a special needs for laboratory stand, by the world's best known company for production of variable resistors, the Chinese company Shenzhen Zenithsun Electronics Tech Co., LTD. - Zenithsun International (Hong Kong) Group Limited, headquartered in Shenzhen-in. Total time required for manufacturing the device was 42 days.

Figure 5. System for controlling DC loads 0-6 kW, 28 V

On system for the regulation of certain load is applied brake torque value, ie. load torque output shaft (combined involvement of one or more switches). Size of the electrical input power is obtained by direct reading of voltage and current values of the digital display on the control system for the load, so that fine adjustments can be made on the device on the potentiometer voltage. Voltage of the DC generator is not constant, but may change in the optimal range of 0÷32 V. The set of load control switches installed three of: 1 kW, 2 kW and 3 kW, and the direct involvement of one of these switches, or by their combination (two or three switches) can be set specific values of 0-6 kW load. For the purpose of presenting the parameters of the load, we will show examples of getting power to the brake of 2 kW, 3 kW and 4 kW, so that the values produced by the voltage and current readings on the consumer and according to equation 1 and 2 are calculated values of electrical resistance and strength, table 2.

Table 2. The values of electric current and voltage regulation system for loading and actual values obtained power on the brake

The starting power required (kW)	Voltage (V)	An electric current (A)	The electrical resistance (Ω)	The actual value of the force on the brake (W)
2	28,2	71	0,40	2.002,20
3	28,6	105	0,27	3.003,00
4	28,5	140	0,20	3.990,00

$$R = \frac{U}{I} \quad (\Omega), \tag{1}$$

$$P = U \cdot I \quad (kW), \tag{2}$$

where:

P - power (kW),
I - electricity (A),
U - voltage (V) and
R - electrical resistance (Ω).

The total power of the device for controlling the load is 0-6 kW, and nominal voltage of 28 V DC. The device can be regulated to work with loads of 0-6 kW, with three levels of load (1 kW, 2 kW and 3 kW). Fans and digital meters are powered by alternating current at 220 V. This type of device is mainly intended for testing loads on specially designed laboratory stands, however, it can also be used for other purposes if they satisfy the characteristics of its durability. Electrical resistance of the device can hold the same value and the high values of the ambient temperature.

CONCLUSION

After spending more than 1.000 hours of work, testing the reliability of cardan shaft, performed on a laboratory stand, where the load is given by electric brake, it can be concluded that this technical solution of electric brakes EC 6/28 is: functional, safe (both for the operators so and environment), reliably, sustainable and technically simple solution.. There are many examples in practice that some machines and mechanisms are very original technical solutions, however, problems arise because of their insecurity for operators and the environment, when it breaks can not be repaired (or because of the inaccessibility of the place of failure or because of lack of original spare parts for replacement) etc. So far developed models of electric brakes on the principles generator DC on laboratory stands were not able to develop greater strength than 1 kW, while the brakes on this model received optimal peak power of 5.04 kW [5].
The main deficiency of testing device is substantially higher energy required for testing.

ACKNOWLEDGEMENT

The work was done as part of the project: *"Improving the quality of tractors and mobile systems in order to increase competitiveness, soil conservation and environmental protection"*, which is financed by Ministry of Education, Science and Technological Development. Project Number TR031046

REFERENCES

[1] Ašonja, A., Adamović, Ž., Gligorić, R., Pastukhov A.G., Mikić, D. (2012). Technical Solution: an Electric Brake for Load Simulation and Testing of the Mechanical Power Transmission, Model: "EK", Type 6/28, the Serbian Academic Center, Novi Sad.
[2] Ašonja, A., Adamović, Ž., Gligorić, R., Pastukhov A.G., Mikić, D. (2012). Technical Solution: Laboratory Stand for Testing the Reliability of Agricultural Cardan Shaft, Model: "ANA", Type: 23-26-26-04, Serbian Academic Center, Novi Sad.

[3] Ašonja, A., Gligorić, R., Desnica, E. (2011). The Developed Model of Experimental Table for Testing the Reliability of Agricultural Cardan Shafts, I International Conference Process Technology And Environmental Protection (PTEP 2011), 138-141, 7th December, Zrenjanin, Serbia.

[4] Ašonja, A., Mikić, D., Stojanović, B., Gligorić, R., Savin, L., Tomić, M. (2012). Examination of Motor-Oils in Exploitation at Agricultural Tractors in Process of Basic Treatment of Plot, Journal of the Balkan Tribological Association, No.3, Vol.18.

[5] Milošević, D., Adamović, Ž., Ašonja, A. (2012.) System Reliability in Energetics, The Association of Intellectuals for the Development of Science in Serbia - ”The Serbian Academic Center”, Novi Sad.

[6] Ašonja, A., Adamović, Ž., Gligorić, R, Mikić D. (2012). The Development of Laboratory Stand Model for Testing the Reliability of Agricultural Cardan Shaft, XXXV Conference "Business Communication and Production Engineering", No.76, June 1-2 2012, Vrnjacka Banja.

[7] Desnica, E., Letić, D., Gligoric, R., Navalušić, S. (2012). Implementation of information technologies in higher technical education, Metalurgia International, Vol.17, No.3, pp.76-82.

[8] Ерохин М. Н, Пастухов, А. Г. (2008). Надежность карданных передач трансмиссий сельскохозяйственной техники в эксплуатации, Белгородская государственная сельскохозяйственная академия, Белгород. (In Russian)

[9] Пастухов, А.Г., Глигорич, Р., Ашоня, А.Н. (2012). Стендовые испытания - механизм оценки качества, XVI международная научно - производственная конференция, «Инновационные пути развития АПК на современном этапе», No.148, 14-16 мая 2012 года, Издательство Белгородской ГСХА, Белгород. (In Russian)

THE VALIDATION OF CHARACTERISTICS OF ROTATIONAL EXCAVATOR EFFECTIVENESS

Slavica Prvulovic[1], Zhetcho Kalitchin[2]
[1] Technical faculty, "Mihajlo Pupin", Zrenjanin, Serbia,
[2] SciBulCom Ltd., P.O.Box 249, 1113 Sofia, Bulgaria
e-mail: prvulovicslavica@yahoo.com

Abstract : In this paper is presented system reliability and disposability of system components. Then is given the review of preventive replacement: at constant durability and at constant date, as one of procedures of preventive maintenance, that is performed with the aim to increase functionality safety of technical systems.
Key words: Management; System; Maintenance, Rotational Excavator

INTRODUCTION

Development of technology and technics , in the beginning of the second half of the twentieth century was connected with all more complex machines and units. Significant progress is made in encreasement of lifespan for essential components, but it usually was not followed by adequate encreasement of lifespan for system units [1, 2]. Known is the fact that unit from which is required functionality of all its parts, has ever less reliability then any of its parts. In certain cases complexity of units and systems has advanced at high speed. With this has not adequately been increased lifespan expected from usage of essential components with longer lifespan [3, 4].
Generally adapted reliability definition is that it presents probability that an element will act without failure to a certain extent in certain surrounding conditions [5, 6]. Often is given quantative demand for technical reliability, for certain equipment, as for example: MTAM, mean time among mistakes, or probability for work without mistake during defined time [7]. With production encreasement, but also population encreasement after 2000 year, one can expect crises in quantity of food, raw materials and energy. On the basis of it, activity should be directed to investigation of better use of work results and to manufacture products that are: reliable in work, easily repaired and longer used [8, 9].

MATERIAL AND METHOD TESTING

During a certain period of time the stoppages and failures of the excavator SR_S 470 x 14/2 were being monitored and recorded.
The results of these machine stoppages and failures of the excavator, [10, 11] are given in the table 1.

Table 1. Machine stoppages and failures of the excavator SR_S 470 x 14/2

DATE	STOPPAGE - FAILURE	Stopage hours (h)
22. 01. 2010.	fitting apron for receiving belt conveyor of the excavator	7
02 – 05. 02. 2010.	repairing of the couple for lifting the mast of the working wheel and replacement of beiaring on the idler	82,30
07. 02 2010.	repairing of damage to the bunker of the working wheel	4
11. 02. 2010.	planned standstill- service	11
24. 02. 2010.	planned standstill- service	11
30. 03. 2010.	oil installation cleaning	3
01. 04. 2010.	bucket teeth replacement and back stay welding on the buckets	6,15
08. 04. 2010.	oil pump replacement	8,50
06. 04. 2010.	fitting of the caterpilar track pin	2,20
10. 04. 2010.	service	5,50
26. 04. 2010.	the colling drum on the receiving belt conveyor broken	9
05. 07. 2010.	dropping off of the sealing gum in the incoming bunker	2
07. 05. 2010.	service	4,15
20. 05. 2010.	welding of the buckets and eye plates on the rear stay	3,05

22 – 23. 05. 2010.	bursting of the hose for unloading mast	19,05
30 – 31. 06. 2010.	damage of the bearing for the working wheel	45,15
01 – 13. 06. 2010.	damage of the bearing for the working wheel (repairing)	294
19. 06. 201010	bucket replacement	3,15
10 – 13. 07. 2010.	caterpillar plate broken (replacement)	71,20
14. 07. 2010.	machine control for lifting and lowering of the first excavator operater	3,30
15. 07. 2010.	filling up oil into the reducing gear of slewing and R.T	2,25
21. 07. 2010.	fitting of rolls on the discharging belt conveyor and adjusting of the receiving belt conveyor	6
18. 07. 2010.	adapting of the receiving belt conveyor and tightening of discharging belt conveyor	3,15
28. 07. 2010.	welding of the sides on the discharging conveyor	3
02. 08. 2010.	torn upron for receiving of the mid- drum (replacement)	4,40
03. 08. 2010.	fitting of the sealing gum holder in the receiving buker	3,20
03. 08. 2010.	repairing of the sloping board holder	3,15
10. 08. 2010.	replacement and adapting of the broking mechanism of the working wheel	2,20
11. 08. 2010.	lach of oil and filling up oil into reducing gear of the working wheel	3,10
11. 08. 2010.	fitting the sides of the working wheel	2
13. 08. 2010.	bunker machine repairing of the working wheel	2,15
15. 08. 2010.	coupling failure of the working wheel (replacement of little gums)	5,10
17. 08. 2010.	planned standstill (oil replacement and welding of eye plates)	3,10
20 – 21. 08. 2010.	loosening of the board girders for the working wheel	18,30
28 – 30. 08 20105.	welding of the sealing apron holder in the receiving bunker of the working wheel	3,25
31. 08. 2010.	frontal apron replacement in discharging hopper	5,40
04 – 08. 09. 2010.	filling up oil into reducing gear of the working wheel	5,10
05. 09. 2010.	adapting the pin of the back and returning stay, welding eye plates and buckets replacement	21,20
29. 09. 2010.	damage, replacement and control of rolls	2,20
30. 09. 2010.	planned machine stadnstill	2,30
07. 10. 2010.	replacement and drawing out of windscreen wiper	7,40
08. 10. 210.	oil machine control in the working wheel reductor	20,30
14. 10. 2010.	filling up oil and oil control in the slewing reductor	3,25
16. 10. 2010.	working wheel reductor control	3,05
16. 10. 2010.	adapting of the working wheel back stay	2
22. 10. 2010.	bearing damage of working wheel incoming shaft	36
28. 10. 2010.	adapting of apron in mid - bunker	2
10. 11. 2010.	eye plate welding on the bucket in working wheel	2,55
22. 11. 2010.	machine failure and turn control (dense oil in reducing gear because of low temperatures)	5
02. 12. 2010.	poor oil pressure of working wheel reductor (installation cleaning and reductor filtering of the working wheel)	11

RESULTS AND DISCUSSION

In view of that, in the table 3 are established the indicators for the reliability of the excavator. There are also given the formulas for calculation.The results from the table 2 connected with reliability and intensity of the excavator failure are given through reliability diagrams of the figure 1 and the diagrams of failures intensity, of the figure 2.

Table 2. The reliability indicators of the rotational excavator SR_S 470 x 14/2

	THE RELIABILITY INDICATORS				TECHNICAL SYSTEM: Excavator SR_S 470 x 14/2						MASTER PAGE	
Ordinat number	Work period	Number of failures	Failures Frequency	Unreliability	Reliability	Failures intensity	Mean time "in work"	Mean time "in failure"	Operative readiness	Mean time of repair duration	Maintenance facility	System effectiveness
	T_i [h]	N_i	$f=N_i/\Sigma N_i$	$F=\Sigma f_i$	R=1-F	$\lambda= f / R$	T_w[h]	T_f[h]	G_r	T_r [h]	P_f	$E=G_r \cdot R \cdot FP_f$
	1	2	3	4	5	6	7	8	9	10	11	12
1	100	0	0	0	1	0	300	2	0,990	1	$e^{-\lambda \cdot T}$	0,970
2	200	1	0,175	0,175	0,825	0,212	500	3	0,990	2	$e^{-0,212 \cdot T}$	0,800
3	300	4	0,070	0,245	0,755	0,093	400	5	0,990	4	$e^{-0,093 \cdot T}$	0,730
4	400	4	0,071	0,315	0,685	0,105	200	4	0,980	3	$e^{-0,105 \cdot T}$	0,658
5	500	5	0,087	0,403	0,597	0,146	900	1	0,999	0,5	$e^{-0,146 \cdot T}$	0,580
6	600	6	0,105	0,507	0,490	0,214	800	8	0,990	6	$e^{-0,214 \cdot T}$	0,475
7	700	8	0,140	0,647	0,350	0,400	1000	10	0,990	8	$e^{-0,400 \cdot T}$	0,310
8	800	9	0,158	0,805	0,190	0,810	1500	6	0,996	5	$e^{-0,810 \cdot T}$	0,286
9	900	10	0,175	0,820	0,180	0,970	2000	4	0,998	3	$e^{-0,920 \cdot T}$	0,262
10	1000	10	0,178	0,821	0,179	0,990	3000	6	0,998	4	$e^{-0,980 \cdot T}$	0,240

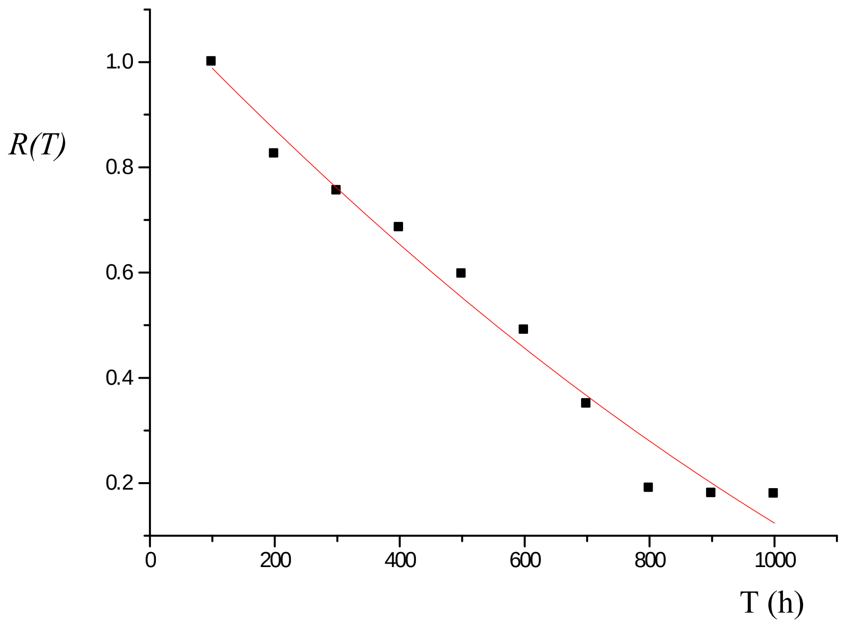


Figure 1. The reliability diagram R(T)= 1,110 – 0,0012 T + 2,598 T^2

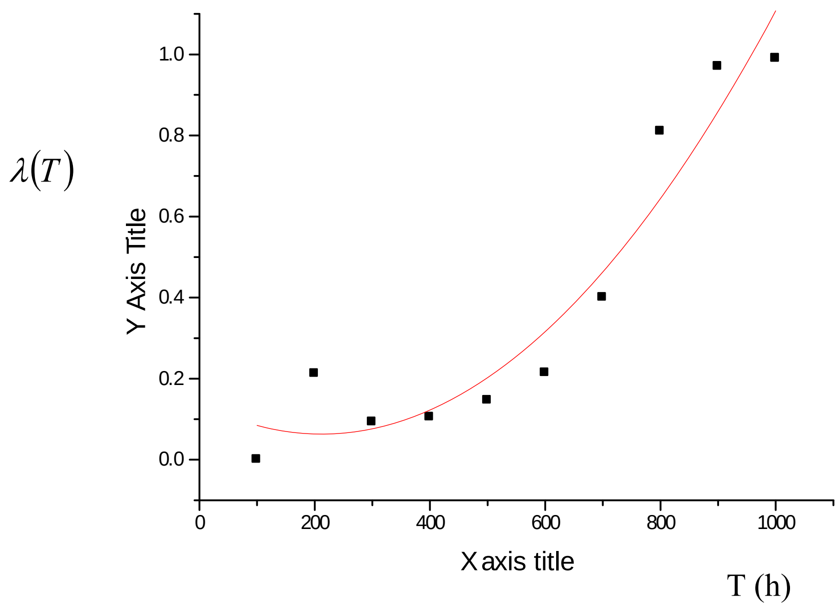


Figure 2. The failures intensity diagram $\lambda(T)$ = 0,139 – 7,158 T + 1,684 T^2

On the basis of the presented results, we can say that with increasing the period of time for work, the system reliability decreases, figure 1, but the failures intensity increases, figure 2.

CONCLUSION

At determing technical reliability one needs to perform distribution of demands for technical reliability of equipment among main elements that compose it. Complexity of each main element of equipment may be determined on the basis of earlier experience with similar types of equipment. After that, it is possible to determine average quantity of mistake per Pert for each main element Baldin[2], Tolmac[7], Prvulovic [10].

At optimization of reliability level one should take into consideration also consequences of system unreliability, i.e loses in production due to system unreliability. System unreliability costs, and excessive increase of reliability is wastefulness of time, energy and raw materials.

General aim should not be increase of efficiency at any price. The essential problem is that man should be protected, secure and he would work easier. The notion of welfare reliability, with which man satisfies his needs, and as his need to work has with it also a human components.

System price and reliability are mutually dependant, so that greater reliability undertakes more expensive system and vice versa. At growth of reliability rate, the costs connected with failures decrease, and they are named maintenance costs. These costs relate, besides maintenance, to replacement and to consequence that appear due to production decrease.

REFERENCES

[1] Adamovic, Z., Todorovic, J., Jevtic, M. ,Maintenance Organization, OMO, Belgrade,1998.
[2] Baldin, A., The Manual for the Maintenance of Industrial System, OMO, Belgrade (in Serbian), 1979.
[3] Adamovic, Z. , Maintenance Technology, Technical Faculty “ Mihajlo Pupin”, Zrenjanin (in Serbian),1996
[4] Maynard, H.B. , Industrial Engineering, Economic Review, Belgrade,1974.
[5] Tolmac, D. , Machines and Appliances, Technical Faculty “ Mihajlo Pupin”, Zrenjanin (in Srbian),1998.
[6] Lambic, M. , Engineering and Innovations, Technical Faculty “ Mihajlo Pupin”, Zrenjanin (in Serbian), 1995.
[7] Tolmac, D., Lambic, M. , Projecting of System Reliability and Maintenance, X International Conference Industrial System, FTN Novi Sad (in Serbian),1996.
[8] Prvulovic, S., Analisy of energetics caracteristics of pnaumatics dryer from aspect of method convective drying development, Master thesis, Technical Faculty “ Mihajlo Pupin”, Zrenjanin (in Serbian), 2001.
[9] Adamovic, Ž., Radovanovic, Lj., Hydraulics and Pneumatics, Technical Faculty “ Mihajlo Pupin”, Zrenjanin (in Serbian), 2005.
[10] Prvulović, S., Tolmač, D., Radovanović, Lj., Metode provere ispravnosti tehničkih sistema na PK »Kostolac« postupcima tehničke dijagnostike, Časopis Tehnička dijagnostika, Društvo za tehničku dijagnostiku Srbije, »TEHDIS«, 2005. br.3-4, str.54-58.
[11] Tolmac, D., Projecting of technological- technical systems, Technical Faculty “Mihajlo Pupin”, Zrenjanin (in Serbian), 1999.

APPLICATION OF THE METHOD OF THERMOGRAPHY IN DIAGNOSTICS OF POWER PLANTS

Božo Ilić[1], Živoslav Adamović[2], Ljiljana Radovanović[2], Branko Savić[3], Nenad Stanković[3]
[1]Technical School Centre Zvornik, Republika Srpska, BiH
[2]University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
[3]Higher Education Technical School of Professional Studies in Novi Sad, Serbia
e-mail: bozoilic66@gmail.com

Abstract: When exploitation of power plants there can occur malfunctions which, if not recognized and repaired timely, can lead to some more significant failures and accidents, therefore, even to unplanned interruptions in supplying of consumers with electric power. Due to that fact, within the programme of preventive maintenance we perform regular thermographic investigations of power plant elements. In this paper we presented a new approach to establishing the place of malfunctioning by thermographic method based on determination of the way, mechanism and direction of heat spreading, as well as the analysis of temperature profile, which indicates that the place of overheating does not always neccessarily represent the place of malfunctioning, as well. The results obtained by this approach showed very high correlation with the results obtained by electric U-I method measurement of contact resistance of connection points.
Key words: method of thermography, power plants, assessment of thermal conditions, heat transfer, places of overheating.

INTRODUCTION

The main task of power plants is to provide consumers with a continual supply of electric current. In order to achieve this task, it is necessary to provide a reliable functioning of power plant elements which is also achieved by regular thermographic investigations. Thermographic investigations can be applied in all the cases when the malfunctions are manifested by deviation of the temperature of the observed object from normal working temperature. In that way the conditions for the repair of malfunctioning in the most favorable moment are created, which prevents the occurrence of more significant failures and accidents, as well as unplanned interruptions in supplying of consumers with electric current [1].
Special convenience of such investigations lies in the fact that they are performed without a direct physical contact with the investigated elements; actually, the investigations are carried out from a fully safe distance. These investigations are carried out under voltage, during normal power plant functioning, without disturbances and switch-off of normal power plant functioning, by which one of the prerequisites for obtaining reliable investigation results is fulfilled. Thermographic investigations are classified into non-destructive methods of investigations, which means that they have no influence on the observed elements which function normally during and after the investigations [2], [3].
In this paper we presented the results of a new approach to establishing the place of malfunctioning of power plant elements by thermographic method based on the determination of the way, mechanism and direction of heat spreading, as well as analysis of temperature profile. Among other things, the results indicated that the places of overheating do not always necessarily represent also the places of malfunctioning, on which occasion we investigated connecting terminals of conductive insulators energy and current measuring transformer in a power plant 35/10 [*kV*].

CRITERIA FOR THE ASSESSMENT OF THERMAL CONDITIONS OF POWER PLANT ELEMENTS

In order to correctly assess the thermal condition of certain element, actually assess whether that very element is overheated, it is necessary to know its normal working temperature, load, temperature of the environment, etc. Normal working temperature of the element is the absolute temperature of that

element. It depends on the load and environmental temperature and is always higher than the environmental temperature. Establishing of the place of overheating is mainly performed by a comparative method which is based upon mutual comparison of the temperature of the elements with the same characteristics (they are made of the same material, they have the same surface conditions, same colour, etc.), and which are exposed to the same load and same environmental conditions, all which contributes to evading the influence of the environment on the results of the measurements. In that way, it is obligatory to determine the referential element for which the element with the lowest temperature of all the given elements was chosen; actually, the referential element is always the correct element. Each element that is being overheated more than the referential one is called the place of overheating, and the temperature difference between that element and the referential one is called overheating. In three-phase systems we compare the temperature of the same elements which are in different phases, and which are exposed to the same load [4]-[6].
Since there are no international standards according to which on the basis of the degree of overheating thermal condition of power plant elements can be assessed, in these investigations we applied the criteria established on the experience of “Infrared Training Centre”, the greatest world company for training in the field of thermography. According to these criteria on the basis of the degree of overheating, the class of thermal condition of elements (“A”, “B” or “C”) should be determined, and then diagnostic recommendations on maintenance activities which are to be undertaken should be adopted, as presented in Table 1 [1].

Table 1. The criteria according to which on the basis of degree of overheating we determine the class of thermal condition of elements (“A”, “B” or “C”), and then adopt diagnostic recommendations on maintaining activities that should be undertaken.

The degree of overheating ΔT [^oC]	The class of thermal condition of elements	Diagnostic recommendations on maintenance activities that should be undertaken
$\Delta T > 30\ [^oC]$ or $T > 80\ [^oC]$	A	Urgent intervention is necessary
$5\ [^oC] \leq \Delta T < 30\ [^oC]$	B	Intervention during the first power plant switch-off is necessary
$0\ [^oC] \leq \Delta T < 5\ [^oC]$	C	It is necessary to follow up the condition and plan the intervention

The mentioned criteria refer to nominal load current of elements. However, if the current load at the moment of thermographic imaging is less than nominal, then the measured degrees of overheating are also lower than those that could be present in nominal current load [7]. Due to that fact, in cases like those it is necessary to calculate the overheating that the elements could have in nominal current load, and then establish the class of thermal condition of that element, which is performed according to the relation:

$$\Delta T_n = \Delta T_m \left(\frac{I_n}{I_m} \right)^2 \quad [^\circ C] \tag{1}$$

where:

I_n [A] – nominal current of elements
I_m [A] – current through element at the moment of thermographic imaging
ΔT_n [^oC] – the degree of overheating which the observed element could have in nominal current load
ΔT_m [^oC] - the degree of overheating of the observed element in current load that was present at the moment of thermographic imaging.

Also, the mentioned criteria refer to uncovered connections, like tensile, suspension and support terminals, connecting terminals of all the devices (disconnectors, circuit brakers, measuring and energetic transformers, cable heads), etc. Establishing of the place of overheating within the device is a more complex process, because it is necessary to know great number of factors, like the construction of the device, some possible directions of heat conduction from the inside to surface of the device, etc.

During the determination of the place of overheating it is necessary to know that in some cases the places of overheating do not necessarily represent also the places of malfunctioning, because the overheating of fully functional places can occur due to heat conducting (by conduction, convection or radiation) to them from the places of overheating which at the same time also represent the places of malfunctioning. Regardless of the fact that the places of overheating do not always represent also the places of malfunctioning, it is positive that the existence of the very overheating indicates that there are present certain malfunctions which are necessary to be repaired [8]-[10].
The causes of the occurrence of power plant element overheating can be different, like for example bad connection points (loose contact surfaces (for example, those that occur due to loose screws), then mechanically damaged (for example, cracked), corroded (for example, because of connection points made of different metals), dirty, burned connection points with present traces of welding between contact surfaces, etc.), overload, asymmetrical load, higher harmonics of current, eddy currents, as well as heat conduction performed by conduction, convection or radiation to those elements from the objects of the environment [11].

USED EQUIPMENT AND DESCRIPTION INVESTIGATIONS

Thermographic imaging were performed with type FLIR Therma CAM SC640 thermographic camera, of 640×480 pixel resolution, spectral range from 7,5 to 13 [μm] and temperature range from -40 to +1500 [^oC], divided into three intervals of ± 2 [^oC] precision from the defined minimal focal distance of $24^o \times 18^o/0.3$ [m] and image frequency of 30 [*Hz*]. Since a part of the investigation was performed in an open space, we paid attention to atmospheric conditions, due to the fact that they can significantly influence the results of the investigations. Wind, rain and snow significantly influence the cooling of power plant elements, and during hot summer days power plant elements could be heated up to extremely high temperatures due to intensive sun radiation. The investigations were performed under favourable atmospheric conditions, in spring, in dry and cloudy weather, at atmospheric temperature of 4, i.e 2 [^oC] and 0,8 [*m/s*] of wind speed, in which way we evaded their significant influence on the accuracy of measurement results.
To determine if the load was symmetric in all stages, the curent was measured with ammeters connected through curent transformers. The temperature of the surrounding structures and the atmosphere was measured with the thermometer, the wind speed with the anemometer, and contact resistances of circuit terminals and ropes by *U–I* method through the ammeter and voltmeter in non-voltage state, while removing detected irregularities in the facility.
In order for thermographic camera to reduce to the minimum different influences of the environment on measurement results and automatically calculate the accurate height and temperature distribution on the surface of the observed element, prior to our imaging in camera software we adjusted the values of the following parameters of the observed power plant element and its environment: emission factor of the observed element, the distance of camera from the observed element, the temperature of the surrounding objects, atmospheric temperature and relative air humidity, as presented in Table 2.

Table 2. The values of parameters of the observed power plant elements and their environment which have been adjusted in camera software prior to the imaging.

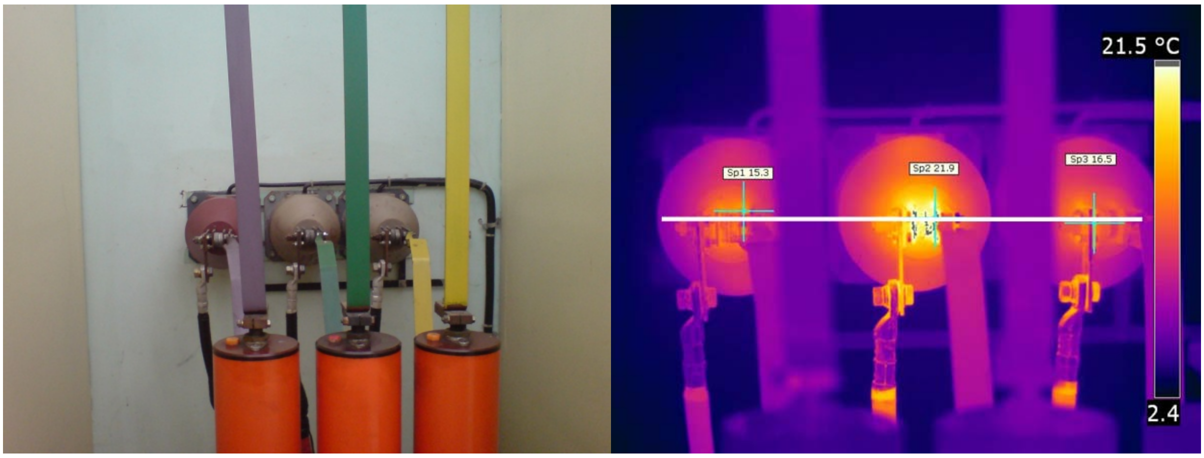
Imaged element	Emission factor	The distance of camera from the observed element	The temperature of surrounding objects [^oC]	Atmospherc temperature [^oC]	Relative air humidity [^oC]
Conductive insulators energy transformer on a 10 [*kV*] side	0,82	5	4	4	60
Current measuring transformer on 10 [*kV*] side	0,78	3	7	7	50

THE RESULTS OF THE INVESTIGATIONS

As a result of thermographic imaging, we obtained photographic and thermographic images of the conductive insulators on a 10 [*kV*] side of energy transformer, as well as of current measuring transformer on a 10 [*kV*] side, which we presented in Figures 1 and 2, respectively.

a) b)

Figure 1. Photographic and thermographic image of conductive insulators energy transformer on a 10 [*kV*] side



a) b)

Figure 2. Photographic and thermographic image of current measuring transformer on a 10 [*kV*] side

In Table 3 we presented results of the investigations; the values of nominal I_n and measured I_m currents through individual elements, then the values of absolute temperatures of individual elements T_i, the temperatures of referential elements T_{ref} and the degree of overheating $\Delta T_m = T_i - T_{ref}$ which those elements had during load at the moment of thermographic imaging, as well as the degree of overheating which those elements could have in nominal current load ΔT_n calculated according to the relation (1) and Table 1determine the classes of thermal element conditions determined separately for each phase.

Table 3. Results of the investigations.

Investigated element	Phase	I_n [A]	I_m [A]	T_i [°C]	T_{ref} [°C]	ΔT_m [°C]	ΔT_n [°C]	Class of the thermal state of the element
Connections endings of conductive insulators with the energy transformer windings on 10 [kV] side	L_1	800	781	10,9	10,9	-	-	ref. el.
	L_2	800	782	11,2	10,9	0,3	0,3	C
	L_3	800	781	33,6	10,9	22,7	23,2	B
Connecting terminal of current measuring transformer on 10 [kV] side	L_1	800	781	15,3	15,3	-	-	ref. el.
	L_2	800	782	21,9	15,3	6,6	6,9	B
	L_3	800	781	16,5	15,3	1,2	1,2	C

ANALYSIS THE RESULTS OF THE INVESTIGATIONS

After the conducted thermographic imaging, we performed the analysis of the obtained thermographic images on the basis of which we determined the places and causes of malfunctions and we also recommended some measures that the maintaining service should undertake in an optimal time period in order to repair the noted malfunctions [4].

The analysis of thermographic images was performed on the computer with the installed Thermal CAM Researcher programme package, specially developed for diagnostic purposes and scientific researches. It enables a more detailed analysis of thermographic images; actually, it enables that in thermographic images we can easily notice the points with maximum and minimum temperature values, as well as their mutual distribution and dependence. As a result of thermographic image analysis, this programme makes a drawing, table, temperature profile and histogram in adequate parts of programme windows or directly in a thermogram. It is also possible to obtain the values of absolute and relative temperatures in relation to previously defined referential temperature [5].

On the basis of Figure 1 and Tables 1 and 3, it is possible to establish that thermal condition connections endings of conductive insulators with the energy transformer windings on 10 [*kV*] side is such that the connection point in phase L_1 is correct for which reason it was chosen to be the referential one; the connection point in phase L_2 is of „C“ class of thermal condition which means that there is a need for a follow up of its condition and planning of an intervention, and the connection point in phase L_3 is of “B” class of thermal condition which means that there is a need for an intervention during the first power plant switch-off. When we carefully analyze thermographic image, actually determine the way, mechanism and direction of heat spreading, we can conclude that connection bus and conductive insulator overheating in phase L_3 is not the consequence of a bad connection point condition, but the consequence of a heat conduction by conduction, to the that connection point with connections endings of conductive insulators with the transformer windings on 10 [*kV*] side in phase L_3, for which reason it is necessary to check up the quality of that connection point during the intervention that it is necessary to check the quality of the rope that connects the winding transformer with ending of conductive insulators. This can also be noted if in Figure 3 we observe temperature profile along the line drawn in thermographic image along the length of the conductive insulators transformer 10 [*kV*] side in all three phases; actually, it can be seen that the temperature connection place endings of conductive insulators with the transformer windings on 10 [*kV*] side (the point with the highest temperature in the diagram) is higher than the temperature of connection bus and conductive insulator in phase L_3, which indicates that there occurred the transmission of heat from that connection point to the connection bus and conductive insulator.

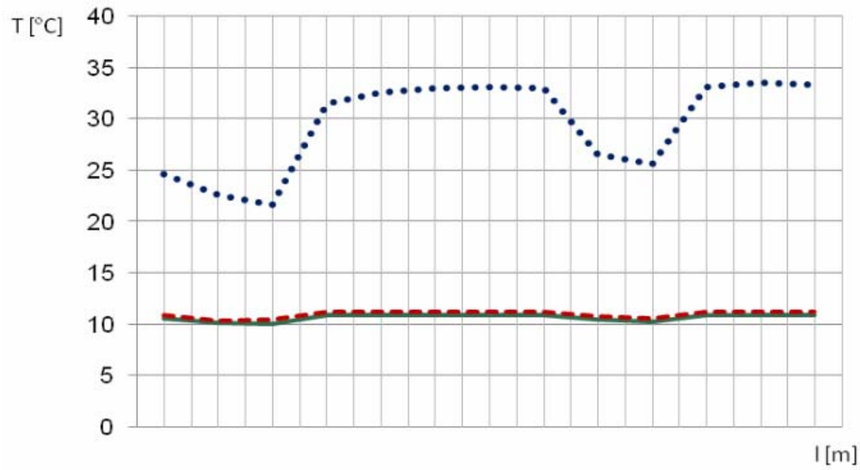


Figure 3. Temperature profile along the line drawn in thermographic image along the length of the conductive insulators energy transformer 10 [*kV*] side in all three phases, full green line referring to the L_1 phase, broken red line referring to the L_2 phase, and the dotted blue line to phase L_3

Also, analogous to previous analyse, on the basis of Figure 2 and Tables 1 and 3, it is possible to establish that thermal condition of connecting terminals of current measuring transformer on 10 [*kV*] side is such that the terminal in phase L_1 is correct for which reason it was chosen to be the referential one; the terminal in phase L_2 is of "B" class of thermal condition which means that there is a need for an intervention during the first power plant switch-off, and the terminal in phase L_3 is of "C" class of thermal condition which means that there is a need for a follow up of its condition and planning of an intervention. However, when we carefully analyze thermographic image, actually determine the way, mechanism and direction of heat spreading, we can conclude that connecting terminal overheating in phase L_2 of ΔT_m = 6.6 [^oC] is not the consequence of a bad connection point condition, but the consequence of a heat conduction by conduction, convection and radiation to the very terminal from close distance of connection place bus, primary of current measuring transformer and current bridge for overriding the transforming ratio, for which reason it is necessary to check up the quality of that connection point during the intervention. This can also be noted if in Figure 4 we observe temperature profile along the line drawn in thermographic image through connecting terminals of current measuring transformer on 10 [k*V*] side; actually, it can be seen that the temperature of connection place bus, primary of current measuring transformer and current bridge for overriding the transforming ratio (the point with the highest temperature in the diagram) is higher than the temperature of connecting terminal of current measuring transformer in phase L_2, which indicates that there occurred the transmission of heat from that connection point to the connecting terminal.

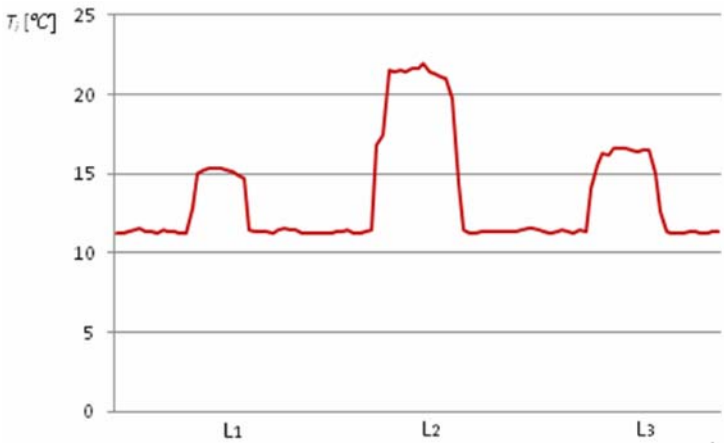


Figure 4. Temperature profile along lines drawn in thermographic image through connecting terminal on of current measuring transformer on 10 [*kV*] side

It is known that due to bad connection points their contact resistance is increased which leads to the occurrence of Joule heat losses ($Q=RI^2t$ [*J*]), as well as their overheating. Therefore, by measuring of contact resistances of connection points we can determine the quality of the very connection points and the cause of their possible overheating [1]. Because of that, aiming at checking up of the results of thermographic investigations, we performed measurements of contact resistance of connection points by the application of electric *U–I* method; we applied the connection point with current and voltage terminals suitable for measurements of low resistances. After reading the measured values of voltage *U* and current *I* , we calculated the values of contact resistances of connection points according to the relation $R=U/I$ [*mΩ*]. The results of the calculated values are presented in Table 4.

Table 4. The results of the calculated values of contact resistances of connection points [*mΩ*]

Investigated element	Phase	Calculated values of contact resistances of connection points [*mΩ*]
Connections endings of conductive insulators with the energy transformer windings on 10 [*kV*] side	L_1	1,347
	L_2	1,345
	L_3	4,658
Connecting terminal of current measuring transformer on 10 [*kV*] side	L_1	1,348
	L_2	1,346
	L_3	1,349

Analyzing the obtained results in Table 4, it can be concluded that increased contact resistances in relation to referential terminals are present only connection ending of conductive insulator with the energy transformer winding on 10 [kV] side in phase L_3 for more than 3 [*mΩ*], for which on the basis of thermographic investigations it was also established to have bad connection points. For connection bus and conductive insulator transformer on 10 [*kV*] side in phase L_3 and connecting terminal of current measuring transformer on 10 [*kV*] side in phase L_2 we measured no increased contact resistances in relation to referential terminals, which means that their connection points are good, confirming the accuracy of the results of thermographic investigations which showed that the overheating of these places were the consequence of heat transmission onto them from other places. The other terminals were overheated due to bad connection points. In this way we showed a very good correlation of the results of power plant elements investigation with the results obtained by *U-I* method of measuring contact resistance of connection points.

CONCLUSION

The results of the conducted thermographic elements investigations of power plant 35/10 [*kV*] showed that there existed certain malfunctions of some of the elements. Since some of the malfunctions required an urgent repair, we performed power plant switch-off in the most favourable moment for the purpose of repairing the malfunctioning, which was also used for the repairing of malfunctions which were not that urgent. On the occasion of repairing of the noted malfunctions by the application of electric *U-I* method, we performed the measuring of contact electric resistance of connection points of connecting terminals and established that only the of connection points which proved to be malfunctioning (i.e bad ones) had increased contact resistances in relation to referential (functional) of connection points. In that way, we confirmed the accuracy of the new approach in establishing the place of malfunctioning based on determination of the way, mechanism and direction of heat spreading, as well as analysis of temperature profile which proved that places of overheating do not always represent also the places of malfunctioning. When removing detected defects and visual inspection it was noted that these compounds are in poor condition. Also, immediately after our performed interventions on repairing of the noted malfunctions, we repeated our thermographic investigations. Their results showed that there were no places of overheating, which also proved that the results of the thermographic investigations were accurate, as well as that all the noted malfunctions present prior to the investigations had been repaired. It is positive that the greatest advantage of thermographic investigations is the establishing of malfunctions in the initial phase of their occurrence. In that way, by undertaking adequate maintaining activities in the most favourable moment, we create conditions for preventing further failures and accidents, therefore also the expenditures they may cause. That is also the way we secure the functioning of a power plant without delays, or with the least possible delays, especially of those planned ones, because delays, mostly unplanned ones can cause great expenditures. Besides, delays can also lead to some further damages of other power plant parts that can jeopardize the safety of people. Therefore, these regular thermographic investigations, which represent a part of the programme of preventive maintenance, serve for reaching a higher reliability of power plant functioning, improving safety of workers at work, reducing maintenance expenditures (through decreasing of maintenance activities and more optimal planning of maintenance activities etc.). Actually, maintenance becomes more economical and of higher quality, and the reliability of providing the consumers with electric current is elevated to a higher level.

REFERENCES

[1] Kutin, M., Adamovic, Z., Tensile features of welded joint testing by thermography, Russian Journal of Nondestructive Testing, 2010, Vol. 46, No 5, pp. 368-393.

[2] Ilic, B., Automatized diagnostic methods and their influence on the reliability of technical systems, PhD thesis (in preparation)

[3] Brkic, R., Adamovic, Z., Research of defects that are related with reliability and safety of railway transport system, Russian Journal of Nondestructive Testing, 2011, Vol. 47, No 6, pp. 420-429.

[4] Adamovic, Z., Ilic B., Savic B., Jevtic, M., Thermography – a reliable diagnostic method, Pan Book, Novi Sad, 2011.

[5] Song, J. H., Noh, H. G., Akira, S. M., Yu, H. S., Kang H. Y., and Yang, S. M., Analysis of effective nugget size by infrared thermography in spot weldment, International Journal of Automotive Technology, Vol. 5, No 1, pp. 55-59, 2004.

[6] Bertmaring, I. C., Using Thermography to Evaluate the Effects of Arm Flexion and Loading on the Anterior Deltoid during a Simulated Overhead Task, Virginia, pp. 4-13, 2006.

[7] Ilic, B., Adamovic, Z., Radovanovic, LJ., Savic, B., Stankovic, N., Thermographic investigations of power plant elements, Proceedings/5th International Symposium on Industrial Engineering – SIE 2012, June 14-15, 2012, Belgrade, Serbia; organized by Industrial Engineering Department Faculty of Mechanical Engineering University of Belgrade and Steinbeis Advanced Risk Technologies Stuttgart, Germany. Publisher Faculty of Mechanical Engineering University of Belgrade pp. 291-296. (ISBN 978-86-7083-758-4)

[8] Park, J.H.; Lee, C.C., A new configuration of nematic liquid crystal thermography with applications to GaN-based devices, IEEE Transactions on Instrumentation and Measurement, Volume: 55 , Issue: 1 2006 , Page(s): 273 –279

[9] Rongqian Yang; Yazhu Chen, Design of a 3-D Infrared Imaging System Using Structured Light, IEEE Transactions on Instrumentation and Measurement, Volume: 60, Issue: 2, 2011, Page(s): 608 – 617

[10] Ummenhofer, T., Medgenberg, J., On the use of infrared thermography for the analysis of fatigue damage processes in welded joints, doi: 10.1016/j.ijfatigue. 2008. 04. 005, 2008, International Journal of Fatigue, Vol. 31, 1, 2009, pp. 130-137.

[11] Zarkovic, M., Stojkovic, Z., Automation of thermographic procedure for monitoring and diagnostic of transmission network elements, Infoteh-Jahorina, Vol. 11, march 2012.

ROTATING EQUIPMENT VIBRATION DIAGNOSTICS IN FUNCTION AN EARLY FAULT DETECTION AND MALFUNCTION PREVENTION

Đorđe Latas[1]
[1]"GRANINA NNS" Belgrade, Serbia
e-mail: grad.nns@eunet.rs

Abstract: This paper represents information on vibrodiagnostics. Vibrodiagnostics provides an early fault detection and malfunction prevention. In that way, unplanned stagnation in the production is avoided, and that can be economical. With the analysis of the vibrations spectrum, by knowing the certain characteristics of the machine we can have a detailed image of the machine operation failures and take up the measures for its secure operation.
Key words: vibrodiagnostics, detection, malfunction, stagnation, prevention, production

INTRODUCTION

Vibrodiagnostics (measurement and analysis of vibrations) is one of the most effective and widely applicable methods of technical diagnostics. Mechanical vibrations represent a plant's response (reaction) to the influence of disturbance forces (unbalance, misalignment, looseness). The presence of mechanical vibrations in operation affects significantly the shortening of the lifetime of components, and eventually it can lead to fatigue of material and damage of plants.
Intense technological development in the past decade has enabled the development of modern diagnostic tools and the development of new diagnostic methods that contribute to a more precise and reliable diagnosis of the condition.
It is generally considered that the lower level of vibration means a better state of a plant. It may not always be true. The occurrence of cracks on the rotor or a turbo aggregate's rotor blade failure can lead to a reduction in the overall level of vibration, which does not mean that the state of the plant has improved.
Following one parameter, in this case the amplitude of the vibration, we are not able to carry out quality control and the referred case would remain unnoticed.
For quality supervision of performance, a number of vibration parameters should be monitored and analyzed:

- vibration amplitude (of displacement, velocity or acceleration)
- spectral diagram (frequency condition)
- phase angle

In recent years, new diagnostic techniques have been developed, such as: Enveloped acceleration, SEE (Spectral Emission Energy), HFD (High Frequency Detection).

VIBRATION MEASUREMENT

General characteristics of vibration

A mechanical vibration implies oscillatory motion of a rigid body compared to the equilibrium position. The cause of this movement is the disturbing (coercive) force. The vibrations that occur only while the disturbing force is acting are called coercive, whereas the vibrations that exist even after the exposure to these forces are called free. The general characteristic of this movement can be expressed by a harmonic time function. The basic parameters that describe this trend are: Frequency, Amplitude, The speed of oscillation, Acceleration.

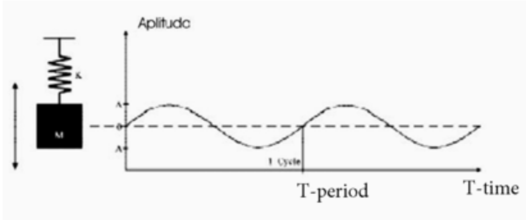


Figure 1. Oscillatory motion of a rigid body

In practice, complex oscillations obtained by the superposition of two or more fundamental vibrations almost always occur. Since each vibration originates from different components, in order to identify the causes, it is necessary to perform frequency_distinction and the intensity of each of them, which is achieved by Fourier transformation.

Any periodic signal can be broken down into a sum of sinusoidal components, which can be presented by Fourier series.

$$x\,(t) = \frac{a_n}{2} + \sum (a_n \cos 2\pi n f\ 1t + b_n\ \sin 2\pi f_1 t)$$

In a complex form:

$$x(t) = \sum_n A_n\ \ e^{\int 2\pi f_1 t} \qquad\qquad A_n\ = \frac{1}{T} x\ (t) e^{-\int 2\pi n f_1 t dt}$$

Coefficients of A_n series_are called harmonics and they represent integer multiples of the fundamental frequency f_0.

In the case of non-periodical signals the following relations are taken:

T→ ∞	1/T→ 0	→	A_n is continual function of f	→	Summary operator Integration operator	→	Fourier's series_i Fourier's integral

X (f) – Fourier's transformation of magnitude x (t) (complex quantity)

Measurement

The largest and most important part of technical diagnostics refers to the measurement and analysis of mechanical vibrations. The term mechanical vibrations refers to vibrations on the surface of machines or their structural elements. Vibrations are caused by the oscillatory motion (rotary or translatory) of machine components or by the working fluid shock in the casing.

To detect vibrations, it is necessary to measure one of three magnitudes (they can be translated one into another by mathematical operations):

The importance of measurement and analysis of vibrations lies in the fact that they contain a large amount of information about a machine performance. Mechanical vibrations are an indicator of machine condition and provide a basis for the diagnosis and troubleshooting on machines. All parameters of mechanical vibrations (displacement, velocity and acceleration) are tools to analyze the dynamic state of the plant. Display of amplitude, frequency and phase angle is applied to the shaft vibration measurement in relation to machine case bearing and vibration measurement on the case. According to the movement of a given structure in relation to outer space, dynamic vibration measurements can be divided into: absolute and relative.

Measuring absolute vibrations is applied to a number of different machines (electric motors, pumps, fans, small compressors, mills). Velocity and acceleration are measurement parameters of absolute vibrations. Typical vibration measurements of critical facilities (turbine plants, huge compressors) include measurements of shaft displacement compared to the case of the bearing. The amplitude of vibrations brought back the best parameter for evaluating the quality of a plant's performance because it directly measures the dynamic behavior of the rotor. These measurements often take place on the machines with plain bearings.

ANALYSIS OF THE RESULTS OF VIBRATION MEASUREMENTS

Vibrodiagnostic equipment

Equipment that allows obtaining information about the state of the machine based on vibration analysis is vibrodiagnostic equipment and it includes: Vibrometers, Vibroanalyzers, Systems for continuous monitoring.

All modern appliances of the world's leading manufacturers of vibrodiagnostic equipment are projected according to ISO 10816 standards, so the alarms in these devices are set at the value of this standard.

Vibrometers

Vibrometers are the basic units of monitoring equipment. The units provide indications for early warning about the violation of the equipment, overloading of individual components, problems in the lubrication system. Using them, we can measure condition parameters: the overall level of vibration, bearing condition and temperature. Due to low cost and simplicity in use, vibrometers are suitable for monitoring the "standard" equipment. Using the appropriate software we can store measurement results, analyze and identify trends.

Vibroanalyzers

Vibroanalyzers are devices that allow the establishment of a comprehensive and periodic monitoring program of mechanical equipment. The main difference compared to vibrometers is ability to analyze the cause of the problem (FFT - spectrum) and the correction of imbalances on the spot.

The choice of measurement points

Measurement points are positions on the machine where vibrations are measured. Measurement points are usually bearing housing or parts of the structure that sufficiently replicate the intensity and the character of the dynamic forces present in the plant performance.

The dynamic behavior caused by vibrations on a measurement point is defined by measurement values of three mutually perpendicular directions. When testing a machine, measurements are carried out in all directions as shown, whereas when monitoring the condition of the machine during operation, measurements are usually carried out in a radial direction.

Spectral Analysis

Spectral analysis is a very effective tool in diagnosing the condition of machines and plants. The recorded frequency spectrum of vibrations for rotating machinery shows increased vibrations on some frequencies (frequency peaks) and the analysis of these peaks and their comparison with the frequency of rotating machine parts (basic frequency, and integer multiples of fundamental frequency) shows the condition of mechanical equipment. Low frequency components (peaks) occur as a result of:

- imbalance of rotating parts,
- misalignment or a bent shaft
- lack of attachment to the frame,
- mechanical backlash,
- damaged belt-transmission
- oil vortex
- electrically induced vibrations.

High frequency components (peaks) occur as a result of:

- ill and injured bearing,
- bad and damaged gear transmission.

Vibration level is evaluated according to the RMS values of vibration velocity in accordance with ISO 10816-3. Standard has provided a real insight into the machine bearing, by following the trends of their changes. The level of vibration of gear pairs (gear) is evaluated based on the RMS value of vibration velocity in accordance with ISO 8579-2.

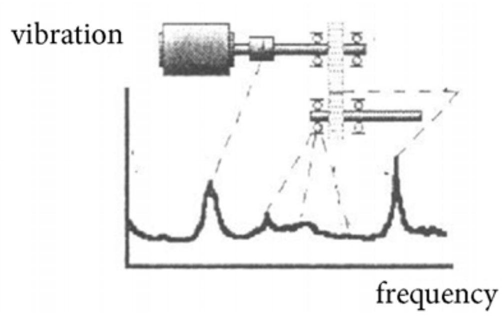


Figure 2. Vibration of rotating parts

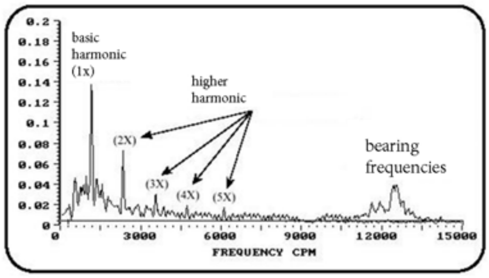


Figure 3. The bearing frequencies

Vibrations caused by bearings damage are often modulated signals. The inner ring of a bearing, ball bearing, the cage rotate so the signals are not of the same intensity so it is convenient to select the envelope from the measurement signal of vibration. The bearing condition, according to manufacturer, is determined by the "envelope" spectrum by measuring the "peak-to-peak" spectrum in gE units. This method is based on the use of signal contents at very high frequencies and low frequency components of the signal repeating damaged bearing. In determining the envelope, the measurement signal is first released through a high-frequency filter, eliminating low-frequency noise that comes from the self-oscillation structure of the machine, imbalance, etc.. The impulses occur at the same intervals, just as the physical process of transition of rolling elements over damage takes place.

INTERPRETATION OF VIBRATIONS

Guidelines for vibration determination

In Table 1 guidance for determining vibration is given to determine possible causes based on the frequency of vibration.

Table 1. Guidelines for vibration determination

FREQUENCY	POSSIBLE CAUSE	OTHER POSSIBLE CAUSES
Rotating velocity (1X)	Imbalance	misalignment curve shaft resonance eccentric shaft, pulley or sprocket force feedback electric
First harmonic (2X)	Mechanic looseness	misalignment, high in the axial direction force feedback resonance loose bearing or part
Second harmonic (3X)	misalignment (axle on axle)	Excessive axial backlash Electrical, air gap Internal misalignment Mechanical parts
Third harmonic (4X)	Fitting problem	This happens as a fitting problem, but it can also be bearing looseness Possible resonance with slower machines Mechanical part

Fourth harmonic (5X)	Mechanical part	Passing impellers with pumps Excessive backlash
Fifth harmonic (6X)	Mechanical part	Passing impellers Rotor sliding on axe (also usually present at
Less than rotating velocity 43% usually 39% - 48%	Oil turbulence	lubrication Oil-throw (whips) FTF
Half of rotating velocity 1/2X	Contact (friction)	In the sliding bearing - contact (0.01 IPS) The resonance of drive belt Driving belt Damaged machine parts
Basic frequency 60 Hz	Electric	Problems with the rotor shafts The eccentric rotor Uneven air gap Unbalanced phases Damaged insulation
Basic sync frequency 120 Hz	Rotor	Rotor resonance Pulsing moment
Higher harmonics frequencies	Gears	The wear of the teeth, look at side-band Fan speed x #blade (aerodynamic) Cavitation, drive x #circuits (hydraulic) Mechanical Parts
High frequencies NON harmonics	Bearings Lubrication	BPRI BPRO BSF FTF

The imbalance of rotating parts

1X vibration causes are imbalance, resonance, curved axle, external mechanical impacts (couplings, pulleys, etc.., machine parts, electric, eccentricity), the internal influences. The imbalance occurs at the rotation velocity and produces clean, sharp shock to 1X. It is necessary to analyze the spectrum, different point s and different positions with data on stage, and correct any errors, then perform balancing. Imbalance in vertical machines is usually the largest transversely to the flow direction. Machines mounted on their own foundation usually show more 1X vibration in the horizontal direction. When imbalance is defined as a mistake, balancing is performed on as many planes as necessary to get a smooth machine running.

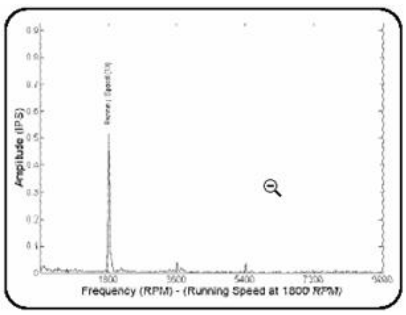


Figure 4. Typical example of imbalance

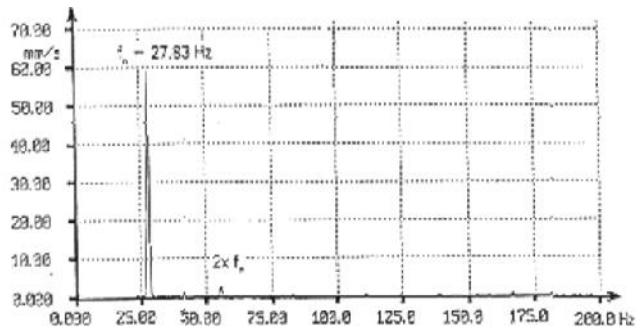


Figure 5. Distinctive basic harmonic

Misalignment

Angular misalignment - expressed in the axial direction in the vicinity of the first harmonic.
Parallel misalignment - expressed in the radial direction in the vicinity of the second harmonic.

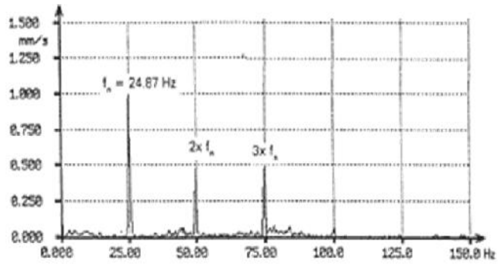


Figure 6. Angular misalignment

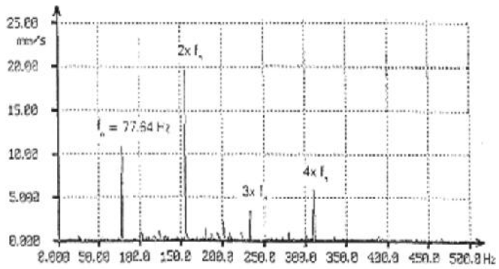


Figure 7. Parallel misalignment

Vibrations due to bearing damage

Bearing damage occurs at higher load than expected, undue or improper lubrication, careless handling, lack of sealing, or tightness is too great, causing insufficient internal backlash, etc.. Each of these factors produces its own type of damage and leaves its distinct mark on the bearing. As a result of testing a damaged bearing it is possible, in most cases, to form an opinion about the reasons for the damage and take the necessary actions to prevent a recurrence of the same damage.

CONCLUSION

Technical diagnostics provides an efficient and reliable method of measurement, analysis and assessment of a machine condition. Increased mechanical and acoustic vibration, loss of performance and the occurrence of specific problems can be identified at an early stage, the causes of such a state can be located and corrective intervention can be planned which significantly reduces the likelihood of unplanned plant failures.
By preventive maintenance, significant results in monitoring the status and trends of vibration can be achieved. The data obtained from the monitoring device help the user to avoid unplanned downtime. These devices provide current information (based on ISO 10816) of the bearing operating conditions, based on which, following the trends of their changes, we can plan the bearing replacement in the regular maintenance of the equipment. This means direct saving of time and money, also, this enables due order only of those bearings that need to be replaced.

REFERENCES

[1] Adamović |Ž, „Technical diagnostics“, Society for Technical diagnostics of Serbia, Belgrade, 2006.
[2] Kalezić M., Nikolić S., „Handbook of vibration and balancing “,Belgrade 2003.
[3] Papić Lj., „Mathematical processing of experimental data and results of test “, DQM, Čačak, 2004.
[4] Standard: ISO 10816-1/1995
[5] Standard: ISO 8579-2,
[6] Šiniković G., Master thesis: "Methods of technical diagnostics", Faculty of Mechanical Engineering, Belgrade, 2006.

SESSION 5: Design and Maintenance of Process Plants

ANALYSIS OF THE GYROSCOPIC EFFECT OF ANGLE PEDESTAL BALL-BEARING

Ljubica Lazić Vulićević[1] , Branko Pejović[2], Cvijan Žepinić[1]
[1]Technical College in Zrenjanin, Serbia
[2]Faculty of Technical Sciences, Kosovska Mitrovica
e-mail: lazic.ljubica@yahoo.com

Abstract: During rotation of angle pedestal ball bearing, ball movement can bee seen as a two-degrees-of-freedom gyroscope. Since the angular velocity of ball's own rotation is much larger than the angular velocity of its rotation around the bearing axis, it is possible to apply approximate gyroscopic theory. Based on this theory, gyroscopic moment is determined depending on the geometrical and kinematical characteristics for two cases of bearing rotation. Subsequently, the relation for determination of the friction moment, which opposes to the gyroscopic moment, is derived. The paper ends with an analysis of obtained dependencies, as well as their applicability to eliminate the unfavorable gyroscopic effects. In addition, some typical types of ball bearings are shown, where the gyroscopic effect is present.
Key words: ball bearings, angle pedestal ball bearings, ball bearings kinematics, gyroscopic effect, gyroscopic moment, friction moment.

INTRODUCTION

Gyroscopic effect occurs in many areas of mechanical engineering. Similarly, the properties of gyroscopes are used for construction of various automatic pilots, navigation instruments, as well as stabilization of ships and torpedoes in military technology. However, the effect of gyroscopes could be negative as well. An example of this will be presented in the paper, using case of certain ball bearings.
Gyroscopic effect, as shown in the paper, can have a certain effect that should not be ignored. This area of bearings theory has not been researched enough.
The aim of this paper is to determine the relationship of the gyroscopic moment and friction moment that opposes him using the case of angle pedestal ball bearings, and to analyze the obtained dependence. The possibilities to eliminate the present gyroscopic effect as well as the possibility of application of derived dependencies with other ball bearing groups will be also proposed.

KINEMATIC RELATIONS

The kinematic relations necessary for the calculation of gyroscopic moment will be determined for two characteristic cases. At the same time, rolling ball without sliding will be considered.

Bearing with fixed outer ring

Kinematical and geometric values for this case are shown in Figure 1. The velocity of the ball with diameter d_k can be expressed through its own angular velocity ω_s:

$$v_1 = d_k \cdot \omega_s \quad (1)$$

Ball center velocity (over velocity pole P) is:

$$v_c = \frac{d_k}{2} \omega_s \quad (2)$$

It follows that:

$$v_1 = 2v_c \quad (3)$$

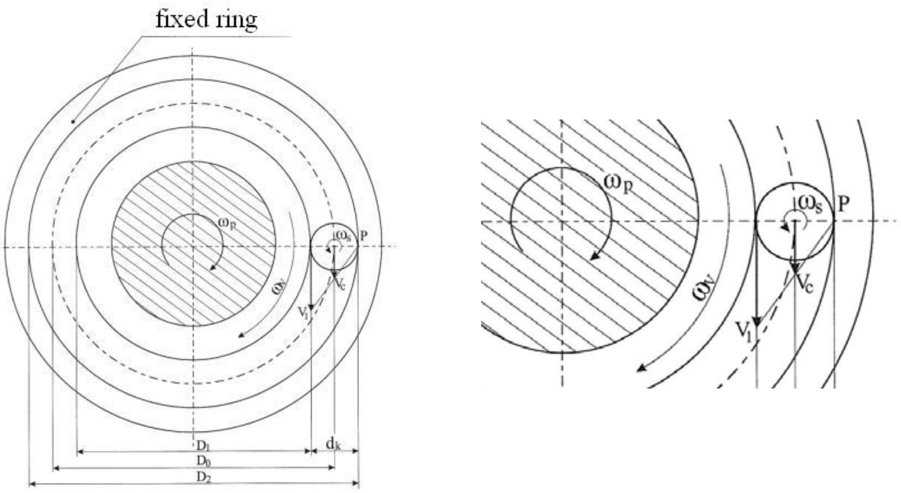


Figure 1. Kinematical and geometric values for the case of bearing with fixed outer ring

The connection between the angular velocity of the ball (round bearing axle) and the velocity of the ball centre round the axle of the shaft (bearing) can be seen here:

$$v_c = \frac{D_0}{2}\omega_p \tag{4}$$

The shaft and the bearing inner ring rotate with angular velocity ω_v, so:

$$v_1 = \frac{D_1}{2}\omega_v \tag{5}$$

From the equation (3), (4) and (5) it follows that:

$$\omega_p = \frac{D_1}{2D_0}\omega_v \tag{6}$$

Angular velocity ω_v can be expressed through the rpm of shaft $\omega_v = \frac{\pi \cdot n_v}{30}$, and diameter of the axis circle:

$$D_0 = \frac{D_1 + D_2}{2} \tag{7}$$

By eliminating $D_{0,}$, according to (6), the angular velocity ω_p will be:

$$\omega_p = \frac{D_1}{2\frac{D_1 + D_2}{2}}\omega_v = \frac{D_1}{D_1 + D_2}\omega_v \tag{8}$$

Similarly, by equalizing the equation (2) and (4) there follows:

$$\omega_p = \frac{d_k}{D_0}\omega_s \tag{9}$$

The ratio of the angular velocity ω_s and ω_p will therefore be:

$$\frac{\omega_s}{\omega_p} = \frac{D_0}{d_k} \tag{10}$$

Since $D_0 » d_k$, it follows that the $\omega_s » \omega_p$. This will be used for the calculation of gyroscopic effect in bearings by applying appropriate theories.
From the relation (6) and (9) there follows the relationship between angular velocity ω_s and ω_v:

$$\omega_s = \frac{D_1}{2d_k}\omega_v \quad (11)$$

Bearing with fixed inner ring

Geometric and kinematic values for this case are given in Figure 2. Kinematic pole is in point *P*.

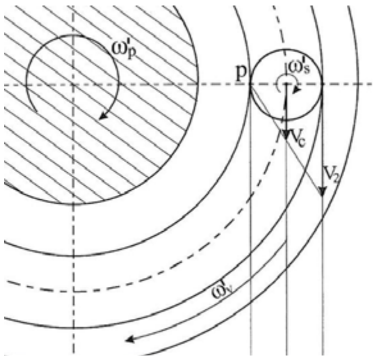


Figure 2. Kinematical values for the case of bearing with fixed inner ring

Kinematic analysis is similar to the previous case. Angular velocity of the moving outer ring is $\omega_v{}'$, while the angular velocity of ball rotation around its own axis is $\omega_s{}'$ and rotation around bearing axis is $\omega_p{}'$. Velocity on the outer ring diameter D_2, will be:

$$v_2 = d_k \cdot \omega_s \quad (12)$$

i.e. from the velocity triangle:

$$v_2 = 2v_c \quad (13)$$

And also:

$$v_2 = \frac{D_2}{2}\omega_v^{'}, \quad (14)$$

Ball center velocity can be expressed in two ways:

$$v_c = \frac{d_k}{2}\omega_s^{'} \quad (15)$$

$$v_c = \frac{D_0}{2}\omega_p^{'} \quad (16)$$

Now, according to the equations (13), (14) and (16) it follows that:

$$\omega_p^{'} = \frac{D_2}{2D_0}\omega_v^{'} \quad (17)$$

Considering that $D_0 = \frac{D_1 + D_2}{2}$, in the same way as in the previous section 2.1., there follows the dependency:

$$\omega_s^{'} = \frac{D_0}{d_k}\omega_p^{'} \quad (18)$$

$$\omega_s^{'} = \frac{D_2}{2d_k}\omega_v^{'} \quad (19)$$

DETERMINATION OF GYROSCOPIC MOMENT

In the observed case, according to relation (10), the angular velocity of ball's own rotation ω_s is much higher than the angular velocity ω_p, which is the angular velocity of precession (angular velocity of rotation around the axis of the center ball bearing and shaft). It follows that the total angular momentum vector in this case falls on the direction of the axis of symmetry, so it is possible to determine the gyroscopic moment that occurs here, to apply an approximate theory of gyroscopes, [8], [9], [10]. In addition, it is obvious that the rotation of bearing and balls is now viewed as a rotation of symmetric gyroscope that performs complex movements.

Considering that the ball performs two movements at the same time, it is obvious that this is a two-degrees-of-freedom gyroscope, [5], [7].

Due to the existence of the angle β in angle pedestal ball bearing, (Figure 3 and Figure 4), there will always be an angle between the vector of angular velocity of ball's own rotation $\overrightarrow{\omega_s}$, and the vector of angular velocity of precession, $\overrightarrow{\omega_p}$.

This will cause the appearance of gyroscopic moment $\overrightarrow{M_g}$, whose direction is determined by Zhukovsky rule, or vector product, so that the gyroscopic moment tends to bring its own gyroscope axis of rotation to coincide with the axis of precession in the shortest possible way, [6], [8], [10]:

$$\overrightarrow{M_g} = J_z \cdot (\overrightarrow{\omega_s} \times \overrightarrow{\omega_p}) \quad (20)$$

That is:

$$M_g = J_z \cdot \omega_s \cdot \omega_p \cdot \sin(\overrightarrow{\omega_s}, \overrightarrow{\omega_p}) \quad (21)$$

For the observed case and according to Figure 4b, there finally follows:

$$M_g = J_z \cdot \omega_s \cdot \omega_p \cdot \sin(180° - \beta) = J_z \cdot \omega_s \cdot \omega_p \cdot \sin\beta \quad (22)$$

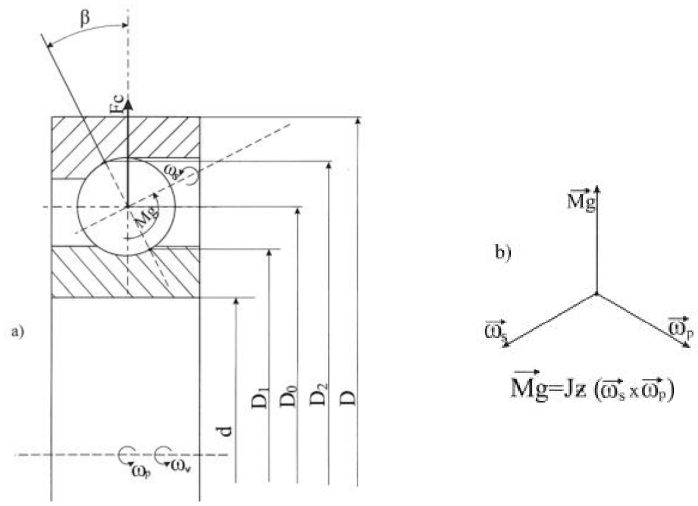


Figure 3. Determination of gyroscopic moment

Accordingly, the *z*-axis is the axis of own rotation, while the *x*-axis is the axis of precession.

In case the angular velocity ω_p has the opposite direction from the default one, the direction of the gyroscopic moment M_g, will also be the opposite.

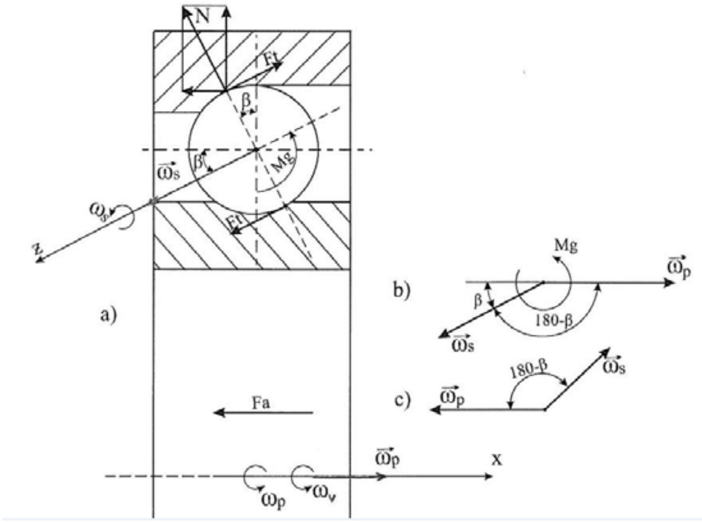


Figure 4.The gyroscopic moment and the friction moment of the ball

The moment of inertia of ball bearings for rotary axis z can be expressed through the material density and balls diameter:

$$J_z = \frac{2}{5} m \cdot r_k^2 = \frac{2}{5} \rho V \left(\frac{d_k}{2} \right)^2 = \frac{\pi}{60} \rho \cdot d_k^5 \tag{23}$$

That is:

$$M_g = \frac{\pi}{60} \rho \cdot d_k^4 \cdot \omega_p^2 \cdot D_0 \sin \beta \tag{24}$$

Considering the relation (6), according to (24), the gyroscopic moment can be expressed through the shafts angular velocity:

$$M_g = \frac{\pi}{240} \rho \cdot d_k^4 \cdot \frac{D_1^2}{D_0} \omega_v^2 \cdot \sin \beta \tag{25}$$

Similarly, using the relation (17) and (19), the gyroscopic moment can be determined for the case of bearing's stationary inner ring, according to (22): $M_g^{'} = J_z \cdot \omega_s^{'} \cdot \omega_p^{'} \cdot \sin(\overrightarrow{\omega_s}, \overrightarrow{\omega_p})$:

That is:

$$M_g^{'} = \frac{\pi}{240} \rho \cdot d_k^4 \cdot \frac{D_2^2}{D_0} \omega_v^{'2} \cdot \sin \beta \tag{26}$$

Gyroscopic moments ratio for the two considered cases, according to (25) and (26) will be:

$$\frac{M_g^{'}}{M_g} = \left(\frac{D_2}{D_1} \right)^2 \tag{27}$$

Since $D_2 > D_1$, it follows that for the same conditions the gyroscopic moment is higher for the case that the inner bearing ring is stationary. Taking into account Figure 5, it follows that relevant diameters for calculation are defined by the intersection with the normal n.

According to Figure 5, it follows that:

$$D_2 = D_0 + 2 \cdot r_k \cos \beta = D_0 + d_k \cos \beta \tag{28}$$

That is:

$$D_1 = D_0 - 2 \cdot r_k \cos \beta = D_0 - d_k \cos \beta \tag{29}$$

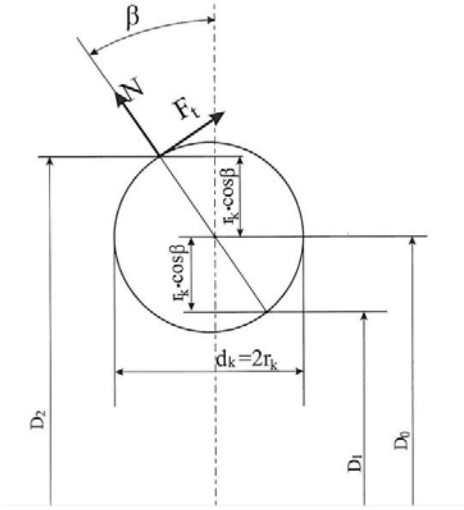


Figure 5. Determination of relevant diameters for calculation

DETERMINATION OF CENTRIFUGAL FORCE

Beside gyroscopic moment, according to Figure 3, centrifugal force F_c, also affects the ball which can be determined, [1], [2], [3]:

$$F_c = ma_n = m \cdot \frac{D_0}{2}\omega_p^2 \tag{30}$$

The ball mass can be expressed through the material density $m = \rho V = \frac{\pi}{6}\rho d_k^3$, and there follows:

$$F_c = \frac{d_k^3 \pi}{12}\rho D_0 \omega_p^2 \tag{31}$$

The centrifugal force direction is along the axis normal to the bearing axis, and it aims to move the ball away from the axis of the bearing (shaft), Figure 3

In case the outer ring is stationary, the centrifugal force can be expressed depending on the shaft angular velocity, replacing (6) in (31):

$$F_c = \frac{\pi\rho d_k^3 D_1^2}{48 D_0}\omega_v^2 \tag{32}$$

By dividing the relation (25) and (32) it is possible to establish a correlation between the gyroscopic moment and centrifugal force.

DETERMINATION OF THE FRICTION MOMENT AND THE POSSIBILITY OF ELIMINATING THE GYROSCOPIC EFFECTS

The friction moment M_t opposes to the effect of gyroscopic moment, and it has the opposite direction from M_g, as Figure 4 shows.

The friction moment of the ball can be expressed through the friction force, Fig. 4:

$$M_t = F_t \cdot d_k \tag{33}$$

The friction force of a ball is $F_t = N\mu$.

The sum of the friction forces for all balls along the x-axis (there are z) is balanced with the axial force F_a, so that:

$$N \sin\beta \cdot z = F_a$$

Now the friction moment of friction for one ball to will be:

$$M_t = N\mu d_k = \frac{F_a}{z\sin\beta}\mu \cdot d_k \tag{34}$$

Obviously, to avoid rotation of the ball there must be:

$$M_t \geq M_g \tag{35}$$

From this equivalence for $M_t = M_g$, through relations (33) and (25) the minimum axial force can be determined so that the condition (35) could be fulfilled, in case the angular velocity of shaft ω_v is known.

For the more common case in practice, when the inner ring rotates, from the $M_t \geq M_g$, if axial force F_a is known, the angular speed of shaft, where there will be no rotation of balls under the influence of gyroscopic moment, can be determined.

$$\omega_v \leq \sqrt{\frac{240 F_a D_0 \mu}{2\sin^2\beta \cdot \pi\rho d_k^3 D_1^2}} \tag{36}$$

Where the angular velocity of the shaft (through the number of shaft rotation) is: $\omega_v = \frac{\pi n_v}{30}$

APPLICATION OF PERFORMED DEPENDENCIES FOR THE OTHER BALL BEARINGS

Based on the above analysis, it is obvious that for the radial ball bearing (Figure 6) the angle between the vector of the angular velocity of its own rotation $\vec{\omega_s}$ and the angular velocity of precession $\vec{\omega_p}$ is equal to zero. It follows that there is no gyroscopic effect here. The same case is with cylindrical roller bearings.

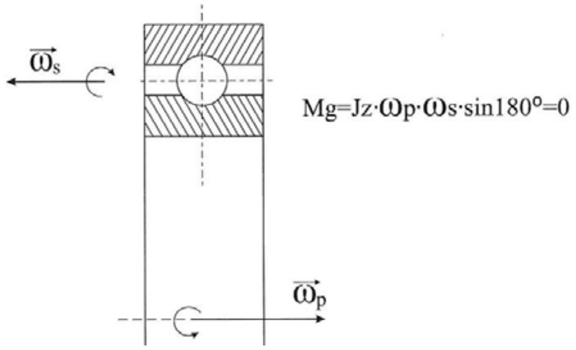


Figure 6. An analysis for the radial ball bearing

In addition, for axial ball bearings the angle between vectors $\vec{\omega_s}$ and $\vec{\omega_p}$ is π / 2, so it follows that the gyroscopic moment is, [11]:

$$M_g = J_z \cdot \omega_s \cdot \omega_p \cdot \sin\frac{\pi}{2} = J_z \cdot \omega_s \cdot \omega_p \tag{37}$$

For bearings with cone rollers, due to the angle of the cone, a gyroscopic moment also occurs:

$$M_g = J_z \cdot \omega_s \cdot \omega_p \cdot \sin\delta \tag{38}$$

Here δ is the angle between a cone roller axis and the bearing (or shaft) axis. Obviously, the angle between the vector $\vec{\omega_s}$ and vector $\vec{\omega_p}$ is equal to the angle δ.

CONCLUSION

As it is shown for angle pedestal ball bearing, there is a gyroscopic moment, which tends to turn every rolling body in a certain direction. This moment has negative influence on operation of bearings because it causes additional loads. From the derived relations it follows that the intensity of gyroscopic moment increases with the angle β according to sinusoidal law, i.e. linear with increasing diameter D_0 in which balls are placed. In addition, the gyroscopic moment increases with the square of the angular velocity ω_p (and thus the square of angular speed of the shaft ω_v), and with the fourth degree of the ball's diameter d_k.

Gyroscopic moment is slightly higher for angle pedestal ball bearing where the inner ring is stationary, than for bearings where the inner ring rotates, under the same conditions.

The effect of gyroscopic moment needs to be eliminated with the axial force of certain intensity, because the gyroscopic effect causes friction moment that opposes it.

This force can be calculated for specific cases, using a particular relation.

For axial force F_a that loads a bearing, there exists critical angular shaft (bearing) velocity ω_v, or a corresponding number of revolutions n_v, above which occurs the gyroscopic effect. This critical angular velocity can be determined for a particular bearing according to derived relation.

The effect of gyroscopic moment also occurs for axial ball bearings, as well as bearing with cone rollers. Calculation of gyroscope moment for these cases can be easily derived based on certain relationships.

For radial ball and radial roller bearings vector of their own rotation coincides with the vector of precession, and the gyroscopic moment ($\sin \beta = 0$) does not occur. For each group of roller bearings, as it can be seen, there is a certain gyroscopic effect that should not be ignored when designing and exploiting bearings in practice since some contact stresses in rolling contact areas may occur, which affects warming of the bearing.

REFERENCES

[1] Ačerkan, N. S.: Sprovočnik mašinostroitelja, Tom 4, knjiga 1, MAŠGIZ, Moskva, 1982.
[2] Dubbel, H.: Taschenbuch für den Maschinenbau, Spreinger-Varlag, Berlin, 1991.
[3] Faires, V.M.: Design of Machine Elements, The Mac Millan Comapany, New-York, 1985.
[4] Niemann, G.: Maschinenelemente, Erster Bund, Spreinger-Varlag, Berlin, 1981.
[5] Köhler, G.: Maschinenteile, Teil 1, Teubnerverlagsgesellschaft, Stuttgart, 1988.
[6] Dunajev, P. E.: Konstruirovanie uzlov i detalij mašin, Izdetelstvo VŠ, Moskva, 1996.
[7] Hall, A.S.: Schaum's Outline of Theory and Problems of Machine Design, Schaum Publishing Co., New York, 1961.
[8] Nikolai, E.L.: Teoretičeskaja mehanika, Gosud. Izd. TT literaturi, Moskva, 1997.
[9] Synge, J. L.: Classical dynamics, Springer-Verlag, Berlin, 1990.
[10] Rašković, D.: Mehanika III – Dinamika, Naučna knjiga, Beograd,
[11] Pejović, B.; Lazić Vulićević, Lj.; Žepinić, C.: Determining and analysis of the characteristic moments of axial ball-bearing, The 7th International Scientific Conference: ″Research and Development of Mechanical Elements and Systems″ IRMES 2011, Zlatibor, Serbia.

RESULTS OF RESEARCH OF CONVECTIVE DRYING

Béla Takarics[1], Imre Orban[2], Dragana Dimitrijević[3], Dragiša Tolmač[3], Jasna Tolmač[3]
[1]Computer and Automation Research Institute, Hungarian Academy of Sciences, Budapest, Hungary
[2]O&M Inzenjering group, Zrenjanin, Serbia
[3]University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
e-mail: takarics@sztaki.mta.hu, imre.orban@ominzenjering.com, tolmac@tfzr.uns.ac.rs

Abstract: The aim of this study is to present a part of experimental and theoretical researches on an industrial pneumatic dryer, in order to determine energetic characteristics, heat transfer coefficient, as well as the drying kinetics curves. Heat transfer is accomplished through convection, thanks to the principle of drying based on direct contact between the heated air and moist material. During that process, intensive heat and mass exchange take place. Based on the results of the research, the models of drying and energetic characteristics are provided.
Key words: convective drying, drying parameters, energetic characteristics

INTRODUCTION

Convective dryers with pneumatic transport of material are the type of equipment used in factories for industrial processing of grains during the drying process of powder like and fine-grained material.
These drying systems have been determined in the studies of the authors provided in the heading References under the following numbers: [1], [2, 3], [4], [6], [8]. These dryers provide continual drying of mealy materials with the concentration c_k= (0.05-2) kg material / kg air. Medium size of the particles of the dried material can be 0.05-2 mm. The velocity of the flow of the heated drying agent (air or gas) in the dryer is 10 - 30 [m/s].
The efficiency of these dryers is estimated according to the thermal degree of heat usage in the dryer, which ranges between 65 – 75%, depending on the drying system (direct or indirect drying). The amount of evaporated moisture on the pneumatic pipe is about 400 [kgH_2O/m^3h], according to the bellow given [5], [9], [11]. The time of drying in these dryers lasts only a few seconds, so the materials that stand well high temperatures in a short period of drying, for example τ= (1 - 3) s, can be dried there.
The implementation of pneumatic dryers is especially common in food processing industry in the factories for industrial processing of grains (wheat and corn processing using wet method).

CHARACTERISTICS OF THE EXPERIMENTAL PLANT

Experimental research is completed in the dryer with pneumatic transport of material, Figure 1. The dried material is the corn bran ρ=300 [kg/m^3].
The heating of the drying agents is done using heaters (1). It is accomplished in the direct contact between the warm gases and the moist material.
The dosage of the moist material in the dryer is done using rotation dosage administrator with the help of stationary crawler conveyors (2). The amount of moist material totals 9000 [kg/h], with the moist w_1=30%. The temperature of the moist material at the inlet of the dryer is t_{W1}=25°C, and the temperature of the dry material at the outlet of the dryer is t_{W2}=40°C.
The moist material is conveyed by warm air – the drying agent using pneumatic pipes of the dryer (3), and it goes into the separator (4) where the separation of the dry material is being conducted, and the warm evaporations go into the atmosphere. During that process the consumption of natural gas which is B=225 [m_n^3/h] for hating the dryer is determined. In Table 1, are provided mean values of the drying agent – warm air and moist of the dried material.

Table 1. Mean values of measuring results of drying temperature and material moisture

Measuring place, according to Figure 1	1-1	2-2	3-3	4-4	5-5
Temperature of hot air, t°C	425	342	222	155	110
Moisture of dried material, w (%)	30	22	16	14	12

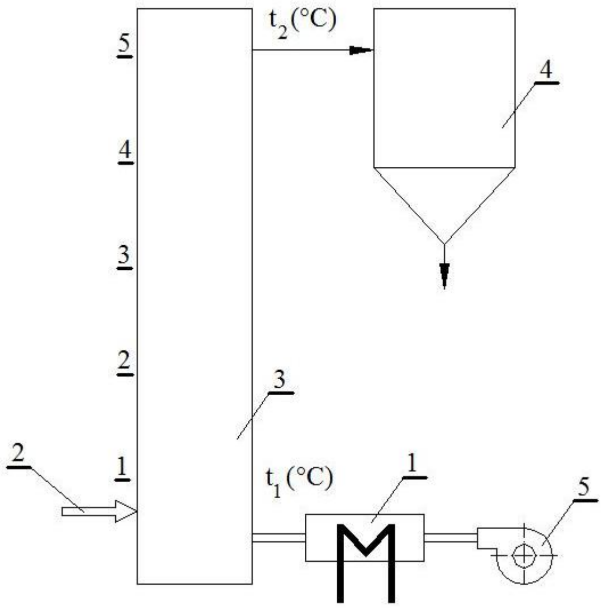


Figure 1. Scheme of experimental pneumatic dryer: 1 – heater with the heating power of Q=3.4 MW, 2 – administration of the moist material, 3 - dryer pipe with the radius d=625 mm and height h=25 m, 4 - separator, 5 - centrifugal fan V = 26000 m_n^3/h, Δp = 3500 Pa, N = 75 kW.

RESULTS AND DISCUSSION

Experimental researches conducted on an industrial dryer with the pneumatic transport of material, Figure 1, had for their aim determination of energy balance, specific energy consumption and thermal degree of utilization, as well as the drying kinetics curves [7, 8]. The results of the energy balance are given in the Table 2.

In the process of experimental drying, total drying power has been determined in relations to Q_U=2000 kW and it presents the starting data for upgrading the dryer. Mean specific consumption of energy equals q = 3920 [kJ/kg w], in Table 2. According to the references provided bellow under the numbers [2], [3], [5], [10], specific energy consumption during convective drying ranges between 3850-5000 [kJ/kg w], in similar drying systems.

Table 2. Energy balance

No.	Energy drying parameter	Symbol and measure unit	Energy value parameter
1	The quantity of evaporated water	W kg h^{-1}	1840
2	Drying heat power	Qu kW	2.000
3	Total heat transfer coefficient	k_u $Wm^{-2}K^{-1}$	310
4	Specific energy consumption	q kJ kg^{-1}	3920
5	Quantity of drying air	V_L $m_n^3h^{-1}$	17.590
6	Thermal degree of utilization	η_T %	74

For the flow of the drying agents (warm air) through the pneumatic pipe of the dryer: V = 17 590 [m_n^3/h], with the diameter of the pipe of the dryer d=625 [mm], the speed of the transport v=15.9 [m/s] is gained. Taking into consideration that the length, i.e. the height of the pneumatic pipe of the dryer is h=25 [m], the time of drying is τ= 1.616 [s].

Based on experimental and theoretical researches [7, 8], [11], the following results and correlation equations of the drying kinetics curves are derived:

$$w = 29.88 - 22.20\,\tau + 7.00\,\tau^2 \quad (1)$$

$$dw/d\tau = 30.90 + 28.67\,\tau + 7.50\,\tau^2 \quad (2)$$

$$t = 432 - 293.45\,\tau + 56.45\,\tau^2 \quad (3)$$

$$dw/d\tau = -32.35 + 4.05w - 0.074w^2 \quad (4)$$

Given empirical equations, gained on the bases of experimental researches, define in the most comprehensive way the character of the drying process.
In Figures 2 and 3, the drying curve and the drying rate curve are shown.

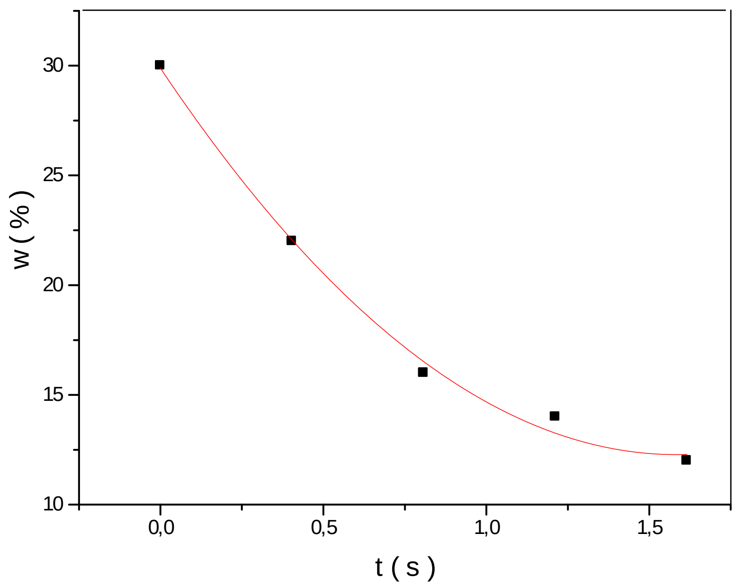


Figure 2. Drying curve

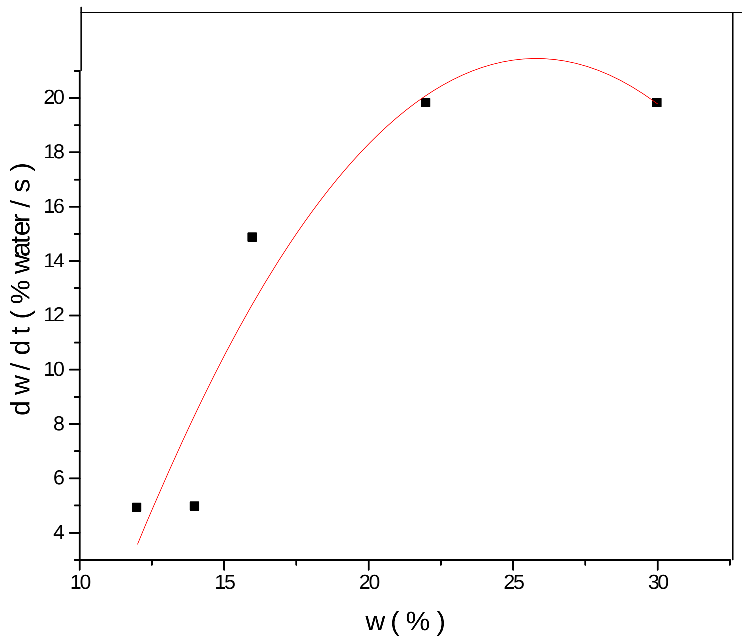


Figure 3. Drying rate curve

At the beginning of drying, the surface of the particles of the moist material is covered with a very thin layer of water, which has the same characteristics as if it were moisture free. Due to the contact between the surfaces of the particles of the moist material with the warm drying agent, starts the process of liquid evaporation. During that process the liquid evaporates faster at the beginning (the first period of drying), since it is physically and mechanically bound moisture, Fig. 2 and 3. In the second period of drying, the speed of drying falls down rapidly since it is physically and chemically bound moisture at this moment.

CONCLUSION

According to the given researches the heat energy of drying Q=2000 kW, specific energy consumption q=3920 kJ/kg of the evaporated water, and thermal degree of utilization η_T = 74 % are gained. Based on the energy balance complete heat transfer coefficient k_u=310 W/(m^2K), according to [5], has been determined. The received results of the research are based on experimental data from the real industrial dryer. Based on that, the results of the research have applicable value, i.e. they may be useful to the designers, producers and users or the same or similar drying systems, as well as used in educational purposes. Experimental and theoretical researches of the relevant parameters of the heat transfer, had also for its aim a more complete energetic description of the problems of convective drying, in order to supplement the knowledge acquired so far on these and similar drying systems.

REFERENCES

[1] Brkić, M., Somer, D.: Energy effective two passage dryer, Contemporary Agricultural Engineering, Vol. 33, No.3-4, pp.227-233, 2007.

[2] Hez, D.: Comparison of processing Economics of Different Starch Dryers, Journal of Starch/Starke, Vol.36. p.369-373, 1984.

[3] Lin, Q., Bakker - Arkema, F.: Capacity Estimation of High Temperature Grain Dryers- A Simplitied Correlation Method, Agricultural Engineering International the CIGR Ejournal,Vol. I, 1999.

[4] Prvulović, S., Tolmač, D., Lambić, M. : Determination of energetic characteristics of convection drying place on pneumatic transportation material, Journal of Process Technic*,* Vol. 1, pp.70-74, SMEITS, Belgrade, 2001.

[5] Prvuloivić, S., Tolmač, D., Lambić, M.: Convection Drying in the Food Industry, Agricultural Engineering International the CIGR Ejournal, Vol.IX, No9, 2007.

[6] Prvulović, S., Tolmač, D. : The results of the research of energy characteristics of convective drying and heat transfer model, Journal of Energetic Technologies, No.3, pp. (24-26), Serbia Solar, 2005.

[7] Prvulović, S., Tolmač, D., Lambić, M., Blagojević, Z.: Heat transfer in vertical pipe of pneumatic dryer, Journal of Energetic Technologies, No.4, pp.11-13, Serbia Solar, 2007.

[8] Prvulović, S., Tolmač, D., Lambić, M., Radovanović, Lj. : Efects of Heat Transfer in a Horizontal Rotating Cyilinder of the Contact Dryer, FACTA UNIVERSITATIS, Vol.5, No 1, pp.47-61, UDC 536.24 : 66.047, Univrsity of Niš, 2007. (ISSN 0354 – 2025).

[9] Tolmač, D., Prvulović, S., Lambić, M., Radovanović, Lj.: Energy effectiveness of convection drying, Contemporary Agricultural Engineering, No.1-2, pp.19-25. 2008.

[10] Tolmač, D., Prvulović, S. : Rationalization of energy consumption and utilization of waste heat in the corn fiber dryer, 29th International Conference of CIGR, "Rational Use of Energy in Agriculture" Procedigs, p.83-90, Olsztyn – Poland, 2007.

[11] Tolmač, D. : Systems energetic parameters for starch drying in grain industry. Journal of Energetic Technologies, No.2, pp.11-13, Serbia Solar, 2005.

[12] Tolmač, D., Prvulović, S., Blagojevic, Z. : Energy parameters for drying starch in the grain processing industry, Journal of Energetic Technologies, No, 1-2, pp. (11-13), Serbia Solar, 2005.

[13] Tolmač, D., Prvulović, S., Radovanović, Lj. : Effect of Heat Transfer on Convection Dryer with Pneumatic Transport of Material, FME TRANSACTIONS, Vol.36, No.1, p.45-49, Faculty of Mechanical Engineering, Balgrade, 2008. (ISSN 1451-2092).

[14] Webb, R.L. : Principles of Enhanced Heat Transfer, John Wiley, New York, 1994.

[15] Wiset, L., Srzednicki, G., Driscoll, R., Nimmuntavin, C., Siwapornak, P. : Effects of High Temperature Drying on Rice Quality, *Agricultural Engineering International: the CIGR Ejournal*. Manuscript FP 01 003. Vol. III. 1-10, 2001.

[16] Yiljep, Y., Fumen, G., Ajisegiri, E. : The Effects of Peeling, splitting and drying on Ginger Quality and Oil/oleoresin Content, *Agricultural Engineering International: the CIGR Ejournal.* Manuscript FP 05 009. Vol. VII. 1-18, 2005.

MECHANICAL MODELING OF INDUSTRIAL MACHINES

Danilo Mikić[1], Eleonora Desnica[2], Aleksandar Ašonja[3], Živoslav Adamović[2]
[1]Tehnical school, Gornji Milanovac, Serbia
[2]University of Novi Sad, Technical Faculty „Mihajlo Pupin", Zrenjanin, Serbia
[3]NS-Termomontaža, Novi Sad, Serbia
e-mail: vtsm@open.telekom.rs

Abstract: The paper that listed the modeling of modern industrial machines and systems with different levels of complexity that are now increasingly common to perform different processes, and concepts are the foundation of any future factories such as robots, Technological cells and the like. Also, a review of the modern mechanical modeling of complex systems, as well as some of their movements.
The base of each model, which defines the procedures for the settlement of principle, but also generally applicable mechanism, or, better yet, a suitable mathematical description of the problem, which provides a formal but also a clear and precise formulation of the problem. Consequently it can be done translating from one environment to another, in order to obtain the model. The study deals with the results of some research in this area for the models realized using the geometry of the robot mechanism with rotating (rotary) bonds, ie. For the case that the inner structure of the robot has only rotational joints, as well as those cases with translational connections. Mentioned structure of the manipulator and showed connection with the so-called. Kinematic pairs or chains.
Key words: modeling, manipulator, model, mehanics, translation, rotation

INTRODUCTION

Mechanical modeling is the process of obtaining kinematic and dynamic (mathematical) description of a phenomenon that takes place in the real world. On the other hand, this description is relatively simple, but sufficiently accurate, to meet its purpose, which is defined by the creator of the model. Application of modeling is not limited only too technical processes, but it's already used in a variety of areas. There is a virtually unlimited number of models that describe different aspects of a real phenomenon, for example, an industrial machine for handling components (robot), can be studied from different viewpoints, [3].
It can be concluded that modeling is important in all areas of technology, from the development of processes and equipment to the design and construction of the plants and in the production process, such as: research and development, design and construction, process optimization and process control equipment, [5].

MODELING SYSTEM

Model is a sample of a system and its main purpose is to facilitate the gathering of information about the actual system it represents. A good model is always a simplified pattern of system designed so that the system provides information about those properties of the system which we are most interested [4].
The method of the model is based on the fact that the real process can be broken down into a number of natural processes that can be described by certain natural laws, thus providing mechanical-mathematical description of the object being modeled. To investigate the characteristics of object modeling is necessary to solve the system of equations that make up the model and matrix rotation transformation. The solution of this system consists of a matrix size that would otherwise be able to obtain measurements on the object modeling, [1], [7].
Any process can be viewed as isolated groups of primary variables that describe a given apperance and describe the state of the system at any point in time. The characteristic parameters can be divided into two main groups: the input size and output size.
The process of developing a mechanical model that reliably describes the behavior of the object is mostly made up of the following steps [1]:

- breakdown processes in a number of elementary operations (ie, the basic operation);
- analysis of elementary (technological) operations;

- the assumptions and simplifications in the model kinematics;
- mathematica consistencyl of model;
- development of an algorithm for solving a given system of equations;
- verification of the model.

MODELING OF MECHANICAL SYSTEMS

Modeling is the process of creating a model of a system. The most widely used method for modeling the system's mathematical description of the system by using the system of equations, matrices rotational transform. Mechanical behavior of the system can be described by differential equations of second order: ((t) x - position change, (t) - a change in speed, (t) - acceleration changes over time.), [2], [3]. Behavior of a real system can be represented as the behavior of a simplified equivalent mechanical systems which are included phenomena such as friction (damping) and elasticity (vibration).

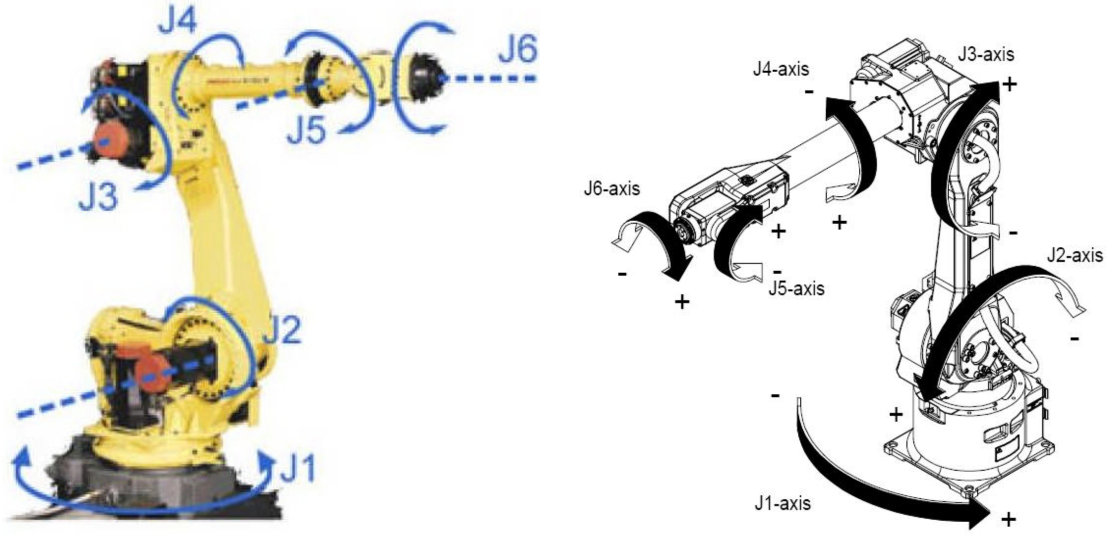


Figure 1. Schematic representation sixth axial controller assembly (robot)

Robot makes the system serially linked segments interconnected joints. Joints may be translational and rotational. Translational joints allow only rectilinear motion along the axis, rotary joints allow only rotation about the axis (Fig. 1).

Translational mechanical systems

Translation motion or translation of a rigid body is called a movement in which all points of the body and describe congruent paths have the same speed and acceleration. A typical example is a linear translation movement of the piston in the cylinder of the internal combustion engine. Translational motion of a rigid body is determined if known velocity and acceleration of a point and its because the translation of a rigid body can be seen as the movement of a point (Fig. 2b). In determining the velocity and acceleration of translatory movement of the body using the same equation as in movement points. When translating circular path with circles of equal radii, their centers are different, and all the points have the same velocity and acceleration [5], [7].

Rotational mechanical systems

Mechanical systems that are accompanied by rotation of the body (mass) around an axis called the known rotational mechanical systems. The behavior of these systems describe quantities such as θ - angle [rad], angular velocity [rad/s], angular acceleration - [rad/s^2], and apperance such as friction and elasticity, moment of inertia [7]. Rotational movement or rotation of rigid body motion is called the point at which the bodies moving in the plane, vertical to a stationary straight line, called the axis of rotation [7]. At the same point of the body describes a circle whose center lies on the axis of rotation. There are a variety of construction joints, and several simpler shown in Fig. 2.

Figure 2. Types of joints: a) rotating, b) translational, c) screw, d) cylinder, e) ball

In the image above is an example of passive joints (not driving actuators) with different degrees of freedom of movement.
Robotic arm segments are defined as rigid bodies, which are located between two adjacent joint. The system segments form the kinematic chain. Start the chain is directly related to the base, while the free end and it is a manipulator that perform technological operations. Each joint has one degree of freedom of movement, either translational or rotational, [7].
We show skeleton of a serial robot arm with six rotational joints (Fig.3), [12]. This is an example of kinematic structure, reduced motion modeling and specifications for the geometric problem of the relative motion of reference frames. Kinematics and dynamics of developing applications independent framework for modeling and computation of kinematic chains, such as robots, biomechanical human models, computer-animated figures, machine tools, etc. It provides objective geometry (point, skeleton, lines), kinematic chains of various families (serial, humanoid, parallel, mobile), and their motion specification and interpolation, [5], [7].

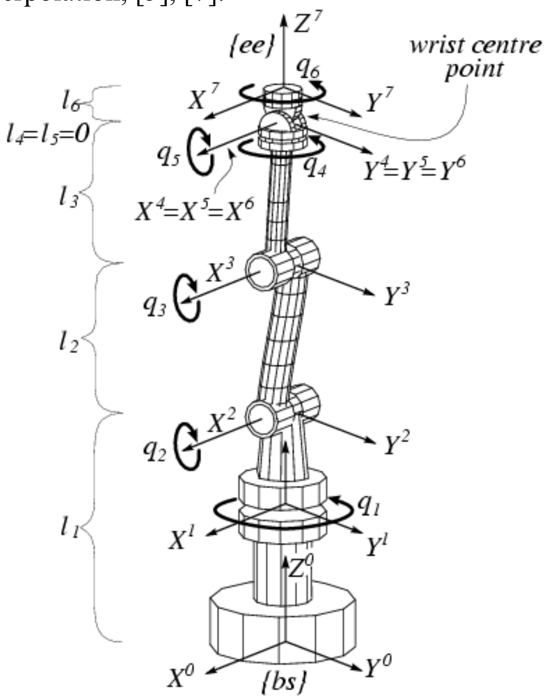


Figure 3. Kinematic Chain: Skeleton of a serial robot arm with six joints rotation

Kinematics robot arm study of geometric and temporal changes of its parameters during the motion of individual segments. Segments robotic arms perform rotational and/or translational movement relative to the reference coordinate system, and is determined for each coordinate system whose axes are placed along the axis of the joint [7], [8].
Direct kinematics determines the transformation matrices that relate the coordinate systems segment and the absolute coordinate system. It solves the position and orientation of the manipulator joint

coordinates relative to absolute (Cartesian) coordinate system. Rotational matrix 3x3 to orientate the position of the movable joint coordinate system relative to the absolute. Position vector in 3D space is described in homogeneous coordinates. Homogeneous 4x4 matrices include rotational and translational displacement matrix start moving coordinate system (equation 1, and 2), [7], [8], and [9].

Inverse kinematics determines the coordinates of the position and orientation of manipulator. It's not a simple solution, but there are several solutions (joint position) to achieve the position and orientation of manipulator, [7], [8], and [9].

The direct kinematics is used to calculate the pose of an end-effector for a given manipulator and a given posture. This is done based on the Denavit-Hartenberg (D-H) parameters given for the robot. With the inverse kinematics the posture of a manipulator is calculated given the posture of its end-effector [2], [3], [5], and [8].

Using the DH parameters, the coordinate's transformation matrix for the robot is calculated:

$T = T_1 \cdot T_2 \cdot T_3 \cdot T_4 \cdot T_5 \cdot T_6 \cdot A_{tool}$

Where:

$$T_i = \begin{bmatrix} \cos(\theta[i]) & -\cos(\alpha[i]) \times \sin(\theta[i]) & \sin(\alpha[i]) \times \sin(\theta[i]) & a[i] \times \cos(\theta[i]) \\ \sin(\theta[i]) & \cos(\alpha[i]) \times \cos(\theta[i]) & -\sin(\alpha[i]) \times \cos(\theta[i]) & a[i] \times \sin(\theta[i]) \\ 0 & \sin(\alpha[i]) & \cos(\alpha[i]) & b[i] \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (1)$$

$$A_{tool} = \begin{bmatrix} \cos(\beta) & 0 & \sin(\beta) & -0,0785 \\ 0 & 1 & 0 & 0 \\ -\sin(\beta) & 0 & \cos(\beta) & 0,154 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (2).$$

INDUSTRIAL ROBOT-MANIPULATOR

Industrial robots-manipulators are devices equipped with a mechanical arm, possessing large movement potential, as well as a steering system characterised by a large autonomy, most frequently in a form of a digital computer. This kind of robots represents an ultimate point in the development line of industrial automatic devices and they are also the most widely used robots in practical applications. Together with CNC machines, industrial robots are typical representatives of flexible automated systems - meaning that they can quickly adapt to the changes in a production programme, i.e. to changes in a production task. With the ability to be used independently or within a complex system, industrial robots represent programmable systems of general purpose, sometimes possessing certain anthropomorphic characteristics such as arms, [10].

The application of manipulatory robots in industry

Industrial robots are machines that can be used to increase the diversity of a production process, in order to increase the productivity and quality of products and goods. These production processes can be divided into two classes: the processes without the contact force, and the processes including a contact force. In the first group are various tasks that, by their nature, do not include a contact force, such as: painting, welding, gluing. Processes and tasks that involve contact are: grinding, cleaning, processing of metal, polishing, cutting of light metals, manipulating objects, assembling, and so on, [10]. Today the areas in which industrial robots are used can be divided into four categories:

1. Transfer of material and assisting machines;
2. Process operations;
3. Assembly operations;
4. Product control and inspection.

Characteristics of industrial robot

The basic characteristics of industrial robots are the :
- working area (service area);
- precision of movement (precision of positioning);
- speed of movement ;
- weight capacity and
- type of drive system.

The working area is the area in which an industrial robot, i.e. its end-effector performs its activities, and this area will depend on its configuration, size and the limitations imposed on the movement of the joints, the segments and the clamp, [10].
The precision of movement (positioning) is a complex concept that relates to the end-effector or the clamp. It contains the following attributes:
- resolution of movement;
- precision and
- repeatability.

Resolution of movement represents a slightest increment in the movement of a clamp. This increment will depend on the resolution of the measuring system and the characteristics of the steering and drive systems.
The precision of industrial robot is related to its ability to effect a position of the clamp in a desired point of a robot's working space.
Repeatability is related to the ability of a robot to position its clamp in the space according to a previously realised programmed movement, [6].
The speed of movement is defined separately for each of the directed axes and depends on the mass of the manipulated path, as well as on the distance and the drive system characteristics. At the present level of technological development of industrial robot, the maximal speeds are 1,5 - 2 *m/s*.
The weight capacity relates to the maximum weight of an object that a robot can manipulate.

The components of an industrial robot

The basic component of industrial robots are:
- Manipulator (mechanical part of an industrial robot);
- Measuring system (sensors);
- Steering system and
- Drive system.

Kinematic determination means a determination robot position and orientation of the pins to the articles in the working space of the robot (manipulator) and of target a stationary reference coordinate system. On the other hand, the position of the robot is determined by the relative angular turning relative and shift movements in the joints of the robot. To make the robot performed the task correctly, in any moment must be determined by the position and orientation of the gripper area, [10], [11].
A manipulator is a device composed of a number of inter-connected mechanical elements, constituting an open kinematical chain. The connections between the elements are realized through joints. Any realization of the desired movements of end-effectors (clamps) is connected to steering along the six axes. In other words, it is generally necessary for the industrial robots to possess six degrees of freedom. In certain cases, (for simper manipulation tasks) it is not necessary to direct all the six axes, since an efficient realization of the particular task can be effected by directing a smaller number of the axes. In Fig. 4 one shows the movements of an industrial robot arm segments - i.e. the typical six degrees of freedom in robot' movement: Display Stand industrial robot, the power system, control system, measuring system (sensors), arms, actuators, hand, [9], [10], and [11].

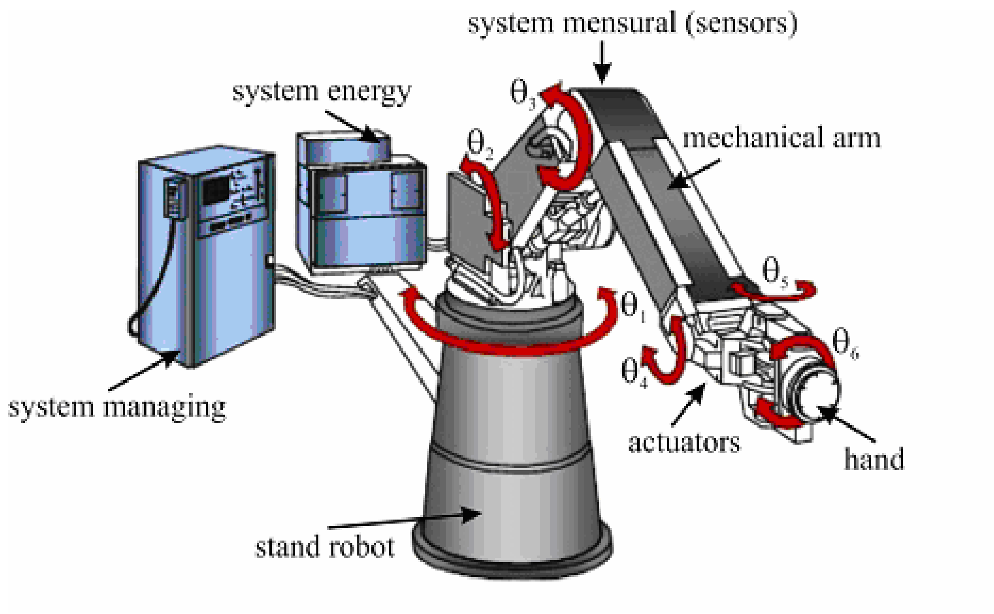


Figure 4. Model of robot: Anthropomorphic robot

RESULTS AND DISCUSSION

One of the important steps in the development of models is proof that the model describes the situation in the real world. In the design phase of a new plant model verification can be performed in a similar industry or existing pilot plant (pilot) plant. Checking the adequacy of the mathematical model consists in comparing the output size (measurement results) on an object with the results given by the model in identical conditions (same input parameters). The checks adequacy model can be used to eliminate systematic errors incurred in modeling due to incorrect assignment of any numeric values present in the system of equations that constitute the model.
Output size of the object is usually obtained measurements. Since the measurement of a stochastic process, then it is necessary to properly process the results of the analysis of the measurement errors that occur at the same time using the theory of probability and mathematical statistics.
Eventually you compare analog output values and the object model and the quality of the model can be expressed by statistical parameters (correlation ratio and sigma).

CONCLUSION

Modern industrial production in most of its branches successfully used robotic systems. When it comes to the mobility of individual members of a robot, the ability to perform a variety of paths, the ability to reach any point in space manipulacijskog with achieving a particular orientation, it can be said that the possibilities of application of robots in the production of virtually unlimited. What limits the application of robots in some operations is the issue of cost. It is not profitable to a robotic structure of a large volume of space, high speed, and power, to performing tasks that do not fully exploit their capabilities. For this reason, the designed manufacturing various industrial robots specifically for certain types of tasks.
Theoretical explanations in this work have been based on the practical implementation and description of a manipulator movement. The same goes for the representations of the kinematical chain and the positions of the individual robot segments-the six-segment mechanical robot arm.
The adopted approach enables us to reach our goal-the movement of a robot-manipulator-through a system comprising six axes. This also enables the robot to have wide possibilities in its working field, while at the same time it is possible to direct a mechanical arm in almost any conceivable way within the given working field. For all these reasons, it is obvious that the advantages of using robot lie not only in the larger productivity, but also in the reduced labour costs and the improved quality control.

This work contemplates the problem of solving the movement of industrial manipulator robots, a problem that has a fundamental significance in the procedures of their successful design and construction of the robot's steering system.

Based on the analyses given in this work, it can be concluded that the movement of a robot-manipulator in performing steering tasks can be effected through defining the known mechanical laws, i.e. the set general coordinates, i.e. the number of degrees of the freedom of movement, through establishing the positions of certain manipulator points (joints, clamp), that is to say through defining the rules of movement, the speed and acceleration of certain typical points, as well as defining the drive forces and moments having an impact on the manipulator segments.

REFERENCES

[1] Bird J., Engineering Mathematics, Newnes (An imprint of Elsevier Science), Oxford, 2003.

[2] Golubović, G., Milićević, I.: „Application transformation matrix in solving the kinematics and dynamics of robots manipulation", Technical Faculty, Cacak, 2009.

[3] И. П. Филонов, П. П. Анципорович, В. К. Акулич, Теория механиzмов, машин и манипуляторов, Минск, Дизайн ПРО, 1998.

[4] Исаев, С., И., и сар.: Теория тепломассообмена (Theory Of Heat And Mass Transfer), Высшая школа, Москва, 1979.

[5] K. S. Fu, R.C.Gonzales, C. S. G. Lee, Robotics: Control, Sensing, Vision, and Intelligence, Mc Graw -Hill Book Company, ISBN 0-07-100421-1, 1987.

[6] Milojković B. R., Grujić LJ. T.: Automatic Control, Faculty of Mechanical Engineering, Belgrade, 1977.

[7] Mikić, D., Golubović, D.: Robot dynamics with application of rotation transformation matrix, 6th International Conference „Research and Development in Mechanical Industry" RaDMI 2006, ISBN-10 86-83803-21-X and ISBN-13 978-86-83803-21-7, p.111-118. Budva, 13-17 September 2006, Montenegro.

[8] Mikić, D., Ašonja, A.: Solving inverse kinematics without applying the matrix rotation, 10th International Conference „Research and Development in Mechanical Industry" RaDMI 2010, ISBN 978-86-6075-017-6, COBISS.SR-ID 178673420, Vol. 1, p. 664-650, 16-19 September 2010, Donji Milanovac, Serbia.

[9] Mikić, D., Ašonja, A.: Configuration workspace industrial robot, Scientific Journal IMK-14 Research and development, Institute „IMK 14. October" AD. Krusevac, year XVII, number (41), 4/2011), p. 53-60, UDK 621, ISSN 0354-6829, Krusevac, 2011.

[10] Mikić, D., Golubović, D.: Industrial robots-manipulators, II. International Conference IPOM, „Computers in business management and communications'' , Proceedings, number. 004(082), 007:004(082), 007:005:004(082), ISBN 99938-815-3-5, COBISS.BH-ID 116760, Traffic-Technical Faculty of Doboj and the Technical College Doboj, p. 38-42, 15-16.09.2006. Teslic, Bosnia and Herzegovina.

[11] Mikić, D., Desnica, E.: Analysis of the model robot using MATLAB, Scientific Journal „Machine maintenance" ISSN 1452-9688, p. 95-99, 19. and 20. 11. 2009. Banja Vrujci.

[12] http://www.orocos.org/kdl_old/

IDEAL SOLUTION FOR GRINDING PLANTS AND PNEUMATIC CONVEYING STRAW

Dragana Dimitrijević[1], Slavica Prvulović[1], Zvonimir Blagojević[2], Dragiša Tolmač[1]
[1]University of Novi Sad, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
[2]Toplifikacija, Požarevac, Serbia
e-mail: dtolmac@sbb.rs

Abstract: This paper describes the design solution of technological milling - grinding and pneumatic transport of straw. The project is designed and implemented for the Victoria Group "in Zrenjanin. The paper contains a description of the technological process, the scheme of technological process, specification of machine technology equipment and energy needs.
Keywords: straw, grinding, pneumatic conveying

INTRODUCTION

The units of the former factory for the production of sugar, "Victoria Group" in Zrenjanin built a plant for the production of briquettes. Biomass used in this particular case the rest of the wheat plant "straw". Installed equipment is purchased from the company "Tech Feed" from Belgrade, which is representative of the world-famous manufacturer of process equipment "Muyang" from China. The required technical capacity of the plant is 8.000 kg / h. In the system there are two hammerhead, one larger - rough grinding and the other for smaller - fine grinding of straw. Lower heating value of straw is about 12 MJ / kg. Freshly ground - chopped straw is transported to the pellet machines. Included are two pellet mills to produce finished product briquettes. Based on the measurements during operation of the plant, established the technical capacity (3.000 to 5.000) kg / h. Given that technical capacity is not achieved, reconstruction was grinding line and air transport straw. Technological scheme of the reconstructed lines, is given in Figure 1.

TECHNOLOGY PROCESS

Straw bales are placed on the conveyor and pass through debalera (1). Feeder carrier (2) is inserted into the straw beater for coarse grinding (3). Pneumatic pipeline (4), is made to transport straw hammerhead for fine grinding (5). Milled straw is then transported through a pipeline (6) to the cyclone (7), where the separation is performed, ie. extract the straw from the air. Using aerial stunts - rotary extractor (8), straw goes into the screw conveyor (9) and mixer (20) and still be fed to the briquetting machine. Aspiration system by using a dust collector - filter (16). The line of pneumatic transport of the suction type and transport was performed using two centrifugal fans (12) and (17). Pneumatic transport capacity is 8.000 kg / h.

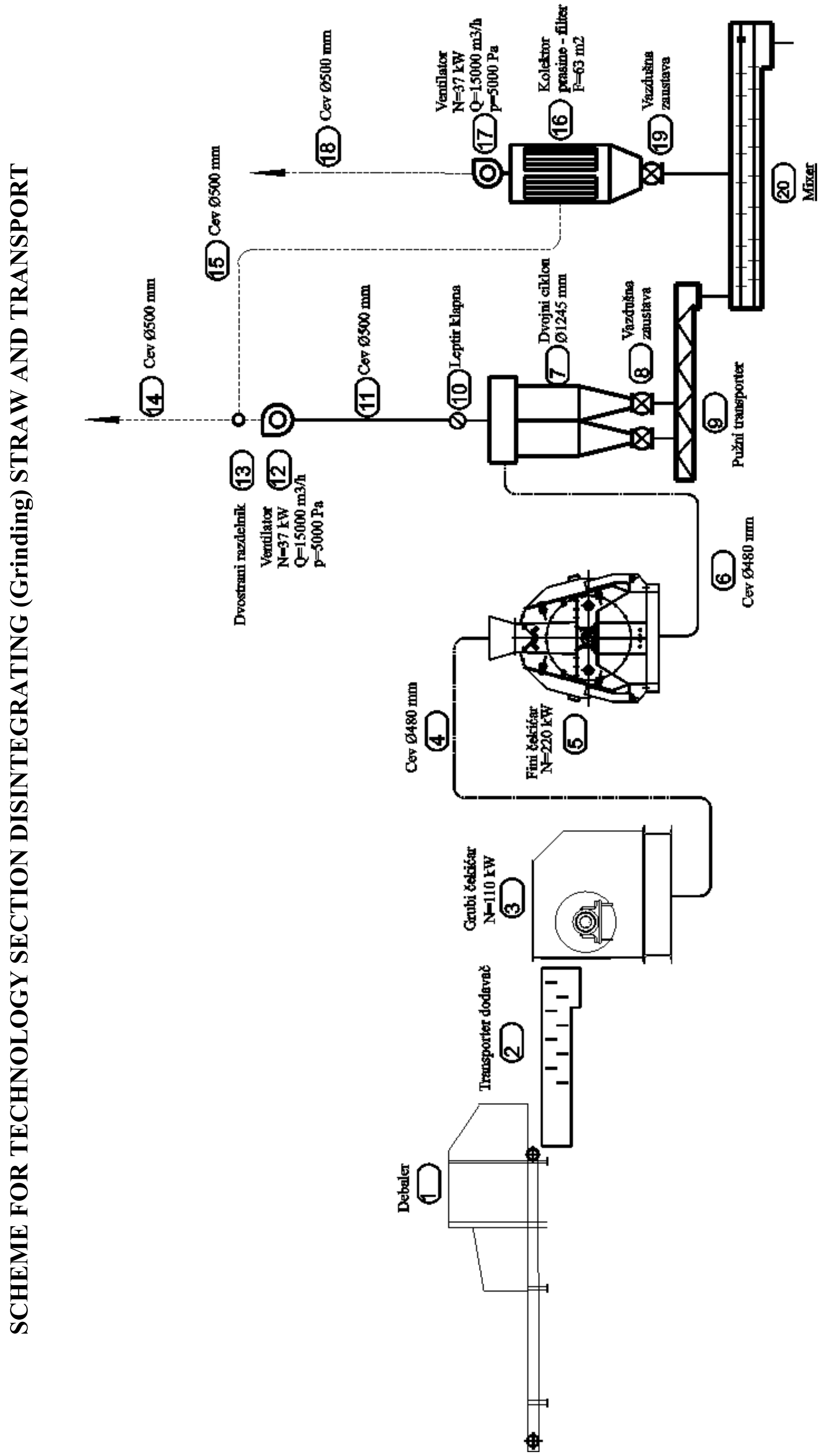


Figure 1. Technological scheme for grinding plants and transporting straw

Figure 2. Application details reconstruction after cyclone *(cyclone diameter D = 1.245 mm)*

Table 1. Machine and equipment specifications

Position	Name	Unit of issue	Quantity
1	Debaler N=4 kW	pieces	1
2	Transport quarterback N = 3 kW	pieces	1
3	Rough Hammer N = 110 kW	pieces	1
4	Pneumatic pipe d = 480 mm	m	25
5	Fine Hammer N = 220 kW	pieces	1
6	Pneumatic pipe d = 480 mm	m	25
7	Cyclones d = 1.245 mm	pieces	2
8	Air Stunts - rotary extractor N = 2.2 kW	pieces	2
9	Screw conveyor n = 3 kW	pieces	1
10	Butterfly valve d = 500 mm	pieces	1
11	Pneumatic pipe d=500 mm	m	5
12	Cenrifugal fan N=37 kW, Q=15.000 m^3/h, p=5.000 Pa	pieces	1
13	Double-sided divider d = 500 mm	pieces	1
14	The pipeline d = 500 mm	m	5
15	Pneumatic pipe d=500 mm	m	10
16	The dust collector - filter F = 63 m2 Solenoid valve: DN25 NP16 Air Cleaner: type - FA1 402 W, NP16 DN25	pieces	1 1 1
17	Cenrifugal fan N=37 kW, Q=15.000 m^3/h, p=5.000 Pa	pieces	
18	The pipeline d=500 mm	m	5
19	Air Stunts - rotary extractor N = 2.2 kW	pieces	1
20	Transporter - Mixer N=3 kW	pieces	1

The total installed power is 423 kW. To work in two shifts tj.16 hours, if the coefficient of 0.95 simultaneity, the power consumption is: 423 x 16 x 0.95 = 6.430 kWh.

CONCLUSION

Crushing plant - grinding and pneumatic transport straw, capacity 8.000 kg / h, built in "Victoria Group" in Zrenjanin, allows the preparation of chopped straw briquetting. Agglomeration is performed on two machines pelleting. After that, the mass of pellets is stored in a separate silo cells. The pellets are used for combustion in boilers to produce steam. Lower heating value of the briquettes (16 to 18) MJ / kg.

REFERENCES

[1] Dimitrijevic, D. : Transport of biomass production and use, Master thesis, Technical faculty "Mihajlo Pupin", Zrenjanin, 2012.
[2] Prvulović, S., Tolmač, D. : Transport Systems - a collection of solved problems, Technical Faculty "Mihajlo Pupin", Zrenjanin, 2012.
[3] Prvulović, S., Tolmač, D. : Transport Systems - a collection of said zadateka, Technical Faculty "Mihajlo Pupin", Zrenjanin, 2012.
[4] Tolmač, D. : Design of Technology Systems - Production Systems, Technical Faculty "Mihajlo Pupin", Zrenjanin, 2008.
[5] Tolmač, D., Prvulović, S., Blagojevic, Z. Radovanovic, Lj. : Theory of system design - designing, investment, re-engineering - Technical Faculty "M, Pupin", Zrenjanin, 2007.
[6] Tolmač, D. : Design, Technical Faculty "Mihajlo Pupin", Zrenjanin, 2009.
[7] Tolmač, D. : Transport Systems, Technical Faculty "Mihajlo Pupin", Zrenjanin, 2006.

SURVAY OF APPLIED POWER SOLUTIONS FOR WIND FARMS

Vladimir Šinik[1], Željko Despotović[2], Slobodan Janković[1], Vojin Kerleta[1]
[1]Technical Faculty „Mihajlo Pupin" Zrenjanin, Serbia
[2]Institute „Mihajlo Pupin" Belgrade, Serbia
e-mail: sinik.vladimir@gmail.com

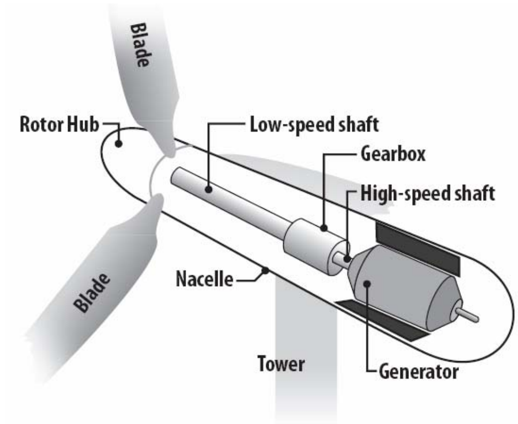
Abstract: The reasons why the wind energy has become the most serious source of renewable energy are presented. Structure of the wind turbine system is outlined. The concepts of conversion of wind energy into electricity and a review of some of the applied solutions for driving wind turbines are included.
Key words: wind energy, wind farm, wind turbine

INTRODUCTION

Wind is simply air in motion. It is caused by the uneven heating of the Earth's surface by radiant energy from the sun. Since the Earth's surface is made of very different types of land and water, it absorbs the sun's energy at different rates. Water usually does not heat or cool as quickly as land because of its physical properties.An ideal situation for the formation of local wind is an area where land and water meet. During the day, the air above the land heats up more quickly than the air above water. The warm air over the land expands, becomes less dense and rises. The heavier, denser, cool air over the water flows in to take its place, creating wind. In the same way, the atmospheric winds that circle the Earth are created because the land near the equator is heated more by the sun than land near the North and South Poles.Today, people use wind energy to make electricity. Wind is called a renewable energy source because the wind will blow as long as the sun shines.
Now as well as in the future, the energy of the wind has proven to be one of the most important renewable energy sources. The main reasons are:
• Unlimited energy supply
• Possibility of conversion into electrical energy by means of wind turbines
• The cost of electricity generated by wind power reduces in proportion to increasing wind energy use
• Environmentally-friendly method of energy generation
• Small requisite land
Energy crises, significant reduction of fossil fuel resources and enormous increase in pollution across the planet have stimulated growth of wind turbines production in the last 30 years at an almost equal pace as the computer industry. Increased wind turbine reliability and the in-roads into world markets would mean that the future for the technology is bright.

STRUCTURE OF WIND ENERGY CONVERSION SYSTEMS

Like old-fashioned windmills, today's wind turbines use blades to capture the wind's kinetic energy. Wind turbines work because they slow down the speed of the wind. When the wind blows, it pushes against the blades of the wind turbine, making them spin. They power a generator to produce electricity. Most wind turbines have the same basic parts: blades, shafts, gears, a generator, and a cable (Fig.1). (Some turbines do not have gearboxes.) These parts work together to convert the wind's energy into electricity.



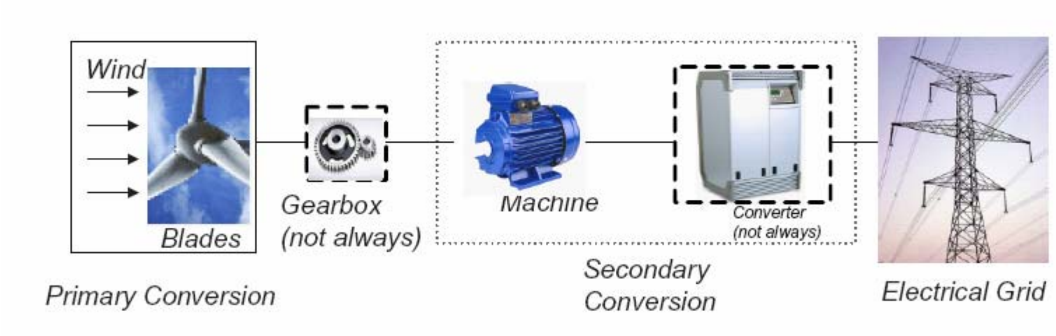


Figure 1. Block diagram of a Wind Energy Conversion Systems

1. The wind blows and pushes against the blades on top of the tower, making them spin.
2. The turbine blades are connected to a low-speed drive shaft. When the blades spin, the shaft turns. The shaft is connected to a gearbox. The gears in the gearbox increase the speed of the spinning motion on a high-speed drive shaft.
3. The high-speed drive shaft is connected to a generator. As the shaft turns inside the generator, it produces electricity.
4. The electricity is sent through a cable down the turbine tower to a transmission line.

The amount of electricity that a turbine produces depends on its size and the speed of the wind. Wind turbines come in many different sizes. A small turbine may power one home. Large wind turbines can produce enough electricity to power up to 1,000 homes. Large turbines are sometimes grouped together to provide power to the electricity grid. The grid is the network of power lines connected together across the entire country.
Modern wind turbines generate electricity at wind speed as low as 2.5 m/s, and for safety reasons the operation of the wind turbine is halted when the wind velocity reaches 25 m/s. In order to have an economical power generation of electricity, an annual average velocity of the wind of 6 m/s is required.
Due to the friction between wind motion and the ground and the internal viscous forces in the air mass, the wind speed increases with increasing altitude. The wind speed is further influenced by the topography of the land such as roughness of the terrain, presence of natural and artificial impediments etc. In order to view the wind energy in its proper vetrocontext, it is important to have at least an approximate estimate of wind energy's strategic potential. Most estimates use the same basic steps: define the climatic and physical characteristics – average wind speed and areas where turbines can be placed; estimate the space available for development from the results of the previous step and finally using current technology estimate the energy yield which can be derived. The second step has major influence on the final outcome and is most difficult to perform accurately. On the other hand, even minor errors in location choice may have negative effects on the overall cost effectiveness. Small and very small turbines (up to 3 kW approximately) usually use a direct-drive system, which offers the advantage of omitting

the gearbox, and utilizing a generator that can operate at the rotational speed of the rotor. Such products can be utilised for remote communications, electric fences, domestic systems, leisure craft etc. Wind turbines rated at several dozens of kW generate threephase electrical current, and are usually connected to utility grids. Medium size turbines produce electricity of several hundred volts at the frequency of 50/60Hz. By means of transformers the voltage is raised to 10 - 30 kV so that electrical grids may transmit it. Although the wind industry has demonstrated technical and commercial feasibility of units of about 1.5 MW, larger wind turbines have been built but the present generation of megawatt machines may well be close to the economic limit of up-scaling. All of these units are connected to the utility grids. In some land based and offshore applications larger generating units are desirable. The most cost effective use of wind turbines is the so-called wind farm, which comprises a large number of individual units.

Parts of the wind farm

Wind farm is a complex operation, which consists of a base and a high column, which carries a mechanical assembly turbine and electric generator circuits for connection. In Figure 2. gives a schematic view of turbine parts, with the percentage share in the total value of the wind farm. All parts can be roughly divided into: the first Mechanical: stub (26.3%), wings (ELISA) (22.2%), carrier wings (ELISA) (1.3%), bearings (1.22%), major axis (1.91%), main housing (2.8%), multiplier (12.91%), the system rotating turbine (1.25%), a system for rotating wings (2.66%), brakes (1.32%), the drive housing (1 , 35%), and the second Electricity: Generator (3.44%), power converter (5.01%), with connections transfoormator (3.59%).

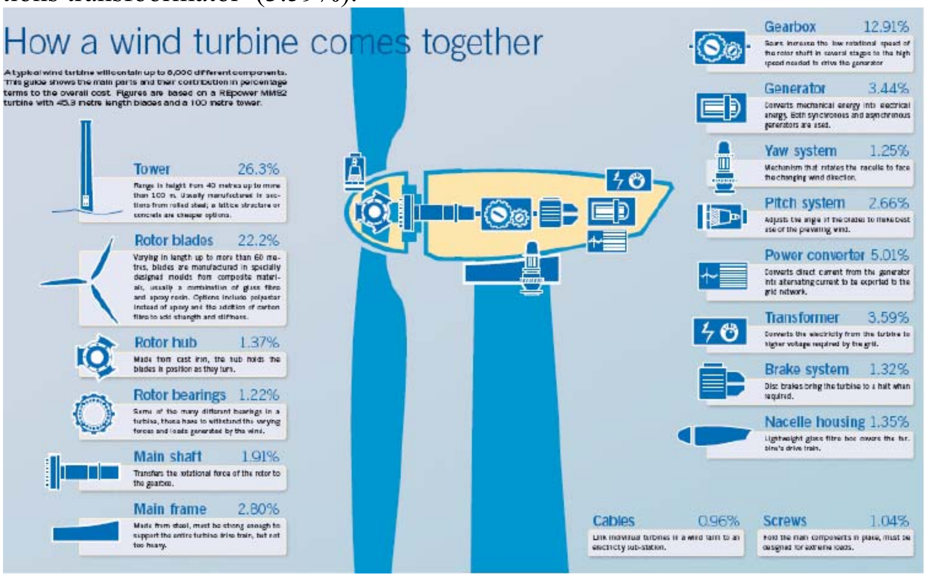


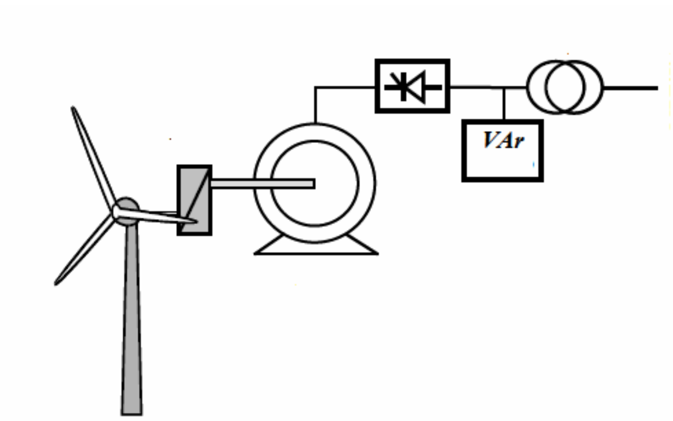
Figure 2. Basic circuit wind farm

OVERVIEW OF APPLIED SOLUTIONS FOR WIND FARM PLANTS

Wind turbine with asynchronous machine connected directly to the network

This approach is implemented in most of the plants which are set in the first wave of development of wind farms, somewhere to 1998 [1],[3].Figure 3 (a) shows the essential parts of the wind farm[2]. A multiplierof a high transmission ratio adjusts the speed of rotation of the turbine generator. There are also asynchronos induction generators, a circuit for soft increase of momentum,a circuit to cover the need of reactive power plants (var source), and a transformer through which the wind turbine connected to the distribution network and the rest of the plant operation systems. At a change of wind speed, relation of wind turbines and rotors is changed by the amount of slip. Depending on the power and performance of the generator, is only 1% to 2% of the nominal value of speed, so it can be considered that these drives have fixed speed of rotation. The result is that these facilities generate a slightly lower yield of active power compared with variable-speed drives and, more importantly they are, a great source of noise. Both of these shortcomings are most pronounced at low wind speeds.They can be substantially mitigated by using a generator with two stator windings (Figure 3.b). The main coil is connected at higher wind speeds when considerable power. The second coil, having a greater the number of poles, is designed for hawer powers. When connected, the speed of rotation of the turbine is smaller in proportion to the greater number of poles and the reduced velocity increases the yield and reduces noise at low wind speeds.

a)



b)

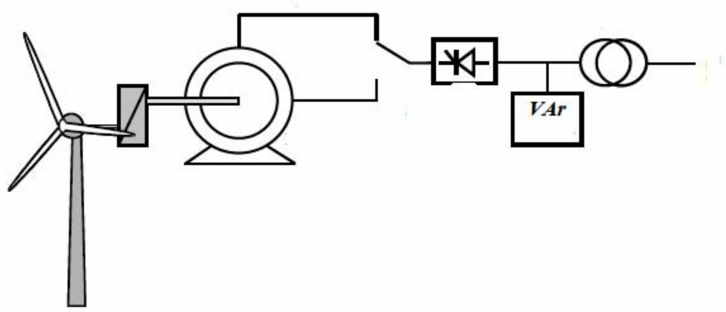


Figure 3. Wind turbine with induction generator directly connected to the network: a) a stator winding and b) two stator windings[1-3]

The main advantage of this solution in comparison with other is lower price. It is feasible due to its simple design and implementation of turbine blades and me of induction generatorsof relatively small diameter, suitable for placement in smaller hubs. On the other hand, it also has significant drawbacks.Under normal conditions in the electricity grid, wind turbine assembly is subjected to rapid changes in the mechanical input power, which is transmitted by the turbine generator. They appear, on one hand, due to expressed frequent changes of wind speed, and on the other due to, the influence of the aerodynamic shadow of turbine pole.In these wind turbines the an electromagnetic torque of the generator can not be regulated, and the input power changes are completely mapped in the output active power. Therefore, the quality of the produced energy is relatively low . In addition, it is not possible to controlthe production level of active power, a production reserve or a limit to the rate of change of the active forces are also beyond control.

Wind turbine based on asynchronous machine with sliding rings controlled by a converter in the rotor circuit

While the wind farms based on asynchronous generators with cage rotor played a major role in the first steps of development of this technology they gradualy lost the leading role, and the asynchronous machines with sliding rings controlled by a converter in the rotor circuit gradualy assumed leadership. So today they account for over 40% of the total electrical energy generated by converting wind energy [1]. Most of the manufacturers of high power wind turbines, base a good part if not the majority of their products on this approach.It can be said that this solution, according to the current state is a leader at the market.

A modern facility includes: control of input mechanical power by power adjustable angle of the wings, large transmission ratio gearbox, asynchronous generator with wound rotor and sliding rings, dual converter which is connected between the rotor and the network, power transformer, and if necessary battery of capacitors (Figure 4).

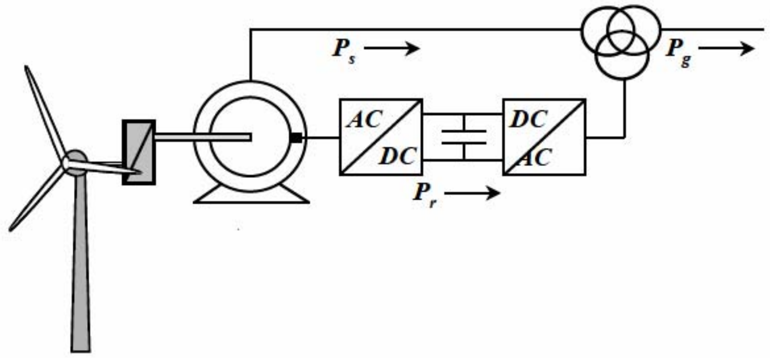


Fig.ure 4. Wind turbine with asynchronous generator with sliding rings and the inverter rotor circuit [3]

This solution has all the meritsrequired by a variable speed rotation. The most important are: increased energy efficiency and reduced wind noise at in low wind speeds. The possibility of a full control of electromagnetic torque also allows the realization of limiters of the power output and reserve power, eliminating abrupt changes in power resulting in better qualityoutput power.

Wind turbine driven by high power converter

Unlike previous solutions where the converter on the rotor side affects the transmission of power from the stator to the network to which it is directly connected, dual converter installed between the generator and the network in some sense separates generator control from control power delivered to the network. This enables a number of important improvements in plant operation and alloms achieving high power. However, the power of the converter is equal to the power at the plant . The set-ups are available at the market are shown in Figure 5. It can be seen that the set-ups contains both synchronous and asynchronous generators, where the application of synchronous solutions exist multiplier as an adaptation stage to the turbine do not require.

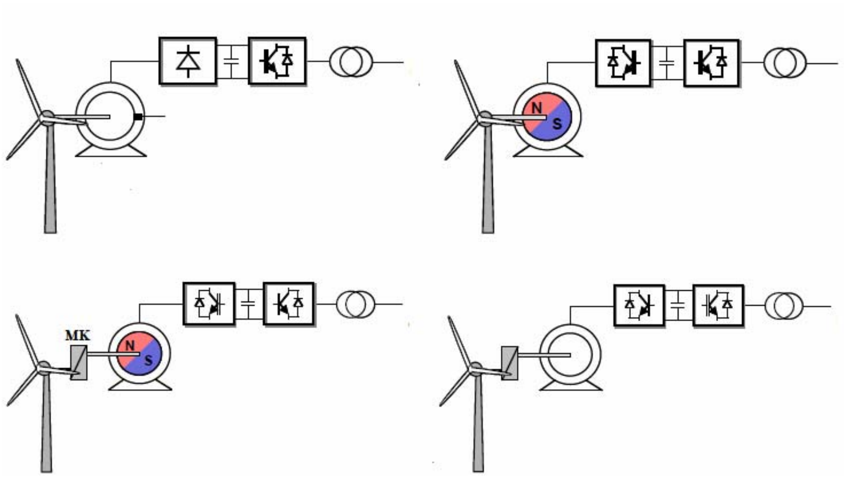


Figure 5. Wind power plants operated by a full power converter: a) synchronous generator with excitation coil directly coupled with the turbine, b) synchronous permanent magnet generator directly coupled to the turbine, v) synchronous permanent magnet generator connected to the turbine through the multiplier, g) asynchronous generator with cage rotor[1-3]

The variable speed wind turbine having hydraulic transmission

DeWind company has developed a solution where the role of power electronic converter replaces the hydraulic circuit, hidrodynamic transmission [4]. The set-up of this wind turbine is shown in Figure 6., where the hydraulic circuit is labeled WinDrive. Coupled with the multiplier, the hydraulic circuit allows different speed of wind turbine rotation from the speed of the rotor of synchronous generator. Generator rotor speed is constant, since the generator is connected directly to the power supply, while the turbine speed is regulated within the range of about ± 30% relative to the mean.

Therefore, the characteristics of this solution resemble these of the solution with induction generator with slip rings and inverter circuit in the rotor. By regulation of the synchronous generator excitation one can achieve the required amount of reactive power. Large series reactance of the stator windings allows the generator to remain connected to the grid during disturbances in the network and permitts its operationwhen voltage drops to a low value.

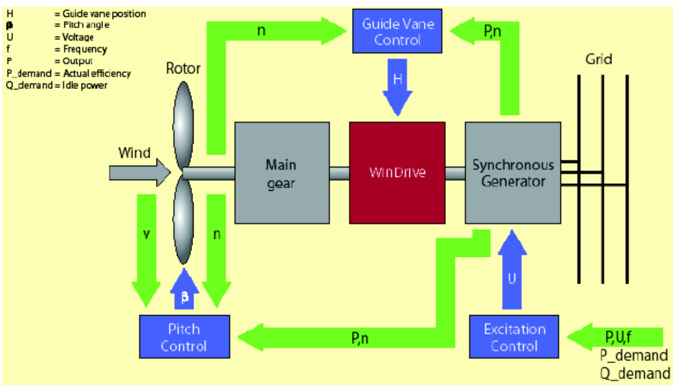


Figure 6. Wind turbine set-up with hydrodynamic transmission [4]

Wind turbines with synchronous machine with permanent magnets and a serial converter

Figure 7. presents a solution based on the wind turbine driving synchronous machine with permanent magnets. Power inverter with a capacitor in DC circuit is connected to star point of the machines. Depeding on the way of coupling with the machine, the inverter can be called a serial converter. The other end of stator terminals of the synchronous machine with permanent magnet is connected to the mains via a transformer . On the mechanical side, the axis synchronous machine with permanent magnets can be connected to the wind turbine or through a multiplier or coupled directly.

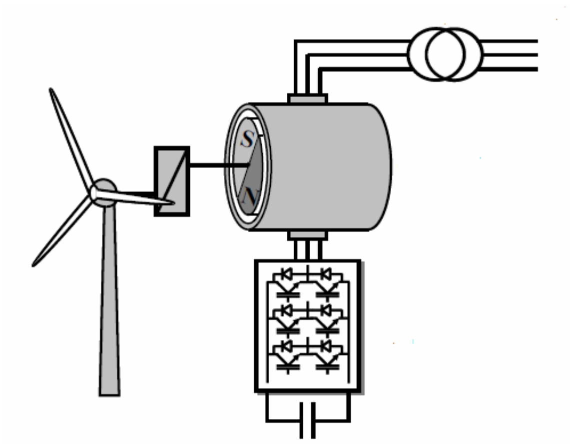


Figure 7. Wind turbines with synchronous machine with permanent magnets controlled by a serial converter[3],[5-7].

Serial converter as an essential part, for providing an attemated response of the electromagnetic and mechanical quantities of the drive when the drive torque changes [5 - 7] and during disturbances of the electrical system [3].Since angular speed of generator rotation is determined by the network frequency , this approach belongs to the group of approaches having constant speed of rotation. Set-up of a drive consisting of a synchronous machine with permanent magnets and a small gear-ratio multiplier, compared to other solutions applied for high powers, requires aminimumof the total required investment, is characterized by the lowest overall weight and high reliability.

CONCLUSION

This paper deals with some solutions that are applied by most of the manufacturers of wind turbines (wind turbine with asynchronous machine connected directly to the network, wind turbine based on asynchronous machine with sliding rings controlled by converter in the rotor circuit, wind turbine drive by bing power inverter, variable speed wind turbine with hydraulic transmission, a synchronous machine with permanent magnets and a serial converter). For each of the solutions, the basic principles of operation, advantages and disadvantages compared to other solutions, and possibilities of connecting to the network, according to the results of the studies published in the scientific literature available.

REFERENCES

[1] A.D.Hansen, L.H.Hansen: Wind Turbine Concept Market Penetration over 10 Years (1995-2004), Wind Energy 2007, no. 10, pp. 81-97
[2] M.R.Dubois: Review of Electromechanical Conversion in Wind Turbines – Final LiteratureReview April 2000, TU Delft, Holand, April 2000
[3] Stevan Grabic : Drive wind turbine with synchronous generator with permanent magnet driven serial converter, Faculty of Technical Sciences Novi Sad, 2011
[4] DeWind: www.eunrg.com
[5] S.Grabić, N. Čelanović, V.Katić: Series Converter Stabilized Wind Turbine with Permanant Magnet Synchronous Generator, in Proc. 12th International Symposium on Power Electronics – Ee2003, Novi Sad, Serbia and Montenegro, November 5-7, 2003, No. T1-1.6
[6] S.Grabić, N. Čelanović, V.Katić: Series Converter Stabilized Wind Turbine with Permanant Magnet Synchronous Generator, in Proc. IEEE 35th Annual Power Electronics Specialists CoferencePESC 2004, Aachen, Germany, 2004, pp. 464-468
[7] S.Grabić, N. Čelanović, V.Katić: Permanent Magnet Synchronous Generator Cascade for WindTurbine ApplicationI, IEEE Trans. Power Electronics, Vol. 23, No. 3, pp. 1136-1142, May 2008

APPLICATION OF ANALYTICAL HIERARCHY PROCESS IN THE SELECTION OF OPTIMAL TECHNOLOGICAL SOLUTIONS

Slavica Prvulović[1], Uroš Karadžić[2]
[1]University of Novi Sad, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia.
[2] Faculty of Mechanical Engineering, Podgorica, Montenegro
e-mail:prvulovicslavica@yahoo.com, uros.karadzic@ac.me

Abstract: In this paper we took into consideration the option of ranking of the systems for drying the corn starch by one of the methods of multicriteria decision making . that is the method of The Analytic Hierarchy Process-AHP. The analysis on the basis of five criteria of the pneumatic dryer, the spiral dryer and the rotating dryer with the drum has been done: the heat transmission coefficient, the costs-the price, the heating power of drying, the termic degree of usage, the specific energy consumption. According to the obtained results the ranking is established: pneumatic dryer – spiral dryer – rotating dryer. By choosing the pneumatic dryer the decision maker would profit most, that is he would have the least loss in comparison with the other here mentioned systems for drying.
Key words: AHP method, the systems for drying, multicriteria decision making, criteria

INTRODUCTION

Most of the technological, political, social and economic problems of decision-making belongs to the group multiattributive decision problems [1].
The ranking of options makes the decision maker take into account is usually large number of quantitative and qualitative attributes (criteria). Attributes are often mutually conflicting, for example, better quality also means a higher price [2]. With the number of options and attributes the problem of choosing becomes more complex.
More recently there have been several methods of decision making developed (decision aid methods) ie. in decision support systems (decision support systems) whose role is to help the decision maker with the selection of optimal alternatives [3].
Analytical Hierarchy Process (The Analytic Hierarchy Process-AHP) is a method of multiatributives, developed by Saaty [4-6]. The method is based on the determination of the structure (hierarchy) of the decision problem, where a complex decision problem gradually "breaks" into a simple set of decision problems. Using AHP method the decision maker does not compare all the options of selection criteria at the same time, trying to determine the most optimal, but the solution comes gradually and systematically. The decision maker determines the relative importance of attributes and options by comparing pairs of attributes or options by certain attributes and their assessment of their relative importance expressed in the adopted absolute scale shown in Table 1. Thereafter, a final decision is most likely to occur using one of the special programs that support the AHP method.
In this paper, for example, the system of choice for drying corn starch, will be used to present the main phase of the decision by the method of Analytic Hierarchy Process. After defining the necessary input parameters, a calculation using the Criterium DecisonPlus program is done[7].
The main stages of AHP methods are:

1) Defining the structure (hierarchy) of decision problems.
2) Mutual comparison of pairs of attributes (options) in order to determine the relative importance (preference) and the allocation evaluations using Table 1
3) Check the consistency of consistency in the assessment.
4) Design and analysis of results.
5) Sensitivity analysis of results.

Table 1. The scale of nine point

Scale	Explanation of ranking
9	Absolutely the most important / desirable
8	Very strongly to the absolutely most important
7	Very strong to very important / desirable
6	Strong to very strong
5	Significantly more powerful / desirable
4	Less to more stronger
3	More less important / desirable
2	Equal to less senior
1	Equally important is desirable
0.50	Equal to the lower small
0.33	Weaker or less important / desirable
0.25	Less strongly to a lesser
0.20	Strongly less important / desirable
0.17	Less strongly to very strongly less
0.14	Significantly less of a bear / desirable
0.13	Very strongly to the absolute lower
0.11	Absolutely the least significant

For the practical implementation of the third, fourth and fifth stage, special software such as Criterium DecisionPlus or EXPERT CHOICE are commonly used.
In the following example the application of AHP method will be demonstrated and explained.

MATERIAL AND METHODS

Selection of products for drying of grains using AHP method

The paper presents the ranking of three alternatives - a system for drying corn starch on the basis of five criteria, using the AHP method. It is essential that the initial phase of making the decision maker defines a set of alternatives and criteria.

Given alternative A:
A - Pneumatic dryers
B - Spiral dryer
C - Rotary drum dryer

Selected criteria Kj:

K1 - Coefficient of heat transfer [W/m2 K]
K2 - The price [EURO]
K3 - Thermal drying power [kW]
K4 - Thermal efficiency [%]
K5 - Specific energy consumption [kJ / kg]

Figure 1 shows the hierarchical structure of the problem of choosing the appropriate system for drying.

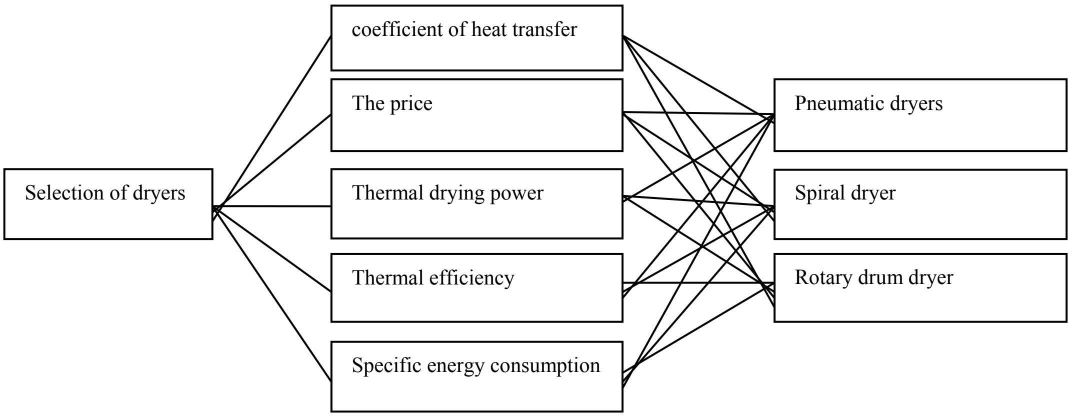


Figure 1. Hierarchical structure of the problem of choice

Then, another important comparison of pairs of each evaluation criteria and preference of alternatives for each criterion is made, according to a scale defined in the table pf nine points, as shown in Tables 2 and 3:

Table 2. Mutual comparison of pairs of criteria

	K1	K2	K3	K4	K5
K1		1	0.33	0.17	0.17
K2			0.33	0.17	0.17
K3				0.5	0.5
K4					1
K5					

Initial comparison matrix of alternatives in relation to the criteria given in Table 3

Table 3. Cross-comparison of pairs of alternative criteria shall apply to individual

K1	A	B	C
A		0.5	5
B			7
C			

K2	A	B	C
A		0.25	5
B			9
C			

K3	A	B	C
A		5	0.33
B			0.14
C			

K4	A	B	C
A		6	4
B			0.5
C			

K5	A	B	C
A		0.33	3
B			7
C			

The data presented in Tables 2 and 3 are the necessary input data which the decision maker determines on the basis of data collected on alternatives and their own preferences. Data is fed into a program that supports the AHP method. In this paper, the calculation has been done by Criterium DecisionPlus program.

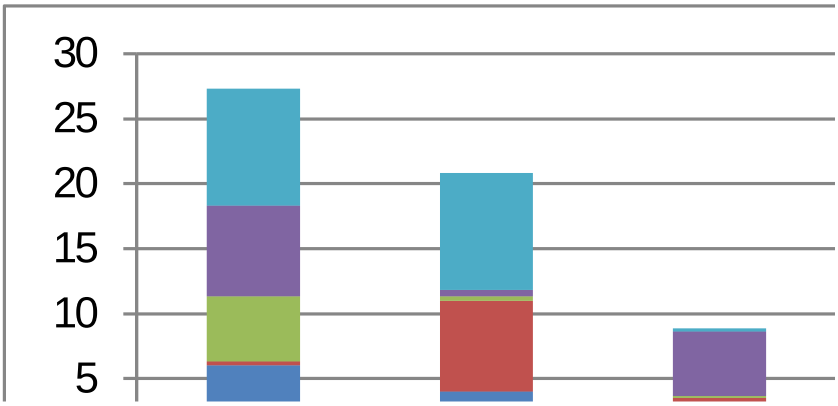


Figure 2. The final comparison of alternatives on all criteria

RESULTS AND DISCUSSION

After entering the data, the program calculates values of the so called consistency ratios (consistency ratio CR) for each set of compared attributes or options (Table 2 and 3). Consistency ratio, by its value, indicates whether there is some inconsistency (illogicality) created by evaluating the relative importance of attributes or options.
The ranking of alternatives in the AHP method is based on the calculated values of total priority alternative (composite normalized vectors). The program automatically determines the overall priorities for all alternatives and the results presented graphically (Figures 2 and 3).

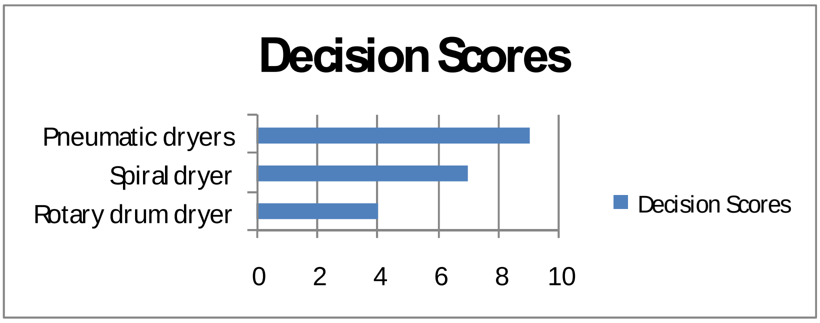


Figure 3. The final ranking system for drying corn starc

CONCLUSION

In this paper, a concrete example of the system of choice for drying cereals, the practical application of AHP method of multi-making is shown, where there are three alternatives offered on the basis of five criteria needed to choose and make the most cost-effective alternative to the ranking given by all criteria. In this case, the selected alternative is Alternative A- pneumatic kiln/dryer, and the result was obtained by using the method that gaveit priority over other alternatives, and confirmed that it dominates them. The ranking was done in the following order A-Pneumatic dryers> B-Spiral dryer> C-rotary kiln, which means that the best one is pneumatic drying kiln, and the worst is the spiral one, based on mentioned criteria and assigned weights.

REFERENCES

[1] Prvulović, S.,Tolmač, D., Blagojević, Z., Radovanović, Lj., Teorija projektovanja sistema - projektovanje, investicije i reinženjering - Tehnički fakultet "M, Pupin", Zrenjanin, 2007.
[2] Prvulović, S., Manasijević, D., Teorija odlučivanja sa primerima, Bor, 2007.(fakultetski udžbenik)
[3] Tolmač, D., Prvulović, S. : Projekti tehnoloških sistema u prehrambenoj industriji, "SM"-Inženjering, Zrenjanin, 2001.
[4] Saaty T.L.: The Analytic Hierarchy Process, McGraw-Hill, Inc., 1980.
[5] Saty, T.L., Multi-criteria Decision Making: The Analytic Hierarchy Process, P ittsburg,RWS Publication,1988.
[6] Saaty T.L.: Axiomatic foundation of the Analytic Hierarchy Process, Management Science, 32(7), 841-855,1986.
[7] http://www.infoharvest.com/ihroot/index.asp

COMPARATIVE ANALYSIS OF VEHICLE DEPENDING ON TYPE OF DRIVE

Antić, B.[1], Vujanić, M.[2], Pešić D.[3], Anđelković D.[4]
[1,2,3]University of Belgrade, Traffic Faculty, Belgrade, Serbia
[4] University of Priština, FTS, Kosovska Mitrovica, Serbia
e-mail: b.antic@sf.bg.ac.rs, m.vujanic@sf.bg.ac.rs, d.pesic@sf.bg.ac.rs, a.dejan@pr.ac.rs

Abstract: This paper gives an overview of modern motor vehicles that are run differently depending on the type of drive (electric, hybrid-electric, powered by hydrogen, liquefied petroleum gas, gasoline and diesel). Conducted a comprehensive comparative analysis of processed vehicles in terms of certain characteristics, such as fuel consumption and emissions of carbon dioxide, especially within each type of operation of motor vehicles.
Keywords: modern motor vehicles, fuel consumption, carbon dioxide emissions, pollution

INTRODUCTION - OPENING REMARKS

Every day in our environment we can hear that the cars are the greatest polluters, while environmentally awakened drivers feel guilty about it. However, traffic is very important for both the economy and social welfare. It is a necessary element in the distribution of goods and services. Without it one can not imagine a trade and regional development. Transportation has also provided expansion of production and increasing competition. But, it should be kept in mind that traffic is not environmentally neutral. Even more, negative impacts of traffic has adversely affected the environment. That is particularly evident in the most densely populated areas and places with the concentration of negative effects, such as exhaust fumes and high-level noise.
Under European regulations dealing with emissions of greenhouse gases, the greatest attention in recent years has been paid to the emission of carbon dioxide. The European Automobile Manufacturers Association in 1998 came to an agreement that CO_2 emissions must be reduced to 140 g/km in the production of new passengers' vehicles. Today's goal is to make emission of CO2 as little as possible (below 100 g / km). [1]
It is very important to note that the traffic is a significant consumer of energy, especially liquid fuels, from which more than half is spent in the cities. During fuel consumption, there is large emissions of carbon dioxide. That is logical, given that CO_2 emission depends directly on the amount of unburnt fuel. It is estimated that during burning of fossil fuels formation of carbon dioxide is about 7 billion a year worldwide, half of which is retained in the atmosphere. That is why the aim is to reduce CO_2 emissions through the use of alternative fuels, such as electricity or hydrogen. [2] In addition, during the last few years, oil crisis has been actual, as well as the growing increase in the price of petroleum products. Beside that, current trends are that the pollution created by cars should be brought to minimum, which imposes as a solution production of electric and hybrid cars. [3] These cars should reduce greenhouse gas emissions and make driving safer and cheaper.
In addition to ecological vehicles, in this comparative analysis conventional and hybrid electric vehicles are included, based on which economic and environmental justification for the use of certain vehicles can be reached.

SELECTED (MODERN) MOTOR VEHICLES

Tesla Roadster

Tesla Roadster is a battery electric vehicle of the company Tesla Motors in California that produces it as a sporty electric car. This is the only vehicle that is produced in mass production, and not as a specific prototype or production, in North America and Europe. Roadster is used as a tool to promote sustainable energy. Tesla produced more than 1,200 Roadsters to sell in 28 countries, and in July 2010 the production of Roadster with right hand drive for the British Isles, Australia, Japan, Hong Kong and

Singapore began. Roadster is the first produced car to use a battery of lithium-ion cells, and can travel more than 200 miles (320 km) per a charge, which is a world record. This record was set by Roadster on 27th September 2009 in "Global Green Challenge" in Australia. In March 2010, Tesla Roadster was the first electric vehicle that won Monte Carlo Rally.

On 11th July 2005, *Tesla* and the British sports car manufacturer *Lotus* made an agreement about the products and services based on the ***Lotus Elise***, where *Lotus* was responsible for the design and development of automobiles, as well as the final production of partially assembled vehicles. *Lotus Elise* participates with about 6% in the construction of a car. Several prototypes of *Tesla Roadster* have been produced from 2004 until 2007. Initial studies were carried out in two vehicles that were called *Test Mules*, on the basis of the electric drive system, which equipped Lotus Elises with all the necessary parts. [4]

Kia Motors

Kia Motors, the oldest Korean car manufacturer, is responsible and environmentally awakened factory that smoothly eliminates the risks and challenges of the 21st century by launching a series of new vehicles with innovative technology and excellent design, as well as minimal adverse impact on the environment. In 1986, *Kia Motors* launched electrical Bestu for mass production, which was a big success in the Korean market. Over the years, the Korean Kia has remained a pioneer in the production of electric and hybrid vehicles and vehicles powered by hydrogen. In accordance with the EU directives on heavy metals, Kia stopped usage of metals such as lead, cadmium, mercury and multi-valence chromium in the production in 2003. Kia's largest environmental achievements are definitely FCEV platform for field vehicle, concept Sportage powered by hydrogen, hybrid vechicle of B-segment Rio, eco environmental concept ***eco cee `d***, which will soon become a production model, and series of innovative environmental technologies used in cee `d vehicle production in Kia's first factory in Slovakia.

Ecological Rio or Rio hybrid was first presented in Geneva in 2007 at the auto show. This car is powered by 1.4 - liter gasoline engine with 90 horsepower, assisted by 12-kW electric motor with 95 Nm AC synchronized electric motor and a CVT gearbox. Rio hybrid was the first Kia's model with the CVT gearbox, which controlles via computer stopping and moving from place and turns on and off the engine when the vehicle is stationary for more than a few seconds. Thanks to the lightweight material components, hybrid Rio is lighter than its "classic" brother for more than 220 kg. The car achieves acceleration of 100 km / h in 12.2 s, and reaches a top speed of 180 km / h. Fuel consumption is 5.29 l / km (44% improvement), which is why the air pollution was reduced to even 37%. CO_2 emission is 126 g / km. [5]

In the production of ***Kia "sid" (cee `d)*** vehicles innovative technologies are applied, which has decreased the negative impacts on the environment. For example, cee `d with DPF filter, 2.0-liter diesel engine that meets the Euro4 standard and 5-speed gearbox compared with models of the same class brings less risk of global warming (3.6%), acidification (14.4 %) and photochemical oxidation processes (6.0%). If cee `d passes 150,000 miles over 12 years, it will produce even 970 kg $CO_2$ less than cars of the same class. In other words, to drive cee `d means to plant a forest of 69 trees, with the assumption that a tree absorbs 14 kg of CO2 per year.

In late 2010, new Kia Sportage received a prestigious international award, which is the result of many months of rigorous environmental review, and which includes the entire process of the production of a new model to its decomposition. It is the ISO14040 environmental certification awarded by TUV Nord. Their inspections showed and proved that *Sportage* received good reviews and ecologically significant improvement over its predecessor. One of the most important improvements of the new *Sportage* in the field of environmental protection is the weight of the vehicle. Although this SUV is longer than its predecessor for 9 cm (total length of 4.44 m), its weight is less than the 87 to 160 pounds (depending on the variant and the technical specifications of the vehicle). This model uses the latest technology to reduce fuel consumption, for example. start-stop system (known as Kia's ISG) and has four engines. The total power of this vehicle is 140 hp. It has a top speed of 177 km / h and acceleration from 0 to 100 km / h achieved in 12 seconds. Fuel consumption is 8.9 liters per 100 km and CO_2 emission is 138 g / km.

World premiere of eco ***Kia Picanto*** electric vehicle was held on 1st March 2011 at the prestigious Geneva Auto Show. It is expected to be available in Republic of Serbia during this year. New Kia Picanto has three completely new and highly efficient engines - two versions of 1-liter 3-cylinder flex-fuel-capable engine and a more powerful 1.2-liter 4-cylinder gasoline mill. All three engines are from Kappa series. Engine power ranges from 51 kW (69 hp) to 63 kW (85 hp) with maximum torque of 94 Nm and 121. All engines will be fitted with ISG technology. CO_2 emissions range from 95 to 105 g / km and fuel consumption is 4.8 l/100 km. [5]

Toyota

In 1997, Toyota launched the HEV (hybrid electric vehicle), vehicle for mass production, ie. serial sale. It is Toyota Prius with aim to reduce CO_2 emissions and combat global warming. Since then, HEV Toyota has sold about 2.2 million of these vehicles. The vehicle has gasoline engine 1.5-liter VVT with 77 hp and 68 hp electric motor. Vehicle final power is simply calculated, so this car has a power of 113 hp. The maximum speed the vehicle can reach is 180 km / h. In the range 0 - 100 km it achieves acceleration in just 10.9 seconds. The drag coefficient is 026. When braking , it uses system „by wire“[1]. Thanks to the extended range of EV (electric vehicles) CO_2emissions are reduced to 59 g / km. These emissions can be even more reduced if windmills or solar panels would be used. Fuel consumption is 3.9 l/100 km. [6]

Mercedes

Mercedes Benz S400 Hybrid is the first vehicle that uses a hybrid drive. In 2009, it appeared on the U.S. and Europe market. This vehicle is powered by 3.5-liter V-6 engine with 205 kW/279 hp and an electric motor with 15 kW/20 hp. Shared power is 220 kW / / 299 hp. The maximum speed that this vehicle reaches is 250 km / h, while acceleration from 0 to 100 km / h is achieved in 7.2 seconds. Maximum torque is 375 Nm.
Mercedes Benz ML-450 Hybrid has a hybrid drive that allows the vehicle to move with the combustion engine, electric motor or a combination of both. BMW Group, Daimler, General Motors and Chrysler have been working on development of the plant. It is designed for the American market. The average fuel consumption and emissions are reduced by about 60% compared to vehicles which exclusively use internal combustion engine. [7]

Honda

Honda Insight was presented at the international auto show in Detroit. This is first hybrid of Honda company. It was produced as a hybrid vehicle with the application of cost-effective version of IMA system[2], which results in greater accessibility for buyers of hybrids with low emissions and low fuel consumption. This car has the combination of the two engines, the petrol VTEC engine of 1.3 liters volume and an electric motor. Fuel consumption per 100 km is 4.4 liters and CO_2 emission is 101 g / km. Top speed is 180 km / h, while the vehicle's acceleration from 0 to 100 km / h is achieved for 12.4 seconds. The car features a system of ecological driving assistance - Eco Assist designed to optimize the amount of energy required to move the car. [8].

[1] System „by wire“ allows better usage of energy during braking, and thus the effectiveness of joint and better machinery. Thus, the short time reaction of the system can be alternatively important in an emergency.
[2] IMA system (Integrated Motor Assist) is consisted of electric motor, an advanced battery pack and intelligent compact drive unit that recycles the kinetic energy of the vehicle braking and deceleration and provides extra power when acceleration is need. This system allows the vehicle moving exclusively on electric power in certain driving conditions, from low to moderate speeds.

Honda CR-Z was presented in Detroit in 2007, while for the European market at Geneva auto show in 2010. This is the first hybrid with a six-speed manual gearbox. The new model is a form of sports coupe 2+2.[3] configuration. Full name of this sports coupe is Compact Renaissance Zero, abbreviated CR-Z.
Honda FCX Clarity FCEV is an electric vehicle, first introduced in Los Angeles at the auto show in 2007. The vehicle is powered by two engines, the main uses hydrogen for drive, and supporting use electrical energy. The hydrogen engine has only 129 hp. Top speed is 160 km / h, the torque is 256 Nm. Acceleration to 100 km is achieved in 9.2 seconds. Consumption of hydrogen per 100 kilometers is just 3.3 liters. The main advantage of this vehicle is that there is no emission of CO_2or this is a vehicle with zero exhaust emissions. Besides, this vehicle uses hydrogen as the only fuel, which is also a step ahead from other, only electric vehicles. [9]

Hyundai

Hyundai Elantra LPI is the first hybrid electric car vechicle of company Hyundai introduced in 2009. This car model was launched primarily for the Korean market. The car is started by the drive, which is based on liquid-petroleum gas (LPG) and electricity. Among other things, this is the first HEV-powered liquid-petroleum gas, and in addition it is also the first vehicle in the world to use a lithium-ion polymer rechargeable batteries. These batteries are thicker during filling and safer than the lithium ion batteries that are found in other HEV, and their advantage is that they can last longer in high temperatures. Acceleration from 0-100 km / h is achieved for 11.7 seconds. CO_2 emissions are 94 g / km and fuel consumption is 5.6 liters per 100 km. [10]

COMPARATIVE ANALYSIS

In Table 1 the main characteristics of selected contemporary organic and conventional vehicles are presented. The study includes *all-electric vehicles* (Tesla Roadstar) and *hybrid-electric vehicle* (hybrid Rio, Kia "cee'd, Kia" Sportage ", Toyota Prius, Mercedes S400 hybrid and ML 450 hybrid, Honda Insight and CR-Z), as well as *hydrogen-powered* (Honda FCX Clarity) and *liquefied petroleum gas* (Hyundai Elantra LPI). Conventional vehicles ("Lotus", Toyota Yaris, Honda Accord) are also presented.

Table 1. Selected modern ecological and conventional vehicles

Manufacturers and models	Power (HP)	Fuel consumption (l/100 km)	CO_2 (g/km)	Acceleration from 0 to 100 km/h (s)	Max speed (km/h)	ABS	ARB[4]	EBD	ESP
Tesla Motors									
Tesla Roadstar	248	/	/	3,9	201	✓	✓		
„Lotus Elise“	134	6,3	149	6,5	204	✓	✓		
Kia Motors									
Rio hybrid	106	5,3	126	12,2	180	✓	✓	✓	✓
Kia „cee´d“	114	3,9	104	11,6	187	✓	✓	✓	✓
Sportage	163	8,9	138	12,0	177	✓	✓	✓	✓
Picanto	65	4,8	95	15,1	152	✓	✓	✓	✓
Tojota									
Prius	113	3,9	59	10,9	180	✓	✓	✓	✓
Auris	136	6,5	152	10,0	195	✓	✓	✓	✓
Mercedes									
S400 hybrid	279	7,0	190	7,2	250	✓	✓	✓	✓
ML 450 hybrid	275	7,7	185	7,8	215	✓	✓	✓	✓
Honda									
Insight		4,4	101	12,4	180	✓	✓	✓	
CR-Z	124	5,0	117	9,9	200	✓	✓	✓	
FCX Clarity	129	3,3	/	9,2	160	✓	✓	✓	
Honda Acord	150	5,4	138	9,4	220	✓	✓	✓	
Hyundai									
Elantra LPI		5,6	94	11,7		✓	✓	✓	✓

[3] 2 +2 configuration is only available in Japan and the EU
[4] ARB – air bags and curtains

Analyzing the table number 4 *from the safety point*, we note that the ecological vehicles are well-equipped with systems and equipment that affects active and passive safety of road users. In addition to these, they include other systems such as IMA, start-stop system and others. So it is in this respect that they are no different from conventional vehicles. From an *environmental point of view,* we see that all-electric cars produce no emissions and have zero emission of CO_2, whereas, hybrid electric vehicles produce the lowest emissions of carbon dioxide, CO_2. Tesla Roadstar is leading with all its properties, and that is the maximum speed of 201 km / h with zero emissions of carbon dioxide. In our market, Toyota Prius is the most frequent, and it provides excellent results with a maximum speed of 180 km / h, with fuel consumption of just 3.9 liters per 100 km driven and carbon dioxide emissions of just 59 g / km, which is more than satisfactory.

Table 2. The average fuel consumption and emissions of CO_2 for hybrid-electric vehicles

Model HEV	**Fuel consumption (l/100 km)**	**Emission CO_2 (g/km)**
Toyota Prius	3,9	59
Honda „Insight“	4,4	101
Rio hybrid	5,3	126
Average value	**4,5**	**95**

In Table 2 we have selected a couple of HEV and came to the conclusion that roughly average fuel consumption is 4.5 liters per 100 km driven, while the average value of CO2 emissions is 95 g / km, which is a very satisfactory result. It is believed that the "greenest" vehicles are those which emitted CO_2 below 100 g / km.

Table 3. The average fuel consumption and CO_2 emissions for vehicles powered by hydrogen

Model of vehicles using hydrogen	**Fuel consumption (l/100 km)**	**Emission CO_2 (g/km)**
Honda „FCX Clarity“	3,3	/
Mercedes „F-CELL“	3,3	/
Average value	**3,3**	**0**

In Table No. 3 We analyzed the consumption of hydrogen and carbon dioxide emissions in vehicles powered by hydrogen. The table shows that the average fuel consumption of these vehicles is 3.3 liters per 100 km driven in zero emission of CO_2. These are excellent results because there are no harmful emissions to the environment, because hydrogen only disposes water.

Table 4. The average fuel consumption and CO_2 emissions for vehicles powered by LPG

Model of vehicles using LPG	**Fuel consumption (l/100 km)**	**Emission CO_2 (g/km)**
Fiat Punto	6,0	116
Hyundai Elantra LPI	5,6	94
Average value	**5,8**	**105**

Based on data from Table No. 4 we conclude that the vehicles using liquefied petroleum gas (LPG), have average fuel consumption of 5.8 liters per 100 km driven, while the average carbon dioxide emissions is 105 g / km.

Table 5. Average fuel consumption (electricity) and CO_2 emissions for electric vehicles

Model EV	Fuel consumption (l/100 km)	Emission CO_2 (g/km)
Tesla Roadstar	***none***	/
Peugeot“Ion“	***none***	/
Average value	/	/

From Table No. 5 it can be concluded that all-electric vehicles do not use fuel, but electricity to run, approximately 1.5 to 2 euros per kilometer, which is three times less than cars that use internal combustion engine. These are also the greenest vehicles with zero emissions of carbon dioxide. The maximum speed of Peugeot "Ion" is only 128 km / h. These vehicles are ideal for the urban environment, but their disadvantage is that they cannot reach high speeds and cannot reach long distances as conventional vehicles. The exception is the Tesla Roadstar.

Table 6. The average fuel consumption and emissions of CO_2 on a gasoline

Model	Fuel consumption (l/100 km)	Emission CO_2 (g/km)
Toyota Auris	6,5	152
„Lotus Elise“	6,3	149
Average value	**6,4**	**151**

In Table No. 6 conventional gasoline vehicles are given and obtained average fuel consumption is 6.4 liters per 100 km and the average CO_2 emission is 151 g / km. Carbon dioxide emission is much higher than with greener cars.

Table 7. Average fuel consumption and CO2 emissions for diesel vehicles

Model	Fuel consumption (l/100 km)	Emission CO_2 (g/km)
Toyota Auris	6,2	138
Honda Acord	5,4	138
Average value	**5,8**	**138**

In Table No. 7 some of conventional diesel vehicles are presented and the average fuel consumption per 100 km is 5.8 liters, while CO_2 emission is 138 g / km. According to these data, diesel vehicles have identical fuel consumption as vehicles using liquefied petroleum gas, however carbon dioxide emission is significantly lower for vehicles with LPG.

Table 8. Comparative analysis of organic and conventional vehicles according to average fuel consumption and average CO2 emissions

Type of vehicle	Average fuel consumption (l/100km)	Average emission of CO_2 (g/km)
GASOLINE	6,4	151
DIEZEL	5,8	138
LPG	5,8	105
HEV	4,5	95
HYDROGEN	3,3	0
EV	/	0

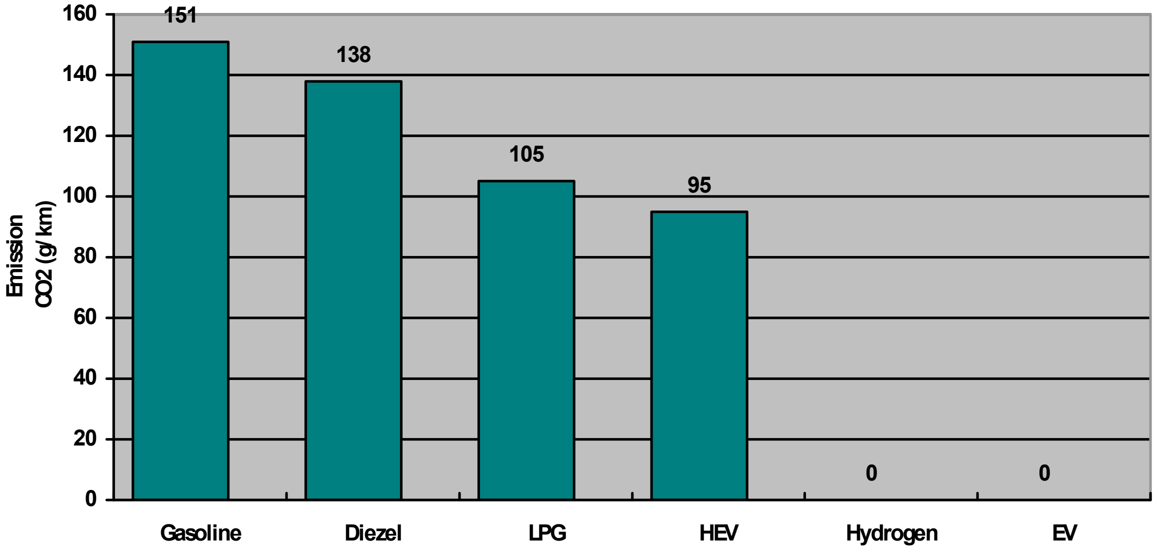


Figure 1. Average CO_2 emissions, depending on the type of drive

With analyzing Table number 8 and chart number 1 it can be concluded that the lowest average emissions are achieved with a fully electric vehicles and vehicles powered by hydrogen, ie. in these vehicles CO_2 emission doesnot exist. Petrol and diesel engines emit the most of CO_2 while HEV meet the standards. Their average CO_2 emission is 95 g / km, which meets the set standards of the European Union, and that is that CO_2 emissions should be below 100 g / km, in order to protect the environment.

CONCLUSION

Reduction of greenhouse gas emissions is more than 50%. When the effect of hybrid electric vehicles on air pollution is evaluated, it should be kept in mind that the biggest problem of air pollution is in cities. The air over cities would be cleaned with usage of hybrid vehicles. On the other hand, in order to prevent global warming due to the greenhouse effect is necessary to reduce the total amount of emissions. HEV also affects reduction in the use of fossil fuels, which reserves are limited and non-renewable. All over the world, alternative fuels are more and more in use, which include biogas, hydrogen and electricity.

Although it is a fact that the transport and automotive industries adversely affect the environment, with constant modernization and innovations which is nowadays normal and necessary due to the emergence of a significant degree of competition that prevails, it seems that this problem is entirely solved thanks to a new era in which we'll step in- an era of ecologically aware car drivers and environmental cars.

Usage of HEV enables quiet and noiseless ride, and it is deal for city driving. Their usage would reduce fuel consumption and emissions, and hence contribute to the preservation of the environment, and therefore human health.

HEV provides plenty of good options when it comes to safety, efficiency, simplicity, environmental cleanliness, and is also suitable for innovation.

Most hybrid electric vehicles, which are discussed in this paper have good performance, good equipment systems, active and passive vehicle safety, as well as good grades when it comes to the safety of road users.

They are massively produced in the world, while in Serbia are still not rooted. However, it is the state that can affect the citizens by allowing them benefits when purchasing HEV, since these vehicles are more expensive than conventional vehicles, which is also their disadvantage.The U.S. has been given various subsidies in purchasing HEV. On the other hand, these vehicles reduce fuel and reduce emissions. When the fuel savings are taken into account, these vehicles are cost-effective for beneficiaries in the long run. In our market, Toyota Prius is the most abundant, and next to it at the recent auto fair in Belgrade one could see Toyota Yaris, Mercedes S 400 Hybrid and other.

In addition to hybrid vehicles, in use are also fully electric vehicles. Their advantage is that they are electricity-driven, which consumes power up to three times less than fuel. Also, the advantage is that they do not emit fumes, and therefore do not threaten the environment and its surroundings.

Disadvantages of electric vehicles are that the battery they use for the single charge can cover very small distance which varies depending on the vehicle from 100 to 200 miles, so they are ideal for short distances, while certainly not for long. In addition, the problem is in the battery itself, because even though it can be charged at any home outlet, it needs a lot of time for that. With each charging the battery life is shortened. The exception is in the range that Tesla Roadstar has - for a single battery charge it can exceed 400 miles. However, for our market, its price is high (100 000 $).

Today, technology is more and more developed in hydrogen production cars. The great advantage is that these vehicles do not emit harmful substances, so there is no CO_2. However, except in California, nowhere else can hydrogen filling station be found.

Carbon dioxide emission is directly related to fuel consumption. Based on comparative analysis of selected organic and conventional modern vehicles, we have concluded that gasoline vehicles, on average, consume the most fuel, up to 6.4 liters per 100 km driven, and the average carbon dioxide emissions is 151 g / km. While EV consume less energy and produce no harmful emissions. HEV meet the standards of the European Union, because on average their emissions are below 100 g / km and fuel consumption (3.3 l/100 km) is twice lower compared to gasoline vehicles.

It can be noted from the above said that the environment-friendly vehicles strongly affect fuel reduction and reduce CO_2 emissions, and therefore the attention should be directed to the improvement of the vehicles and to lowering prices or providing purchasing benefits, so that as many as possible of these vehicles could be found on the streets of the major cities.

REFERENCES

[1] http://www.vrelegume.rs/ecofriendly/ECOFriendlypress1.pdf/
[2] D. Filipovic, Traffic impacts on the environment, Traffic Engineering Faculty, Belgrade, 2009.
[3] Raca D: Modern electric machines used for hybrid and electric vehicles, MA, Novi Sad (2008)
[4] http://en.wikipedia.org/wiki/Tesla_Roadster
[5] http://www.kia.eu/
[6] http://www.toyota.rs/
[7] http://www.mercedes-benz.rs/
[8] http://www.honda-srbija.rs/
[9] http://www.honda-srbija.rs/code/navigate.php?Id=23&ObjId=1
[10] http://www.hyundai.co.rs

SESSION 6: Basic operations, Machinery and Processes

EXPERIMENTAL INVESTIGATION OF OPERATING AND DYNAMIC PROPERTIES OF ADSORPTION FILTER PROTOTYPE

Miomir Raos[1], Ljiljana Živković[1], Amelija Đorđević[1], Nenad Živković[1], Jasmina Radosavljević[1], Emina Mihajlović[1]
[1] University in Niš, Faculty of Occupational Safety, Niš, Serbia
e-mail: miomir.raos@znrfak.ni.ac.rs, ljiljana.zivkovic@znrfak.ni.ac.rs, amelija.djordjevic@znrfak.ni.ac.rs, nenad.zivkovic@znrfak.ni.ac.rs, jasmina.radosavljevic@znrfak.ni.ac.rs, emina.mihajlovic@znrfak.ni.ac.rs

Abstract: The aim of the paper is an examination of flow-thermal, operating and dynamic properties (velocities of gas mixture, flows, pressure drops, temperatures, humidities, chemical pollutants tests, efficiency) and performance of the adsorption filter prototype in the filter-ventilation system. The paper presents the results of experimental research conducted on the original apparatus in the laboratory for air quality management at the Faculty of Occupational Safety in Niš. Examination of flow-thermal, operating and dynamic parameters of the observed filter prototype was carried out on an experimental ventilation setup with a variable flow rate of gas mixture. Experimental data were registered with appropriate measuring equipment, which helped us obtain a picture of the behavior of the adsorption filter prototype compared to simulated parameters of the gas mixture. By measuring and data acquisition, we reached the assumptions for identifying the observed process, and thus the possibility of modeling and controlling process parameters.
Key words: experiment, air purification, ventilation, adsorption filter

INTRODUCTION

Figure 1. shows the schematic of filter-ventilation system elements with a system for data acquisition. Elements of a filter-ventilation system represent the electromechanical system for experimental testing and simulation of flow, thermal, and operating parameters of the gas mixture, and prototypes of filter compartments. Within the frame of the filter-ventilation system, there are elements for air-conditioning and simulation of test pollutants, modules – supports for the emission filter prototypes, as well as measuring and acquisition equipment, components for distribution of the gas mixture and ventilator unit with flow regulation.

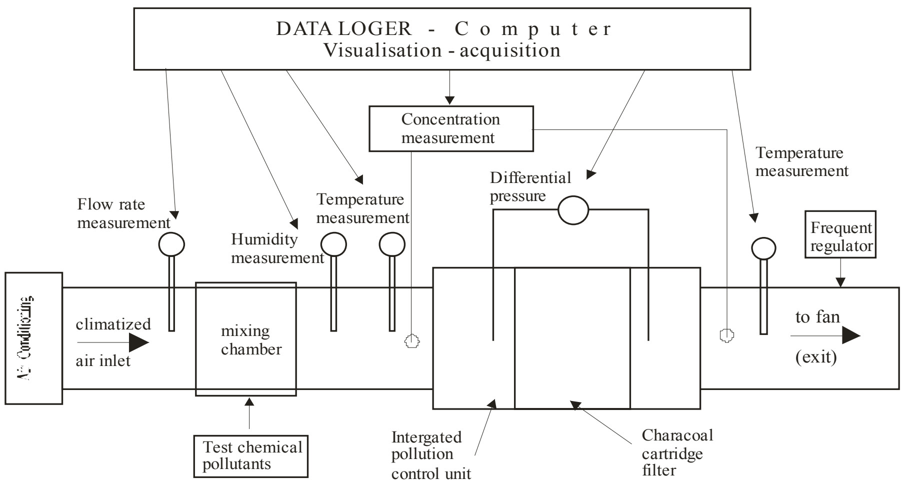


Figure 1. Schematic of the filter-ventilation system with data acquisition system

CONCEPT OF THE CLEANER MODULE FOR GASEOUS CHEMICAL POLLUTANTS

The cleaner module for chemical pollutants is a compact input-output line segment of the filter-ventilation line, which includes two oppositely directed diffusers and a connecting element of the square cross-section between them. A panel was made of plastic material (PVC) by adequate vacuum

processing method, which resulted in proper compactness, strength, and smoothness of the interior walls of modules. This is important because of the module's good mechanical resistance to vibration when the gas mixture flows through the module. Total length of the cleaner module for chemical pollutants is 1270mm. Connection of diffusers with the body of the module is made by flanges, bolts, and nuts with a suitable sealing element in the flange.
Figure 2. provides an overview of the cleaner module for chemical impurities with measuring and data acquisition equipment.

Figure 2. Cleaner module for chemical pollutants with air ducts (fig. left), on top differential pressure transmitter, (fig. right, behind – air conditioning unit, in front – measuring and data acquisition)

We stored adsorption filling in the form of cartridges, filled with activated carbon, in the cleaner module for chemical pollutants. The main function of the modules for treatment of chemical pollutants is to provide adequate housing and position of cartridges or activated carbon fillings, and to provide adequate flow characteristics of the gas mixture when it passes through adsorption filling.

CLEANER OF GASEOUS CHEMICAL POLLUTANTS

Selection of a cleaner of chemical pollutants is conditioned by the very nature of pollutants, the conditions in which it is used, the desired degree of separation of impurities, capacity, features, ventilation system, etc.
In the experimental part of the paper, we used the adsorption filter prototype with activated carbon as a filling, which was developed in cooperation with local manufacturers of purification systems – Eco Engineering from Bor.
Activated carbon was placed in proper cylindrical cartridge prototypes, with a precisely defined size, adequate resistance to chemical and mechanical effects, and low aerodynamic resistance to the passage of the gas mixture through the cleaner module.
Figure 3. shows a cartridge filled with activated carbon.

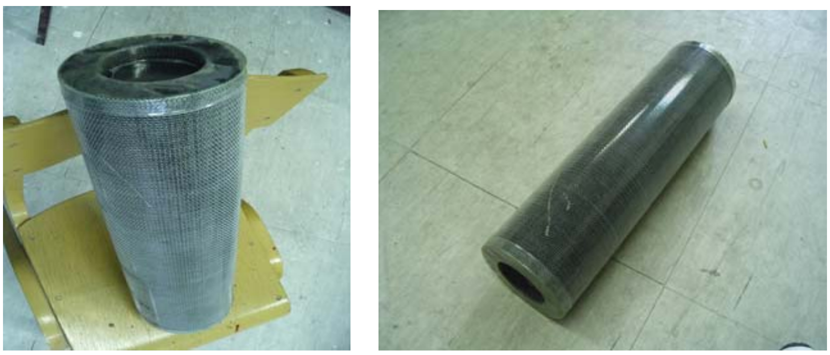


Figure 3. Cartridge with activated carbon.

The cartridge is cylindrical, and its axis corresponds to the flow direction of the gas mixture, which ensures an axial input of the gas mixture into the cartridge area, and then, by a radial flow direction through adsorption filling, its output from the cleaner module for chemical impurities. Radial movement of the gas mixture through the adsorber layer is possible due to existence of a blind panel which the gas mixture strikes when entering the cleaner module and due to perforated inner and outer layer of the cartridge. Size of the perforation is less than the grain size of the adsorber – activated carbon, so as to avoid grains falling through the holes of cartridge layers.

Cartridge housing is made by perforation of acid-resistant plastic film, 1.4 mm thick (variable number and size of perforations per square centimeter), thus reducing the weight and price of the filters. The cartridges are in a chessboard layout and form a cluster group that is built into the adsorption filter module. Figure 4. shows an adsorption filter in the form of a cluster group, used in the experimental part of the paper.

Figure 4. Adsorption filter in the form of a cluster group

For adsorption filling of the cleaner module for chemical pollutants, we used pellets of activated carbon manufactured by Calgon Carbon Corporation from USA (European Branch – Chemviron Carbon) with different granularity (3mm, 4mm), Envirocarb^{TM} series AP4-60 AP4-60 [4].

This type of activated carbon has a very high density that contributes to a fairly good volume activity, which is important if the activated carbon is used as adsorbent in the form of volume structures. In addition to this positive feature, activated carbon pellets in this series are characterized by good mechanical strength, easy and inexpensive recycling, low ash content, resistance to thermal loads, and low pressure drop of activated carbon in a layer. This results in reduction of fan strain (less power). EnvirocarbTM AP series is currently widely used in the fields of ventilation and air conditioning, treatment of volatile organic compounds (VOC), groundwater remediation, treatment of aerosols during painting and lacquering, solvent reparation (with moderate boiling points, e.g. benzene), treatment of industrial odors, treatment of kitchen fumes, and so on.

TEST GASEOUS CHEMICAL POLLUTANTS USED IN THE EXPERIMENT

A simulation of test chemical pollutants is conducted by means of a controlled dosage of gaseous test chemical pollutants. This module contains the source-reservoir of chemical pollutants, proper measuring and regulating apparatus, as well as elements for insertion into the air duct.

For the experimental part of the paper, we used Isobutylene as a test chemical pollutant, an organic chemical compound with the formula C_4H_8 [5]. Isobutylene is a hydrocarbon that occurs in nature both from natural and from anthropogenic sources. It is a part of natural gas and crude oil. Its presence is usually associated with the environments such as oil and natural gas source, refineries, gas stations, and reservoirs. In addition, its presence is substantial in urban and suburban environments and comes from fossil fuel

combustion. Anthropogenic sources of isobutylene are associated with different technologies to obtain this gas. Isobutylene is obtained commercially by procedures of catalytic or thermal cracking of petroleum fractions, and by various other procedures, such as dehydration tert-butyl alcohol, thermal dehydrogenation of isobutylene, and so on. Concentrations of isobutylene are recorded in urban settings in the range from 1 to 10ppm (according to the Manufacturing Chemists Association, Inc., 1974). Atmospheric conditions significantly degrade isobutylene through photochemical processes.

RESULTS OF EXPERIMENTAL RESEARCH – OPERATING PROPERTIES OF ADSORPTION FILTER PROTOTYPE

The group of tests shows concentrations of gaseous test samples in front of and behind the adsorption filter. Concentrations were displayed in terms of velocity and flow of the gas mixture in the ventilation duct. Additionally, we presented a comparative view of concentrations depending on temperature and relative humidity of the gas mixture.

Generally, there is noticeable change in concentration in the secondary air duct at the entrance of the adsorber module, which shows a trend of rapid growth when the gas flow is launched through the test line. Simultaneously, the concentration exiting the adsorber module in the tertiary air duct has a very low value, which indicates intensive extraction of gas impurities in the adsorption filling. As the velocity of gas mixture in the duct increases, there is a decline in input concentration as a result of increasing amount of fresh air intake compared to the same amount of test chemical pollutants (gas substance), up to values close to zero, which indicates a large percentage share of air intake in relation to small input concentrations of the gas. On the other hand, the output concentration retains extremely low values until the velocity of gas mixture at about 0.3 m/s in the adsorber module, which indicates a good function of the adsorption filter, which operates in this range with the efficiency percentage of 93-97%.

Increased velocity of the gas mixture in the duct leads to increased output gas concentration up to the velocity of the gas mixture when the output and input concentration values of test isobutylene begin to overlap. This indicates extremely high velocities and flow rates of the gas mixture, when the adsorption filling is not able to adequately separate the gas and there is slight "passing", rather than separation, of the gas mixture. Efficient adsorption process involves specific time of contact that is different from the nature of chemical contaminants, flow conditions, thermodynamic parameters, and adsorption filling properties.

It is necessary to design the adsorption module so that it has moderate flow velocities in order to achieve adequate contact time and, consequently, the maximum separation of gaseous impurities.

Figures 5-8 provide a comparison of concentrations, first in front of and then behind the adsorption filter in function of the thermodynamic parameters and velocity of gas mixture through the test line. We can observe the dependence of adsorption processes on changes in temperature and humidity of gas mixture. As shown in the figures, when the temperature of the gas mixture is increased, there is reduced activity of the adsorber which is manifested through an increase in output concentrations of test gaseous impurities. The increase is more prominent if the velocity increases, or the contact time decreases. On the other hand, low humidity affects the increase of input concentrations of test pollutants. Generally, high velocity gas mixture adversely affects the adsorption process because of the reduction of contact time between the gas mixture and the adsorption layer. Experiments reveal that lower moisture content in the air and lower operating temperatures are more favorable to the adsorption process because the adsorption process is prominently exothermic.

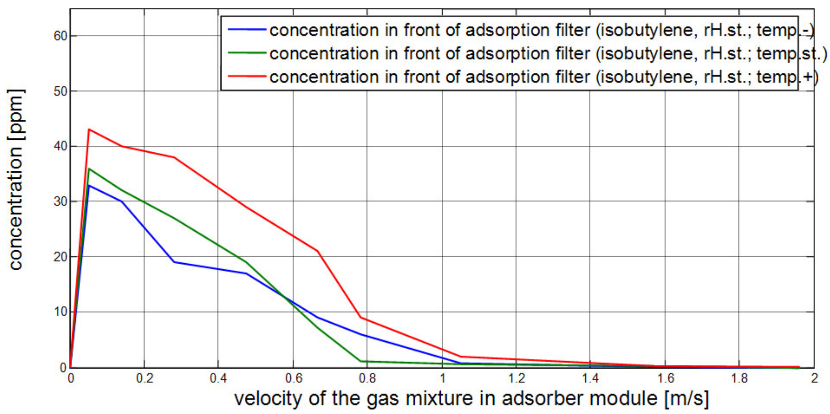


Figure 5. Change of concentration (adsorption filter entrance) in function of gas mixture velocity (Isobutylene, rH st.; temp .-, st., +)

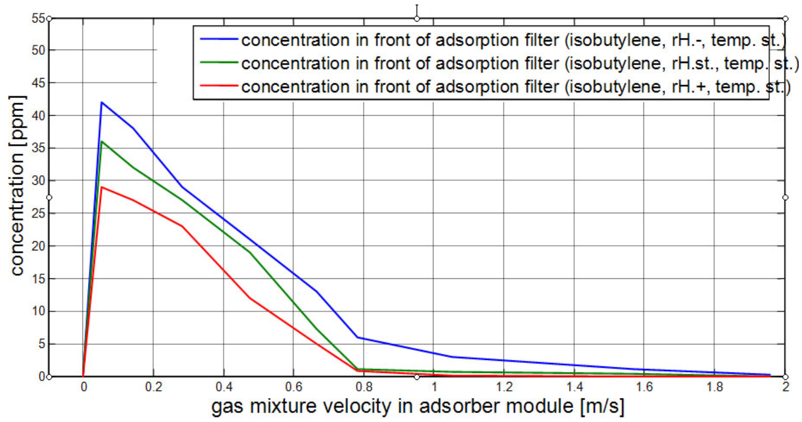


Figure 6. Change of concentration (adsorption filter entrance) in function of gas mixture velocity (Isobutylene, rH -,st.,+; temp. st.)

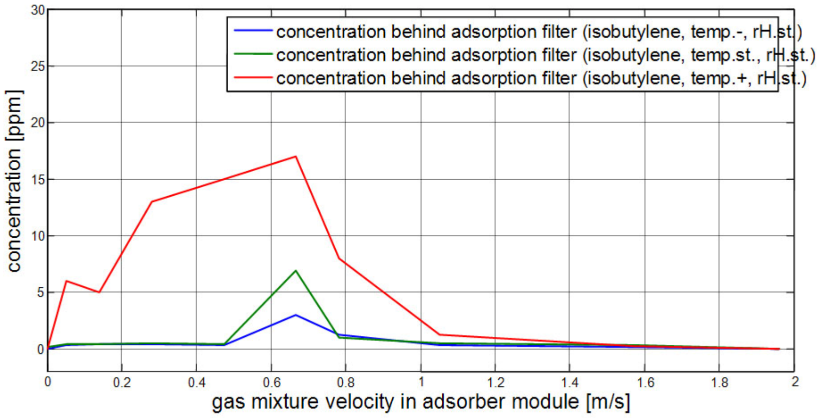


Figure 7. Change of concentration (adsorption filter exit) in function of gas mixture velocity (Isobutylene, rH st., temp. -,st.,+)

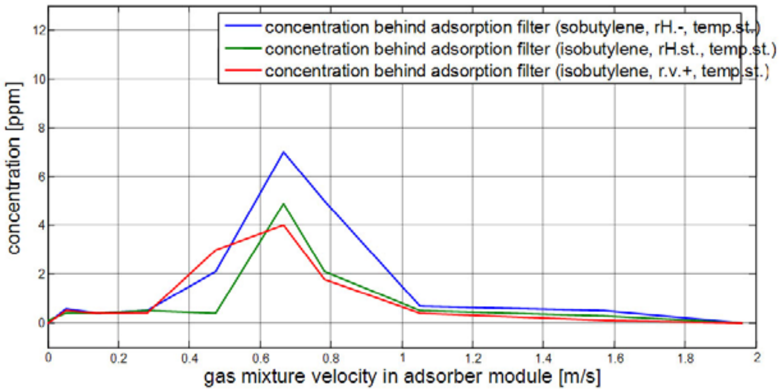


Figure 8. Change of concentration (adsorption filter exit) in function of gas mixture velocity (Isobutylene, rH -,st.,+; temp. st.)

RESULTS OF EXPERIMENTAL RESEARCH - DYNAMIC PROPERTIES OF ADSORPTION FILTER PROTOTYPE

In this group of dynamic tests, adsorption filter (activated carbon cartridges) was exposed to standard microclimatic conditions. This implies relative humidity values of (50-55%) and temperature of (22-23°C), with constant recommended velocity values in the test line and a constant flow of the gas mixture. Recommendations pertain to the contact time of the gas mixture and adsorption charge from 3 to 5 sec, allowing a maximum separation of gaseous impurities in the process of adsorption. At the entrance of the primary air duct, the gas mixture is dosed with a constant concentration of the test pollutant, isobutylene. The diagrams show changes in flow and thermodynamic parameters of the gas mixture, temperatures, relative humidities, velocities and differential pressures on the adsorption filter, and changes of input and output concentrations of isobutylene in front of and behind the adsorption filter. The process of dynamic testing of the adsorber is terminated when the input concentration reaches the exit of the adsorption filter, i.e. after the filter breakthrough.

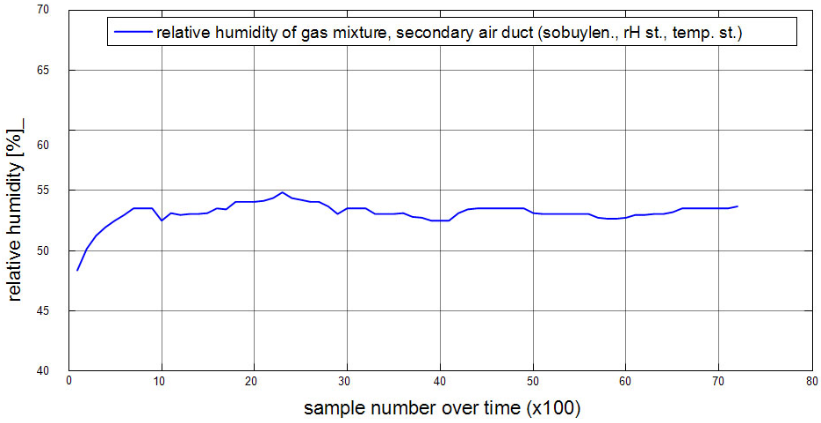


Figure 9. Change of the relative humidity of air through adsorption filter, Isobutylene, rH st.; temp.st.)

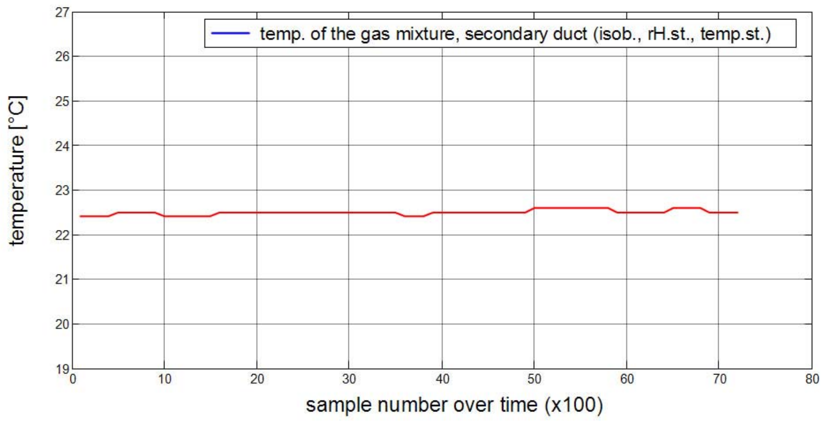


Figure 10. Change of air temperature through adsorption filter , Isobutylene, rH st.; temp.st.)

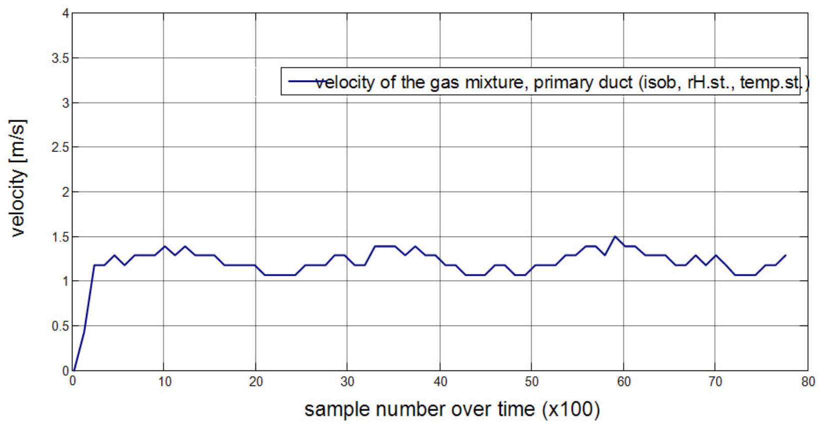


Figure 11. Change of air velocity through adsorption filter, Isobutylene, rH st.; temp.st.)

Figure 12. shows the change in concentration in front of and behind the adsorption filter. Although the appearance of the output concentration curve changes (up to about 46x100 samples) is a straight line, in reality it is not straight and changes intensively within a very narrow range of 0.4 to 0.6ppm. However, due to the large scale of the diagram, this change is seen as a straight line. Over the number

of 46x100 samples there is a significant increase in the output concentration value of and it approaches the input value. This means that the adsorption filter is being saturated up to the moment when it no longer collects the test pollutant – Isobutylene, i.e. when the adsorption filter breakthrough actually occurs. From that moment, the adsorption filter is practically unusable and must be replaced.

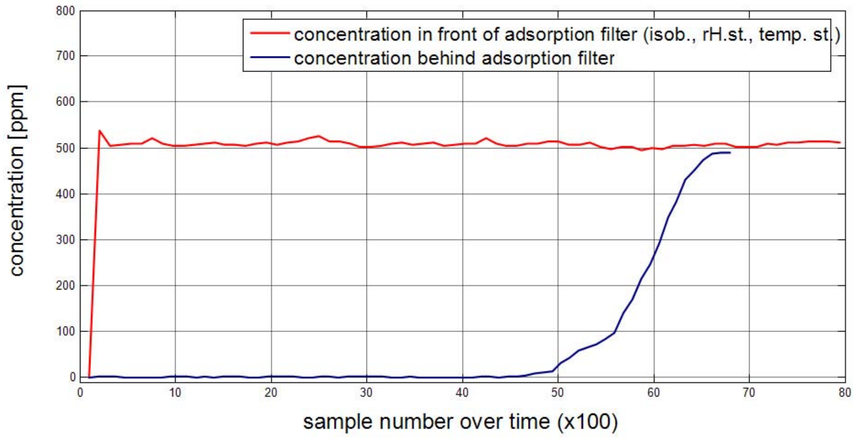


Figure 12. Change of concentration (adsorption filter entrance and exit in function of sample number (x100, Isobutylene, rH st.; temp.st.)

Figure 13. shows the change of differential pressure on the adsorption filter. Change of differential pressure is relatively small and, as observed by previous researches, it does not significantly affect the functioning of the filter-ventilation system as a whole. As seen from the chart, values of differential pressure range from 290 to 320mbar, so this effect can be neglected in the overall assessment of the filter-ventilation system.

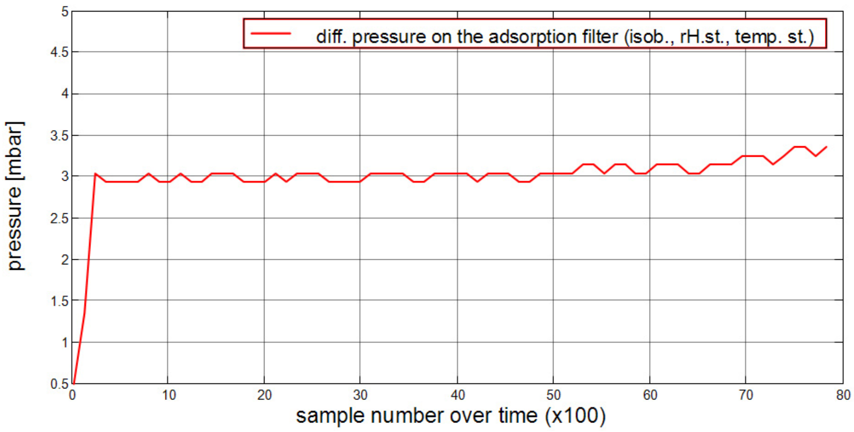


Figure 13. Change of differential pressure on the adsorption filter in function of sample number (x100, Isobutylene, rH st.; temp.st.)

EFFICIENCY OF ADSORPTION FILTER PROTOTYPE

Adsorption filter efficiency is determined based on the analysis of input and output test pollutant concentrations, measured during dynamic testing to the breakthrough (saturation) point. Initial efficiency of the adsorption filter is very high, about 0.97, and decreases with time as the adsorption filling is saturated. Figure 14 shows that the curve of efficiency changes of the adsorption filter has a high and constant value at the beginning until about 4500 samples per time when it begins to show a declining trend. The characteristic slope of the curve of efficiency changes is different for each adsorbent and adsorption filter and it results from complex adsorption kinetics and the conditions in which the process of adsorption takes place.

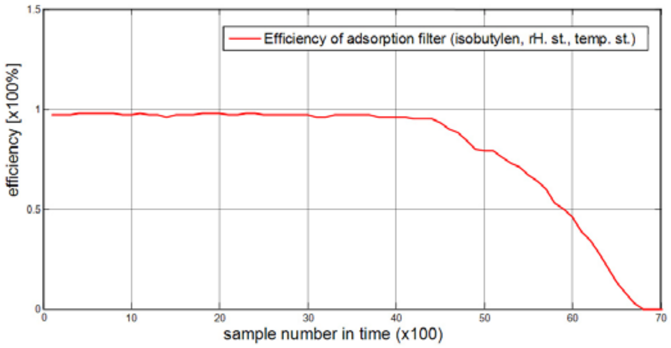


Figure 14. Change of efficiency of the adsorption filter in function of sample number (x100, Isobutylene, rH st.; temp.st.)

CONCLUSION

The paper presents the results of experimental examination of flow-thermal parameters and dynamics properties of the adsorption filter prototype in the filter-ventilation system. Specificity of the adsorption filter prototype is design, geometry and material used for housing of the filter. Cartridge housing is made by perforation of acid-resistant plastic film with variable number and size of perforations per square centimeter, thus reducing the weight and price of the filters. The cartridges are in a chessboard layout and form a cluster group that is built into the adsorption filter module made from plastic material (PVC) by adequate vacuum processing method. All structural features contribute to a good efficiency, lower weight and lower cost of the cartridge and adsorption module. Dynamic characteristics of adsorption filter are very good and characterized by low pressure drop in relation to changes in temperature, humidity and velocity of the gas mixture in the ventilation system. Also, adsorption filter is characterized by good separation of test gaseous pollutants and large capacity allocation.

Experimental data were registered with appropriate measuring equipment, which helped us obtain a picture of the behavior of the adsorption filter prototype compared to simulated parameters of the gas mixture. Therefore, by measuring and data acquisition, we reached the assumptions for identifying the observed process, and thus the possibility of modeling and controlling process parameters as well as structural characteristics of the adsorption filter.

ACKNOWLEDGEMENTS

This research is part of the project No. III-43014 and project No. III-42008. The authors gratefully acknowledge the financial support of the Serbian Ministry for Science for this work.

REFERENCE

[1] Raos M., Živković Lj., Đorđević A., Todorović, B.: Modelling of the filter-adsorber type air cleaner by using Neural Network, Scientific Journal Facta Universitatis, Series: Physics, Chemistry and Technology Vol. 7, No 1, 2009, pp. 23 – 31, DOI: 10.2298/FUPCT0901023R

[2] Raos M., Živković Lj., Đorđević A., Živković, N., Radosavljević, J.: Concept of the filter-adsorbet type integrtated air purifier, Scientific Journal Facta Universitatis, Series: Physics, Chemistry and Technology Vol. 8, No 1, 2010, pp. 57 – 66, DOI: 10.2298/FUPCT1001057R

[3] Raos, M., Živković, Lj., Živković, N., Todorović, B.: Moddeling of air pollution control devices using neural networks, Scientific Journal Facta Universitatis, Series: Workig and Living Environmental Protection, VOL. 2, No 5, Niš, 2005, 485-492.

[4] Raos M., Živković, Lj., Todorović, B., Živković, N., Đorđević, A., Radosavljević, J.: Modelling of parameters of the air purifzing process with a filter-adsorber type purifier by use of neural network, Scientific Journal Strojarstvo, 2011.

[5] EnvirocarbTM, Adsorption capacity, Chemviron Carbon, Application & Service Bulletin, European operations of Calgon Carbon Corporation, Belgium, 2004., Calgon Carbon, Pittsburg, PA, USA, 2004.

[6] Isobutylene CAS:115-11-7, Product Identification, Airgas Inc., Randor, PA, USA, 1998.

WELDING WORKS FROM THE STANDPOINT OF EXECUTION AND FIRE PROTECTION

Martina Balać[1], Jelena Nikolić[1], Aleksandra Đerić[1], Aleksandar Petrović[2]
[1]Belgrade University, Innovation center of the Faculty of Mechanical Engineering, Serbia
[2] Belgrade University, Faculty of Mechanical Engineering, Serbia
e - mail: mbalac@mas.bg.ac.rs

Abstract: This paper presents the importance of welding works execution, proper selection of material as well as the appropriate protection of the steel structure and welded joints. Practice, so far, has shown that steel structure breaking under higher temperatures has been caused by the stress increase over critical value, as well as by the change of mechanical characteristics of the material. That's the reason why it is very important to protect steel structure as well as the welded joints, by the material which in the case of increased temperatures can support the deflection of the basic structural element, without bigger cracks.
Key words: welding, quality, stress, temperature, protection, fire

INTRODUCTION

Welding is considered to be a special procedure in terminology of quality system standards. Standards for quality systems usually demand that welding procedures be realized according to the written procedure in welding procedure specification.
Within this paper, we are going to show how important the fire protection of steel structures and welded joints is, especially because material damage caused by fire is big and number of killed people has been increased during previous years. The cheapest way of protection and material damage decrease is undertaking the appropriate protection measures. Therefore it is very important that welded joints are protected because they change their structure in case of increased temperature.
With welded structures, it is necessary to ensure control from the design phase, through the phase of material selection, production and accompanying elements.
In order to ensure quality of welding works, the welder's skill is important to a large extent. Special attention should be paid to the quality of welding works i.e. to ensuring of the certain quality of welding elements. Welders have to have the certificate on professional competence according to the appropriate part of standard SRPS EN ISO 9606: 2008 – Welder testing: Resistance flash welding.
In order to provide all necessary information needed for the manufacturing process, manufacturer has to carry out the review of contract requirements, as well as the review of data regarding structure. Manufacturer has to confirm his capabilities regarding the fulfilment of all contract requirements. Procedures which should be carried out by the supervisor during the execution of welding joints, in order to ensure the quality, have been defined by standards SRPS EN ISO 3834: 2008 – Quality requirements during welding.
For the commencement of welding work execution, regarding the fire protection, it is necessary to perform the contract review.
Requirements of the contract entered into by buyer and manufacturer, and according to SRPS EN ISO 3834 – 2/2008- Quality requirements during welding – Resistance flash welding by metal material.

Table 1. Comparison of quality requirements during welding

Elements	SRPS EN ISO 3834-2 (general quality requirements)	SRPS EN ISO 3834-3 (standard quality requirements)	SRPS EN ISO 3834-4 (basic quality requirements)
Contract review	Complete documentation review	Less detailed reviews	The existence of ability and information to be determined
Structure review	Welding procedure confirmed		
Subcontractor	To be observed the same as the main subcontractor		All requirements have to be met
Welders – operators	Checked according to ISO 9606		
Coordination in welding	Managing staff having the appropriate knowledge, e.g. SRPS EN 719 or people with the same knowledge		Not required, but the manufacturer has the staff
Control staff	There have to be enough staff and competent staff available		Sufficient and competent approach for the third party if necessary
Manufacturing equipment	Necessary for the preparation, cutting, welding, transport, lifting, together with safety devices and protective clothing		Requirements not determined
Device maintenance	It has to be done, maintenance plan necessary	Requirements not determined, have to be adequate	No requirements
Manufacture plan	Necessary	Orientation plan necessary	No requirements
Welding procedures specification (WPS)*)	Welder has to have instructions (ISO 9956-2)		No requirements
Welding procedure qualification	In accordance with the appropriate part of standard ISO 9956 application of standard or contract requirements to be confirmed		Requirements not determined
Operating instructions	There has to be welding procedure specification (WPS) or the appropriate operating instruction		No requirements
Documentation	Necessary	Not determined	No requirements
Consumables testing	Only if specified by the contract	Not determined	No requirements
Storing of consumables and handling consumables	Minimum according to the supplier recommendation		
Storage of basic material	Protection depends on the environmental influence, it has to be determined		No requirements
Heat treatment after welding	Necessary specification and complete record	Necessary specification approval	No requirements
Control before, during and after welding	When required for the specified operation		Obligatory when specified by the contract
Inconsistencies	Procedure has to exist		
Calibration	Procedure has to exist	Not determined	
Identification	Necessary, when feasible	Necessary, when essential	Not determined
Economy			Not determined
Records on quality	Have to exist for the purpose of determining responsibility for manufacturing		When required by the contract
	Have to be kept for five years at least		
*) In national terminology designation STZ is used.			

Quality requirements are selected in order to fulfil the type of welded structure.

Part 2. General quality requirements have to include the following:

a) standards which will be applied, together with all additional requirements,
b) welding procedure specification, test procedures without demolition and heat treatment procedures,
c) procedure which should be used for qualification of welding procedure,
d) check of the professional qualifications of personnel,
e) heat treatment after welding,
f) control and test,
g) selection, identification and/or traceability, for example for the materials, welders and welded joints,
h) the way of quality control, including the independent control authority too,
i) other requirements during welding, for example inspection of consumables and additional material, for example test of consumables and additional material, ferrite content in weld metal, aging test, hydrogen content test,
j) environmental conditions necessary for field welding, e.g. very low temperatures or any other needs regarding the provision of protection from the adverse weather conditions,
k) subcontracting,
l) procedure in case of nonconformities.

For example, inappropriate selection of the material can cause problem during welding, i.e. the appearance of fissures which can cause the breaking of structure under increased temperatures. Unless all contract requirements are met, quality of welded joints is directly jeopardized which endangers the elements of the structure exposed to high temperatures.

Structure requirements (requirements from the group of standards SRPS C. T3…. subgroup of welding standards) have to include:
a) position, approachability and welding sequence,
b) finish surface and seam profile,
c) basic material specification and welded joint characteristics,
d) permanent washer,
e) welded joints which are to be made in the workshop or on the field,
f) measurements and details of preparation of the joint and complete joint,
g) use of special methods, e.g. provision of complete welding in without washer during single welding,
h) quality and levels of acceptability for welded joints,
i) other special requirements, e.g. acceptability of forging (hammering), heat treatment.

Manufacturer has to have coordination personnel available during welding, qualified according to standard SRPS EN 719 Coordination in welding – tasks and responsibilities, and they have to be responsible for the activities related to quality. Personnel for planning and performing control and testing of welded products, should also have the valid certificates.

Manufacture plan, which is to be carried out by the manufacturer should include:
– specification of sequence of operations needed for structure to be manufactured, e.g. for single parts, or subassembly and final erection procedure;
– Identification of welding procedures and related procedures which are required during the manufacturing of structure and references regarding appropriate specification of the procedure. Qualification of welding procedure has to be done in accordance with the appropriate part of ISO 9956 Welding procedure has to be qualified before manufacturing.
– Specification for control and testing, including the participation of independent inspection authority.

During the welding activities manufacturer has to introduce the storing, handling and consumables usage procedures in order to prevent the humidity absorption, oxidation, different damages.

Standard NFPA 51B - Standard for Fire Prevention in Use of Cutting and Welding Processes, which is the part of the American group of standards for fire prevention (National Fire Protection Association) has been prepared for the guidance of welders and cutters (including persons who perform cutting and welding), fire watchers, their supervisors (including outside contractors), and those in management on whose property cutting and welding is to be performed. This standard covers provisions to prevent loss of life and property from fire in the use of oxy-fuel gas and electric arc welding and cutting and equipment where such equipment is used for cutting and welding.

According to NFPA 51B welding shall be permitted only in areas that are or have been made fire safe. Within the confines of an operating plant or building, the welding work area shall be either

(1) a specific area designed or approved for such work, such as a maintenance shop or a detached outside location that shall be of non-combustible or fire-resistive construction, essentially free of combustible and flammable contents, and suitably segregated from adjacent areas; or
(2) where work cannot be moved practically, as in most construction work, an area made fire safe by removing combustibles or protecting combustibles from ignition sources.
Welding shall not be permitted in the presence of explosive atmospheres (e.g., mixtures of flammable gases, vapors, liquids, or dusts with air) or explosive atmospheres that can develop inside unclean or improperly prepared drums, tanks, or other containers and equipment that have previously contained such materials or that can develop in areas with an accumulation of combustible dusts.
For example standard SRPS EN 60974 – 7:2009 – Electric-arc welding equipment. Burners, specifies safety and construction requirements for torches for arc welding and allied processes. All testing for the purpose of fire protection have to be carried out on burners fitted with the cable – hose assembly normally supplied, at environmental temperature from 10°C to 40°C. The most common cause is occurrence of sparks, so validation of the torch body, the cable – hose and other components has been carried out before welding activities. Besides that, torches for arc welding are not intended for operation during rain or snow or equivalent conditions, which is also specified by this standard
After welding, if there is any heat treatment, manufacturer is responsible for the procedures which have to be compatible with basic material, welded joint, and structure.
In order to provide conformity with the requirements of the contract it is necessary to carry out the control and testing of welded products. Control and testing are carried out before the commencement of the welding, during the process, and after welding. If the repairs are done, it is necessary that appropriate procedure exists, after which repeated control and testing are to be done in order to prevent irregular use of welded elements.
For safe welding execution, regarding fire and explosion protection, contractor of works, head of works and head of fire protection service, on whose facility the welding is carried out, are to be held directly responsible. Persons responsible have to be acquainted with legal obligations, responsibilities and fire and explosion protection measures which are to be taken during the use of welding equipment and work execution. Decree on fire protection measures during the execution of welding, cutting and soldering works ("Official Gazette of RS Serbia" number 50/1979) closely specifies the fire and explosion protection measures during the execution of welding works.
In standard NFPA 51– Standard for the Design and Installation of Oxygen – Fuel Gas Systems for Welding, Cutting and Allied Processes, the way of welding device handling and storing has been described, and preventive measures for fire and explosion protection have been given, and they are as follows:

- Acetylene and oxygen bottles are to be kept in the upright position and placed far enough from the inflammable materials,
- Burners for welding or cutting have to be maintained properly,
- Rubber pipes, tie-ins, cables have to be of the high quality and in the upright position,
- E.g. electric-arc welding device has to be earthed.

For the purpose of determining the appropriate organization and undertaking measures necessary for successful functioning and execution of fire protection, Ministry of internal affairs performs the categorization of objects, activities and land regarding the fire risk depending on the technology process which goes on in them: types and quantities of material produced, processed or stored, types of material used for building construction, importance and size of building and type of vegetation (article 23, Law on fire protection, "Official Gazette RS" number 111/2009).
Buildings, activities and land are sorted in the following categories:

- High fire risk – first category of fire risk,
- Increased fire risk – second category of fire risk,
- Certain fire risk – third category of fire risk.

Pillars, as main building elements, are structures which are fire resistant, which depends on the material type, cross-section dimensions and other factors which are significant for fire protection. What kind of resistance, a certain pillar will show in fire conditions, depends great deal of construction material characteristics.
All classic materials used in the construction (brick, concrete, steel, wood, etc) act differently in case of fire, which depends on thermal characteristics of certain material, as well as on its volume.

Steel as a material mostly used in industry from the fire protection point of view is very unfavourable material because of great heat conductivity as well as the high value of bilk weight, and at temperature of 600°C deflections appear because of which it is not possible to count on the steel structure strength, it loses its bearing capacity and often causes the structure breaking.

Resistance of steel pillars depends also on it if the pillar is covered by coating, or if the pillar is of the type where, from the first moment, high temperatures influence the steel directly. Fire resistance of a material is material resistance to open flame and increased temperatures. That is why, the steel pillars fire resistance can be improved by fire-resistant material coating. Depending on the thickness of the scrim and fire-resistant material (for example plaster) by which the pillar is protected, fire resistance can amount to 4 hours. By coating of steel pillars their resistance to the influence of high temperatures is increased and during the fire it shows very high durability.

If it is reacted on time and if it is not allowed to fire to take hold, breaking can be prevented and then only structure deflection will appear which, in case of steel structures, can be easily repaired by cutting the deflected part and inserting new structural element.

Experiments which have been carried out in order to examine the durability of steel structures and welded joints during fire, have shown that deterioration of supporting part of the structure depending on the quantity of combustible material i.e. fire load, happens within 15 to 30 minutes, if that structural element is not protected, by anything, from the direct contact with the flame.

Steel structures and welded joints in that case justify their existence in case of fire, too, if their ability to bear constant and movable load is maintained until the end of fire.

It is possible only if the temperature of the structure does not exceed the allowed values, i.e. if stress surplus from the load and stress caused by heating and deforming of the structure does not exceed real allowed values for the certain type of steel.

Temperatures appearing during a fire mostly vary and depend on the quantity of combustible material as well on its calorific value.

The most common cause of structure breaking (in cases of increased temperature) is the stress increase over the critical value. Stress temperature is most obvious in case of statically undetermined systems, because rigid joints do not allow any deflections without changing the stress state, and that is the most obvious on the constructions in welded make.

In case of increased temperature mechanical and physical characteristics of material, dynamic strength, corrosion resistance and other characteristics of certain concepts of fire resistance and refractoriness are significantly changed.

Structure operating conditions on high temperatures demand from welded joints besides provision of necessary mechanical conditions under normal temperatures, maintenance of necessary fire resistance and refractoriness too.

Testing necessary for evaluation of material fire resistance is obligatory for welded joints too. Scope of welded joints testing depends on the structure exploitation conditions. Regarding the steel under the temperature load, strength of material is directly connected to environmental temperature.

Permanent strength is the basic parameter which determines the probability of the fracture of the part during its exploitation.

Permanent strength of welded joints of heat treated steel can be significantly decreased and can cause premature fracture in weakened heat influence area (ZUT). For the purpose of increasing the fire resistance of steel structures, stability during fire can be increased by decreasing real stresses in the structure at the expense of cost-efficiency and enabling the free deflection of the structure.

The other way is to change the static system of structure itself. However, that would significantly cause rise in structure price, so in many cases it is resorted to different ways of coating the bearing structure by some material more stable at high temperatures.

Concrete, reinforced concrete, different plates on concrete base, clay plates, ceramic plates, plasters, different gypsum boards and other materials performing better characteristics in high temperature conditions are mostly used for coating. Coating cross-section, i.e. protection layer thickness is directly connected to the value of heat conductibility coefficient, because the lesser heat conductor the material used for protection is, the thinner it is. In fire where high temperatures are created it is inevitable that the deflection will occur which coating has to follow without fracture.

CONCLUSION

Besides the fact that by insulation of steel elements (pillars, supports and similar), high temperature (occurring during fire) protection is performed, welded joints are protected too. Lately, it has been worked on getting the material which will be as thin as possible and show the high values of fire resistance.

After a series of fire caused by careless operation during welding, cutting or soldering i.e. during the operations involving the open flame and greater quantity of hot particles, Decree on fire protection measures during welding, cutting and soldering has been adopted ("Official Gazette RS Serbia" number 50/1979). Statistic data show that the most common causes of fire are open flame, then short circuit on electrical installations, heating of conductors, sparkling tool operation.

The way building structure will act in case of fire, mostly depends on material it has been made of. Basic requirement which is to be met by materials used for insulation of steel structure is that materials have the minimum heat conductibility coefficient, and bulk weight as small as possible, and strength of material is to be such to withstand the changes occurring in case of increased temperatures and to follow the deflection of basic structural element without the occurrence of bigger cracks.

This is especially important in order to protect the heat influence area too (ZUT) of the welded joint, because in that case basic material structure has already been changed in welding process.

REFERENCES

[1] Bogner, M, M. Borisavljević, V. Matović, M. M. Bogner, Zavarivanje, drugo dopunjeno izdanje, ETA, Beograd 2007.

[2] Sekulović, Z, M. Bogner, S. Pejović, Preventivna zaštita od požara, ETA, Beograd 2012.

[3] Balać, M. Obezbeđenje kvaliteta u zavarivanju, Menadžment totalnim kvalitetom & izvrsnost, Beograd novembar 2009, Vol.37, br.3-4, str.133-138.

[4] Uredba o merama zaštite od požara pri izvođenju radova zavarivanja, rezanja i lemljenja ("Službeni glasnik RS Srbija" broj 50/1979).

[5] SRPS C.T3. 003: 1984 – Zavarivanje i srodni postupci- Postupci zavarivanja i lemljenja – Termini i definicije.

[6] SRPS C.T3. 008: 1993 – Zavarivanje – Položaji zavarivanja – Definicija uglova nagiba i zaokretanja

[7] SRPS C.T3. 010: 1995 – Zavarivanje i srodni postupci – Tehnički uslovi za zavarene spojeveizvedene topljenjem na čeliku – Nivoi kvaliteta.

[8] SRPS C.T3. 020: 1982 – Zavarivanje – Klasifikacija grešaka u zavarenim spojevima izvedenim topljenjem metala.

[9] SRPS C.T3. 022: 1984 - Zavarivanje i srodni postupci – Greške površine reza pri rezanju gasnim plamenom i plazmom – Klasifikacija, vrste i definicije.

[10] SRPS C.T3. 025: 198g - Zavarivanje i srodni postupci – Delovi dobijeni rezanjem gasnim plamenom, Opšte tolerancije.

[11] SRPS EN ISO 3834:2008 – Zahtevi kvalliteta pri zavarivanju.

[12] NFPA 51 – Standard for the Design and Installation of Oxygen – Fuel Gas Systems for Welding, Cutting and Allied Processes.

[13] NFPA 51B – Standard for Fire Prevention During Welding, Cutting and Other Hot Work.

[14] NFPA 70B – Recommended Practice for Electrical Equipments Maintenance.

[15] NFPA 70E – Standard for Electrical Safety Requirements for Employy Workplaces.

DRYING BIOMASS IN A FUNCTION OF INCREASING ENERGY RESOURCES

Srećko Ćurčić[1], Sandra Milunović[1], Milan Pavlović[2], Dragiša Tolmač[2]
[1] University of Kragujevac, Technical faculty Cacak, Serbia
[2] University of Novi Sad, Technical faculty “Mihajlo Pupin”, Zrenjanin, Serbia
e-mail: sreckoc@tfc.kg.ac.rs

Abstract: As the price of energy, including biomass, are constantly increasing, it is important that their use of energy-efficient. In the process of incineration and gasification, biomass drying increases their efficiency, improves performance and can increase the production of steam up to 60%. In this paper an analysis of drying and removing water from biomass, which is an important and effective part of improving the efficiency of biomass combustion and gasification systems. The paper presents a method for drying of biomass and comparison of work and energy characteristics of the most commonly used dryer for biomass.
Key words: biomass, drying and energy potential.

INTRODUCTION

The importance of biomass as fuel is becoming more and more as the demand for renewable energy sources increases, and the supply of wood fuel decreases. Bark, plywood and sawdust were of old considered as a waste and were a problem in terms of delay and are they represent required goods, while other residues such as waste from food processing and agricultural waste are increasingly being used as a fuel source.

The price increase of conventional energy sources has significantly changed the economics of efficient use of biomass resources. It is now more important than ever to make efficient use of biomass resources. One way of efficient use of biomass is dry biomass. Biomass dried due because of volume reduce, increase heat capacity, ease storage, transport and handling and a greater possibilities for dry biomass processing (storage, pelleting, gasification).

The science of biomass drying and thermal processing of biomass in general, has a long tradition in Europe, and intensive scientific research and development of equipment and devices for process control in the last 40 years have made it possible to dry biomass of empirical skills become a controlled industrial process. In Europe, the annual industrial dryers to dry on the tens of millions of cubic meters of sawn timber. Drying process requires large amounts of energy, but it is necessary step in the processing industry and an important item for the wood value increasing.

The overall efficiency can be improved by adjusting size boilers and kilns, including other energy efficiency measures, again taking advantage of the heat from the boiler or gasifikators or other sources of waste heat in the facility. Economizers of chimney kilns and boilers can be used in conjunction with each other in some systems to get out the maximum benefit from re-used heat from the boiler. The heat from the dryer can also be re-used, for the purpose of the facility.

BIOMASS DRYING

Biomass has a high moisture content, and for the most efficient use need to dry. Gasification process requires a relatively low moisture content of fuel, fuel dry is necessary. There are different ways to dry biomass and each method has its advantages and disadvantages. Biomass drying mechanism consists of two short, simultaneous processes: the biomass heat transfer on the biomass transport of evaporated moisture. Heat is usually transmitted by convection, conduction or with their combination.

The drying process consists of three stages: predrying, drying (first drying phase) and grain drying (second drying phase). In phase predrying, which is short, the material is heating to the wet-bulb temperature. In the drying phase from the material allocated free moisture while the temperature of material equal to the wet bulb temperature. At the phase of grain drying from the material stands tied humidity and temperature of the material begins to rise due to the increase of the steam-related

moisture. To prevent cracking and deformation of drying material must be carefully regulated drying speed in the grain drying phase.
Medium for drying is usually gas which is intermediary in the process of heat transfer. Drying medium may be in direct or indirect contact with the biomass. It can be air, steam, a mixture of steam and air or flue gases, for example from the combustion process. If the drying process uses steam in direct contact with biomass it must be overheated, because otherwise vapors condense and thus increase the moisture content of materials. If gases are used as a medium they must not be in condition of saturation.
Moisture that is subtracted from the biomass can be drained naturally or by force. Forced moisture transport is increasingly used for increasing overall process efficiency and reduce drying costs.
Drying of biomass improves combustion efficiency, increase steam production and improve the operation of boilers. In the boiler or gasifikators, moisture in the fuel must first be heated and evaporated, taking with them a large amount of heat through the chimney. Although fuel kilns also use energy on heating and evaporation of moisture, the drying process is more effective if it is done with the help of equipment that has been specifically designed for this purpose.
Boiler for biomass combustion will work more efficiently if the fuel with optimal dryness. If the fuel is too wet, it may be that it is impossible to hold a flame without additional fossil fuels use. With dry fuel, the flame is stronger and more balanced, and helps complete combustion. Air emissions in boiler are reduced (although emissions from kilns must also be taken into account.) More complete combustion process results in a smaller amount of volatile organic compounds and ash.
Before drying, the water can be removed from wet raw materials by using a trough, filters and screens, presses and centrifuges for drying. In addition, wet raw materials can be mixed with dry materials in order to obtain an acceptable moisture content for a given mixture. Some materials may be less moisture dried sufficiently with easy storage with cover with occasional turning. Other types of biomass, such as rice stalks, saw dust from carpentry shops, dry does not need.

Moisture content

Gasifikators require less than 55-60% moisture content, and even less than 20%, so they can not work with biomass with a high moisture content. The drying process of biomass is also important in the process peletization, in which the content may require a lower percentage of moisture than with gasifikators and boilers.
For wood chips with a moisture content of 45%, the maximum efficiency of the boiler with standard equipment is about 74%. If the same standard equipment burn dry wood (~ 10% to 15%), efficiency can be about 80%, which affects the increase in steam production from 50% to 60%.
Table 1 shows the measured values of moisture content for different materials. In the timber industry, freshly felled hardwood, softwood, and herbaceous materials typically have a moisture content of 40% to 65%. The remains of crops exposed to drying in the open, such as straw, corn cobs, husks and bark, usually have a moisture content of 15% or less. Municipal solid waste usually contains from 10% to 30% moisture. Biomass with a high moisture content means different residues of food and beverage production, sludge from waste water treatment and waste from animal farms.
Moisture content is critical in incineration, gasification and peletization. With the exception of furnace with the floating heating, boilers that are into the wood demand fuel with the humidity below 55% to 65% in order to maintain combustion. Incineration with wood using, the optimum moisture content is generally lower, between 10% and 15%.
The maximum moisture content, which is necessary for the gasification depends on the type of gasifikators. Most gasifikators for biomass are layers of fixed particles with a downward flow because they are the most appropriate for small sizes and small quantities of tar. Layers of fixed particles with a downward flow can not withstand moisture contents exceeding 20%. Layers of fixed particles with upward flow and fluidized layers can withstand higher moisture content of 50% to 65%. Moisture content can reach 95% in gasifikatorima thanks supercritical water processes but this type of gasifikators is still in the research and development stage.

Table 1. The mass of moisture content for different types of biomass

Raw material	The mass of moisture content (%)
Waste food - fruits and vegetables	
Waste from apple	72
Chery	37.8
Orange peel	10.8
Peel of melons	27.6
Black Walnut Hulls	11.6
peanut shell	9
peanut skins	8
Waste of wet potato	86
Waste from sugar beet	45-55
Fish waste	76
Waste fruit and vegetables - greengrocer	88
Wood products	
Shavings	45-55
Waste from pine sawmill	11.3
Construction Waste	12-17
Bark	30-60
Sludge from pulp & paper	50-70
Agricultural waste	
Rice husks	8.5-10
Mealies	10 - 43
Soy Hulls	9
Beef fertilizer	88 - 99.7
Municipal waste	
Sewage sludge - Biological solid waste	90-97
Septic tanks - biological solid waste	98
Municipal Solid Waste	12-32

Biomass may require peletization to facilitate dosing and use, reduce transportation costs, homogenized mixed substrates, and/or to achieve a uniform size in order to improve the process of gasification or incineration. Pellet mills generally require a moisture content of less than 15% to produce a stable and durable pellets.
Waste with a high moisture content often can not be dried so drying to be profitable, except maybe using a passive method of removing water, as for example, the use of bag filters, as will be discussed below. For this waste, conversion technologies such as anaerobic digestion and fermentation is likely to be more cost-effective than incineration or gasification.

DRYERS CLASSIFICATION AND DRYING PRINCIPLES

By now there has not adopted general classification of dryers, because they differ according to different criteria: method of bringing heat (convection and contact), the type of heating medium (air, gas, steam), pressure (atmospheric and vacuum), type of drying (continuous and discontinuous), and direction of flow cross-media and biomass (same direction, different directions and cross directions).
In the selection and design of drying systems, it is important to take into account many factors, such as energy efficiency, emissions of pollutants into the environment, working conditions, maintenance and re-utilization of by-products suitable for the sale on the market.
The most common used types of dryers for biomass drying are rotary dryers with direct or indirect heating, mobile dryers, waterfall, compressed air dryers, dryers with superheated steam and microwave dryer. Right dryer selection depends on many different factors, including the size and characteristics of raw materials, capital costs and maintenance requirements, different emissions into the environment, energy efficiency, heat sources available, available space and the danger of fire. Table 2 presents the main parameters of dryers.
Dryers for fuel can be classified by means for drying, ie stream which passing through the material to be dried on: superheated steam, hot air or gas. Dryers that use air and flue gas emissions characterize

the risk of fire, while the superheated steam that is not the case. When drying with superheated steam occurs condensation, which must be treated in order to obtain compounds from the condensate, which are products for the market, such as oil from wood.

Table 2. Dryers parameters

Tools in the drying process	Gas, hot air or superheated steam
Heating	Directly or indirectly
Medium for heat transferring	Gas, hot air, steam or hot water
Pressure	Atmospheric, vacuum, overpressure
Heating source	Burners in dryers Boilers (flue gas or steam) Regenerated heat from processes which are realizing in the facility

Dryers can be classified according to whether they are direct or indirect heat. In the case of direct heating, means enabling the transfer of heat (gas, hot air or superheated steam) passes directly through the material to keep it dry. If it is heated indirectly, means that allow the transfer of heat passing through the heat exchanger tubes or indirectly heating material. Means for the transfer of heat in dryers with direct heating at the same time are means for drying, which is not the case in the dryer with indirect heating. Dryers with direct heating as efficiently, although they do not suistable for drying of all kinds of biomass. Dryers with indirect drying are suitable for fine powders drying.
Dryers can be made to operate at atmospheric pressure or under pressure. Drying of the biomass under pressure (vacuum) lowers the boiling point of water and thus lowers the temperature that is required during drying, increasing the opportunities for using waste heat in the plant. Vacuum dryers typically have high capital investment, but achieves energy savings due to the possibility used heat utilization. Dryers that use superheated steam can operate at a pressure greater than atmospheric, thus creating the conditions for the re-use of heat at a higher temperature, which increases efficiency.

Natural drying

Natural drying is the oldest type of biomass drying. How much biomass can be dried depends on various factors such as initial moisture content, biomass types, and locations of storage ie. whether biomass is stored in an open or closed space. The amount of heat that is transferred from the air to biomass is also an important factor in drying. When using an open storage weather have a great impact on drying. Over time, the kept biomass dry naturally, because over time the air absorbs some moisture. Some materials, such as residues after editing parks, shell and leaf stalks can be dried naturally, so it will be stored in a covered, open area or with solar drying. The final moisture content of the air-dried material usually ranges from 15% to 35%, depending on the size and characteristics of the material and environmental conditions.
Drying in the open air is slow and depends on weather conditions. The material which we are drying will need to be stirred occasionally or they will have to dry in the plant. Drying in the open air is generally not suitable for materials that have a high water content because they are prone to rapid decay.

Drying in gas flow

Drying in gas flow has been widely used method of drying. Equipment for drying on this principle is available in the market and have a stable operation. For the evaporation of moisture from the biomass uses heat of the gas which mainly directly heating biomass, although there are devices in which biomass is heating indirectly. At the exit of the drying cooled gas separation and evaporated moisture is carried out in a cyclone. A major drawback is the inability of the gas drying efficiency of the latent heat of evaporated moisture. Commonly used dryers in gas flow are rotary dryers.

Drying in the superheated steam flow

Drying in the flow steam can be run in direct or indirect contact with the biomass. For direct drying that takes place in an environment of steam, it is possible to use the latent heat of condensation of steam obtained from the evaporated moisture. With this drying there is no danger of fire in the dryer. The lack of direct drying in the flow steam is the presence of organic compounds in the transpiration and presence of corrosive condensate that must be removed.

Superheated steam, which is by convection in contact with wet fuel, depending on the temperature of the material can be condensed and thus increase the moisture content of the material that being dried. When the material temperature rises the moisture evaporates. This process realizes at constant temperature and evaporation continues until the material is wet. If the flow steam or steam temperature increases, the amount of extracted moisture will increase significantly.

In this dryers, superheated steam directly from the boiler goes into the dryer. Steam temperature remains above the saturation temperature, so there is no condensation and evaporation of moisture from the biomass. More amount of steam at a lower temperature and pressure go out from the dryer, and then goes back into the process. If you achieve extra steam for use in another process, it is possible to re-use a lot of energy, from 70% to 80%. The steam generated by the dryers will be with the same pressure in the dryer, and maintaining the pressure above atmospheric level allows recovery of heat at a higher temperature.

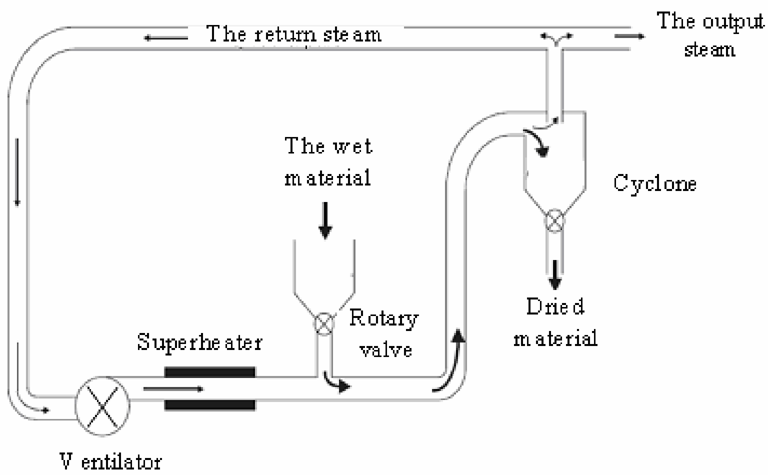


Figure 1. Superheated steam drying [1]

THE BASIC DRYERS FOR BIOMASS

Rotary dryers

Dryers have low power consumption, and heating can be directly and indirectly. Rotary dryers for directly drying consist of slowly rotating drum which is set at a slight angle to the horizontal and cyclone (Figure 2). Wet material enters on the upper side and go out the lower side of the dryer. Drying medium is in direct contact with biomass and can be same current flow or opposite current flow in relation to the material for drying. The material is drying inside the drum is moving due to gravity. Inside the drum are wings that carry material for dry around the edges, forming a smooth cascade through which go hot gas.

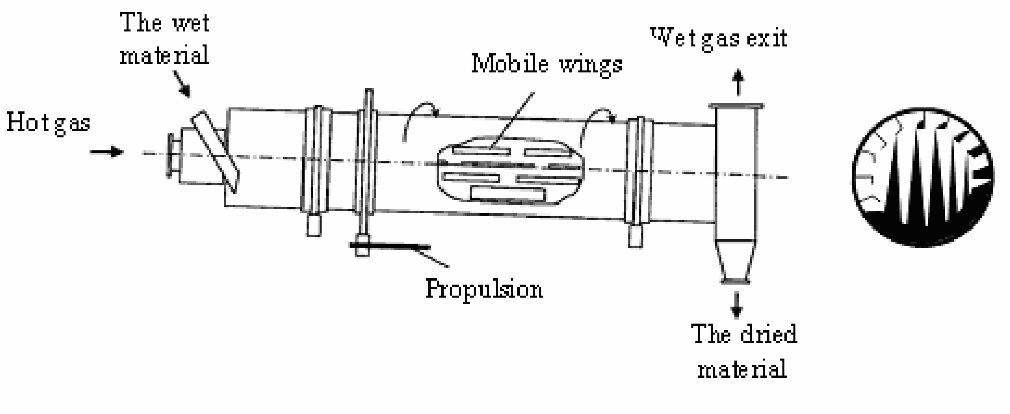


Figure 2. Rotary dryer for direct drying and internal cross section of drum [2]

Primary drying occurs when biomass in cascades falling down when gas and biomass have good contact. When the biomass is in contact with the superficial drum drying is minimal. Dryer often has a ventilator on the exit that is used to vacuum drying gas. For opposite flow drying raw materials is the driest when are in contact with the hottest gas current. This may increase the risk of ignition due to which the use of this form of drying limited. On the other hand, in the same current flow drying process and achieve better heat transfer. Input temperature of the raw material that can be heated to high temperature achieves 1000°C. To dry bark in commercial installations input temperatures are usually limited to 250° C, for security reasons. The duration of drying depends on numerous factors such as the shape and number of blades, speed of rotation, speed of gas, inclination for drying and length of dryer.

Compared with rotary dryer with steam pipes for indirect heating, dryers with direct heating have lower operating and maintenance costs and greater availability (ie, less time spend on maintenance). Dryers which have lower temperatures such as mobile or cascade dryers have several advantages over rotary dryers with direct heating. By comparison, the rotary dryer with direct heating characterized by increased emissions of volatile organic compounds and particulate matter, less opportunities to reuse waste heat, and higher risk of fire especially after drying off. Before leaving the dryer raw materials must pass through the cyclone, bag filter, scrubber, or electrostatic precipitators to make it free from particles.

In rotary dryers with indirect heating with steam pipes uses steam from the boiler for fuel drying, steam passes through pipes or other heat exchanger which is located inside the drum. Dryers with indirect heating are, in general, less efficient than dryers with direct heating because they lead to inefficiencies due to heat transfer from the steam pipe to the material.

Mobile dryers

In mobile dryers, raw materials spread on the surface of the perforated tape and thus the material is drying in a continuous process. If we use more tape, they can be connected in series or in a group. Mobile dryers can be used for a wide range of materials because of their mobility.

Due to the low operating temperatures there is little danger of fire. Emissions of volatile organic compounds from the dryers will also be small. The advantage of mobile dryers than many other types of dryers is that the material after drying is not distracted. Because of this processed material, returned to the dryer must pass through a sieve because they can not pass through the perforations in the tape.

The negative impact on the environment of mobile dryer with one omission is larger than the rotary dryer that has approximately the same capacity. Mobile dryers with number of omissions where conveyors placed one above the other in which case the material falls in cascades from the top to the bottom conveyors, with significant savings in space. This dryers used in many industries, because they have better effect and lower costs.

Cascade dryers

Cascade dryers are widely used for drying of biomass in Europe, especially in Sweden. They can be seen as a dryer with flude layer. The material enters into the flow of warm air moving in indoor. Air moves upward, and then descends to the bottom of the falls and then it re-erected. Upon completion of the process, the material is fed through the holes that are on the walls of the dryers. Cascade dryers operate at temperatures between those on that work mobile and rotary dryers. Their disadvantage is that they are prone to corrosion and erosion of dry surfaces and therefore have higher maintenance costs.

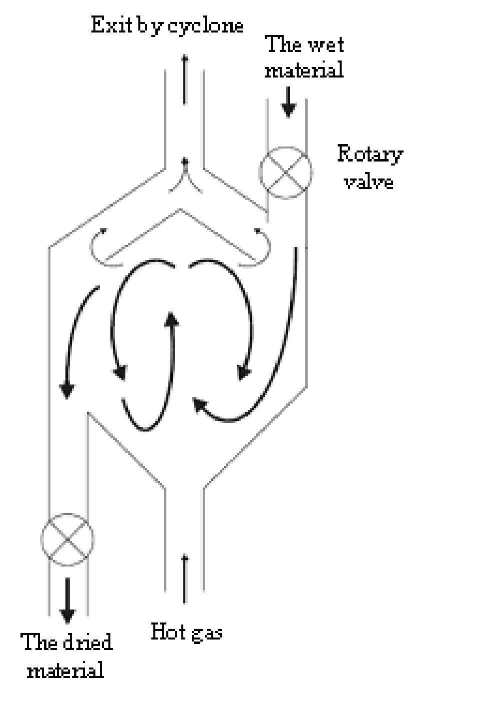


Figure 3. Cascade dryer

Pneumatic dryers

Commonly uses for granular biomass drying. The drying principle consists in the pneumatic transport of biomass in the flow of hot air in a vertical pipe height of 20 m (depending on the% of water to be taken away). Air speed should be greater than the speed of floating and it is 10 to 30 m/s. This drying process removes the free moisture. Particle dimensions are 8 to 10 mm, and biomass in the pneumatic tube inserted through the inlet funnel through the dispenser. The air is re-heated by heaters and driven by ventilators. Current of warm air through the material refers to cyclones pneumatic tube, and out of it again in a pneumatic tube from which it is transported to another cyclone. In the second cyclone stands material from air.

Pneumatic dryers are cost-effective if they use for drying large quantities of material. Power consumption is higher than in other types of dryers, because they need to achieve high air flow, which is crucial to the floating material. Pneumatic dryers have little negative impact on the environment. On the other hand, they are prone to corrosion and erosion and have a greater risk of fire at the end of the drying process.

Microwave dryers

Industrial microwave dryers use in many industries, especially where need to improve: the quality of products, drying speed and effective removal of the last traces of moisture. The advantages of this dryer are quick drying, uniformly heating, better energy efficiency, improved process control, and often the least negative impact on the environment. The disadvantage of microwave dryers are higher investment costs.

Comparison of different types of dryers given in Table 3.

Table 3. Comparison of different types of dryers

Type of dryer	Requirements for raw materials	Investment costs and operating costs	Operation and Maintenance Requirements	Emissions into the environment	Energy Efficiency and re-use of heat	Negative impact on the environment	Risk of fire
Rotational	Sensitive to particle size. High silt content of the paper is prone to accumulation. Rough bark can be a problem.	---	Low	Higher emissions compared with low - temperature dryers	Less chance of re-utilization of waste heat	---	Higher than in the low-temperature dryers
Mobile	Fine materials must first be passed through a sieve and then returned to the dryer	Similar to the rotation, lower costs of auxiliary equipment	Higher than in rotary dryers	Less particulate emissions	Great opportunities for reuse of heat due to low temperatures	Higher than in rotary dryers with similar dimensions	Low
Cascade	Requires that the material be approximately the same size	Higher than in rotary dryers	They are subject to corrosion and erosion	---	Re-use of heat is difficult. High costs of compressor.	Lower than in rotary and mobile dryers	Medium – There is a risk after the end of the drying process and dryer to turn off
Pneumatic	Requires smaller size material	Higher than in rotary dryers	They are subject to corrosion and erosion	---	Re-use of heat is difficult. High costs of compressor.	Lower than in rotary and mobile dryers	Middle
Dryers with superheated steam	Requires smaller size material	Large	High. Susceptible to corrosion.	There are no air emissions. Condensation requires treatment.	High efficiency when re-use low pressure steam. No heat loss during heating of air.	Lower than in rotary and mobile dryers	Not

CONCLUSION

Biomass is organic material that keeps the sunlight in the form of chemical energy. Biomass fuels include wood, wood waste, straw, manure, sugar cane and many other byproducts as outputs of various agricultural processes. All biomass were made of green plants converting sunlight into plant material through photosynthesis. Since the industrial revolution, most of the energy needs of the developed world, demand was satisfy by the processing of fossil fuels such as coal, oil and natural gas. Biomass, however, is still the dominant form of energy that people use in less developed countries, it is considered that biomass energy accounts for about 15% of primary energy consumption in the world and about 38% of primary energy consumption in developing countries. To achieve maximum energy effects of the available biomass their drying is necessary. There are a variety of biomass drying technology, and some of them are given here. Which technology for drying biomass we will choose depends on the type and amount of moisture and on the amount of biomass.

ACKNOWLEDGEMENT

This research is supported by Ministry of Science and Technological Development Grant No 42013: Research of the cogeneration potential in utility and industrial power plants of the Republic Serbia and opportunities for the regeneration existing and construction of new cogeneration plants (2011-2014) . This support is gratefully acknowledged.

REFERENCES

[1] Björk H and Rasmuson A, A method for life cycle assessment environmental optimisation of a dynamic process exemplified by an analysis of an energy system with a superheated steam dryer integrated in a local district heat and power plant, Chemical Engineering Journal, 87(3), pp. 381-394, 2002.
[2] Brammer J G and Bridgwater A V, Drying technologies for an integrated gasification bio-energy plant, Renewable and Sustainable Energy Reviews, 3(4), pp. 243-289, 1999.
[3] Biofuel Database, Commonwealth Scientific and Industrial Research Organisation, www.det.csiro.au/science/energyresources/biomass.htm
[4] Jekayinfa1, S.O. and O.S. Omisakin, The Energy Potentials of Some Agricultural Wastes as Local Fuel Materials in Nigeria, http://ecommons.cornell.edu/bitstream/1813/10436/1/EE%2005%20003%20Jekayinfa%20final%20Oct2005.pdf
[5] Esteban, M.B., et al, Evaluation of fruit–vegetable and fish wastes as alternative feedstuffs in pig diets, dx.doi.org/doi:10.1016/j.wasman.2006.01.004
[6] Institute for Environmental Research and Education, Biomass, www.iere.org/documents/biomass.pdf
[7] McCann, Mark A. and Robert Stewart, Use of Alternate Feeds for Beef Cattle, University of Georgia, 2000, pubs.caes.uga.edu/caespubs/pubcd/l406-w.htm
[8] Stanton, T.L. and S.B. LeValley, Feed Composition for Cattle and Sheep, Colorado State University Extension, www.ext.colostate.edu/PUBS/livestk/01615.html
[9] Klass, Donald L., Biomass for Renewable Energy, Fuels, and Chemicals, Academic Press, 1998.
[10] K. C. Das and E.W. Tollner, Composting Pulp and Paper Industry Solid Wastes: Process Design and Product Evaluations, Proceedings of the Conference Composting in the Southeast Europe, 1998, http://www.p2pays.org/ref/12/11563.pdf.
[11] Bruce, D.M. and M.S. Sinclair, Thermal Drying of Wet Fuels: Opportunities and Technology, 1996, EPRI TR-107109.

CFD SIMULATION OF ENTROPY GENERATION IN PIPELINE FOR STEAM TRANSPORT IN REAL INDUSTRIAL PLANT

Goran Vučković[1], Gradimir Ilić[1], Mića Vukić[1], Milan Banić[1], Mladen Stojiljković[1], Gordana Stefanović[1]
[1]University of Niš, Faculty of Mechanical Engineering, Niš, Serbia
e-mail: [1]vucko@masfak.ni.ac.rs

Abstract: The success of methods to increase the energy efficiency, to a large extent depends on the efficiency of individual elements, devices and apparatus, which are in the system. Energy efficiency operation of each of the elements of the system can be achieved with good design, which requires knowledge of the processes that take place in the device. The pipelines are an integral part of every industrial plant.
The objective of this paper is to illustrate the CFD simulation of entropy generation in one part of pipeline for steam transport in complex industrial plant, like a way of reducing irreversibility production in pipelines. The irreversibility of any fluid flow in pipelines is due to two factors, the transfer of heat across the stream to stream temperature difference (heat transfer irreversibility) and the frictional pressure drop that accompanies the circulation of fluid through the apparatus (fluid friction irreversibility).
In this paper the pipeline for steam transport in rubber industry is analysed. The superheated steam at the pressure 10 bar is a fluid that transfers the energy from the steam boiler to the apparatus in the factory. For a defined geometry of pipeline, the model was created, and as results are represented the fields of local entropy generation due to heat transfer and fluid friction, and the total entropy generation in the pipeline.
The minimum values of the local entropy generation rate in the steam flow meter (2.801×10^{-7} W/m^3K and 6.274×10^{-7} W/m^3K) are obtained in the core of fluid at the straight part of pipeline with constant cross-section. The maximum values (1.705 W/m^3K and 14.360 W/m^3K) are occurs near the wall. In the case of pipe curve at 90º turns the local entropy generation rate has a minimum values (3.223×10^{-10} W/m^3K and 4.730×10^{-10} W/m^3K) in the core of stream in the inlet of curve, and maximum values (1.733 W/m^3K and 14.580 W/m^3K) near the wall due to heat transfer and friction between the fluid and the wall. On the entropy generation has a dominant influence of irreversibility due to friction in comparison to the irreversibility caused by heat transfer.
Keywords: CFD, entropy generation, energy efficiency, pipeline

INTRODUCTION AND BACKGROUND

Heat transfer, as a way of thinking and formulation problems, is considerably older than thermodynamics. The foundation of knowledge of entropy production goes back to Clausius and Kelvin's studies on the irreversible aspects of the Second law of thermodynamics. Since then the theories based on these foundations have rapidly developed [1]. Entropy generation is associated with thermodynamic irreversibility, which is common in all types of heat transfer processes. Different sources are responsible for generation of entropy like heat transfer across finite temperature gradient, characteristic of convective heat transfer, viscous effect etc. Entropy generation through heat and fluid flow is designed to bridge the gap between three cornerstone subjects: heat transfer, thermodynamics and fluid mechanics. From historical point of view entropy generation through heat and fluid flow became a part of engineering thermodynamics in the last decade of previous century [2].
Flow through pipelines and heating situations find wide applications in industry. Bejan [2] focused on the different reasons behind entropy generation in applied thermal engineering. Generation of entropy destroys available work of a system. Therefore, it makes good engineering sense to focus on irreversibility of heat transfer and fluid flow processes and try to understand the function of entropy generation mechanism. Bejan [3] presented a study of four basic convective heat transfer phenomena from the unique point of view of entropy generation, and illustrated, in a very modest way, the place thermodynamics duly occupies in heat transfer. Mahmud and Fraser [1] analyzed Second law characteristics of heat transfer and fluid flow due to forced convection of steady-laminar flow of incompressible fluid inside channel with circular cross-section and channel made of two parallel plates. Different problems are discussed with their entropy generation profiles and heat transfer irreversibility characteristics. Guo, et all [4] presented the viscous dissipation effect on the entropy

generation for laminar flow region in curved square microchannles is numerically investigated. Aniline and ethylene glycol are selected as the working fluids. Sahin and Mansour [5] investigated a numerical solution to the entropy generation in laminar viscous fluid flow through a circular pipeline, with uniform heat flux at wall boundary condition. Zaharnah and Yilbas [6] the influence of fluid viscosity on the entropy generation rate is investigated in the pipeline flow at different wall temperatures. The temperature and flow fields are computed numerically using the control volume method. It is found that fluid viscosity influences considerably temperature distribution in the fluid close to the pipeline wall. Yapici et all [7] presented in study the investigation of the local entropy generation in compressible flow through a suddenly expanding pipe. Air is used as fluid. To determine the effects of the mass flux, the ambient heat transfer coefficient and the inlet temperature on the entropy generation rate, the compressible flow is examined for various cases of these parameters. The flow and temperature fields are computed numerically with the help of the computational fluid dynamics (CFD) code. In addition to this CFD code, a computer program has been developed to calculate numerically the entropy generation and other thermodynamic parameters by using the results of the calculations performed for the flow and temperature fields. Ko [8] three-dimensional laminar forced convective flow and entropy generation in a 180-deg curved rectangular duct with longitudinal ribs equipped on the heated wall have been investigated by numerical methods. The effects of rib size under different flow conditions with various Dean number and external flux are particularly highlighted. Ko and Ting [9] numerically analyzed entropy generation for laminar forced convection in curved rectangular ducts and air as the working fluid under constant heat flux condition; and found that there exists an optimal Dean number for each aspect ratio, and the optimal Dean number increases as the dimensionless heat flux increases.

METHODOLOGY

Local Rate of Entropy Generation in Convective Heat Transfer

The purpose is to study the volumetric entropy generation rate distribution throughout the fluid in the pipeline. This requires solution of velocity and temperature fields in the fluid. The governing equations and the boundary conditions for this steady problem with constant thermophysical properties are as follows:

Continuity ($\nabla \cdot \rho \vec{w} = 0$):

$$\frac{\partial}{\partial x}(\rho w_x) + \frac{\partial}{\partial y}(\rho w_y) + \frac{\partial}{\partial z}(\rho w_z) = 0 \tag{1}$$

Momentum ($\rho(\vec{w} \cdot \nabla w) = -\nabla p + \mu \nabla^2 \vec{w}$):

$$\rho\left(w_x \frac{\partial w_x}{\partial x} + w_y \frac{\partial w_x}{\partial y} + w_z \frac{\partial w_x}{\partial z}\right) = -\frac{\partial p}{\partial x} + \mu\left(\frac{\partial^2 w_x}{\partial x^2} + \frac{\partial^2 w_x}{\partial y^2} + \frac{\partial^2 w_x}{\partial z^2}\right) \tag{2a}$$

$$\rho\left(w_x \frac{\partial w_y}{\partial x} + w_y \frac{\partial w_y}{\partial y} + w_z \frac{\partial w_y}{\partial z}\right) = -\frac{\partial p}{\partial y} + \mu\left(\frac{\partial^2 w_y}{\partial x^2} + \frac{\partial^2 w_y}{\partial y^2} + \frac{\partial^2 w_y}{\partial z^2}\right) \tag{2b}$$

$$\rho\left(w_x \frac{\partial w_z}{\partial x} + w_y \frac{\partial w_z}{\partial y} + w_z \frac{\partial w_z}{\partial z}\right) = -\frac{\partial p}{\partial z} + \mu\left(\frac{\partial^2 w_z}{\partial x^2} + \frac{\partial^2 w_z}{\partial y^2} + \frac{\partial^2 w_z}{\partial z^2}\right) \tag{2c}$$

Energy ($\rho c_p(\vec{w} \cdot \nabla T) = \lambda \nabla^2 T + \mu \Phi$):

$$\rho c_p\left(w_x \frac{\partial T}{\partial x} + w_y \frac{\partial T}{\partial y} + w_z \frac{\partial T}{\partial z}\right) = \lambda\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2}\right) + \mu \Phi \tag{3}$$

In the fluid flow, irreversibility arises due to the heat transfer and the viscous effects of the fluid. The entropy generation rate can be expressed as the sum of contributions due to thermal and viscous effects, and thus it depends functionally on the local values of temperature and velocity in the domain of interest. In these systems, when both temperature and velocity fields are known, the local or volumetric entropy generation rate at each point can be calculated as follows equation, in tensor notation [10]:

$$\dot{S}'''_{gen} = \frac{\lambda}{T^2}(\nabla T)^2 + \frac{\mu}{T}\Phi \quad , \tag{4}$$

or in development form:

$$\dot{S}'''_{gen} = \frac{\lambda}{T^2}\left[\left(\frac{\partial T}{\partial x}\right)^2 + \left(\frac{\partial T}{\partial y}\right)^2 + \left(\frac{\partial T}{\partial z}\right)^2\right] + \frac{\mu}{T}\Phi \tag{5}$$

In equitation (3) and (5) Φ is the viscous dissipation function, which is [11]:

$$\Phi = \left\{ 2\left[\left(\frac{\partial w_x}{\partial x}\right)^2 + \left(\frac{\partial w_y}{\partial y}\right)^2 + \left(\frac{\partial w_z}{\partial z}\right)^2\right] + \left(\frac{\partial w_y}{\partial x} + \frac{\partial w_x}{\partial y}\right)^2 + \left(\frac{\partial w_z}{\partial y} + \frac{\partial w_y}{\partial z}\right)^2 + \left(\frac{\partial w_x}{\partial z} + \frac{\partial w_z}{\partial x}\right)^2 \right. \tag{6}$$

$$\left. -\frac{2}{3}\left(\frac{\partial w_x}{\partial x} + \frac{\partial w_y}{\partial y} + \frac{\partial w_z}{\partial z}\right)^2 \right\} .$$

The first and second term on the right side in equitation (4) and (5) represent, respectively, the local entropy generation rate due to heat transfer and fluid friction.

In accordance with the foregoing, equation (5) can be symbolically represent in the form: $\dot{S}'''_{gen} = \left(\dot{S}'''_{gen}\right)_{HT} + \left(\dot{S}'''_{gen}\right)_{FF}$, (7)

The total entropy generation rate over the volume can be calculated as follows [7]:

$$\dot{S}_{gen} = \iiint_V \dot{S}'''_{gen}\, dxdydz \quad . \tag{8}$$

Based on the known values of entropy generation can be by applying the theorem of lost available work, or Gouy-Stodola theorem, determine the amount of exergy destruction. The destruction of exergy is proportional to the value of the generated entropy, where the coefficient of proportionality is the reference temperature [12]:

$$\dot{E}_D = T_0 \dot{S}_{gen} \tag{9}$$

Owing to exergy destruction, but and exergy loss, the exergy rate at the outlet is less than the exergy rate at the inlet. These exergy quantities are related by the exergy rate balance, which at steady state can be expressed as [13]:

$$\dot{E}_i = \dot{E}_e + \dot{E}_D + \dot{E}_L \tag{10}$$

The rate of exergy loss equals the rate of exergy transfer associated with heat transfer, and is thus given by [10]:

$$\dot{E}_L = \dot{E}_q = \int_i^e \left(1 - \frac{T_0}{T_b}\right)\dot{q}'dL \tag{11}$$

where is:

$$\dot{q}' = k_l\left(t_{f,l} - t_0\right) \tag{12}$$

To obtain the information which irreversibility dominated for entropy generation, due to heat transfer or fluid friction, Bejan was define dimensionless parameter - Irreversibility distribution ratio. The irreversibility distribution ratio is equal to the ratio of entropy generation due to fluid friction to heat transfer [2]:

$$\phi = \frac{\left(\dot{S}'''_{gen}\right)_{FF}}{\left(\dot{S}'''_{gen}\right)_{HT}} \quad . \tag{13}$$

Heat transfer irreversibility dominates over fluid friction irreversibility for $0 < \phi < 1$ and fluid friction dominates when $\phi > 1$. For $\phi = 1$, both the heat transfer and fluid friction have the same contribution for generating entropy In the case $\phi \gg 1$ or $\phi \to \infty$ entropy generation is occurs only due to friction.

As an alternative irreversibility distribution ratio, defined Bejan number [1] which describes the contribution of heat transfer entropy on overall entropy generation, is defined as [8]:

$$\mathrm{Be} = \frac{\left(\dot{S}'''_{gen}\right)_{HT}}{\dot{S}'''_{gen}}, \tag{14}$$

Bejan number ranges from 0 to 1. Accordingly, $\mathrm{Be} = 1$ is the limit at which the heat transfer irreversibility dominates, $\mathrm{Be} = 0$ is the opposite limit at which the irreversibility is dominated by fluid friction effects, and $\mathrm{Be} = 0.5$ is the case in which the heat transfer and fluid friction entropy generation rates are equal. [1, 7].

Using equations (7) and (13) can be established a relationship between Bejan's number and irreversibility distribution ratio [1]:

$$\mathrm{Be} = \frac{1}{1+\phi}. \tag{15}$$

Computational Procedure

The general theory of fluid motion is too difficult to enable the user to attack arbitrary geometric configurations. It is possible to apply merely numerical techniques to arbitrary geometries. Computational fluid dynamics turns out the methods are applicable to a number of systems of equations which fall under the category of conservation laws. Therefore, a suitable numerical method and/or computational fluid dynamics code is frequently used to solve the governing equations in this field. The CFD code is the program by which fluid flow can be predicted through arbitrary geometries, giving such information as flow speed, pressures, residence times, flow patterns, etc. The main advantage of this approach is in its potential for reducing the extent and number of experiments required to describe such types of flow.

Calculation Tools

The ANSYS CFX 13 program was chosen as the CFD computer code to calculate entropy generation in a steam pipeline. The software was chosen due the ease with which the analysis model can be created, and because the software allows input of new equations necessary for calculation of entropy generation rate. Furthermore, ANSYS CFX computer code enables the definition of wall heat transfer coefficient as a user function, which parameters are solved during the solving of fluid flow equations. The ANSYS CFX computer code uses a finite-volume procedure to solve the Navier-Stokes equations of fluid flow in primitive variables such as velocity (w_x, w_y, w_z) and pressure. Noted computer code includes various turbulence models [14] among which k-ε model was selected in entropy generation rate calculation. k-ε model calculates turbulent viscosity (μ_t) as a function of turbulent kinetic energy (k) and turbulence dissipation rate (ε). Fluid flow equations include the viscous term in order to calculate entropy generation rate due to fluid friction.

The thermo-physical properties of steam were adopted according to the International Association for the Properties of Water and Steam (IAPWS) equation of state, incorporated into ANSYS CFX computer code. In ANSYS CFX, the analytical equation of state is used to transfer properties into tabular form. These IAPWS tables are defined in terms of pressure and temperature, which are then inverted to evaluate states in terms of other property combinations, such as pressure/enthalpy or entropy/enthalpy [14].

As ANSYS CFX calculates automatically derivates of temperature and velocity components, the expressions necessary to calculate volumetric entropy generation were inserted into solver by the CFX Command Language (CCL).

The finite element mesh was created from pipeline geometrical model by patch confirming method. Boundary layer was inflated with 20 layers with total thickness of 3 mm. The finite element mesh has 3508655 nodes which form 2662769 tetrahedrons and 5972280 wedge elements. All mesh quality parameters (Orthogonality angle, Expansion factor and Aspect ratio) are in permissible range for a double precision solver.

Simulation Values

Steam pipeline boundary conditions were defined based on actual measurement of mass flow rate, temperature and pressure at inlet and outlet. The simulation parameters are given in Table 1.

Table 1. Overview of simulation parameters

[1] Parameters	[2] Value/setting
[3] Analysis type	[4] steady state
[5] Steam properties	[6] IAPWS IF97
[7] Thermodynamic state	[8] gas
[9] Temperature of the surrounding, °C	[10] 10
[11] Reference pressure, atm	[12] 0
[13] Heat transfer model	[14] total energy
[15] Inlet flow regime	[16] subsonic
[17] Inlet volumetric flow rate, m^3/h	[18] 150/400
[19] Inlet steam temperature, °C	[20] 181.4/182.6
[21] Inlet turbulence	[22] medium intensity and eddy viscosity ratio
[23] Outlet flow regime	[24] subsonic
[25] Outlet static pressure, bar	[26] 9.85/9.25
[27] Wall mass and momentum	[28] no slip wall
[29] Wall roughness, mm	[30] 0.2
[31] Wall heat transfer coefficient, W/m^2K	[32] calculated during solve[1]
[33] Turbulence numerics	[34] high resolution
[35] Advection scheme	[36] high resolution
[37] Execution control	[38] double precision
[39] Convergence criteria - Residual Target	[40] RMS $\leq 10^{-5}$

[1]The wall heat transfer coefficient was calculated during the solve procedure based on equation:

$$k = \frac{1}{\frac{1}{\alpha_{ex}} + \frac{d_{is}}{2\lambda_{is}} \ln \frac{d_{is}}{d_{ew}} + \frac{d_{is}}{2\lambda_{pw}} \ln \frac{d_{ew}}{d_{iw}} + \frac{d_{is}}{d_{iw}} \frac{1}{\alpha_{in}}} \tag{16}$$

Background of Industrial Plant and Pipeline Geometry

The energy system in a representative industrial plant, Fig. 1, consists of four parts: Energy supply sector (EN), Factory 1 (F1), Factory 2 (F2) and Engineering department (IN).

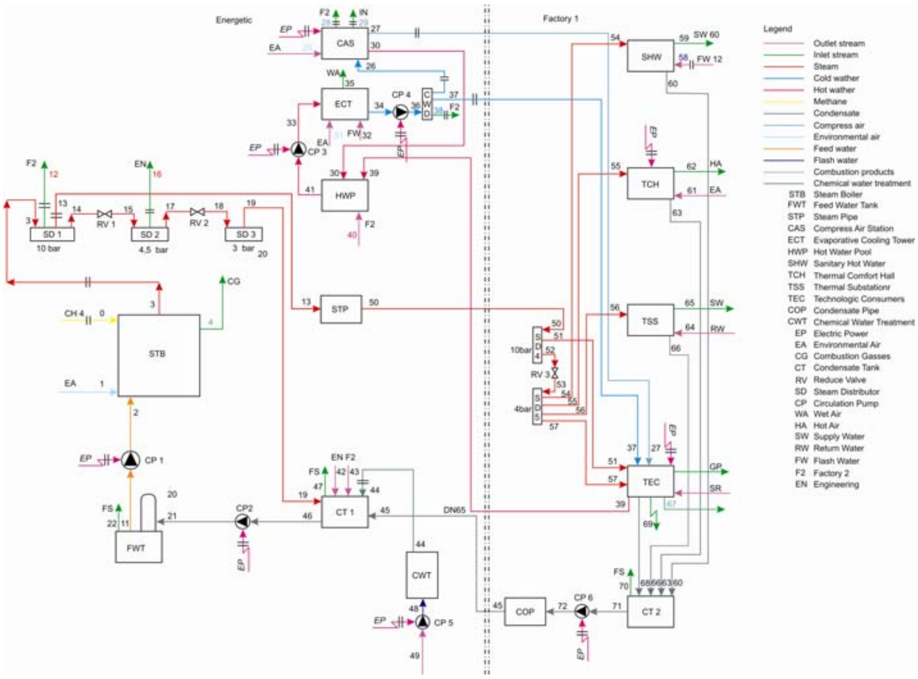


Figure 1. Flow diagram of the representative industrial plant

Energy supply sector is a part of the factory complex where chemical and thermal treatment of water is being carried out, and superheated steam for their own use and supply of all other consumers is produced.

The boiler produces superheated steam at the pressure of 10 bars, which is then distributed to factories 1 and 2, and partly reduced at lower pressures in accordance with the needs of consumers. Factory 1 is the largest consumer of energy in the whole complex and is supplied with energy using the superheated steam at the pressure of 10 bars. The focus point in this paper is a pipeline in which distributed superheated steam at 10 bars from Energy supply sector to Factory 1.

The present steam pipeline, Fig. 2, is made of steel with a nominal diameter of DN 150 with total length of 148.7 m. In one part of the pipeline cross-section is reduced for the steam flow meter. Pipeline contains more curves at angle of 90^{o} and two elements for compensate expansion due to temperature change.

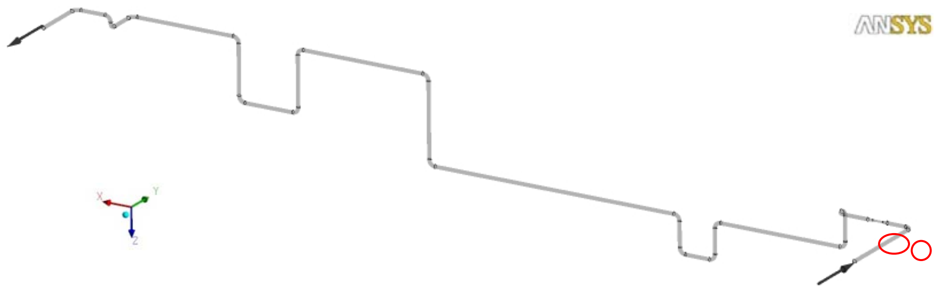


Figure 2. Real steam pipeline

The pipeline is to reduce heat losses to the environment covered with insulation material thickness of 80 mm. Due to that pipeline mainly located in open space, insulation material is protected by aluminium tin. From the inside area pipeline is not an ideal smooth, but has a certain roughness, which is characterized with roughness height 0.2 mm.

RESULTS AND DISCUSSION

Analysis Results for the whole Steam Pipeline

The results of numerical calculations for the whole pipeline are given in Table 2. From the collected results, it can be concluded that with increasing volumetric flow rate of 2.67 times, respectively with 150 m^3/h to 400 m^3/h, the total entropy generated due to irreversibility in the pipeline increases more than 10 times, and in the same amount increases exergy destruction. The dominant effect of entropy generation is due by fluid friction.

Table 2. Overview of results for whole steam pipeline

[41] Parameters	[42] Units	[43] Case 1	[44] Case 2
[45] $\dot{V}$	[46] m^3/h	[47] 150.00	[48] 400.00
[49] p_i (measured)	[50] bar	[51] 10.000	[52] 9.420
[53] p_i (simulation)	[54] bar	[55] 9.883	[56] 9.277
[57] p_e (measured)	[58] bar	[59] 9.850	[60] 9.250
[61] p_e (simulation)	[62] bar	[63] 9.850	[64] 9.250
[65] T_i (measured)	[66] K	[67] 454.540	[68] 455.740
[69] T_e (simulation)	[70] K	[71] 451.823	[72] 454.555
[73] T_o	[74] K	[75] 283.140	[76] 283.140
[77] T_0	[78] K	[79] 298.150	[80] 298.150
[81] $\dot{S}_{gen}$	[82] W/K	[83] 0.0003755	[84] 0.003792
[85] $(\dot{S}_{gen})_{HT}$	[86] W/K	[87] 8.942e-5	[88] 3.122e-5
[89] $(\dot{S}_{gen})_{FF}$	[90] W/K	[91] 0.0002861	[92] 0.003761
[93] ϕ	[94] -	[95] 3.200	[96] 120.464
[97] Be	[98] -	[99] 0.238	[100] 0.00824
[101] k	[102] W/m^2K	[103] 0.307597	[104] 0.308593
[105] t_z	[106] K	[107] 452.90	[108] 455.01
[109] $\dot{Q}$	[110] W	[111] -1,309.68	[112] -1,332.24
[113] $\dot{E}_D$	[114] W	[115] 0.112	[116] 1.121

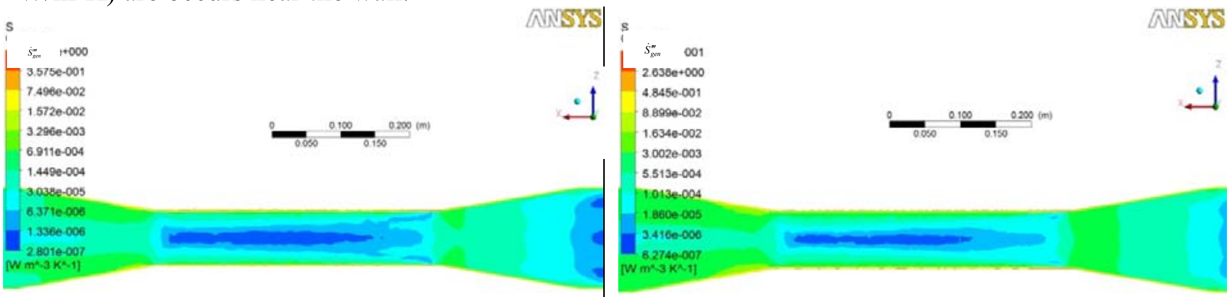
On the other hand, at higher volumetric flow rates decreases the value of entropy generation due to the irreversibility caused by convective heat transfer, but to a much lesser extent than the increase of entropy generation by friction of fluids. The dominance of irreversibility due to fluid friction is expressed through the values of irreversibility distribution ratio, which in both cases is greater than 1 (3.200 and 120.464). For the higher volumetric flow rate (Case 2), irreversibility distribution ratio has a far higher value, 120.464. Also, both the values for the dimensionless criterion, Bejan's number, are close to zero (0.238 and 0.00824), indicating little impact of irreversibility due to convective heat transfer in the steam flow of 150 m^3/h, and almost insignificant impact of irreversibility due to convective heat transfer in the steam flow of 400 m^3/h.

Analysis Numerical Results for Local Entropy Generation and Bejan Number for Characteristics Parts of Steam Pipeline

In general, the local entropy generation rate is maximal, as expected, near the wall due to heat transfer and friction between the fluid and the wall. The temperature of the fluid will decrease gradually towards the pipe wall and outlet, and the temperature gradients in the radial and axial directions will occur, which in turn will increase the local entropy generation rate.

Furthermore, the local entropy generation rate is maximal at the flow meter (Fig. 3) and in pipeline curves (Fig. 5). In this paper we analyzed first curve at the pipeline and fluid flow meter (Fig. 2).

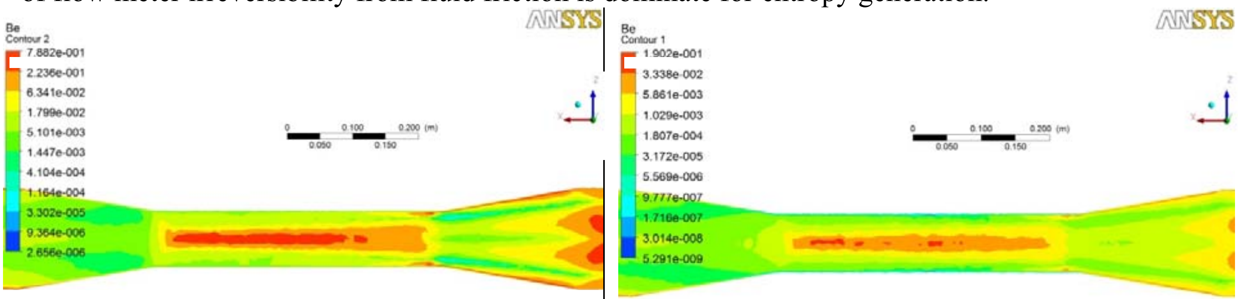
As known, in a pipe flow, the cross-section contraction in flow meter accelerates fluid, and the sudden expansion in the pipe produces the high velocity gradients which also increase the local entropy generation rate. It is obvious from Fig. 3 that local entropy generation rate increases with the increase in fluid mass flow rate i.e. fluid velocity. The minimum values of the local entropy generation rate in the both cases (2.801×10^{-7} W/m^{3}K and 6.274×10^{-7} W/m^{3}K) are obtained in the core of fluid at the straight part of pipeline with constant cross-section. The maximum values (1.705 W/m^{3}K and 14.360 W/m^{3}K) are occurs near the wall.



a) volumetric flow rate 150 m^3/h *b) volumetric flow rate 400 m^3/h*

Figure 3. Local entropy generation rate at flow meter (logarithmic)

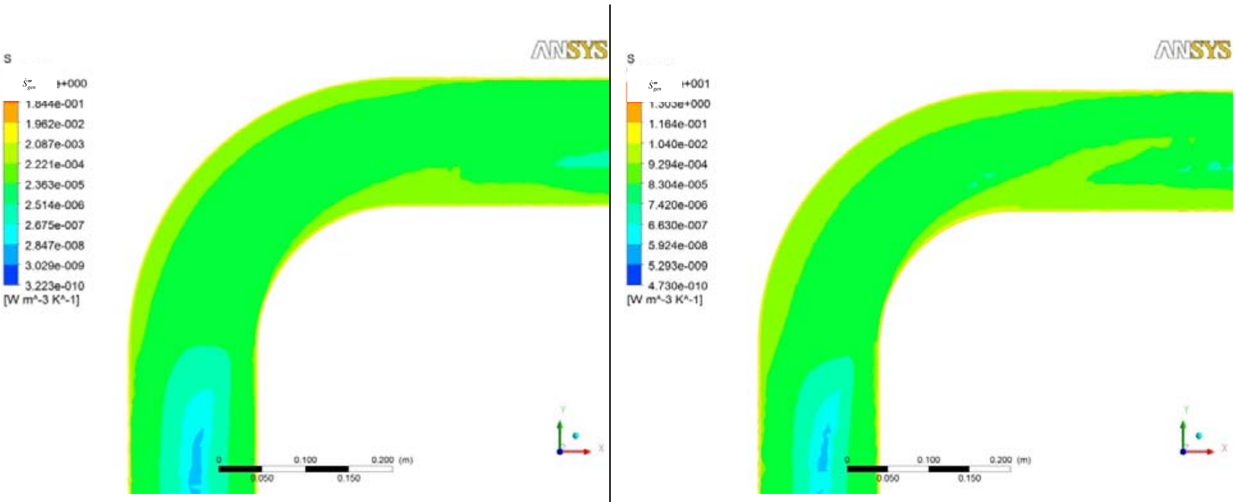
Fig. 4 shows the distribution of Bejan number in steam flow meter. As Bejan number values are smaller than 0.8 for the lower mass flow rate, and smaller than 0.2 for higher mass flow rate.
In the first case in very small area (only part of red zone, $0.5 < Be \leq 0.7882$) irreversibility from convective heat transfer is dominate for local entropy generation. In the point where is Be=0.5 irreversibility from convective heat transfer and fluid friction are equal for local entropy generation. In the other part of flow meter values of Bejan number is very close to zero, it is clear that irreversibility from heat transfer has less influence on resultant local entropy generation rate then irreversibility from fluid friction.
In the second case, all values of Bejan number are smaller than 0.5 and for these reason, in whole part of flow meter irreversibility from fluid friction is dominate for entropy generation.



a) volumetric flow rate 150 m^3/h *b) volumetric flow rate 400 m^3/h*

Figure 4. Bejan number at flow meter (logarithmic)

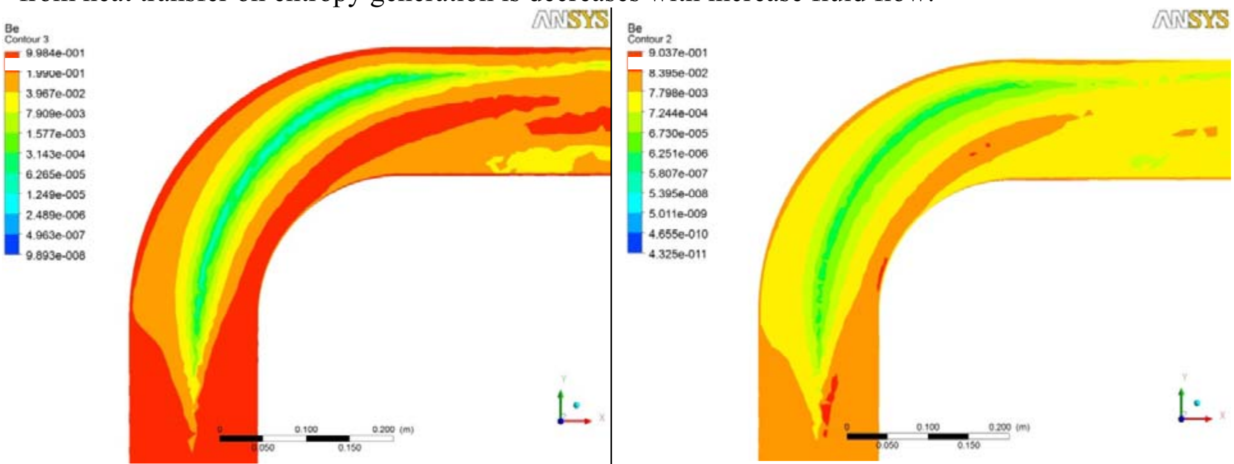
The velocity change in curves and the consequent change in velocity gradients also increases the local entropy generation rate (Fig. 5). Again, the local entropy generation rate increases with the increase in fluid mass flow rate. The local entropy generation rate in the both cases has a minimum values (3.223×10^{-10} W/m^{3}K and 4.730×10^{-10} W/m^{3}K) in the core of stream in the inlet of curve, and maximum values (1.733 W/m^{3}K and 14.580 W/m^{3}K) near the wall due to heat transfer and friction between the fluid and the wall.
Fig. 6 shows the distribution of Bejan number in pipeline curve.
As maximal Bejan number values are relatively high (0.9984) for the lower mass flow rate is clear that irreversibility from heat transfer has dominant influence on resultant local entropy generation. But this value and values higher than 0.5 valid only in very small area having in mind that the red zone includes values for Bejan number from 0.1990 to 0.9984. In the point where is Be=0.5 irreversibility from convective heat transfer and fluid friction are equal for local entropy generation. In the other part of pipe curves values of Bejan number is very close to zero, it is clear that irreversibility from heat transfer has less influence on resultant local entropy generation rate then irreversibility from fluid friction.



a) volumetric flow rate 150 m^3/h *b) volumetric flow rate 400 m^3/h*

Figure 5. Local entropy generation rate at pipeline curve (logarithmic)

In the second case, all values of Bejan number are smaller than 0.5 and for these reason, in whole part of pipe curve irreversibility from fluid friction is dominate for entropy generation. Furthermore, no matter what heat transfer losses are greater for higher volumetric flow rate, influence of irreversibility from heat transfer on entropy generation is decreases with increase fluid flow.



a) volumetric flow rate 150 m^3/h *b) volumetric flow rate 400 m^3/h*

Figure 6. Bejan number at pipeline curve (logarithmic)

CONCLUSIONS

The paper presents a numerical simulation of entropy generation in the real pipeline superheated steam. The results of numerical simulation show good agreement with measured data in regard to temperature. The inability to predict pressure drop is a consequence of relatively coarse mesh in the core of the pipeline. Due to relatively coarse mesh the CFX solver cannot accurately calculate fluid friction losses and thus irreversibility from fluid friction. Noted trade-off in coarse mesh in central fluid region was introduced to decrease the computational resources necessary to perform calculations i.e. decrease of time necessary to perform calculations to a reasonable frame. Regardless of the above simplifications, examples of steam flow meter and pipe curve, it is shown that the irreversibility of friction far more influence on the generation of entropy than irreversibility from heat transfer, and therefore on the loss of available work or exergy destruction. Having in mind previous, the general conclusion is that in order to increase the energy efficiency of the system should significantly decrease the friction between the pipe wall and fluid.

Nomenclature

Be - Bejan number
$\dot{E}$ - exergy flow rate, W
d - diameter, m
k - heat transfer coefficient, W/(m^2·K)
p - pressure, bar
q' - heat transfer rate per unit of length, W/m
$\dot{Q}$ - heat transfer rate, W
$\dot{S}_{gen}$ - entropy generation rate, W/K
$\dot{S}'''_{gen}$ - local entropy generation rate, W/(m^3·K)
t - temperature, ^{o}C
T - temperature, K
$\dot{V}$ - volumetric flow rare, m^3/h
w - velocity, m/s

Greek symbols

α - convective heat transfer coefficient, W/(m^2·K)
ϕ - irreversibility distribution ratio
Φ - viscous dissipation function, s^{-2}
λ - thermal conductivity, W/(m·K)

Greek symbols (continue)

μ - viscosity, kg/(s·m)
ρ - density, kg/m^3

Subscripts

b - boundary
D - destruction
e - outlet
ew - external wall
ex - external
FF - fluid friction
HT - heat transfer
i - inlet
in - internal
is - isolation
iw - internal wall
L - loss
o - environment
pw - pipe wall
q - heat transfer
0 - reference state

REFERENCES

[1] Mahmud S., Fraser A.R.: The Second Low Analysis in Fundamental Convective Heat Transfer Problems, Thermal Science 2003; 42: 177-86.
[2] Bejan A: Entropy Generation through Heat and Fluid Flow, John Wiley&Sons; 1982.
[3] Bejan A.: A Study of Entropy Generation in Fundamental Convective Heat Transfer, Journal of Heat Transfer 1979; 101: 718-25.
[4] Guo J., Xu M., Cai J., Huai X.: Viscousn Dissipation Effect on Entropy Generation in Curved Square Microchannels, Energy 2011; 33: 5416-23.
[5] Sahin Z.A., Mansour B.R.: Entropy Generation in Laminar Fluid Flow through a Circular Pipe, Entropy 2003; 5: 404-16.
[6] Zaharnah A.T., Yilbas S.B.: Thermal Analysis in Pipe Flow: Influence of Variable Viscosity on Entropy Generation, Entropy 2004; 6: 344-63.
[7] Yapici H., Kayatas N., Kahraman N., Baştürk G.: Numerical Study on Local Entropy Generation in Compressible Flow through a Suddenly Expanding Pipe, Entropy 2005; 7: 38-67
[8] Ko H.T.: Numerical Investigation on Laminar Forced Convection and Entropy Generation in a Curved Rectangular Duct with Longitudinal Ribs Mounted on Heated Wall Ducts, Thermal Science 2006; 45: 390-404.
[9] Ko H.T., Ting K.: Entropy Generation and Optimal Analysis for Laminar Forced Convection in Curved Rectangular Ducts: A Numerical Study, Thermal Sciences 2006; 45(2): 138-50.
[10] Bejan A., Tsatsaronis G., Moran M.: Thermal Design and Optimization, New York: John Wiley&Sons; 1996.
[11] Bird B., Steward W., Lightfoot E.: Transport Phenomena, John Wiley&Sons; 2002.
[12] Szargut J., Morris D.R, Steward F.R.: Exergy Analysis of Thermal, Chemical, and Metallurgical Processes, New York: Hemisphere Publishing Corporation; 1988.
[13] Edited by Frangopoulos C.: Exergy, Energy System Analysis and Optimization - Exergy and Thermodynamic Analysis, Vol. 1, EOLSS Publishers Co. Ltd; 2009.
[14] ANSYS CFX 13.0, Theory manual.

OPTIMAL PARAMETERS FOR THE COMBUSTION OF PELLETS AND WOODCHIPS IN BOILERS

Branislav Stojanović[1], Jelena Janevski[1], Mladen Stojiljković[1], Dejan Mitrović[1], Marko Ignjatović[1]
[1]University of Niš, Faculty of Mechanical Engineering in Niš
e-mail: banes@masfak.ni.ac.rs

Abstract: Objective of this paper is to define the optimal parameters for the combustion of pellets and woodchips taking into account their specificities. First, specificities of biomass combustion are analyzed, with special focus on wood chips. Fuel humidity content, temperature and time of combustion is taken into account. Based on stoichiometric for combustion and kinetics of combustion, necessary quantity of air for combustion is determined as well as the air flow into the combustion chamber and mixing fuel and air.
Key words: combustion, pellet, woodchips

INTRODUCTION

Any material derived from wood could be treated as biomass, but only wood in certain shapes can be used to generate heat. Using wood from forests and residues from production process as a fuel contributes to sustainable energy supply, so wood is becoming more significant as a renewable energy source. Three types of wood are most popular in heat production: logs, chips and pellets. Use of wood in boilers for central heating with automatic fuel supply is of special interest both in residential applications and in district heating systems. In order to achieve this type of boiler operation it is necessary that wood used must be easily dosed. This characteristic is present in wood chips and pellets. Wood properties significantly influence both technological and environmental requirements of burning process. This is why construction specifics of burning equipment are adjusted to every type of fuel used in order to achieve optimal parameters of combustion process. Complexity of combustion process influences the fuel supply mechanism, combustion chamber and flue gases treatment. Basics required for designing boilers with low emission is good knowledge in wood combustion process through drying, thermal decay, gasification, gas combustion and mechanism for creating by-products of combustion. Although wood chips and pellets are derived from wood, each of this fuel type has its special properties, especially ash and moisture content.

WOOD CHIPS AND PELLETS CHARACTERISTICS

Wood chips are produced from foresting residues and by mechanical treatment it is prepared as fuel for fully automated boilers. Having in mind diversity of sources for producing wood chips, moisture content could vary significantly. In dry wood moisture content is in range 20 to 30%, but in case of green residues it could reach almost 60%. This value of moisture content requires drying before using it as biomass fuel or before fuel storage.
Quality of wood chips, size and ash and moisture content are defined with CEN/TS 14961 (Table 1, 2)

Table 1: Wood chips size - CEN/TS 14961

Class	Main fraction > 80% mass	Fine fraction < 5% mass	Rough fraction max chips length
P16	3.15mm ≤ P ≤ 16mm	< 1 mm	max 1% > 45 mm, oll < 85 mm
P45	3.15mm ≤ P ≤ 45mm	< 1 mm	max 1% > 63 mm
P63	3.15mm ≤ P ≤ 63mm	< 1 mm	max 1% > 100 mm
P100	3.15mm ≤ P ≤ 100mm	< 1 mm	max 1% > 200 mm

Table 2: Wood chips moisture content - CEN/TS 14961

Class	Limit value moisture content in 15%	Mark
M20	≤ 20	dry
M30	≤ 30	storage
M40	≤ 40	good for limited storage
M55	≤ 55	
M65	≤ 65	

Pellet is a product produced exclusively by pressing sawdust and other sawmilling wastes from dry wood of significant heating value using huge pressure without adding any adhesives. It is produced from oak, beech, ash, common hornbeam, polar, lime tree etc. It is quality fuel with high heating value, usually cylindrically shaped with low moisture content (app. 10%) and ash content. Due to its size and shape it is easily transported and supplied into boiler combustion chamber. Pellets have become the symbol of ecology in the last few years. Properties of pellets defined with various standards are shown in Table 3.

Table 3: Properties of pellets [1]

	DIN 51731	ONORM M 7135	DIN plus
Diameter (D)	4 - 10 mm	4 - 10 mm	4 - 10 mm
Length	< 50 mm	< 5 x D	< 5 x D
Density	> 1.0 – 1.4 kg/dm3	> 1.12 kg/dm3	> 1.12 kg/dm3
Heating value	17.5 – 19.5 MJ/kg	> 18 MJ/kg	> 18 MJ/kg
Moisture content	< 12 %	< 10 %	< 10 %
Ashes content	< 1.5 %	< 0.5 %	< 0.5 %
Sulphur	< 0.08 %	< 0.04 %	< 0.04 %
Nitrogen	< 0.30 %	< 0.30 %	< 0.30 %
Chlorine	< 0.03 %	< 0.02 %	< 0.02 %

Moisture content and humidity

For determining moisture content in wood, two physical quantities are used. Moisture content (w) is defined as ratio of moisture and mass of wood, while the wood humidity (u) is defined as the ratio of moisture and mass of dry wood. These two are connected by equation 1, so for limit values of w, u has been recalculated in the Table 4.

$$u[\%] = \frac{w[\%]}{100 + w[\%]}100 \qquad (1)$$

Heating value

Lower heating value of dry wood (Hus) is in range 18.1-19.0 MJ/kg, so for the engineering purposes it is assumed at 18.3 MJ/kg (5.1kWh/kg). Moisture in wood affects its heating value as it is shown with the following equation:

$$H_u = \frac{H_{us} - 2.5\frac{u[\%]}{100}}{1 + \frac{u[\%]}{100}} \qquad (2)$$

WOOD COMBUSTION PROCESS

Wood is a solid fuel with high concentration of volatiles. While heating, 80-90% of wood mass is converted to gas, mainly carbon monoxide (CO), hydrogen (H2) and hydrocarbons (CmHn). In Figure 1, function of solid particles content and temperature is shown.

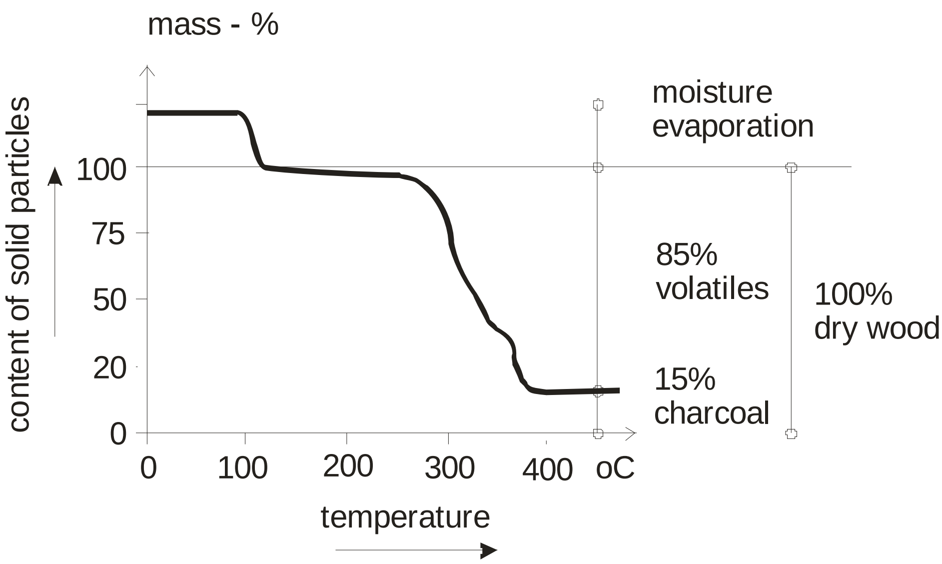


Figure 1. Reducing mass of solid particles while heating wood (without air supply) as a function of temperature [2]

Wood combustion is a complex process developed in several phases. Combustion starts with drying and degazation. While increasing its temperature, wood firstly gives away its moisture, which can account for 15-20% of wood mass. While drying, wood is heated above 100^{o}C. Only when moisture from wood pockets evaporates, wood temperature starts to increase. Then, chemically and physically bonded moisture in wood itself starts to evaporate.

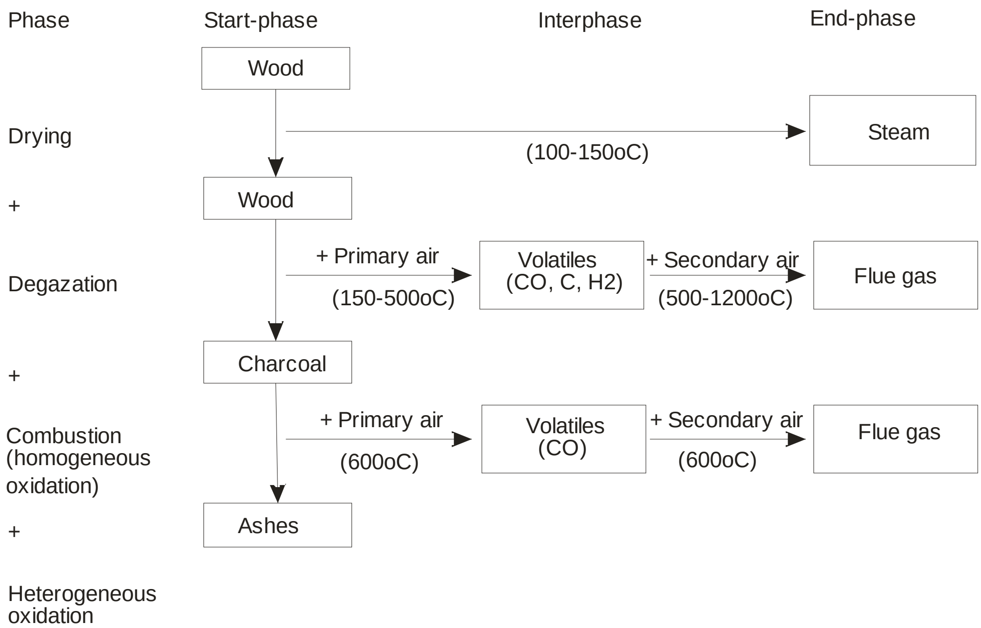


Figure 2. Biomass combustion in stages [3]

Although first organic product of decay occur at 60°C, real process of thermal decay starts at 160-180°C (pyrolysis or degazation). With further temperature increase, thermal decay reactions intensify. From 250°C this process is very intensive. Reactions switch from endothermic to exothermal phase. In this phase, pyrolysis is not controllable, which affects the possibility to control combustion with manual air supply.

Degazation phase last until temperature of app 600°C is reached. By this time, wood mass has reduced to 15% by releasing moisture and volatiles. Only charcoal remains. During degazation phase app. 70% of wood energy content is released. Gas formed during this phase is rich with volatiles, especially carbon monoxide, hydrogen and organic compounds. Gas is highly reactive and starts to oxidize in the presence of oxygen from air with releasing energy until carbon dioxide and water occur (flame).

If by any chance, combustion process determines to early in this stage (heat transfer to another medium), particulate matter and gas with intensive smell full with volatiles, tar and char would occur. In exploitation conditions, complete combustion is approximately developed. Real goal scenario can be only to emit products of incomplete combustion under certain acceptable level.

Combustion of volatiles

Reactions in flame are realized through radicals. They are created on higher temperatures from normal molecules or from reaction with already present radicals. In this phase, radical combustion, it is necessary to provide sufficient quantity of oxygen, to achieve good mixing with gas and to have enough time for reaction to develop.

Charcoal combustion

Final product of wood pyrolysis is coal. This, carbon rich, residue (app. 90% C) combusts at temperatures higher than 600oC. Charcoal combustion is opposite to degazation and practically is flameless. By charcoal oxidation app. 30% of wood energy content is released. At the end of this process, ashes remain with roughly 0.5-1% of wood mass.

Differences in combustion of volatiles and charcoal are significant. Chemically, it is heterogeneous oxidation of solid phase, which requires reactive oxygen to reach the surface of charcoal. CO firstly occurs which oxidizes to CO2. CO2 is partly then defunded back to charcoal surface where it reacts with carbon producing carbon monoxide:

$$2C + O_2 \leftrightarrow 2CO$$
$$2CO + O2 \leftrightarrow 2CO_2$$
$$CO_2 + C \leftrightarrow 2CO \quad (3)$$

It is important to know that wood is solid fuel rich with volatiles. This is why combustion chamber designed for this type of fuel must satisfy requirements for combustion of gaseous fuels. In manual fuel feed boilers this combustion process can be easily detected with carbon dioxide concentration in flue gases. While feeding 10 kg of dry wood, drying process is finished after several minutes. Degazation occurs in combination with flame and rapid increase in CO2 concentration. After 15min combustion is reached which is represented with maximum CO2 concentration. Afterwards, CO2 concentration decreases. After 1 hour, more than 95% of wood is burned.

NOx concentration

Concentration of nitrogen oxides (NOx) represent the sum of the concentrations of NO and NO2 in the flue gas. In contrast to carbon monoxide, which in reaction with atmospheric oxygen is quickly destroyed, the nitrogen oxides (NO2 especially) remain toxic. These gases, even in small concentration, influence health, especially human respiratory system. In addition, these gases increase GHG emission effect of combustion process.

NOx created during the process originates from three sources: thermal NOx, prompt NOx and fuel NOx (chemical NOx). Thermal NOx refers to NOx formed through high temperature oxidation of the diatomic nitrogen found in combustion air. The formation rate is primarily a function of temperature and the residence time of nitrogen at that temperature. At high temperatures, usually above 1600 °C, molecular nitrogen (N2) and oxygen (O2) in the combustion air disassociate into their atomic states and participate in a series of reactions. Prompt NOx is attributed to the reaction of atmospheric nitrogen, N2, with radicals such as C, CH, and CH2 fragments derived from fuel, where this cannot be explained by either the aforementioned thermal or fuel processes. Since, in pellet combustion, temperatures are in the range 800-1100oC, thermal and prompt NOx should not occur. So, the whole NOx concentration originates from the conversion of fuel bounded nitrogen during the combustion process [Stickstoff1].
NOx emissions can be reduced by various primary and secondary measures.

CONDITIONS FOR PROPER COMBUSTION

Requirements for good combustion could be expressed as:

- proper fuel to air ratio,
- sufficiently high temperature,
- sufficient retention time fuel stays in combustion chamber
- good mixing of air with volatiles.

Proper fuel to air ratio
Oxygen is required during combustion and it is provided from air entering the combustion chamber. Depending on fuel type, theoretical quantity of air for full combustion can be calculated. At any time during combustion sufficient quantity of air must be provided, because ideal mixing of air and fuel is not possible in real applications. This implies especially on solid fuels and charged dozing. Excess air shouldn't be too large because temperature of combustion would decrease.

Combustion temperature

Temperature in combustion chamber influences all chemical reaction within combustion chamber. In order to achieve good combustion it is necessary that temperature remains above 650oC (methane ignition temperature). Higher the oxidation temperature, faster the reaction. At very high temperatures (above 1300oC) unwanted nitrogen oxides develop. The risk of this is very low while wood combustion because these temperatures occur locally. High temperatures of combustion provide lower emission of carbon monoxide and hydrocarbons thus improving overall combustion efficiency. So, it is desirable to operate with as low possible excess air and to reduce heat exchange within the combustion chamber itself. Temperature within combustion chamber is directly linked with time fuel stays in combustion chamber. Desired range of temperatures in combustion chamber is between 800oC and 1300oC.

Retention time

If fuel stays longer in combustion chamber, combustion of gases would be better. The higher the temperature and better the mixing, less time is required to achieve same quality of combustion.
In practice, this time is not taken into account because gasification develops in all combustion chamber. This is why experimental results are more accurate that the analytical solution.

Mixing

During oxidation of carbon or hydrogen from fuel, good contact with oxygen from air must be provided or the combustion process wouldn't start. Good mixing of air with volatiles from fuel must be provided thus reducing the excess air and reducing time volatiles stay in combustion chamber for the same quality of combustion.
Here are some basic measures for combustion of pellets [4]:

- separation of primary and secondary air supply,
- coefficient of excess air λ = 0.6 do 0.8,
- keeping flue gases in area of primary combustion of about 0.5s with intense mixing
- as low as possible excess oxygen in area of secondary combustion while providing complete combustion,
- flue gas recirculation back to combustion area, in order to reduce oxygen and combustion temperature. This is required for lowering NO_x.

CONCLUSION

Based on everything above, following factors and their influence on combustion process of wood fuel could be summarized (Figure 3)

Input	**Combustion process**			**Output**
Fuel quantity	Drying phase	Degazation phase	Oxidation phase	Flue gases quantity
fuel content				Flue gases temperature
Moisture content				O2 content in flue gas
Particle size				Temperature in combustion chamber
Boiler capacity				Parameters in parts of boiler
Type of combustion chamber				Pollutant content in flue gases
Air supply				
Recirculation				

Figure 3. Combustion process – influence factors and their effects

Phases of combustion process for wood chips and pellets are the same as in combustion process of wood logs. Main difference is in size of fuel particles and in moisture content in fuel. These differences lead to some specifics of combustion process. Since, it is fairly new fuel, optimal combustion chamber characteristics are still investigated in the sense of complete combustion of fuel followed by allowed emissions. This is why there are several design solutions which are focused on fuel and air supply for combustion process.

ACKNOWLEDGEMENTS

This paper was done within the framework of the project TR 33051-”The concept of sustainable energy supply of settlements with energy efficient buildings” (2011-2014), financed by the Republic of Serbia Ministry of Education and Science.

REFERENCES

[1] Verfasserin, anlehnend an Fachagentur für Nachwachsende Rohstoffe online: Qualitätsanforderungen an Holzpellets. http://www.fnr-server.de/,
[2] Thomas Nussbaumer: Holzenergie, Schweizer Baudokumentation, August 2000
[3] Rainer Marutzky, Klaus Seeger: Energie aus Holz und anderer Biomasse, Grundlagen/Technik/Entsorgung/Recht, DRW-Verlag, 1999
[4] Obernberger, I.: Nutzung fester Biomasse in Verbrennungsanlagen unter besonderer Berücksichtigung des Verhaltens aschebildender Elemente, Band 1, 4. Aufl., Graz 2005.
[5] Hans Hartmann, Bioenergie-Kleinanlagen, Gülzow, 2007
[6] Informations- und Demonstrationszentrum Erneuerbare Energien e. V. online: http://www.idee-nrw.de.

ENERGY BALANCE OF A TUNNEL DRYER IN REAL INDUSTRIAL PLANT

Edib Dedeić[1], Goran Vučković[2]
[1]Corridors of Serbia, Belgrade, Kralja Petra Street 21, Belgrade Serbia
[2]University of Niš, Faculty of Mechanical Engineering, Niš, Serbia
e-mail: vucko@masfak.ni.ac.rs

Abstract: Drying of terracota products is one of the most important phases in technological process of production and it is very complicated. Drying of clay products is performed technologicaly, mainly by using unsatured humid air. In this type of drying, moisture from material is transporting to unsatured humid air, so the process, in fact, is reduced to transport of the substance from one phase to another. It could be said that the process of drying is mainly conditioned by character of the current temperature and concentration field in multyphase system humid material – environment as well as properties of material which is exposed to the process of drying. Due to the enormous variety of material used in ceramic industry as well as the influence that processing of raw materials and shaping ceramic elements have on the process of drying, each individual case represents problem in itself and his solution requires detailed examination.
In this work is presented procedure of thermal budget of a dryers, which was applied for making energy balance of dryer in IGM "SLOGA" from Novi Pazar. Goal of this work is to indicate the importance of properly energy balancing of dryer, considering that the results will be used later on for determination of dimensions of device which provides given capacity by dried material, budget and selection of auxiliary devices (fireboxes, exchangers, cyclone,etc), with a view to optimal exploitation of plants.
Key words: energy balance, dryer, humid air, energy savings

INTRODUCTION

Drying of terracotta products is one of the most important phases in technological process of production and it is very complicated. Water on the surface of moist products evaporates and goes into the air. Evaporating on the outer surfaces of the terracotta products allows water from the internal parts of the product to penetrate toward surface and to evaporate. This process continues up to a point when condition of the remaining moisture in the product does not change. Therefore we have two parts of the process of evaporation: evaporation on the surface and movement of water toward surface.

DESCRIPTION OF A TUNNEL DRYER

In the picture 1 is shown scheme of tunnel dryer type "Lingl" which is placed in The Construction Material Industry " SLOGA" from Novi Pazar. In the same picture is shown air distribution by which the process of drying is performed.
Dryer consists of three systems, each with two tracks, that are marked with I, II and III and with special return track (PK) . Axial fans for ejection of saturated air are marked with V1, V2, and V3.
With black arrows is marked direction of movement of cart with material that is drying and with grey airflows.

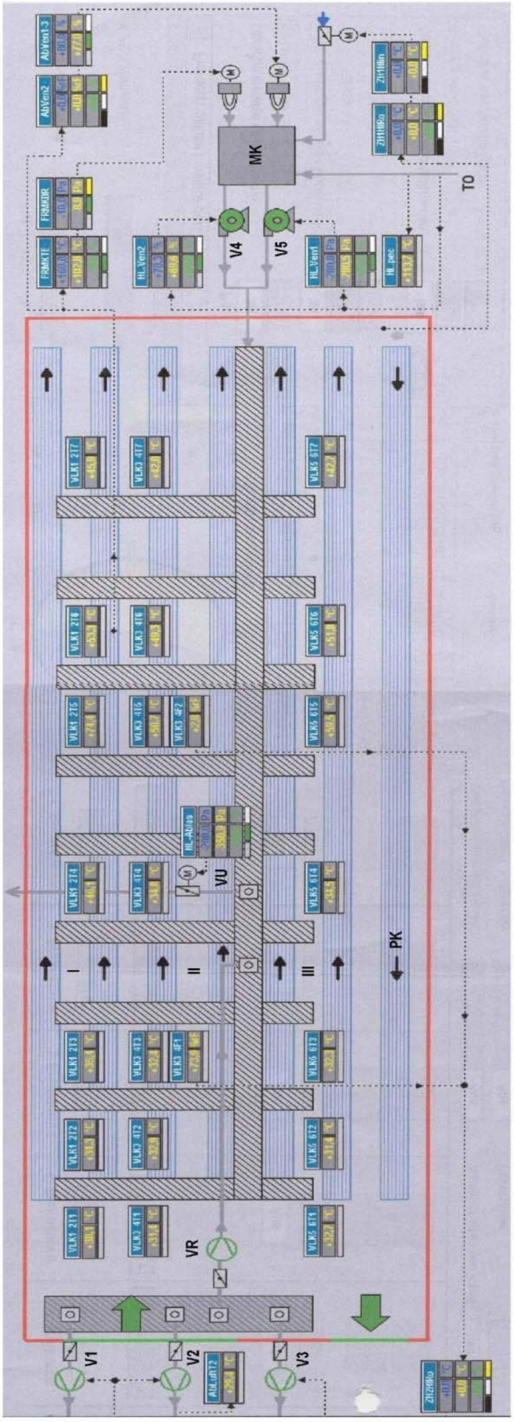


Figure 1. Schematic view of a tunnel dryer "Lingl"
I, II, III – Input tracks; PK – Return track; V1, V2, V3 – Axial fans for insertion of saturated air; TO – warm air; MK – Mixing chamber; V4, V5 –Centrifugal fans; VR – Recirculation fan; VU – Fan for ejection of excess warm air to the atmosphere

Warm air (TO) which is taken from the tunnel furnace is inserted into the mixing chamber (MK), where it is mixed with air from the environment, and through two centrifugal fans (V4 and V5) is inserted into the central canal of the warm air of dryer.
In the picture 1 are also shown two generators that serve as an additional source of heat and are used mainly during first commissioning of dryer when there is no residual heat from the furnace. Fan for recirculation of satured air in the first third of dryer, is marked with VR. In the middle of the dryer is set fan VU which expels excess of hot air into the atmosphere. It regulates air overheating in the first section of dryer.

MATERIAL AND THERMAL BALANCE OF DRYERS

When it comes to material balancing of dryers usually is known the annual capacity of the propulsion or of the dryer per dried material of humidity d_2, %, as well as initial humidity of material d_1, %.
Flow of dry material is :

$$\dot{G}_2 = \frac{G_g}{a \cdot b}\text{, kg}_{sm}\text{/s,} \qquad (1)$$

where is:

G_g – annual capacity of dryer per dried material, kg,
a - number of working hours over 24 hours,
b – number of working days in a year.

The values of a and b depend on the character of the production. Usually for the dryers with the *continuous* work is used that the a = 22h, b= 330, working days. Sometimes is taken 7000 working hours during the year.
If the drying process leads to loss of material, flow is adjusted:

$$\dot{G}_2' = \frac{\dot{G}_2}{K} \qquad (2)$$

where K is the coefficient that takes into account the loss of material and its value ranges from 0,95 to 0,99.
Flow of humidity that evaporates during the drying process is:

$$\dot{G}_v = \dot{G}_2 \frac{d_1 - d_2}{100 - d_1}\text{, kg}_v\text{/s.} \qquad (3)$$

Then the dryers capacity, flow per humid material:

$$\dot{G}_1 = \dot{G}_2 + \dot{G}_v\text{, kg}_{vm}\text{/s.} \qquad (4)$$

In the drying process, mass of absolutely dry material does not change, and removal of particles or other losses, so the flow of absolutely dry material is:

$$\dot{G}_s = \dot{G}_1 \cdot \frac{100 - d_1}{100} = \dot{G}_2 \cdot \frac{100 - d_2}{100}\text{, kg}_{sm}\text{/s} \qquad (5)$$

Where is:

$$\dot{G}_1 = \dot{G}_2 \cdot \frac{100 - d_2}{100 - d_1}\text{, kg}_{vm}\text{/s.} \qquad (6)$$

In dryer with multiple zones, material balance is compiled for each zone, starting from the initial and final humidity in it; in the first zone d_1 and d'_2 ; in the second zone d''_1 and d'_2 etc. where $d''= d'_2$, so it is:

$$\dot{G}_v = \dot{G}_1 \cdot \frac{d_1 - d_2'}{100 - d_2'}\text{, kg}_v\text{/s.} \qquad (7)$$

Material flow at the entrance to the second zone of dryer is:

$$\dot{G}_2 = \dot{G}_1 - \dot{G}_v\text{, kg}_{vm}\text{/s.} \qquad (8)$$

In some cases can be specified change of humidity of the material in the dryer under variable drying regime by the exponential law: u_r - u_2 = $u_1 \cdot e^{-k}$ = $u_1 \cdot e^{-k_1 x}$, where k and k_1 are constants which are determined starting from the decrease in humidity in the dryer of the total drying time or the length of the dryer $x = l$, $u = u_2$, x is current coordinate m, and l – length (path) that material exceeds in the dryer, m.
Humidity of the material per zones is determined from the requirement that the time of staying of the material in them is the same. Mass of absolutely dry air in the process of drying air does not change if there is no draining or suction of fresh air. Therefore, the calculation of the drying device is easier to be performed per 1 kg of absolutely dry air.
Material balance of dryer is:

$$\frac{\dot{G}_1 \cdot d_1}{100} + \dot{L} \cdot x_1 = \frac{\dot{G}_2 \cdot d_2}{100} + \dot{L} \cdot x_2 \qquad (9)$$

or

$$\dot{L} = \frac{\dot{G}_v}{x_2 - x_1} \text{ kg}_{sv}\text{/s}, \qquad (10)$$

where is L – flow of the drying agent and x_1 and x_2 are initial and final humidity of gas.
Consumption of the drying agent (gas) per 1 kg of evaporated moisture is:

$$l = \frac{\dot{L}}{\dot{G}_v} = \frac{1}{x_2 - x_1} \text{, kg}_{sg}\text{/kg}_v. \qquad (11)$$

For convective dryers with a *single pass* (without recirculation) of drying agent and dryer with conductive and radiation mode of heat input, flow of drying agent and fuel is most easily determined *analitically* from the heat balance of dryer. For convective dryers with recirculation of produced gases, for multiple – season dryers with inter – heating of drying agent, gas flow, fuel, etc. The most rational way to determine is graphic – analytical using $h – x$ diagram for humid air.
For the drying process, evaporating of moisture and realization, along with drying of other thermal processes the heat is brought to the material. It is possible to bring it in different ways, depending on the method of drying. If on the basis of experimental data, drying regime is known then from the heat balance is determined heat flux required for drying and flow of proper fuel, value of the electric energy needed, vapor. To determine the heat flux is set heat balance of drying chamber. For stationed process, equation of heat balance is equality between the amount of heat at the entrance to the drying chamber and at the exit from it.
The total thermal flux of dryer is:

$$\dot{Q} = \dot{Q}_i + \dot{Q}_m + \dot{Q}_o + \dot{Q}_2 + \dot{Q}_d \pm \dot{Q}_x + \dot{Q}_t \qquad (12)$$

where is:
Q_i – thermal flux required for evaporation,
Q_m – thermal flux required for warming,
Q_o – thermal flux which is submitted to the environment,
Q_2 – thermal flux which is dissipated with the produced drying agent,
Q_d – thermal flux required for the discruption of energy ties moisture with material and other endothermic processes,
Q_x – thermal flux of chemical reactions (sign is taken when separating the heat),
Q_t – thermal flux for heating of the subsequently introduced masses (vapor, compressed air, etc.) and for transport devices.
For dryers with continuous work is calculated the amount of heat needed for 1 hour, and for dryers with periodic work amount of heat for a day of drying. When graphic – analytical calculating using the h – x diagram for air gives the equation:

$$q = q_i + q_m + q_o + q_2 \pm q_x + q_{t.} \qquad (13)$$

Thermal flux needed for evaporating of moisture is:

$$\dot{Q}_i = \dot{G}_v \left(h_{dp} - h_v \right) \qquad (14)$$

for water is:

$$\dot{Q}_i = \dot{G}_v \left(r_o + c_{dp} t_2 - c_v \theta_1 \right) \qquad (15)$$

where is:
h_{dp} - enthalpy of overheated steam at a temperature of exhaust gasses,
h_v - enthalpy of the fluid at an initial temperature of material,
t_2 – temperature of the exhaust gasses,
θ_1 – initial temperature of the material.

It is also:

$$q_i = \left(r_o + c_{dp} t_2 - c_v \theta_1\right). \qquad (16)$$

If the initial temperature of the material is lower than zero *($\theta < 0^0C$)* in equation (14) should be taken value of enthalpy of ice, and in equation (15) conditionally taken $\theta_1 = 0^0$C. In doing so, thermal flux for heating the subcooled fluid and ice 0^0C and its melting should be taken in determining the total thermal flux of heating the material.
Thermal flux for heating the material is:

$$\dot{Q}_m = \dot{G}_2 \cdot c_2 \cdot \left(\theta_2 - \theta_1\right) \qquad (17)$$

where is :
θ_2 – temperature of material after drying,
c_2 – specific heat capacity of dry material of moisture d_2.
It is also:

$$q_m = \frac{\dot{G}_2}{\dot{G}_v} \cdot c_2 \cdot \left(\theta_2 - \theta_1\right) \qquad (18)$$

If part of the moisture in the material is in the solid state *($\theta_1 < 0^0C$)*, thermal flux for heating the material is:

$$\dot{Q}_m = \dot{G}_2 c_2 \cdot \theta_2 + \dot{G}_{\check{c}}\left(q_{\check{c}} + c_{\check{c}}\theta_1\right) + \left(\dot{G}_v - \dot{G}_{\check{c}}\right) \cdot c_{vp} \cdot \theta_1 \qquad (19)$$

or for 1 kg of moisture:

$$q_m = \frac{\dot{G}_2}{\dot{G}_2} \cdot c_2 \cdot \theta_2 + \frac{\dot{G}_{\check{c}}}{\dot{G}_v} \cdot \left(q_{\check{c}} + c_{\check{c}} \cdot \theta_1\right) + \frac{\left(\dot{G}_v - \dot{G}_{\check{c}}\right)}{\dot{G}_v} \cdot c_{vp} \cdot \theta_1 \qquad (20)$$

where is:
$q_{\check{c}}$ - heat of melting the solid phase,
$c_{\check{c}}$ - specific heat capacity of the solid phase,
$\dot{G}_c$ - flow of the solid phase, of the frozen moisture,
$\dot{G}_v - \dot{G}_c$ - flow of the subcooled fluid
c_{pv} - specific heat capacity of the subcooled fluid.
At the effect of water with the material,cooled to 0^0C, there is no moisture in the form of ice.
Thermal flux which is submitted to the environment through the walls is:

$$\dot{Q}_o = k \sum F \cdot \left(t_{sr} - t_0\right) \qquad (21)$$

where is:
k – coefficient of heat transfer through the walls of dryer,
F – outer surface of the dryer,
t_{sr} – mean temperature in the dryer,
t_0 – temperature of the environment.
Mean temperature in the dryer (in the zone) is:

$$t_{sr} = \frac{\frac{\left(t_1 + t_2\right)}{2} + \frac{\left(\theta_1 + \theta_2\right)}{2}}{2} \qquad (22)$$

where is t_o – temperature of the outside air; for open type dryers t_o is temperature of the environment. Thermal isolation of a dryer is chosen so that the outside temperature does not exceed 40^0C, or that the coefficient of heat exchange is from 1,1 to 2,2W/(m^2K).

$$\frac{\lambda_i}{\delta_i} = 1{,}1 - 2{,}2 \ \text{W/(m}^2\text{K)}, \tag{23}$$

where is λ_i – thermal conductivity of the isolation material, and δ_i – thickness of isolation.
Using the equation (23) determines the thickness of the isolation layer. If dryer is placed outside of the building, isolation thickness is determined so that the minimum value of the ambient temperature in winter, inside wall of the dryer has a temperature above the dew point. In order to determine the dimensions of the dryer, it is assumed that the specific losses to the environment are:

$$q_0 = 125 \div 420 \ \text{kJ/kg}_v, \tag{24}$$

depending on the initial moisture of the material; smaller value is taken for the wetter materials.
Thermal flux which is dissipated with the exit gases is:

$$\dot{Q}_2 = \dot{L} \cdot (h_2 - h_0) \tag{25}$$

where is:
h_2 – enthalpy of the drying agent at temperature t_2 and initial moisture of the drying agent x_o,
h_o – enthalpy of the outdoor air,
L – flow of the drying agent (considering suction of the outdoor air thrown into the atmosphere, part of the sucked air is 10 – 15 % of the total gas).
Thermal flux that is used for dehydratation and other endothermic is:

$$\dot{Q}_d = q_d \cdot \dot{G}_2 \tag{26}$$

where is q_d – specific dehydratation heat, reduced to 1 kg of dry product.
At different drying methods, the heat can be spent on heating of additional materials and transport devices.
During drying,spraying, dispersing of the solution is performed by compressed air or with vapor, in tunnel dryer transport devices (wagons coming out from the dryer are cooled, etc.)
Additional thermal flux is:

$$\dot{Q}_t = \dot{G}_n \cdot c_n (t_2 - t_n) + \frac{\dot{G}_T}{\tau} c_T \cdot (t_t - t_0) \tag{27}$$

where is:
G_n – flow of the subsequently brought substances,air, etc.
c_n – spacific heat capacity of the substances introduced,
t_n – temperature of the introduced substances (if the vapor is added or air in term of pressure, temperature is determined by calculation, taking into consideration adiabatic spread of the substance),
τ - time of drying,
c_t – specific heat capacity of material of the transport devices,
t_t – temperature of the transport devices at the same movement of the substance of the drying agent, t_t is equal to the temperature of exhaust gasses t_2, at oppositely initial temperature of the gas, t_1.
It is also:

$$q_t = \frac{\dot{Q}_t}{\dot{G}_v} \tag{28}$$

Often in the drying process occurs simultaneously with evaporation chemical reactions during which the heat is realised or consumed. Thermal flux Q_x is necessary to take in to the total balance of dryer and to determine the required flow of the drying agent.

THE RESULTS OF HEAT BALANCE OF TUNNEL DRYER TYPE "LINGL"

The tunnel dryer "Lingl" uses for drying of building materials in machinery "BUDUĆNOST" Industry of Building Materials "SLOGA" from Novi Pazar. The dryer consists of three tunnels.

Basic technical data:

- Dimensiones of gitter block: 190x250x190 mm
- Weight of raw block: 9,4 kg
- Weight of dry block: 8,4 kg
- Number of block in dryer: 76032
- Number of pieces per one tunnel: 25344
- Number of pieces in one wagon: 576
- Number of input tunnel in the dryer: 3
- Number of returned tunnels in the dryer: 1
- Number of wagons on track: 22
- Time of drying: 48 h
- Gathering by drying: 3%
- The active length of the dryer: 59,4 m
- The amount of water evaporated during drying per 1 block: 1 kg
- Number of wagons in one day (38016/576) 66 wagons/day

Energy balance of one tunnel

The amount of water: 25344 kg_{H2O}/1 tunnel
The amount of humid material: 238233.6kg per tunnel
The amount of dry material: 212889.6kg per tunnel
For the calculation of the heat balance are used following parameters:

- middle temperature of the tunnel dryer 70°C
- relative humidity of the air in the tunnel (adopted value)40%
- input temperature of the materials for the period from November to December 15°C
- relative humidity at the exit 70%

The moisture content in i-x diagram
x=0,086 kg of the moisture/kg of the air
The heat of evaporation of H_2O, r=2257 kJ/kg, for t=15 °C and φ=70%
x= 0,008 kg of the moisture /kg of the air
C_p=1 kJ/kgK the air
C_p=0,879 kJ/kgK dry clay
C_p=0,477 kJ/kgK steel
C_p=4,2 kJ/kgK water

1. The amount of water for warming the tunnel from 15°C till 70 °C (per 1 tunnel)
   a) The heat of warming dry blocks 30876.5MJ
   b) The heat of warming transport and auxiliary devices 1695.5MJ
   c) The heat of warming wagons 2907MJ
   d) The heat of warming water in blocks 17563.4MJ
   Total heat for warming 53042.27MJ

2. Evaporation 171604.2MJ
   a) The total heat required for warming water materials, transport equipment and evaporation: 224646.5MJ
   b) The amount of heat required to warm the air to prevent condensation in the material: 53610.63MJ
   The total heat required to dry the block in a single chamber 278256.66MJ + Q_{gub}

3. Heat losses in the tunnel are related to the heat losses, through the walls, ceiling, doors and floor.
   a) heat losses through walls: 3367MJ
   b) heat losses through the ceiling 9755MJ
   c) heat losses through the door 164.7MJ
   d) heat losses through the floor of the tunnel 16105.13MJ
   Total shell losses: 29392MJ

Total amount of heat in the tunnel dryer:	**307649MJ**	**6409MJ/h**

The analysis of the results of heat balances indicates that the part of heat losses through the tunnel dryer shell in relation to the total required heat for about 10%, represents a significant amount of energy. By isolating certain parts of the dryer and reducing losses, it may reduce outlay of energy per unit of production, and thereby increase the energy efficiency of dryer.

CONCLUSION

Considering that the results of the energy balance of dryers are used to determine the dimension of devices which provide a given capacity per dried materials, calculation and choice of auxiliary devices (furnaces, exchangers, cyclones, etc.), it is the proper determination of the energy balance thats is of vital importance for the future optimal exploitation of the plant.

Taking into account the coupling furnace – the dryer and the fact that as the agent of drying are used hot combustion products which leave the furnace with high temperature, it would be energy effective and economically justified, especially in summer regime, to use the part of energy of combustion products from the furnace for any other technical or sanitary needs. Considering the technology of "pressure" of clay it is recommended that the excess of energy have to be used for steaming of clay in the place where it was, which would achieve more balanced moisture of clay, and it would give a better final quality of the dried product without microcracks.

REFERENCES

[1] Likov A. V, Teorija suški, Moskva, 1950.
[2] Likov A. V, Teplomassoobmen, Energija, Moskva, 1978.
[3] Stefanović M, Voronjec D, Kozić Đ, Nove tendencije u razvoju termodinamike sušenja, Termotehnika broj 1-2 godina XX, 3 ÷ 19, Beograd, 1994.
[4] Valent V, Sušenje u procesnoj industriji, Hemijska industrija, vol. 48, broj 10 ÷ 12, 1994 i vol. 49, broj 1 ÷ 5, Beograd, 1995.
[5] Đorđević B, Valent V, Šerbanović S, Termodinamika i termotehnika, Beograd, 1987.
[6] Milojević D, Analiza kinetike prenosa toplote i materije pri konvektivnom sušenju gustog sloja zrnastih kapilarno-poroznih koloidnih materijala, Magistarski rad, Beograd - Vinča, Beograd, 1979.
[7] Raković A, Analiza kinetike sušenja prirodnih materijala, Magistarski rad, Beograd - Vinča, Beograd, 1987.
[8] Dedeić E: Istraživanje procesa sušenja glinenih proizvoda u komornim i tunelskim sušarama sa aspekta energetske efikasnosti postrojenja, Magistarski rad, Mašinski fakultet u Nišu, Niš, 2006.

DEPENDENCE OF CHANGE IN THERMAL DIFFUSIVITY AND CONDUCTIVITY COEFFICIENTS ON THE DEGREE OF FLUIDIZATION

Jelena Janevski[1], Branislav Stojanović[1], Mladen Stojiljković[1], Mića Vukić[1]
[1]University of Niš, Faculty of Mechanical Engineering in Niš, Niš
e-mail: djoje@masfak.ni.ac.rs

Abstract: The paper presents experimental research of thermal diffusivity and conductivity coefficients of the siliceous sand bed fluidized by air. It also provides an outline of researches of these coefficients conducted so far by other authors, whose experiments were performed in conditions similar to those in the own experiment. On the basis of experimental research, the influence of the process's operational parameters on the obtained values of the bed's thermal conductivity has been analyzed. The results show direct dependence of thermal conductivity on the intensity of mixing, the degree of fluidization, and the size of particles. In the axial direction, the coefficients which have been treated have values an entire order higher than in the radial direction. Comparison of experimental research results with experimental results of other authors shows good agreement and the same tendency of thermal conductivity change, depending on the size of particles and the intensity of mixing.
Key words: fluidized bed, heat transfer, experiment, thermal diffusivity, thermal conductivity

INTRODUCTION

The fluidization phenomenon has attracted the attention of numerous researchers. Its appliance in numerous technological operations stems from its excellent properties, which are reflected in: intensive mixing of solid particles, a high contact-surface between gas and solid particles, an almost constant temperature in the entire bed, as well as simple insertion and removal of the material from the bed. Due to its good characteristics, the fluidized bed has an important application in industrial processes. In the past several decades, numerous papers and studies of the process of fluidization and its application have been published, most of which are based on experimental research. The field of heat conduction has been of high interest to researchers, since the fluidized bed is characterized by high heat conductivity. These facts have motivated experimental research with the chief goal of determining thermal diffusivity and thermal conductivity coefficients of the fluidized bed for particles of siliceous sand of differing fractions. The influence of the most important parameters on the values of thermal diffusivity and conductivity coefficients of the fluidized bed has been analyzed through obtained experimental results; also, certain experimental studies of other authors have been considered.

THERMAL CONDUCTIVITY OF THE FLUIDIZED BED

Since specific thermal capacity of solid particles is volumetrically higher than specific thermal capacity of gas by several orders, moving particles are basic heat holders in the bed. Transfer of heat by the flow of gas is relatively small and, consequently, negligible. In this case, ordinary Fourier's equation can be used for describing the process of heat propagation in the fluidized bed, where thermal diffusivity coefficient reflects the intensity of the mixing of material in the bed. Its value can be measured by a modified method of the instantaneous heat source, whose essence is as follows: a strong instantaneous thermal impulse is created in the fluidized bed by quickly pouring a small portion of previously heated particles of that same material into it, and the moment of achieving maximal temperature ($\tau_{max} = \frac{r^2}{2na}$) at certain distance from the heat source is registered. The movement of bubbles enables the mixing of particles in the emulsion phase, both in the direction of the bed's height, and in the radial direction, whereby a certain amount of particles passes through any observed intersection of the bed. Since particles in the non-isothermal bed differ with respect to the value of enthalpy, a resulting flux of warmer particles will appear if their concentration is higher on one side of the observed intersection. Presupposing that the concentration of warmer particles per unite of volume changes in the direction of the flow of particles only, their resulting thermal flux per unit of surface can be expressed as:

$$q = -D_s \frac{dI}{dx}. \tag{1}$$

If the following expression of enthalpy is introduced into expression (1):

$$I = \rho_n \cdot i = \rho_p \cdot (1-\varepsilon_{mf}) \cdot c_p \cdot t, \tag{2}$$

we obtain:

$$q = -D_s \cdot \rho_p \cdot (1-\varepsilon_{mf}) \cdot c_p \cdot \frac{dt}{dx} = -\lambda \cdot \frac{dt}{dx}, \tag{3}$$

where λ is thermal conductivity coefficient of the fluidized bed, which is defined as:

$$\lambda = D_s \cdot \rho_p \cdot (1-\varepsilon_{mf}) \cdot c_p = a \cdot \rho_p \cdot (1-\varepsilon_{mf}) \cdot c_p = a \cdot \rho_n \cdot c_p. \tag{4}$$

REVIEW OF RESEARCH INTO THERMAL DIFFUSIVITY AND THERMAL CONDUCTIVITY OF THE FLUIDIZED BED

For determining thermal diffusivity coefficient in the axial direction, Zabrodski [1] used a glass pipe, length 1m, diameter 80mm. On the upper surface of the bed, an instantaneous surface heat source was created by pouring a small portion (5-7% volumetrically) of particles heated in a furnace up to temperature 100-700°C. The time of particle pouring was less than 0.5s. For measuring the temperature of the bed, two thermo pairs were used; one of them was placed on the distributor, the other at half the height of the bed. Measurements were performed with several mono-dispersion and poly-dispersion fractions of differing types of material for differing heights of the stagnant bed. The processing of experimental data has shown that thermal diffusivity coefficient in the axial direction can be described by the following equation:

$$a_a = 0,44(N-1)^{0,54} Ar^{0,144} (1-\varepsilon_f)^{-1} \left(\frac{H_{mf}}{D_t}\right)^{1,3} \tag{5}$$

Determination of thermal diffusivity coefficient in the radial direction is performed in a pipe with diameter 175mm. Instantaneous spot heat source was obtained by quickly pouring a small portion of warm sand particles along the axis of the apparatus through a glass pipe with diameter 25mm. For temperature measurement, a thermo pair was placed at the height of the pouring of particles from the pipe, at the distance of 60-70mm from its axis.

The research has shown that there is a highly intensive mixing of material in the fluidized bed in the axial direction. Axial thermal diffusivity coefficient was within a_a=(10-60)cm^2/s. On the other hand, mixing of material in the radial direction was relatively weak. Values of radial thermal diffusivity coefficients were: a_r=(0.4-1.5)cm^2/s.

In their published paper [2], Peters, Orlichek, and Schmidt tried to calculate thermal conductivity coefficient by determining temperature profile in the fluidized bed. The apparatus was in the shape of a parallelepiped, width 65mm, length 450mm, height 480mm, which was not completely filled with sand (d_{ekv}=0.23mm). As a source of heat, they used an electric heater consisting of a wire spiral, which provided heat evenly along the transverse section of the bed. Thermal isolation of the vessel prevented thermal loss through the wall from being higher than 7%. Calculated numerical values of thermal conductivity in the axial direction were within (1163-1977)W/mK, while in the radial direction, they were of order (1200-2000)W/mK. Zabrodski [1] states that those values are significantly increased, and that they are practically impossible to obtain on the basis of such experimental conditions.

On the basis of the foregoing facts, it can be concluded that research of thermal conductivity of the fluidized bed shows the existence of dispersion of results obtained by various authors, since they show complex dependence of thermal conductivity coefficients on various factors.

EXPERIMENTAL RESEARCH OF THERMAL CONDUCTIVITY IN THE FLUIDIZED BED

The goal of experimental research of the fluidized bed in this paper is determination of thermal conductivity coefficient and of thermal diffusion in axial and radial directions, depending on operational characteristics of the fluidized bed: velocity, degree of fluidization, and the size of particles. Experimental research was conducted on a laboratory apparatus made at Mechanical Engineering Faculty of Nis. The apparatus consists of a measuring part, above which is a pipe for the supply of heated sand into the bed, a device for the supply of air, and a device for measurement, regulation, and registering of the process. Special attention was paid to the construction of the device for the supply of heated sand into the bed. Material, which was previously heated up to temperature 250-350°C, was instantaneously inserted into the fluidized bed by quick surface pouring through the pipe with diameter 45mm onto bed surface.

A fan from the external environment supplies the air necessary for fluidization. The flow of air is measured by a standard aperture, while a valve enables the desired flow of air. In order to stabilize the flow of air, the sections in front of and behind the aperture are long enough. A chamber isolated by glass wool helps even distribution of air on the intersection of the operational part of the apparatus. A distributor is placed at the inlet into the operational part of the apparatus, while a tapered extension is placed above, which prevents the removal of minor fractions. Chrome-aluminum thermo pairs are used for temperature measurement; one of them is placed immediately above the distributor, while the other is placed at the outlet from the bed.

PRIOR MEASUREMENTS

In order to start experimental determination of thermal conductivity coefficient, certain measurements were performed prior to it. Siliceous sand with differing fractions was used as material for fluidization. Siliceous sand was selected because of its favorable application in numerous processes in fluidized beds (for example, carbonization of coal in the fluidized bed). Subsequent to sifting in standard sieves, fractions of siliceous sand with average particle diameter 0.3mm, 0.5mm, and 0.9mm, were separated. Within prior measurements, the following characteristics were determined for each fraction:

- actual sand density $\rho_{\rho,}$
- bulk sand density $\rho_{n,}$
- equivalent particle diameter d_p,
- porosity at minimal fluidization rate $\varepsilon_{mf,}$
- minimal fluidization rate U_{mf}.

Bulk particle density of particles was determined by pouring freely a certain mass of sand into a calibrated vessel, while actual density was determined by a picnometer. The value of specific thermal capacity was taken from literature [4].

As has been said, for determining thermal diffusivity and thermal conductivity coefficients in the axial direction, two thermo pairs are placed in the axis of the stagnant bed, whereby the first was placed at 43.5mm from the distributor, and the second on the surface of the bed. Subsequent to this, the fan is started; by adjusting the flow of air, the desired velocity of air at working temperature is obtained. At this working velocity of air, with known minimal fluidization rate, the degree of fluidization was determined. In this established state, an already prepared portion of previously heated sand is instantaneously, very quickly, inserted through the fixed pipe. During the movement of inserted hot sand through the fluidized bed, the thermo pairs measured temperature in the bed, while registration was performed on an acquisition system. For a set fluidization rate, separate bed temperatures were registered at each 0.02s. What can be noticed is that temperature in the bed increases, due to the movement of hot sand particles. At the same time, the time span between two maximal increases in temperature registered by the thermo pairs is read. For known distance between the thermo pairs and read time, the value of thermal diffusivity coefficient is calculated. Since thermal diffusivity is determined in the axial direction, it is assumed that, in the equation, the value of n=1 [3]. For a certain degree of fluidization and the existing conditions, the experiment was repeated several times. The

velocity of air was then increased and another experiment was performed, for the same sand fraction, in the way described above. After measuring a certain fraction, the operational part of the apparatus is emptied and another fraction is pouring; the same experiment is repeated on it.
In the own experiment, the values of thermal diffusivity coefficient in the radial direction were determined by the same procedure as the values of axial diffusivity. As has been described, the difference lay in the positions thermo pairs, which were, in this case, in the same plane, and in the value of constant n, which was now n=3.

RESULTS AND DISCUSSION

On the basis of experimental results, diagrams of dependence of change in thermal diffusivity coefficient on the degree of fluidization were made. The coefficient changed as a parameter within anticipated limits, in both axial and radial directions. A comparative review of the dependence of thermal diffusion coefficient on the degree of fluidization for all three sand fractions is given. This dependence is highly complex, so that explanations of the effect of velocity are sometimes contradictory in existing literature.
With the increase of the degree of fluidization, thermal diffusivity coefficient in the axial direction increases for all three cases of the size of sand particles, whereby different increase rates can be noticed. Naturally, it must be remembered that the main reason for the increase of thermal diffusivity coefficient with the increase of fluidization rate is more intensive mixing of particles. With particles with average equivalent diameter of 0.3mm, thermal diffusivity coefficient continually increases up to the value of the degree of fluidization N=3, when a sudden increase of its value can be noticed, while the fluidized state becomes similar to one of the ‘bad’ forms of fluidization. Uniformity of fluidization is not guaranteed for a certain degree of fluidization, so that the character of the bed causes the dispersion of results.
With particles with average equivalent diameter 0.5mm, a more intense tendency towards the increase of thermal diffusivity coefficient with the increase of the degree of fluidization can be noticed (Fig. 1). The maximum of thermal diffusivity coefficient at approximate degree of fluidization N=3 can appear as a consequence of increased content of smaller particles in sand sample. However, it can be confirmed that the main reason for the occurrence of extremes is maximal intensity of mixing of particles, i.e. transition from one form of fluidization into another. In the case of the largest particles, the experiment showed the biggest increase of thermal diffusivity coefficient with the change of the degree of fluidization.

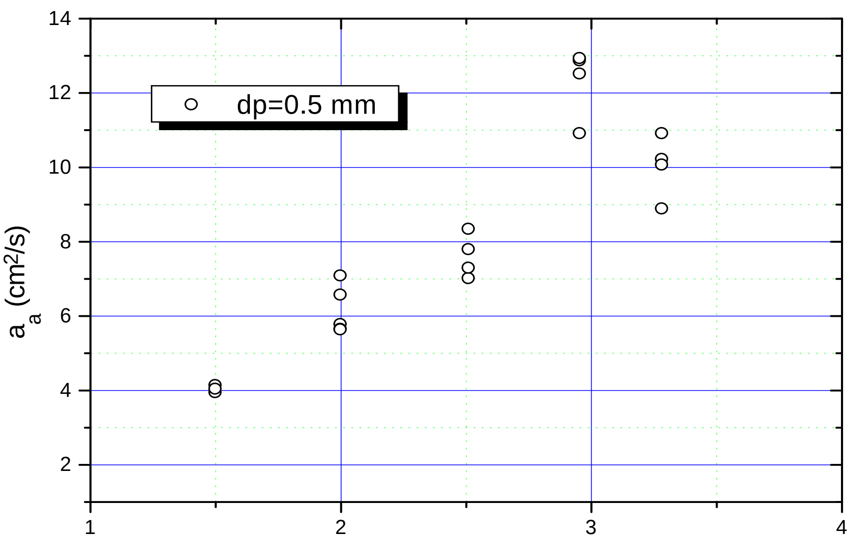


Figure 1. Dependence a_a=f(N)

For assessment of the intensity of mixing in the fluidized bed, coefficient of effective thermal conductivity is authoritative. In view of the interrelationship between thermal conductivity and thermal diffusivity coefficients, Figure 2 shows the dependence of averaged values of thermal conductivity coefficient on the velocity of the fluidization agent. Since thermal conductivity and thermal diffusivity are connected through specific thermal capacity of particles and the density of the fluidized bed, which directly depends on the porosity of the bed, the way in which thermal conductivity coefficient changes with the degree of fluidization is similar to the way in which thermal diffusivity coefficient changes with the degree of fluidization. The maximal value of thermal conductivity, which occurs at degree of fluidization of approximately N=2.5, once again points to the fact that, at that velocity of the fluidization agent, mixing of particles brings about more intense contacts and collisions of solid particles. The occurrence of the maximum can also be accounted for by a decrease in the density of the fluidized bed, and an increase in its porosity with the increase of gas velocity, which may cause differing character of the change of thermal conductivity coefficient.

Generally, the obtained values of thermal diffusivity coefficient in the radial direction are smaller by an entire order (Figures 3 and 4). In contrast to diffusivity coefficient in the axial direction, in this case, what can be observed with all average equivalent diameters is occurrence of the maximum of thermal diffusivity coefficient in the radial direction at fluidization rate N=2.5. According to numerous researchers [1, 2], local concentration of particles influences the passage of heat in the sense of its intensification, when the model of annular distribution of particles on the transverse section of the column, with a solid core in the center, a rarefied bed around the core, and a dense ring next to the wall, is deteriorated. At the same time, mixing of particles and the frequency of their mutual collisions increases, which enhances more intensive diffusion of heat. These facts show that it is within this degree of fluidization that the most optimal fluidization rate, from the standpoint of the best thermal conductivity, can be found. Certain fluctuations of the values of thermal diffusivity can be observed in the diagrams of dependence of thermal diffusivity coefficient on the degree of fluidization. The cause of these fluctuations may be successive arrival of differently heated particle packages at observed places, and sometimes bubbles which pass through the bed. When bubbles go through the bed, at some moment, one of the two thermo pairs may be inside a bubble, thus registering the temperature of air inside the bubble. Since the temperature of air inside a bubble is higher than the temperature of air and of solid particles in the emulsion phase, an increase of temperature will occur at that place at that moment.

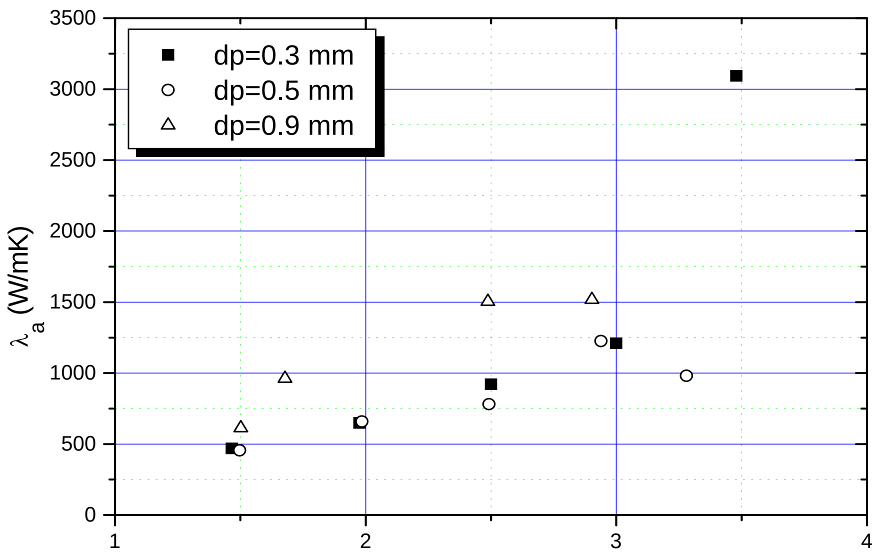


Figure 2. Dependence λ_a=f(N)

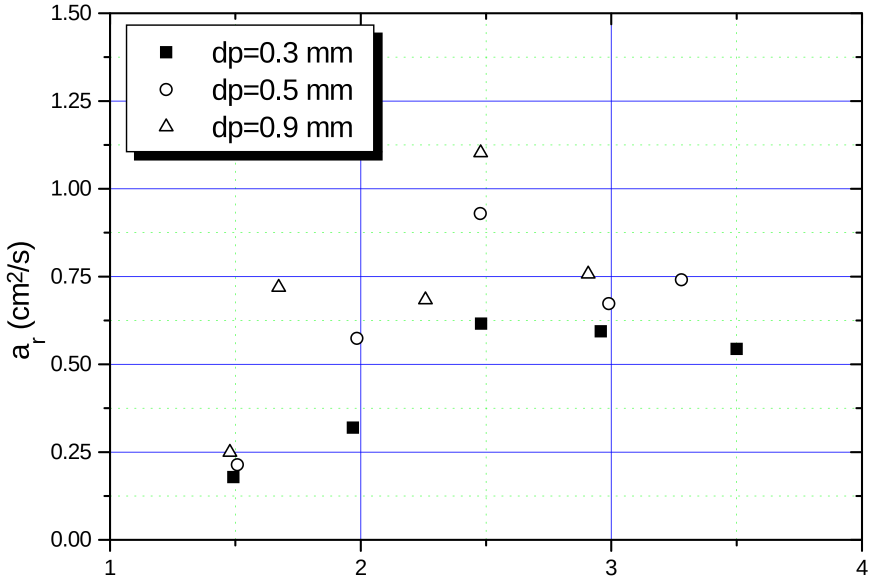


Figure 3. Dependence a_r=f(N)

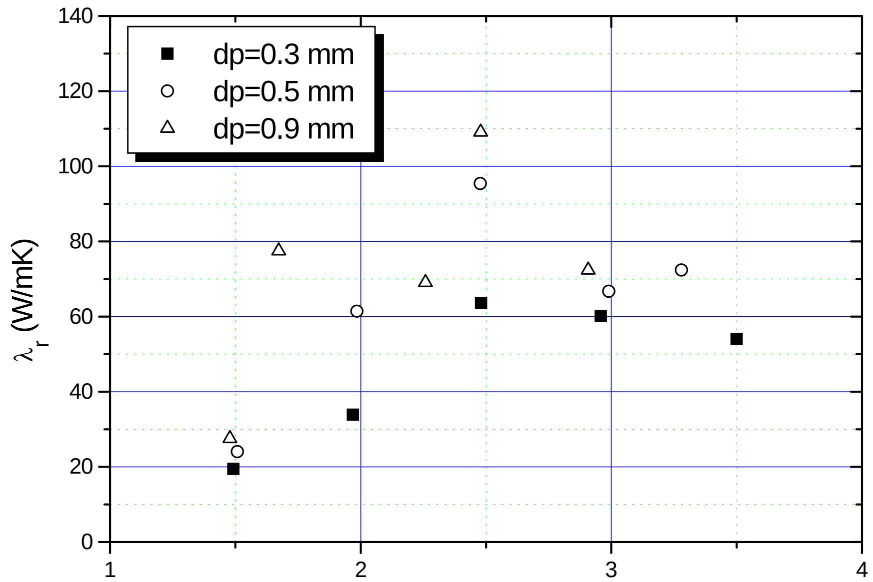


Figure 4. Dependence λ_r=f(N)

By means of their interaction, all treated hydrodynamic parameters influence in a highly complex manner global heat transfer in the fluidized bed, and, consequently, thermal diffusivity and thermal conductivity coefficients. Domination of some of them occurs only in a limited range. The results obtained through the experiment point to the fact that porosity of the bed, i.e. concentration of particles, although a very important factor of heat transfer in the fluidized bed, is not independent from particle flux, relative particle and gas velocity, and reverse mixing.

CONCLUSION

On the basis of presented results of experimental and theoretical research of thermal conductivity coefficients in the fluidized bed which have been conducted so far, as well as on the basis of the results of own experimental research, it has been confirmed that the fluidized bed has very good thermal conductivity [5,6], which enables its application in numerous industrial processes of heat exchange.

The results obtained in experimental research have shown that thermal conductivity coefficient depend on hydrodynamic structure of the fluidized bed. Although the change in thermal diffusivity and thermal conductivity coefficients differs in axial and radial directions, it generally depends on fluidization rate and the size of particles.

For all treated fractions of the sand, the values of thermal conductivity coefficient of the fluidized bed in the axial direction were within 450-3100 W/mK, which also represents maximal reached value in all measurements. The obtained values of those same coefficients in the radial direction are within 19-110 W/mK, which provides a satisfactory level of agreement with the results of other authors.

Despite the complexity of the analysis of thermal conductivity through the fluidized bed and existing constraints of the used laboratory apparatuses, the obtained results provide a realistic review of thermal conductivity in the fluidized bed, so that they can be used with actual industrial plants.

REFERENCES

[1] Zabrodskiñ S. S., Gidrodinamika i teploobmen v psevdoozizennom sloe, Moskva-Leningrad, GosÌnergoizdat, 1963
[2] Peters K., Orlichek A., Schmidt A., Chem. Ing. Tech., Vol.25, No.6, pp. 313-316, 1953
[3] Jovanovic G. N., Catipovic N. M., Fitzgerald T. J., Levenspiel O., Fluidization (J. R. Grace, J. M. Matsen, eds.), Plenum, New York, pp. 325-332, 1990
[4] Janevski J., Determination of the thermal conductivity and thermal diffusivity coefficients by gas fluidized beds, MSc. Thesis, Nis, 2000
[5] Naumann E. B., Chem. Eng. Sci., No.36, pp. 957-966, 1981
[6] Stojanović B., Janevski J., Stojiljković M., Experimental investigation of thermal conductivity coefficient and heat exchange between fluidized bed and inclined exchange surface, Brazilian Journal of Chemical Engineering, vol. 26, no. 02, pp.343-352, April-June 2009.

SESSION 7: Computer Technologies and Engineering Education

DEVELOPMENT OF REQUIRED SKILLS BY USING COMPUTER SOFTWARE IN THE EDUCATION OF FUTURE ENGENEERS

Cvetanka Mitrevska[1], Vesna Mundisevska-Veljanovska[2], Vangelka Trajkovska[3]
[1]SOTU Gorgi Naumov, Bitola, Macedonia
[2]SOU Taki Daskalo, Bitola, Macedonia
[3]ASUC Boro Petrusevski, Skopje, Macedonia
e-mail: cvmit@t-home.mk

Abstract: With the implementation of the European standards in the educational process, as well as the technical-technological development and the globalization, the cooperation between the educational institutions and the business sector is evidently even more required in order to match the future engineer's skills and knowledge with the new technologies and the demand on the labor market.
In this work the results of a conducted research are given, regarding the differences in quality, quantity and the duration of the acquired knowledge of the students-future engineers in the mechanical vocation and acquired with and without usage of computer software in the secondary vocational school Gorgi Naumov from Bitola, Macedonia. The results of the research point out the importance of the computer usage for the development of certain skills required in the engineer's education.
Key words: skills, computer software, education, engineers.

INTRODUCTION

In modern educational conditions, it is a challenge the students to acquire critical opinions, actively participate in the lectures, to develop problem-solving skills, team work, to self-evaluate themselves and use their skills.
The effective engineers need to possess wide range of skills and knowledge beyond the technical expertise in their discipline. Engineers need to have not only understanding of the theory but also about the skills necessary for successful implementation of the of the theory into practice, effective communicational skills, capability of team work, leadership skills and life learning capacity. Some are general, while some focus on specific issues like the design, education and engineering integration with other disciplines, sustainability of life environment, capability to work in multidisciplinary teams and professional skills. Usually, the importance of the professional skills and cultural awareness is emphasized when it comes to successful engineer practice. Those characteristics will enable the engineer's practical usage not only in engineering but also in research, management and other areas.
The modern engineer profile from the aspect of wider businessmen requirements should possess:

- deep theoretical knowledge and understanding of technical processes,
- creative capability and design,
- capability to find alternative and optimal solutions,
- wider knowledge of basic cognitive disciplines,
- knowledge of the quality of the process and the impact upon it,
- advanced communicative skills,
- certain experience and
- team work capability.

USAGE OF COMPUTER SOFTWARE IN THE EDUCATION OF THE FUTURE ENGINEERS

Examining the computer usage in Macedonia, in the last few years we have conducted several researches that have confirmed the positive impact of the computer supported education on the quality, quantity, and the duration of the acquired knowledge over the "traditional" method, independently of the initial motivation of the students about the contents. This time the research was conducted in the secondary vocational school Gorgi Naumov in Bitola with students-future engineers from mechanical vocation on their first year of study. The subject of the research were the difference in quality, quantity and the duration of the knowledge of the students gained with and without the usage of a computer software on the subject Technology of elaboration.

The research uses method of pedagogical experiment with parallel groups and the research techniques: test for the assessment of general mental capabilities, test for the assessment of the students' precognition of the subject Technology of assessment - final examination and test for evaluation of the knowledge in the subject Technology of assessment - evaluation control. The tests used are made in accordance with the standard of the subject and consist of thirteen multiple choice questions, divided by the complexity of the subject according to the Blum's taxonomy: 40% of the questions they are familiar with, 30% of what they logically understand and 30% of their usage, analysis, synthesis and evaluation.

Thirty two students participated in the experimental group and thirty one in the control group. Based on the data of the initial evaluation of the general mental capabilities of the participants in the experimental and control group we concluded that, according to all significant parameters there is high level of equality of both groups on the general mental level as well as the precognition.

During the lectures of the subject Technology of assessment the experimental group used educational software with educational contents. The educational software is adequate to the educational targets and the lectures and enables the students to learn the content divided in didactical units after the example of programmed learning (model of linear programming). In this model, after every didactic step there are various questions and if the students fail to answer correctly, the computer automatically maintains at the same level. If the students answer correctly, the program enables them to pass to the next level of the educational content. After passing all didactical steps, the program enables evaluation of the acquired knowledge and gives feedback.

The educational software was used during the first semester of the school year, and the same was repeated for the final examination. The quality analysis of the success achieved at the test for the subject Technology of assessment shows that students from the experimental group scored 77,63% which is 15,58% higher than the score of the students from the control group 62,05% -Table 1.

Table 1. Results of the final examination

Level	**Question no.**	**Results in %**	
		Experimental group	**Control group**
Group A - Knowledge	1	100	100
	2	100	98,3
	3	94,8	91
	4	90,6	83,4
	5	95,1	60,1
	6	77,5	73,5
	7	76,7	74,2
	8	69,8	60,6
	9	66,9	50,3
	10	83,8	61,2
	11	82,5	59,3
	12	77,3	41,3
Average result		**84,58 %**	**71,1 %**

Group B - Understanding	13	85,4	72,8
	14	71,7	57,9
	15	69,7	56,8
	16	63,6	48,6
	17	77,2	62,4
	18	86,4	72,2
	19	71,6	53,1
	20	86,3	71,3
	21	78,1	63,4
Average result		**76,67 %**	**62,06 %**
Group C - Usage	22	81,6	57,1
	23	75,5	65,6
	24	59,8	49,2
	25	68,6	58,8
	26	76,3	63,7
	27	85,1	69,6
	28	61,3	44,1
	29	64,7	39,5
	30	61,8	29,2
Average result		**71,63 %**	**52,98 %**
		77,63 %	**62,05 %**

Four months after the final examination were conducted a research of the duration of the student's knowledge. The results of the control showed that the results of the experimental group are 20.12% better than those of the control group - Table 2.

Table 2. Results of the control examination

Level	**Question no.**	**Results in %**	
		Experimental group	**Control group**
Group A - Knowledge	1	100	97
	2	99,3	94,2
	3	100	91,5
	4	85,8	80,4
	5	94	53,1
	6	76,2	61,6
	7	75,1	62,3
	8	68,5	51,5
	9	65,6	48,9
	10	74,3	51,5
	11	70,6	53,5
	12	69,8	33,4
Average result		**81,6 %**	**64,91 %**

Group B - Understanding	13	71,8	67,1
	14	64,4	45,2
	15	63,5	51,6
	16	57,3	49,3
	17	73,5	47,7
	18	84,4	50,6
	19	61,2	39,2
	20	83,9	40,9
	21	76,1	43,3
Average result		**70,68 %**	**48,32 %**
Group C Usage	22	78,3	44,4
	23	66,5	48,3
	24	58,6	38,9
	25	67,6	50,1
	26	72,4	44,5
	27	85,2	49,3
	28	56,3	36,2
	29	62,9	34,7
	30	59,6	26,1
Average result		**67,49 %**	**41,39 %**
		71,66 %	**51,54 %**

In figure 1 comparative results between the final and the control examination are shown.

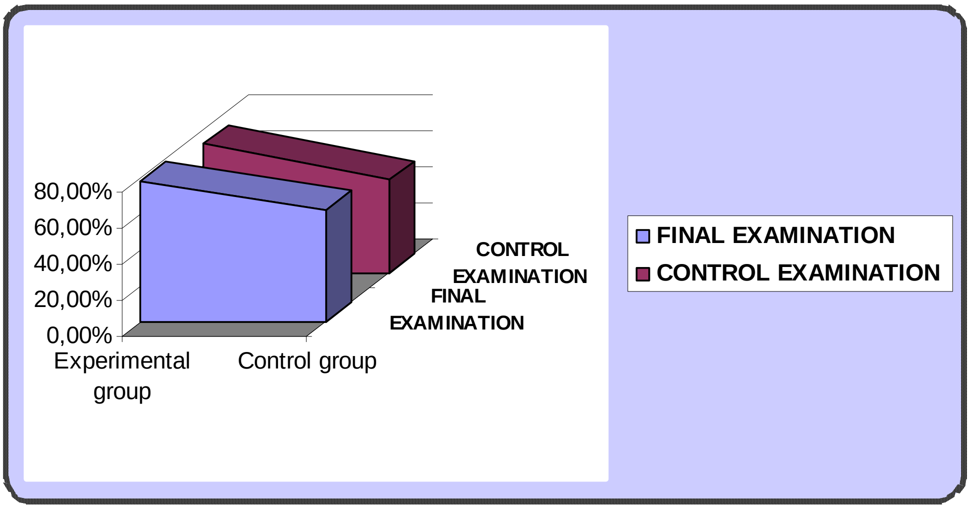


Figure 1. Comparative results between the final and the control examination

The above mentioned results of the research show that by using the software for the subject Technology of assessment in mechanical vocation, efficiently contributes to the development of certain skills such as capability to find alternative and optimal solutions and knowledge of the quality of the process and the impact upon it, skills necessary for the future engineers education which will enable them easier and more efficient practical usage of the acquired knowledge and involvement in the labor market as qualitative work force that will lead the society forward.

CONCLUSION

The results of this research give space for further research and analysis of many questions that will lead to a construction of a teaching strategy for a subject which will enable efficient development of the necessary skills for the future engineers by using computer software during the lectures. In this way, the computerization of the schools in Macedonia after the model “computer for every child” is a big step ahead, even more if they are used actively and if adequate software is used for every subject.

According to the given knowledge we can conclude that the computer usage in the education of the future engineers enables:

- two way communication, that keeps the student in mobile position by using dynamic illustrations , animations and operations he/she is to conduct while learning
- individual learning
- connecting with data base
- developing skills required on the labor market
- new roles for the teacher of creator of activities, innovator, coordinator and motivator
- easier modeling of the educational process as well as easier control and record
- modern organization of lectures in accordance with individual competencies and interests.

The usage of this computer software in order to engage the students in active participation and the development of skills required on the labor market, gives opportunities of redesigning the work in the schools in a society where the skills and knowledge will create productive, responsible and confident people.

REFERENCES

[1] Aditya, J., Preparing Engineers for a Global World: Identifying and Teaching Strategies for Sensemaking and Creating New Practices, http://fie conference.org/fie2009/papers /1177.pdf, from Internet,2009.
[2] Hadjerrouit, S., Designing a Pedagogical Model for Web Engineering Education: An Evolutionary Perspective, Journal of Information Technology Education, Volume 4, 2005.
[3] Mandić, D., Radovanović, I., Uvod u opštu informatičku pedagogiju, Učiteljski fakultet, Beograd, 1998.
[4] Mitrevska, C., Ispituvanje na efektivnosta i efikasnosta na kompjuterski poddrzanata nastava, DLK Razvitok, Bitola, 2009.
[5] Mitrevska, C., Mundisevska-Veljanovska, V., Trajkovska, V., Nastava i ucenje pomocu kompjutera, Tehnologija, informatika i obrazovanje / za drustvo ucenja i znanja - Zbornik na trudovi 1, pp.730-733, Tehnicki fakultet Cacak, Srbija, 2011.
[6] Vilotijevic, M., Didaktika – organizacija nastave, Zavod za udzbenike i nastavna sredstva, Uciteljski fakultet, Beograd, 1999.

ENGLISH PHRASES AND TERMS IN CURRICULUM OF MECHANICAL ENGINEERING SUBJECTS

Eleonora Desnica[1], Duško Letić[1], Erika Tobolka[1]
[1]University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
e-mail:desnica@tfzr.uns.ac.rs

Abstract: As far as the English language is concerned, it is of utmost importance to determine the position of English as an academic language and its role in the studies of mechanical engineering. It is obvious that today English is not learned only for the pleasure and prestige of knowing a foreign language, but also because of the fact that it has become the language of international trends in technology and commerce. This paper presents an overview of necessary and often used English phrases and terms in teaching mechanical engineering subjects as well as in teaching computer aided design.
Key words: English phrases, mechanical engineering, CAD (computer aided design)

INTRODUCTION

The English language has become by far the most prominent and relevant language in the world. In almost every kind of situation, English serves as the intermediary means of communication between persons not sharing a mother tongue, no matter what their vernacular languages are. [1]
Nowadays, English is regarded as very important in international business, economy, science, technology and even sports, where language does not play such a significant role as in other aspects of contemporary life. It is overwhelmingly dominant in scientific and technological communication with all relevant and ground-breaking information being primarily published, distributed and stored in English. As far as engineering disciplines are concerned, foremost with mechanical engineering in mind, the English language plays the same role as in other similar fields being the most important language in conveying knowledge and new inventions on the international scale. Being constantly utilized in all aspects of such a broad discipline as mechanical engineering is, it is crucial for students to understand and perform well in the language for variety of reasons, mainly those concerned with their career advancement and scientific development. [1]

THE ENGLISH LANGUAGE IN ENGINEERING

The knowledge of any language used to be a sign of a well-rounded education, but with no clear reason as to why it was necessary. However as English has became accepted in modern technology and commerce, a number of learners with specific reasons for learning English have come to the front: business people who want to sell their products, doctors and engineers who need to stay in touch with the new developments in their respective fields, and most importantly for us, students who need to use textbooks and journals available only in English, and who need English in order to advance and succeed in their careers. That is how many different reasons for studying English sprang out all of a sudden. [1]
English for Specific Purposes (ESP) has been taught at faculty of engineering and become an integral part of its curriculum. The main objective of the teaching procedure is gaining system and communicative competence based on student's specific, engineering knowledge. [2]
Foreign language of vocation is best learnt and adopted when students are able to apply their learnt knowledge immediately in practice.
[3]

COMPUTER-ORIENTED DESIGNING

Changes in techniques tend to be evolutionary. CAD (Computer Aided Design) has burst through in techniques as nothing before so the effects have started to be felt in every phase of constructing and

designing. If ever in technique we had something that could be considered revolutionary, then it was CAD.
The process of designing is an interactive process (between a man and designing aids) where a designer arranges and changes (edits) certain elements in a model that he builds and adjusts in accordance with functional requests defined in advance. The term “computer aided design” means designing a system and/or a process with the aid of a computer. Computer aid to the designing process means that a computer ensures resources for easier creating, permanent storing and modifying of the parameters of a model-design. [4]
Development of information technologies, especially computers and corresponding software systems that have made an important support to a designer during designing process, conditioned a new way of thinking in designing process. Today designers have a powerful tool that assures selection of the best solution in all steps of the designing process at a particular time and under the particular conditions. Every moment a designer must have a clear vision of a series of actions which lead him in as quick and rational manner as possible to a desired model, i.e. standard technical documentation. Three-dimensional objects in engineering are often created by means of drawings. The process of modeling begins with a conception (idea) by describing an object by means of a 2D (two-dimensional) drawing and its specification.
Education of mechanical engineers is a process that has to provide knowledge of relating natural science, social and technical disciplines, training in using and applying specific methods and development of creativity. CAD (Computer Aided Design) is just one of the methods in design and the software that can be applied in design teaching to encourage development of creative abilities of students.
Using computers in teaching is necessary to modernize the general technical culture of students, future creative professionals: designers and managers, primarily in the field of developing engineering. Beside its compatibility with the inevitable trend of the future: computer and other communications of designers by means of the graphic units and computer networks, introducing computers in teaching presents one of the greater challenges for teachers because it brings with it creation of a new model of teaching as well.
Knowing the theory of design should be an element of general professional knowledge of each engineer of technical disciplines. The greater requirements in quality can be satisfied only if the potential designers are ready to be educated and if certain conditions for realization of education are provided. Due to the new tools and methods the designer is equipped with, the conditions for widening the domain of his professional improvement are created. [5]

English phrases and terms in curriculum of computer aided design

Computer usage in designing and constructing is not news any more, but inevitable. Introducing computer technology in designing and constructing process changes the character of user’s work and changes his professional preparation. There are plenty of techniques of governing the application of the corresponding program packages for the designing process. The choice of AutoCAD and AutoCAD Mechanical tools in the teaching 2D engineering design is based on a range of their applicability and extent in use with direct realization of engineering designs.
The field of 2D designing lays the groundwork for working in any CAD surroundings and therefore directions of further research are imposed. Spreading knowledge of CAD package and work on parameter-designed models come first. Designing with its requests includes needs for the simulations of real conditions as well as analysis of interaction of models with the surroundings.
AutoCAD Mechanical is a highly sophisticated CAD/CAE program package meant for interactive mechanical drawing and calculation in 2D field. It is also possible to use it for certain engineering analysis – simulation and optimization. Considering that it contains the core of AutoCAD, it enables 3D modeling and editing of an object. The tools for graphic representation and simulation in AutoCAD Mechanical are relatively simple and are performed in interactive work joined together with calculation, 2D drawings, analysis and design examining. Design calculations are an unavoidable part of the designing process. They can be performed before (for the sake of selection of dimensions) or after designing. Modern approaches to designing are reduced to calculation integration (simulation, optimization, stress analysis, dynamics and other) in the course of geometric modeling. [5]

Efictive and proper use of reference material in foreign language is one of the main priorities in teaching of CAD. Correct use of software means knowing the phrases and terms in English that are being used in mechanical engineering.
The following tables (1 to 7) show the referent phrases and terms that are being used in some fields of mechanical engineering subject within AutoCad software and AutoCad Mechanical.

Table 1. Design concepts reference [6]

Design	**FEM** (Finite Element Method)
CA (Computer Aided)	**NC** (Numerically Control)
CAD (Computer Aided Design)	**CNC** (Computer Numerically Control)
CAM (Computer Aided Manufacturing)	**DNC** (Direct Numerical Control).
CAE (Computer Aided Engineering)	**FTM** (Flexible Manufacturing System)
CAA (Computer Aided Analysis)	**EDM** (Engineering Data Management)
CADD (Computer Aided Design Drafting)	**PDM** (Product Data Management)
CAQ (Computer Aided Quality Assurance)	**CE** (Concurrent Engineering)
CAT (Computer Aided Testing)	**R&D** (Research and Development)
CIM (Computer Integrated Manufacturing)	**ICG** (Interactive Computer Graphic)
CG (Computer Graphics)	

Table 2. Tolerance and Fit names reference [6]

Dimension	Mating
Dimensional style	Clearance
Shaft	Fit Type clearance
Hole	Maximum clearance
Symmetric	Minimum clearance
Parallel Baseline	Zero line Straightness
Chain	Flatness
Nominal dimension	Circularity
First List	Cylindricity
Dimensional tolerance	Profile of any line
Fit name	Profile of any surface
Deviation	Parallelism
Upper deviation	Perpendicularity
Lower deviation	Angularity
Maximum limit of size	Position
Minimum limit of size	Concentricity and coaxility

Table 3. Constructional details reference [6]

Fine thread	External thread
Blind	Regular thread
Gear	Undercut
Outer Contour	Right Inner contour
Profile	Left inert contour
Parallel key	Standard parts
Shaft Generator	Slope 1: x
Centerhole	Woodruff key
Standard runout	Cylinder

Table 4. Screw connection reference [6]

Screw connection	Eye bolts
Hole	Ashew head bolts
Tapper holes	Screw diameter estimation
Blind holes	Inch
Material class	Nozzle
Countersink head type	Screw assembly
Hex head tpes	Whitworth screw
Socket head types	Gap
Tapping screws	Bolted connection
Conventional type	Binding thread
Regular threaded	Compression strain.
Speciality head types	Groove
Studs	Thread
Wing screws	Side view
Edison screw	Slice
Whitworth screw	Pipe thread
Nut	Key

Table 5. Profiles and Rivets reference [6]

I - Shapes	Steel shapes
L - Shapes	Rivets
U - Shapes	Bronze bush
T - Shapes	Box
Z - Shapes	Block of steel
T - Shapes	Blade profile
O - Shapes	Thread profile
Square / Rectangular hollow	Profile bar
section	Flats
Square / Rectangular bars	Toots profile
Countersunk head rivet	Drilled rivet hole
Plain rivet	Machine rivetting
Fasteners	Riveting by machine

Table 6. Bearing types reference [6]

Roller bearing type	Tapered roller bearing
Needle roller bearing drawn cup	Needle roller bearing with
Roller bearing self-aligning	handened raceways
Thrust roller bearing	Thrust needle roller bearing
Thrust tapered roller bearing	Static load rating
Thrust spherical roller bearing	Dynamic load rating
Radial deep groove ball bearing	Bearing calculation
Radial deep groove ball bearing filling slot	Radial load
Radial deep groove ball bearing external aligning	Axial load
Angular contact ball bearing	Contact angle
Angular contact ball bearing filling slot	Radial load factor
Magneto ball bearing	Axial load factor
Self -aligning ball bearing	Static safety
Thrust ball bearing	Hub
Cylindrical roller bearing	

Table 7. Shaft calculation reference [6]

Moment inertia	Gear Load
Coordinates of centroid	Movable support
Angle of deflection	Notch
Beam calculation	Strength
Beams	Stress
Support	Yield factor
Single force	Shafts
Bending moment	Helix angle
Fatique failure.	Pressure angle
E - modules	Bending moment (in Y-Axis)
Calculating shaft	Torsion
Deflection line	Bend
Deflection moment	Resultating bending moment
Fatique factor	Resultant deflection
Fixed support	

CONCLUSION

What is important to state is that the majority of students see English as the means for reaching better professional and material position, that is, an important asset in their future careers. Even though many of the students think that English is absolutely necessary for their professional careers no matter where they start them, but believe that by knowing any of the more important languages a person acquires a crucial facilitating tool for a successful career. Yet, English is still their primary concern when it comes to knowing foreign languages, and they acknowledge its pole position in the business. [1]

Today English is something of a primary concern for every individual and especially academic citizens who are at the forefront of contemporary civilization. No matter what the occasion might be, it is becoming more and more important and necessary to know and speak the English language well, and to be capable of using it appropriately. The modern world has searched for a new lingua franca that would expedite the ever-growing means of communication and interaction among people in every aspect of life, and has found it, due to numerous circumstances, in English. The students at the Technical faculty in Zrenjanin are conscious of this fact and it is up to everyone concerned to make it possible for them to reach the desired level. [1]

REFERENCES

[1] Tasić, M., English language teaching in mechanical engineering, Facta Universitatis, Series: Linguistics and Literature Vol. 7, No 1, 2009., pp. 101 – 112.
[2] Šafranj, J., Coursebook series for the needs of teaching English at faculty of engineering, Pedagoška stvarnost, LI, 3–4, 2005., pp. 239-248.
[3] Šafranj, J., Integration of content-based instruction into the ESP classroom, Pedagoška stvarnost, LIV, 7–8, 2008., pp. 716-729.
[4] Desnica, E., Letić, D., Advancing machine elements teaching in technical fields at university level education, Journal Machine design, Faculty of Technical Sciences, Novi Sad, 2007., pp.45-48.
[5] Desnica, E., Gligorić, R., Letić, D., Educational trends in engineering design teaching in higher education of technical vocations, Internacional Conference »New trends in design and technical documentation creation 2011", Nitra, Slovačka, 2011., pp. 140-144.
[6] Letić, D., Desnica, E., Davidović, B., AutoCAD Mechanical 2011, Computer bibliothec, Čačak, 2011.

EDUCATION OF MECHANICAL ENGINEERS IN USA AND SERBIA

Jesa H. Kreiner[1], Zvonko Sajfert[2], Dario Pavlović[3]
[1]California State University at Fullerton, California, USA
[2]University of Novi Sad, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia
[3]University of Zagreb, Faculty of Civil Engineering, Zagreb, Croatia
e-mail: kreiner@fullerton.edu

Abstract: This paper presents the results of the research which has been carried out with the aim to objectively monitor the level of professional training and professional competency of engineers in Serbian companies. The research has been carried out through a survey in which the engineers from Serbia have been asked to respond to the same questions as those in the USA. This survey has made possible comparison of engagement and current knowledge of engineers in the USA and Serbia, as well as the level of support of top management concerning education of employees in both countries. The survey has also included managers from Serbian companies who were taken as a control group answering the same questions as engineers. Generally, the obtained results do not differ considerably from the expected ones. There are some differences between American and Serbian experts, but it is encouraging that Serbian experts do not lag behind substantially when compared to their American colleagues. The principal difference seems to be in the fact that companies in the USA invest more in professional training of their employees than the ones in Serbia, as well as that American engineers are far more engaged in activities of professional associations than engineers and managers from Serbia.
Key words: knowledge, education, engineers, managers, Serbia, USA

INTRODUCTION

In the last few decades knowledge in the field of engineering has been rapidly increased. In order to stay current and competitive in their work engineers are faced with a great challenge: continual education and maintenance of requested knowledge level necessary for successful job performance. The questions such as – in what degree engineers are engaged in refreshment of their knowledge or how much top management takes care of employees' education – are always present in this field. The questions concerning the comparison of these problems in different countries, especially the position of countries in transition versus countries with developed economies are being asked as well. These are the themes this paper deals with.
According to (National Academy of Engineering 2004), science and engineering knowledge are currently doubled every 10 years. The same source states that the world has encountered exponential changes and that the greatest changes have taken place in the last 100 years. The Bureau of Labor Statistics predicts that the demand for mechanical engineers will continue to grow. Much of this growth, according to the BLS, will come from the demand for improved machinery and machine tools, as well as emerging technologies such as biotechnology, material science and nanotechnology (Bureau of Labor Statistics, U.S. Department of Labor 2007).
Engineers who do not make the effort to remain current quickly become obsolete. In order to identify obsolescence in engineers it is essential to first identify what it is. Literature has provided several definitions; two of them being used for this study. Kaufman provides this definition: "Obsolescence is the degree to which organizational professionals lack the up-to-date knowledge and skills necessary to maintain effective performance in either their current or future work roles." (Kaufman 1974)
Kaufman's view focuses on what the individual is lacking, whereas, Fossum et al. seems to point towards a shift in job requirements: "Obsolescence occurs when the person requirements of a job which are demanded by its tasks, duties and responsibilities become incongruent with the stock of knowledge, skills, and abilities currently possessed by the individual; given that the knowledge, skills, and abilities were previosly congruent with job demands." (Fossum et al. 1986)
Previous research has examined what engineers are doing to stay current and what motivates them to stay current. Barton and Bommer found that engineers prefer to access new technology through professional literature, their co-workers, and vendors (Barton / Bommer 1992). Aryee found that an engineer's motivation to update is affected by their work environment in the form of peers and

organizational policy. He also fuond that increased age reduces motivation while increased job involvement increases motivation (Aryee 1991). While this research has looked at updating methods and motivation, not much has been done to identify the effectiveness of different forms of updating.
This paper is a continuation of the project which may help to understand what engineers can do to stay at the cutting edge of their profession and it is also an expansion of the works previously published in (Kreiner 2006; Miles / Kreiner 2007; Kreiner / Miles 2008).

METHODOLOGY

The research has been carried out through the survey in which the engineers from Serbia have been asked to answer the same questions as those in the USA. This survey has made possible comparison of engagement and current knowledge of engineers in the USA and Serbia, as well as the support of top management concerning education of employees in both countries. The survey has also included managers from Serbian companies who have taken part as a control group answering the same questions as engineers. 25 mechanical engineers from the USA, 30 mechanical engineers from Serbia and 30 managers from Serbia have been included in the survey. All the interviewed belong to the age group between 30 and 45 years of age and they are all employed in companies.
The following four obsolescence indicators (OI) have been analyzed in the survey:
a) How well do you understand current technical literature in your field?
b) How often do your colleagues ask for your professional help?
c) How often do you participate in important projects or / and in making key decisions?
d) To what degree do you consider yourself current in your field?
The first three indicators are provided by Willis and Dubin (Willis / Dubin 1990). The last indicator used in this research is subjective, but can provide equally important insight. The interviewed have given marks to indicators from 1-5.
Obsolescence indicators have been viewed in relation to the following five updating trends (UT):
UT1: What is the amount of financial support that you are given for your professional improvement from your company? (more than 1000 euros per year / less than 1000 euros per year)
UT2: Have you attended professional courses in the last 3 years (yes/n)
UT3: Do you read current professional journals, published in the last 5 years, on regular bases (at least once a month)? (yes / no)
UT4: Are you the member of any professional association? (yes / no)
UT5: How much time per week do you spend improving yourself professionally? (more than 4 hours per week / less than 4 hours per week)
The methodology of the survey has been carried out in this way: for each updating trend (separately) the obsolescence indicators have been analyzed depending on the characteristics of the considered updating trend. For example, for the fourth updating trend (4. Are you the member of any professional association?), the engineers from the USA are examined first – they answer "yes" and then for this group of the interviewed the average marks are found, separately for each out of four obsolescence indicators. After that the engineers from the USA who say "no" for the same updating trend are examined and, again, the average marks separately for each out of four obsolescence indicators are found as well. The same procedure is done for the engineers in Serbia, as well as the managers in Serbia. For all groups of the interviewed the same procedure is done for each updating trend separately. In this way we get fifteen graphs (three for each updating trend) where all obsolescence indicators among the engineers from the USA, the engineers from Serbia and the managers from Serbia can bee seen.

RESULTS

Updating Trend 1: Employer Financial Support

In the graphs 1, 2 and 3 the research results for Updating Trend 1 are presented for mechanical engineers from the USA, mechanical engineers from Serbia and for managers from Serbia.
The interviewed were divided in two groups – those, who were given more than 1000 euros per year from their company for professional training and those who were given less than 1000 euros per year.

In the USA, 19 out of 25 interviewed engineers had more than 1000 euros per year and 6 engineers were given less than 1000 euros per year while in Serbia only 4 out of 30 engineers had received more than 1000 euros per year. When managers are considered, in Serbia 9 out of 30 managers were given more than 1000 euros per year and 21 of them were given less than that. Companies in the USA invest much more in professional development of their employees.

The results for obsolescence indicators (OI) are expected and uniform. It means that those interviewed who were given more than 1000 euros per year for their professional training mostly have somewhat higher marks for OI. The greatest exception represents the result for OI d) concerning engineers in Serbia which may be the consequence of a small number of the interviewed Serbian engineers with more than 1000 euros per year (only 4).

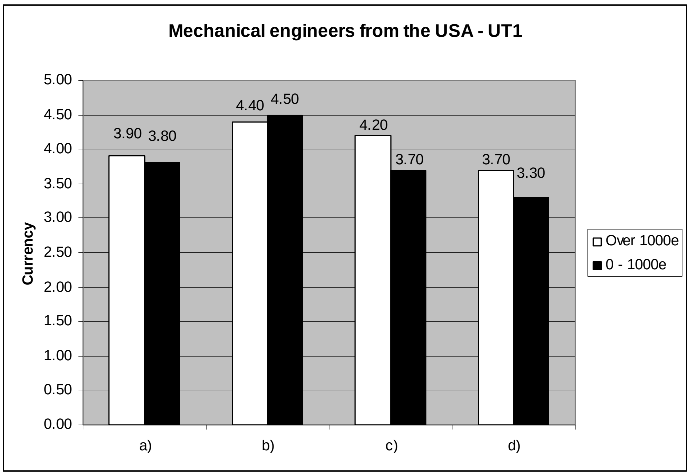


Figure 1. Mechanical engineers from the USA - Updating Trend 1: Employer Financial Support

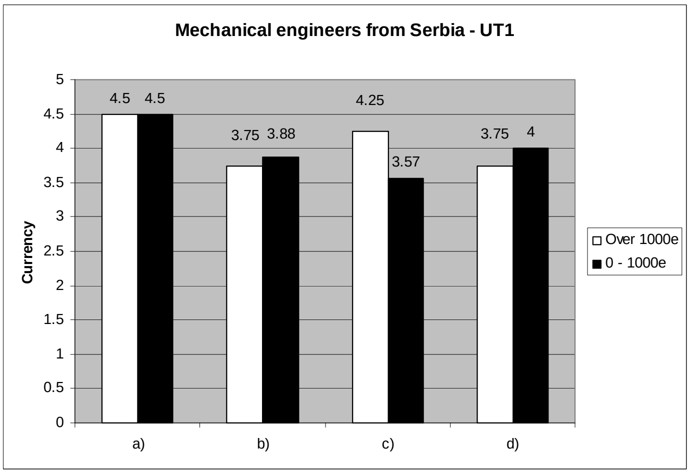


Figure 2. Mechanical engineers from Serbia - Updating Trend 1: Employer Financial Support

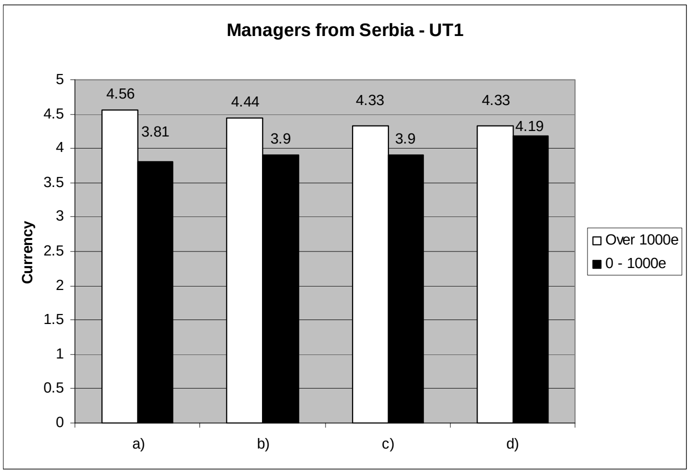


Figure 3. Managers from Serbia - Updating Trend 1: Employer Financial Support

Updating Trend 2: Formal College Courses

Pictures 4, 5 and 6 present the research results for Updating Trend 2, for mechanical engineers from the USA, mechanical engineers from Serbia and managers from Serbia.
The interviewees are divided in two groups - those who have attended professional courses in the last 3 years and those who have not. In the USA, 14 out of 25 interviewed engineers have attended these courses in the last 3 years. In Serbia, 24 out of 30 engineers have attended such courses. The same accounts for Serbian managers – 24/30 managers have attended professional courses and only 6 of them have not. On the basis of these facts it can be concluded that more engineers and managers from Serbia attend professional courses than their colleagues in the USA,. This may be the result of recent privatization of Serbian companies.
The results for obsolescence indicators (OI) are expected and uniform. It means that the interviewed who have attended professional courses in the last 3 years mostly have somewhat higher marks for OI. The only exception is the result for OI b) concerning engineers in the USA.

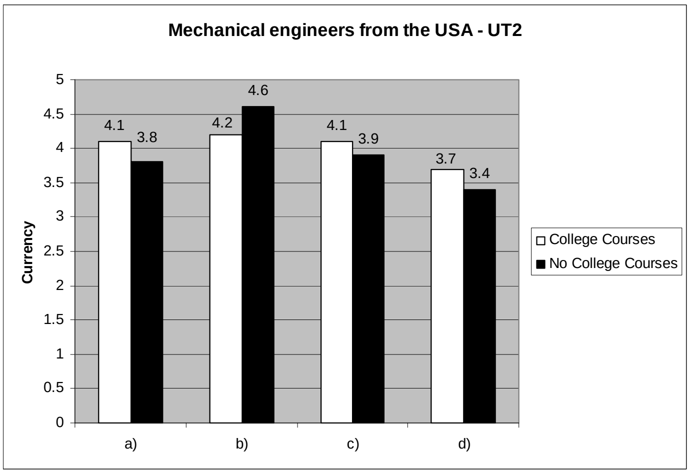


Figure 4. Mechanical engineers from the USA - Updating Trend 2: Formal College Courses

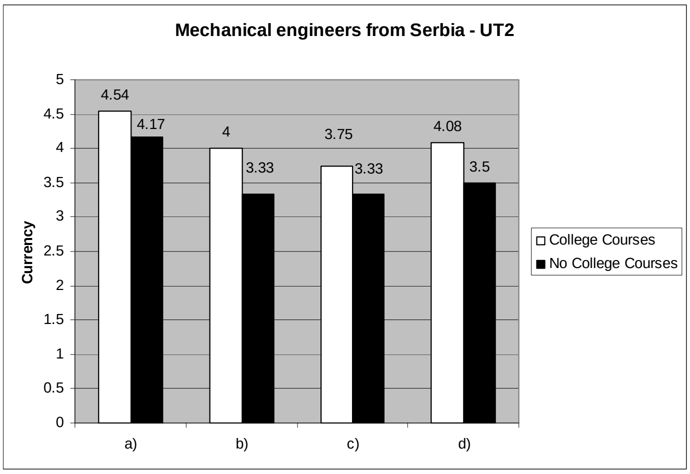


Figure 5. Mechanical engineers from Serbia - Updating Trend 2: Formal College Courses

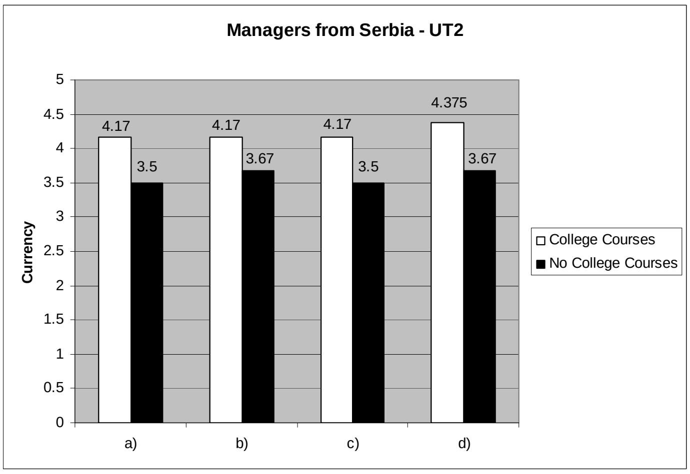


Figure 6. Managers from Serbia - Updating Trend 2: Formal College Courses

Updating Trend 3: Reading Technical (Management) Journals

Pictures 7, 8 and 9 present the research results for Updating Trend 3, for mechanical engineers from the USA, mechanical engineers from Serbia and managers from Serbia.

The interviewees were divided in three groups – those who read current professional journals on regular basis (at least once a month), those who read professional journals (published in the last 5 years) and those who do not read these journals at all. In the USA, 20/25 interviewed engineers read current professional journals on regular basis, while in Serbia 24/30 engineers regularly read such journals. In Serbia 21/30 managers read current professional journals regularly. It can be noticed that, in relation to reading current professional journals, American and Serbian experts are uniform.

The results for obsolescence indicators (OI) are uniform and expected for the interviewees who read current professional journals on regular basis – they mainly have somewhat higher marks for OI. The only exception is the result for OI d) found in the answers of the engineers from Serbia.

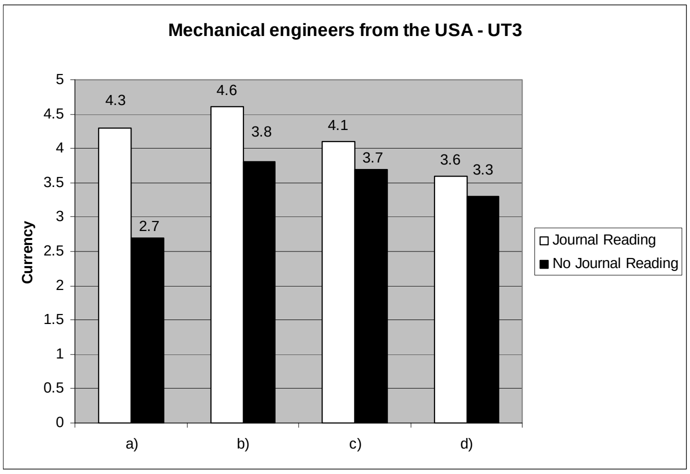


Figure 7. Mechanical engineers from the USA - Updating Trend 3: Reading Technical Journals

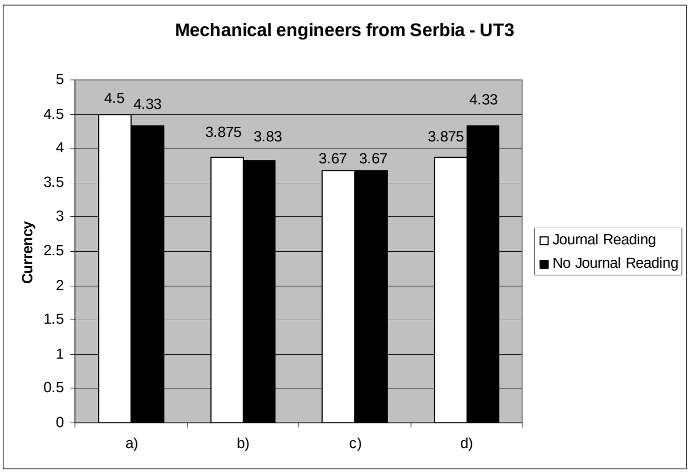


Figure 8. Mechanical engineers from Serbia - Updating Trend 3: Reading Technical Journals

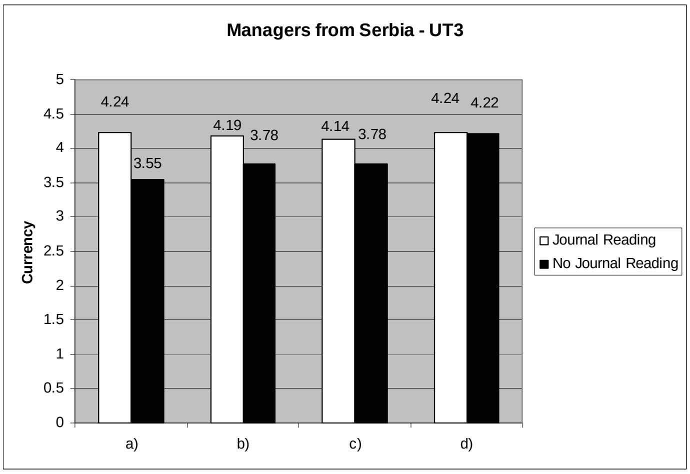


Figure 9. Managers from Serbia - Updating Trend 3: Reading Management Journals

Updating Trend 4: Professional Society Membership

Graphs 10, 11 and 12 present the results for Updating Trend 4, for mechanical engineers from the USA, mechanical engineers from Serbia and for the managers from Serbia.
The interviewees were divided in two groups – those who are members of some professional associations and those who were not. In the USA 22/25 interviewed engineers are members of some

professional associations. In Serbia only 10/30 engineers belong to professional associations. Considering managers in Serbia, the similar trend can be noticed – only 8/30 managers are members of professional associations. Comparing to their colleagues in Serbia, engineers and managers in the USA are far more engaged in activities of their professional societies.
The results for obsolescence indicators (OI) are uniform and expected – the interviewees who are members of some professional associations mostly have higher marks for OI. The only exception is the result for OI b) found in the answers of the engineers from the USA.

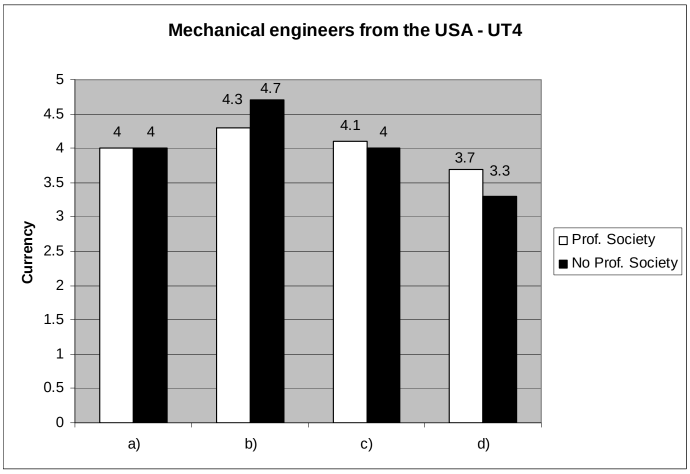


Figure 10. Mechanical engineers from the USA - Updating Trend 4: Professional Society Membership

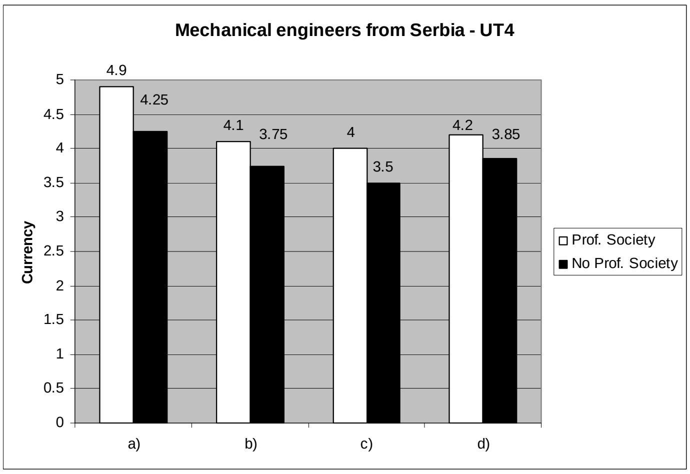


Figure 11. Mechanical engineers from Serbia - Updating Trend 4: Professional Society Membership

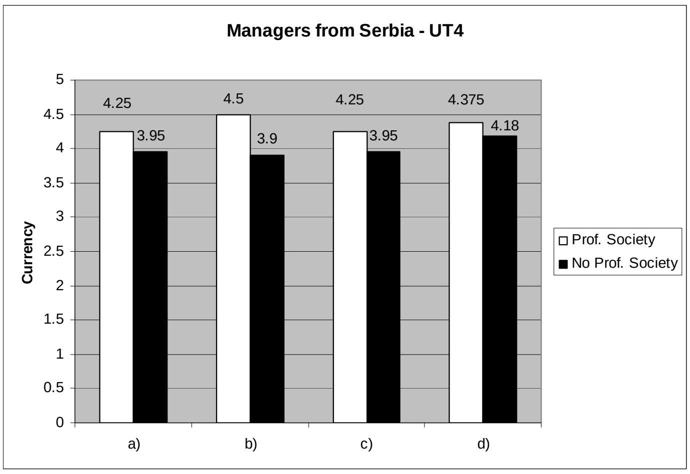


Figure 12. Managers from Serbia - Updating Trend 4: Professional Society Membership

Updating Trend 5: Time Spent on Technical Development

The charts 13, 14 and 15 present the research results for Updating Trend 5, for mechanical engineers from the USA, mechanical engineers from Serbia and managers from Serbia.
The interviewed are divided according to the quantity of time they devote to professional improvement per week (more than 4 h per week / less than 4 h per week). In the USA, 16/25 interviewed engineers devote more than 4 h per week to professional improvement. In Serbia, 22/30 engineers spend more than 4 h per week on professional improvement. In Serbia, 18/30 managers devote more than 4 h per week to professional improvement while 12 managers spend less than 4 h in these activities. Here again, American and Serbian experts are almost uniform concerning the amount of time they devote to their professional improvement.
The results for obsolescence indicators (OI) are expected and uniform. The interviewed who spend more time per week on professional improvement have somewhat higher marks for OI.

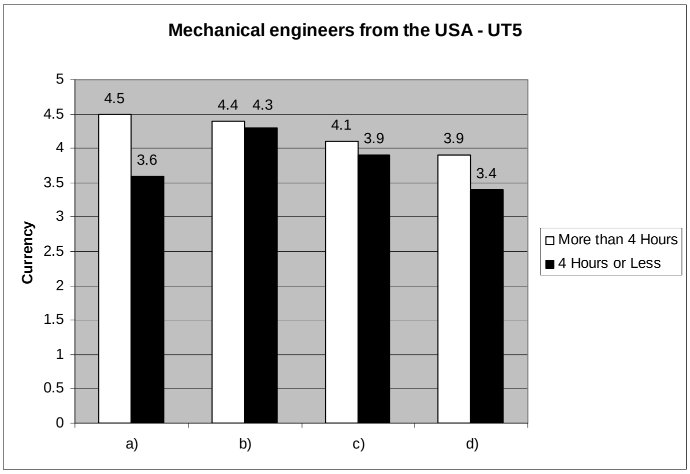


Figure 13. Mechanical engineers from the USA - Updating Trend 5: Time Spent on Technical Development

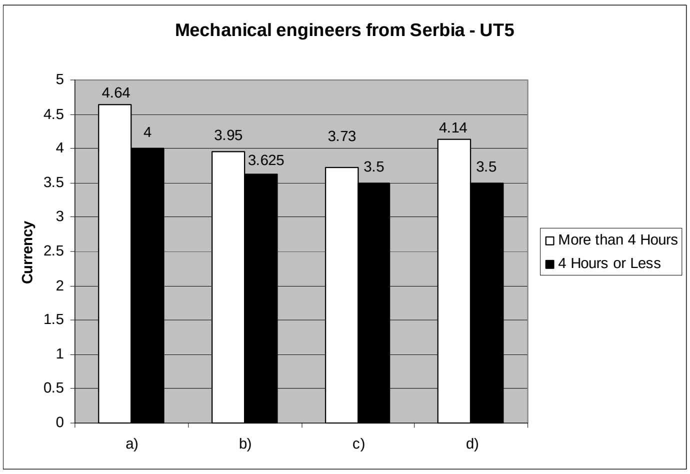


Figure 14. Mechanical engineers from Serbia - Updating Trend 5: Time Spent on Technical Development

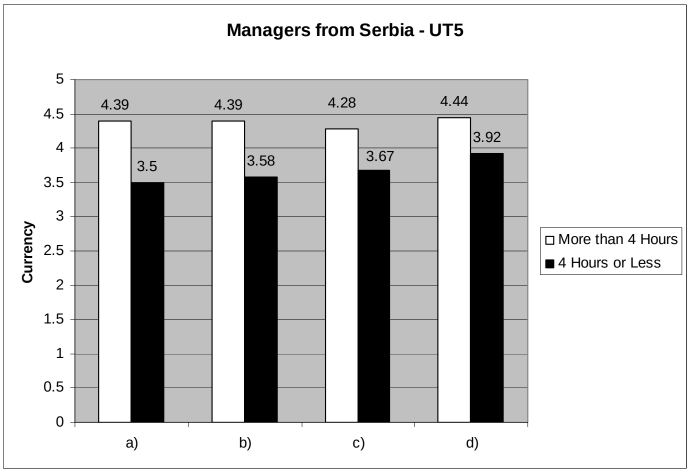


Figure 15. Managers from Serbia - Updating Trend 5: Time Spent on Technical Development

CONCLUSIONS

When American experts are compared to their Serbian colleagues, the research has shown the following:

- Companies in the USA invest much more in professional development of their employees.
- Both engineers and managers in Serbia attend professional courses more than engineers in the USA.
- American and Serbian experts are uniform with regard to their regular reading of current professional journals with regard to the cutting edge of developments in the field.
- Engineers in the USA are far more actively engaged in professional associations than are Serbian engineers and managers.
- According to the time they devote to professional improvement per week, there is the uniformity in behavior between American and Serbian experts.

The results for obsolescence indicators (OI) are expected and uniform – which means that the interviewed experts, who had better results for updating trends, mostly have somewhat higher marks for OI. There are several exceptions which are mostly related to OI b) concerning American engineers and OI d) concerning Serbian engineers.

Concerning American engineers, the most positive influence on OI have UT3 – regular reading of current professional journals and UT5 – weekly time spent on professional improvement. The least positive influence on OI is reflected by UT4 – membership in professional associations.

Concerning Serbian engineers, the most positive influence on OI have UT2 – attending professional courses and UT4 – membership in professional associations while the least positive influence on UT3 – represents regular reading of current professional journals. This result is quite opposite in the USA.

When Serbian managers are considered, the most positive influence on OI have UT5 – time per week spent on professional improvement and UT2 – attending professional courses. The least positive influence on OI has UT4 – membership in professional associations. It may be said that Serbian managers are positioned between Serbian engineers and American engineers.

Generally speaking, the obtained results do not differ much from the expected ones. There are certain differences between American and Serbian experts but it is encouraging to establish that Serbian experts do not lag behind in comparison to their American colleagues. There are also possibilities for further research efforts in this domain, first of all concerning the number of interviewees and considering more obsolescence indicators and updating trends.

REFERENCES

[1] Aryee, S. (1991): Combating obsolescence: Predictors of technical updating among engineers, Journal of Engineering and Technology Management, Vol. 8, No. 2, pp. 103-119.
[2] Barton, B. / Bommer, M. (1992): Myths about engineers maintaining professional technical competence, International Journal of Continuing Engineering Education, Vol. 2, No. 1, pp. 22-30.
[3] Bureau of Labor Statistics, U.S. Department of Labor (2007): Occupational Outlook Handbook, 2006-07 Edition, Engineers, http://www.bls.gov/oco/ocos027.htm
[4] Fossum, J.A. / Arvey, R.D. / Paradise, C.A. (1986): Modeling the Skills Obsolescence Process: A Psychological / Economic Integration, The Academy of Management Review, Vol. 11, No. 2, pp. 362-374.
[5] Kaufman, H.G. (1974): Obsolescence and professional career development, Amacom, New York, pp. 193.
[6] Kreiner, J.H. (2006): Combating obsolescence - Redefining the Ever-Evolving Engineering Profession, FME Transactions, Vol. 34, No. 4, pp. 227-230.
[7] Kreiner, J.H. / Miles, D.J. (2008): Maintaining Currency and Staying at the Cutting Edge of the Profession, ESDA2008-59597, Proceedings of the 9th Biennial ASME Conference on Engineering Systems Design and Analysis, Haifa, Israel.
[8] Miles, D.J. / Kreiner, J.H. (2007): Efforts in Maintaining Currency in Engineering and Avoiding Obsolescence, IMECE2007-43841, Proceedings of the 2007 International Mechanical Engineering Congress & Exposition, ASME, Seattle, WA.
[9] National Academy of Engineering (2004): The Engineer of 2020: Visions of Engineering in the New Century, National Academies Press, Washington, DC, pp. 101.
[10] Willis, S.L. / Dubin, S.S. (1990): Maintaining professional competence: approaches to career enhancement, vitality, and success throughout a work life, Jossey-Bass Publishers, San Francisco, pp. 328.

LEVEL OF REPRESENTATION DEMOCRATIC RELATIONS IN SCHOOLS

Ivan Tasić[1], Jelena Tasić[2], Dajana Tubić[3], Teodora Mitić[2]
[1]University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
[2]Primari school, Veternik, Serbia
[3]Vocational school Odžaci, Odžaci, Serbia
e-mail: tasici@tfzr.uns.ac.rs

Abstract: This paper explores the question of quantity of democracy practiced in the school as an institution. Democracy is seen as a tool in the assessment of the situation and the development of relations in the school and education. Relationships in the school as the main theme of this paper will be explored in many aspects. In the recent past, the subject was surveyed that dealt with problems of primary education and disputed considering mainly used quantitative indicators, which show the quality of the realization of the program of work, the quality of discipline, punishment and reward students in elementary schools. Primary, teachers methods were investigated, as they are the basis for success in educational attainment, education and socialization. In recent times, there is a paradigm situational or interaction constructivist approach where more attention is paid to qualitative indicators that provide insight into the quality, the manner of interaction between students and teachers, as well as other subjects in school. It is a course of education and democracy and the student uses and provides the institutional context. That is, the emphasis is on the extent and quality of conscious participation of students in building and maintaining relationships at school.
Key words: democracy, school, students

INTRODUCTION - THE AIM AND OBJECTIVES OF RESEARCH

Starting from the above problem, mentioned, and recorded the object of research, a few goals are formulated and provided :
1.Explore how, in practice, in the school setting, the democratic relations and rules are conducted with the main actors and participants in the education process
2.Whether and how democratic relations and rules of operation are all in the interest of education of students?
3.How, how much and how lecturers, teachers, homeroom teachers, school leaders and all those who deal with the problem of education contribute or hinder student participation in decision-making in a democratic way, and how they use knowledge about democracy in their own intellectual, educational and teaching activities and self-education.
From this way appointed goal of research derive the following tasks:
1.Identify how the school as an institution (institution) planned, assisted and provided that democracy take root, to be presented to the student, that the student uses it, to serve him, to train him, make him know democracy and its form, uses it to acquire practice and experience necessary for future action,
2.To examine how the contact (and if any) is established: parent, homeroom teacher, teaching, school management, the environment,
3.Do students participate, and how, in deciding in teaching - training process and the realization of the program (from the conclusion, help the weak and infirm, planning excursions and all forms of the scene where the decision).

Hypothetical framework

The initial hypothesis of the study is that the school is a social group in which specific interrelationships between key entities (elements) and a group of students, teachers, parents, governors and the environment take place.. The school is a basic, beginner social context in which child passes through the process of socialization of primary school age. If you participate in this process knowingly, autonomous and responsible, the student will "work out", gain experience to apply the principles of democratic rules and procedures, and later in the civil society.

Research method

Instruments

Based on the case of studies and the set goal, we decided to use, as a main instrument questionnaire consisted of three parts (for school leaders, teachers and students). The questionnaire contained combined, open and closed questions. Then the scale is used to assess the attitudes of teachers and students about the possibilities and the importance of participation in decision-making on important issues relevant to their work and progress in school. To complete the process as successfully as possible, statistical methods are used in research.

Sample

The survey is based on a sample of 1195 respondents (students - 1065, teachers / professors - 121, Director / Secretary - 9) of 9 schools from school west Backa region. The questionnaire consisted of students from fifth to eighth grade.

RESULTS OF RESEARCH

Estimated statistical overview Questionnaire

The first part of the questionnaire (10 questions) was intended to provide an overview of the school management reviews (director or secretary) of the general conditions in which the school is located, how it works, what are the problems that present the most significant action taken to school success performed tasks in the education of students.
Of the total number of directors and the school secretary who answered the questionnaire, 30% of them think that the school is well-equipped, 40% believe that is medium-featured, while 30% of them think that the school is ill-equipped. From this we see that the school equipment is a significant problem, and therefore, one of the basic conditions for successful work is not completed. True, the scope of this research is not of decisive moment, but it can spoil the atmosphere in which democratic processes take place, no matter that we here consider the school as a social group with set or spontaneous relationships and roles in it.
To show the results of their operations and impact on the environment (energy exchanged harmony, tolerance and democracy), the school should periodically organize meetings with parents and citizens. When asked if the school organizes debates and discussions that would provide an opinion of parents and citizens about the situation in the school, 60% of directors answered yes, while 30% said they do not organize such gatherings. In order to better establish the relationship and communications of school and environment we asked whether parents or people give comments and suggestions related to the operation of the school. Of the total number of directors and secretary, 80% answered that parents give comments and suggestions for the school, while 20% of them are not faced with such remarks. Most remarked was "about success in school" - 40%.
The first score is related to the question of "society's attitude towards school." A third of respondents ranked this relationship with the lowest grade (1), while an additional 35% of respondents give a minimum passing grade (2) toward school social attitudes. It is indicative that no one has that relationship with the highest marks. Respondents expressed their perceptions of social attitudes toward school, which can be understood as a consequence of the situation in society and in some protests and distrust of the plans and projects to be undertaken in an attempt to resolve the current issues and reforms in education.
Willingness to building democratic relations in the school as a social group in the classroom as part of it, is best to be checked by monitoring categories of participation. We set up a question to teachers about their opinion on whether, and in what issues should students be involved and thereby make decisions. We see that the teachers are not inclined to believe that students need to discuss and decide major mode of the class, as well as interesting facts about the issues and content of teaching, which is an indicator of fear of teachers to a more open approach to what is the essence of teaching. They want

to keep their monopoly on issues of class and the ways of the planned educational units. Of course, students of this age are not fit enough to significantly affect the quality of teaching units, but should take into account their sense of whether they are more or less interesting and appealing in a matter that is presented to them, and the manner in which it is presented. It is interesting that a small percentage of teachers who believe that students should be more involved and make decisions on issues that seem directly related to the immediate attention of students, such as going on excursions - trips, getting dressed in the school choice students will receive a award. This could be another indication of narrowing the space in which students influence their socialization flows in the school process.

Analysis and testing of hypotheses

Based on the analysis of the issues, we can conclude that the student is directed to the desired type of socialization, because these issues within more than 51% of teachers expressed the following views:
- It is believed that the presence of democratic principles and procedures is at a high level, it is ready to talk to the students on the topic of what happens in the classroom, especially as it relates to behavior of classes, as a collective, as well as the discussions in the areas of teaching;
- Supports to participate in decision making: Planning schools, with related methods and evaluation criteria, decorating classrooms, organizing cultural and artistic events;
- The provision of more information, refer students to other sources, and they promise to provide the information the second time
- when students encounter the problem, encourage them to look at all aspects of the problem;
- Ongoing discussions and dialogue with students believe that everyone should have the opportunity to have their say.

Also, more than 51% of the students in the previous paragraph confirms the expression of opinions in the following formats:
- Discusses discipline in the classroom and at school;
- discusses how to be more successful in school
- how to cancel classes due to absences of extracurricular activities
- wants more discussion on how to be more successful in school
- and wants to discuss it more about what is good and what is bad in life
- regularly or sometimes discuss the events of the school.

Another goal that we set in the founding of our theoretical research should directed us at: Exploring the ways in which a student needs to provide ideas, suggestions, sees problems and seek solutions alone, but with the help of others. Based on the analysis of the issues, come up with ways, as the student needs to give ideas and suggestions, and evident problems. Teachers argue (over 51%) that is based on:
- Decision-making in the school in which to participate, and students relating to school organization, methods and evaluation criteria, decorating classrooms;
- Providing more information by sending students to other sources or providing promise to get the information as soon as possible, and that the same will process together.;
- providing the opportunity for all students to express their opinions.

The opinion of the majority (over 51%) of students that may be included in this analysis is the following:
- Most students sometimes participate in the arrangement of the classroom, or on the distribution of sitting in the pews;

*Students do not participate in the discussion:
1.About where to go on trips and excursions
2.Out of school curriculum topics
3.The introduction of new activities in the school.

The third goal of the research we want to investigate is how, how much and what kinds of issues and problems:

Students should discuss, how to take more part in creating and influencing their own socialization. By analysis, we find out that students talk with teachers or would like to discuss primarily discipline in the classroom and in school, and how to be more successful in school.

Of the total number of schools in the survey, in 84% of them, parents make suggestions and proposals for the school, 66% of teachers give high positive ratings (4 or 5) in the evaluation of the survey questions "representation of democratic principles and procedures with their students" , many teachers provide information to students, in the field of education, and everything that happens in the classroom, especially as it relates to behavior classes;

Students talk about the following topics with their teachers:

How to be more successful in school - 34.55%,

About the discipline in the classroom and at school - 13.44%;

What is good and what is bad in life - 10.17%.

In order to determine the real situation, we have introduced an interview with the educators as another research tool and its results will be used in this place as a correction factor in the ultimate determination of attitude and expression of the degree of democracy in their schools, and to evaluate the frequency of decision-making and participation, as the main indicators of democratic procedures and methods of measurement of democracy in schools, especially in the case of primary education.

We opted for an interview with the educators in the sample schools because their views on the researched topic has a special significance, as they observe both sides (teachers and students) and may present a full and valid opinion on democratic relationships in school. Data collected by an interview show that the school no separate question of development of democracy in their activities, they often do not even respect democratic procedures, and sometimes without consulting all parties interested in the wider participation and decision making.

Educators as the most realistic, estimate that there is little interest to teachers dealing with additional education for democracy, little more students show interest, but it is not enough to create a democratic atmosphere and energy. A characteristic example where one interviewed, when asked whether teachers believe that student involvement in the wider democratic procedure is not for their age, he replied: "I think, unfortunately." The interview showed that students are not sufficiently informed and prepared to participate more important, especially to decide on important issues of the school process. "It is necessary to familiarize them with the rules, the organization of the school and then take concrete actions to their participation in school activities," answers one of the interviewed teachers. They are not included in the procedures and processes, their presence in the bodies, activities and procedures is only formal and declarative. There is considerable reservations about schools in terms of interest, involvement and encouragement of students (and teachers) to the understanding, learning and practicing democratic content in everyday school life and activities. By analysis of data obtained by interview, we find out that democratic "infrastructure" is not developed in the schools, and there are important preconditions for the inclusion of students and teachers in the very democratic procedures and democratic processes.

It takes a lot more preparation in that direction. This analysis established an additional factor which has contributed to the "leveling" of the difference in the attitudes and opinions of teachers and students. This additional factor showed that students' attitudes are closer to our basic hypothesis that can contribute significantly to its verification.

CONCLUSION

Democratic relations in the school, as demonstrated by this study, are only in its infancy. There are, for now, the modest resources expressed the desire, will and motivation of participants in the educational process. The school is still developing as a state (public) institutions, and very slowly as a social group in which the democratic, creative, creative and free way to place the process of socialization of children, such that they are aware of that process. This issue needs a lot of work. Educators are the only ones who feel this problem and point to his presence. Because of its availability processes of teaching and didactic pedagogical tasks, they are not able to pay more attention to this problem and to take action in this regard. It turns out that every school (or the school together) should have a sociologist, who would pay attention to the development of relations in the school, their democratization, building a creative, tolerant, determined personality, thus creating the preconditions for socialization of students in the elementary school level that takes place in the best and socially useful way.

REFERENCES

[1] Bitem, D., Bojl, K., Introduction to Democracy: 80 questions and answers, Creative Center, Belgrade, 1997.
[2] Koković, D., Sociology of Education, University of Novi Sad, 2000.
[3] Tasić, I., Sajfert, D.,The organization of the school, "Tehnical Faculty" Mihajlo Pupin ", Zrenjanin, 2011.
[4] Kekez Babić, S., Tasić, I.,Didactics, "Technical Faculty Mihajlo Pupin, Zrenjanin, 2012.
[5] Popov, Ž., Education, Democracy, schools,Democracy, Education, personality, Belgrade: Institute for Educational Research, 125-134,1997.

CONSTRUCTION FOUNDATIONS OF MODELING ROBOT - MANIPULATORS WITH FIVE DEGREES OF FREEDOM

Slobodan Stefanović[1], Zoran Janjić[1], Živoslav Adamović[2], Danilo Mikić[3]
[1]The School of Higher Applied Professional Education, Vranje, Serbia
[2]University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
[3]Tehnical school, Gornji Milanovac, Serbia
e-mail: slobodanstef@gmail.com

Abstract: The construction of robot manipulators with five degrees of freedom implies the control of the mechanical arm movement using microcontroller in any kind of environment. Manipulator movement control presented in this paper allows manipulation of the mechanical arm in any position. The algorithm obtained has been successfully tested on the mechanical arm. This kind of arm was constructed and analyzed with the aim to be mounted on the robot for carrying the items from one place to another.
Key words: Robot, manipulator, mechanical arm, modeling and robot control

INTRODUCTION

In literature one can find various ways of the systematization of industrial manipulative robots. The criteria used are very often based on their technical characteristics and they are completely valid only within a certain period of time. The adopted classification is based on the type of mechanical structure of the minimal configuration of the robot because it is one of the most important features, and which is relatively unchanging over time. In this paper, basic configurations of industrial robots will be presented.
Robot structural system ***Robix RCS-6*** is a combination of light industrial properties and the simplicity of educational robots application. It is a modular system that allows forming of manipulator configurations to 6 rotational joints. Actuators in the joints are direct current motors. The structure of the system is given in Figure 1.
It would be pointed out here to some fields of technology and production which contributed substantially to the emergence of robot development. Those fields simply required robot type devices. One such field is nuclear technology. It comprises work with radioactive materials and work that entails radiation exposure, for example, when assembling and dismantling nuclear reactors or in case of accidents at nuclear power plants. In order to solve these problems copying manipulators were first developed. Mobile manipulators (on wheels or tracks) were developed later, for a variety of complex operations at nuclear plants. They were remotely managed by television images taken by the vehicle mounted camera. The camera could be mounted at greater depths, as well as in space exploration.
What is robotics?
Robotics is a multidisciplinary branch of science which combines systemic knowledge of mechanics, electronics, computing and automatics. Because of its great importance in the post-industrial society, it enters the field of medicine, economics, sociology and art. At the same time, robotics is a very attractive, challenging and creative discipline. It usually has a noble cause as its mission - for example, to perform tedious and monotonous jobs instead of man. Those kinds of jobs could be dangerous or harmful to human health as well.

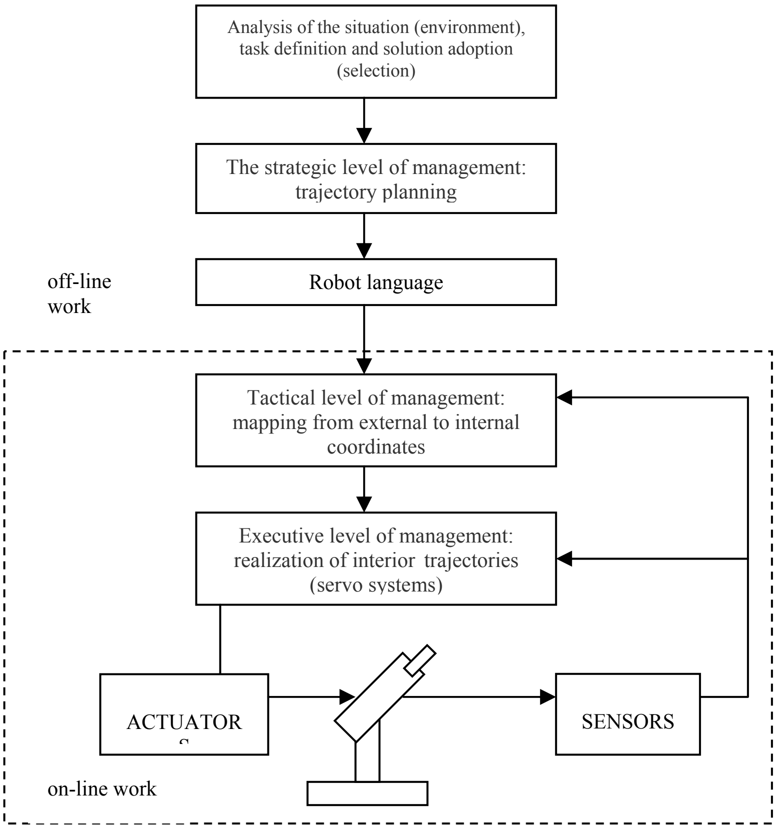


Figure 1. Robot application in industry

Robotics is a relatively young technical branch, but it already has its own rich tradition. It turned out that robots have, just like people, passed generation cycles. Each new generation of robots has received enhancing unification in respect to the previous one, which is primarily related to the achieved level of intelligence, supporting computer power, enhanced dynamic indicators and advanced control algorithms.

WHY ROBOTS?

Basically, there are two reasons why the application of robots is necessary:

1. There is a need for men replacement in dangerous and inaccessible areas. Or the processes which should be carried out are very complex and they cannot be done by man. One such field is nuclear technology. It comprises work with radioactive materials and work that entails radiation exposure, for example, when assembling and dismantling nuclear reactors or in case of accidents at nuclear power plants. For example, in nuclear reactors the presence of men is not allowed due to radiation, and in deep waters it is not possible due to high pressure. When doing space exploration the presence of men is often impossible; in dangerous and confined areas the presence is forbidden due to volatile gases, unwanted radiation and temperature; the machines could be dangerous because of the possibility of injuries and others.
2. Robots can reliably realize very complex tasks, without error and fatigue, for as long as necessary (as they are programmed), and they could also change a task (change the program). Therefore, the application of robots has become widespread, from all fields of engineering and technology, transportation, medicine and games to the ordinary needs.

WHAT ONE SHOULD KNOW ABOUT ROBOTS

In order to make robots and machines easier to use, and that we could make them ourselves, it is necessary to know:

- mechanics, ie. what kind of movements are being executed and in what way,
- construction and operation,
- management.

The main components of industrial robots are:

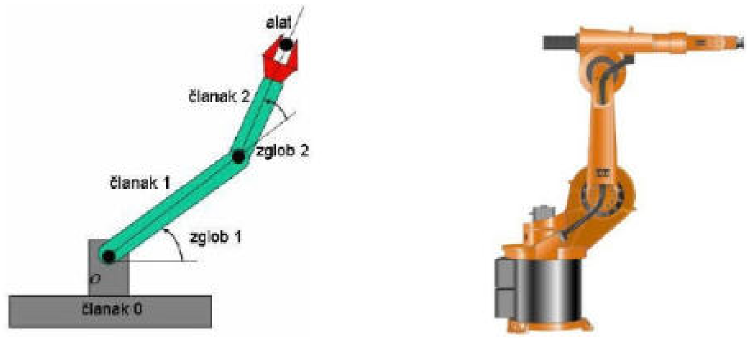
- Mechanical structure or manipulator consists of a series of rigid links connected by joints. Manipulator behavior is determined by arm, which provides mobility –the wrist provides versatility and the manipulator end effecter performs operations required by the robot.
- Actuators (drives) place the manipulator at certain movement by moving joints. Electric and hydraulic motors are most commonly used, but sometimes air motors are used as well.
- Sensors detect the status of the manipulator (proprioceptive sensors) and, if necessary, the status of the environment (heteroceptive sensors).
- Management system (computer) enables management and manipulator movement control.

ROBOT DIVISION

There are two basic types of joints that are used in industrial robots: revolute joints and prismatic joints. The revolute joint performs a rotation around the axes, while the prismatic (linear) joint performs axis linear motion. Two adjacent joints are connected by rigid links. The hand is attached to the wrist (in technical jargon the hand is called end effecter, tool or gripper). End effecter of the manipulator is not considered part of the robot, but it serves to perform certain tasks required from the robot.
For each robot there is a characteristic rotational or translational axis movement of its segments. As the movement of the robot takes place in 3D space, the first three axes are commonly used to determine the position of the wrist, while the remaining axes determine the orientation of the end effecter. The overall manipulator possesses six axes, so it can result in any position and orientation of the end effecter within the workspace. The robot workspace is the set of points in three-dimensional space that can be reached by the end effecter. The shape and volume of the workspace depend on the structure of the manipulator, and on the present limitations of mechanical joints.

ROBOTS IN INDUSTRY

Due to high demand for robots, it comes to hyper production and rapid development of robots ("evolution"), their social self-organization, and general rebellion against the humans that ends in complete eradication of the human species. Unfortunately for them, Rossum's formula for producing robots was also destroyed. In that way robots are faced with the problem of failure to renew their kind. In the epilogue of the drama, there is a spark of love between two robots of different sexes of the most advanced generation which gives a glimmer of hope for the possible survival of the robot kind.
The field of robotics is so broad that it cannot be completely defined in a general sense. The same applies to the notion of the robot. Industrial robot is most commonly understood by the term robot. It is also called robot manipulator, or robot arm. Robot or robot arm could be modeled as a chain of rigid ankles, which are connected by movable joints (see Figure 1.1 (a)). Joints are typically rotational or translational. The example of an industrial robot with rotary joints is shown in Figure 1.1, right. Thus, in robots with rotary joints could be seen the similarity with the human hand, and such robots are called articulated robot arms. Some ankles of such robots correspond to the human breast, upper arm and forearm, while the joints correspond to the shoulder, elbow and wrist. At the end of the robot arm there is a closing mechanism (Figure 2), which is also called a tool, or hand. The grab usually has two or more fingers, which are capable of opening and closing.



(a) Osnovna struktura industrijskog robota; (b) Industrijski robot Kuka.

(a) BASIC STRUCTURE OF INDUSTRIAL ROBOTS
(b) (HOOK) INDUSTRIAL ROBOT
ALAT – TOOL; CLANAK – ANKLE; ZGLOB – JOINT

Figure 2. Robot workspace

Robot is a software-controlled mechanical device that uses sensors to conduct one or more of the final mechanisms according to the specific predetermined path within its workspace, in order to manipulate physical objects:

- rectangular or Cartesian (TTT),
- cylindrical (RTT),
- spherical (RRT),
- rotational (RRR)
- SCARA (Selective Compliance Assembly Robot Arm) - RTR, TRR or RRT gra.e.

Workspace of the robot with rectangular configuration is a prism. Such a robot is schematically shown in Figure 2 left. An example of the same type of industrial robots is shown in Figure 2 right. In these robots there is a direct link between joint variables and spatial tool coordinates.

Workspace geometry

Nowadays, there are four basic structures of manipulators. Manipulator division, with respect to the workspace geometry,
is:

1. Cartesian or rectangular, or TTT,
2. cylindrical or RTT,
3. spherical or RRT,
4. articulated or RRR,
5. SCARA (Selective Compliance Assembly Robot Arm) - RTR, TRR or RRT gra.e.

The following robot configurations (Fig. 3 and 4) were determined by using different combinations of rotation (R) and translational (T) joints for the first three axes. The rectangular configuration of the robot has three translational joints whose axes are vertical to each other (Fig. 3). If the first joint of rectangular structures is replaced by a rotary joint, then cylindrical robot configuration is obtained (Fig. 4.). If the second joint of cylindrical configuration of the robot is substituted by a rotary joint, then spherical robot configuration is obtained (Fig. 4).

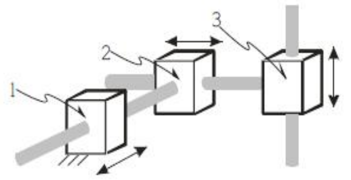


Figure 3. Descartes (rectangular) robot configuration

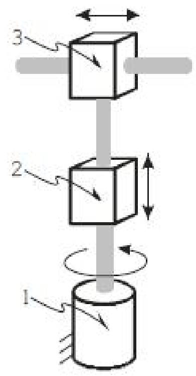


Figure 4. Cylindrical robot configuration

Robot SCARA-type (Selective Compliance Assembly Robot Arm) also possesses two rotational and one translational joint, as shown in Fig. 5. If all three rotational joints are used, then rotating manipulator structure (also called the link arm, anthropomorphic or joint) is obtained (Fig. 6).

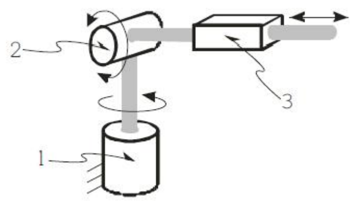


Figure 5. Spherical (polar) robot configuration

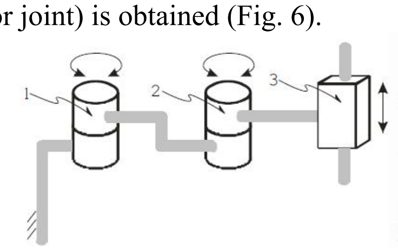


Figure 6. SCARA robot

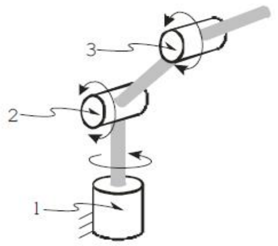


Figure 7. Anthropomorphic robot configuration (rotational robot configuration)

MODELING AND CONTROL OF ROBOT MANIPULATOR

In every application of industrial robots performing a specific task involves a specific movement, which is attributed to the end effecter. The movement may be undisturbed if there is no physical interaction between the end of the manipulator and the environment, or it can be limited if there is such interaction. The manipulator joint drive (actuator) with commands that are consistent with the desired motion trajectory is in charge for the successful performance of the end effecter movement. End effecter motion control requires accurate analysis of the characteristics of mechanical structures, actuators and sensors. The aim of such analysis is to determine a mathematical model of industrial robot components. Robot manipulator modeling is necessary in order to find the appropriate control strategy.

Modeling Problem

Robot model construction includes the mathematical formulation of its components, ie. drive (motor) models for joint movement control, segment kinematic models (segment length and joints axis location) and inertial models of mass, mass center and moments of inertia of the segments and the load. The parameters of these models are necessary to measure or estimate by application of different

procedures. Robot design is determined by understanding the workspace in which the robot operates and its tasks set.
Kinematic analysis of manipulator structure refers to the description of manipulator motion with respect to the fixed coordinate system (Cartesian), not taking into account the forces and moments that cause the motion. It is important for the differentiation of kinematics and differential kinematics. Kinematics describes the analytical relationship between the joint position and the end effecter position and orientation. Differential kinematics describes the analytical relations between the joint motion and the manipulator motion in terms of velocities.
In manipulator robotics, there are two kinematic tasks: 1. direct kinematics problem, 2. inverse kinematics problem.
General procedure that describes the movement of the top of the end effecter as a function of joint movement is based on the theory of linear algebra. The inverse problem solution is of crucial importance for the transformation of the desired movement of the end effecter from the workspace into the corresponding movement in the joint space. Kinematic model availability is useful for determining the relations between force and torsion (torque) applied to the joints and the forces and moments applied to the end effecter in static equilibrium configurations. Manipulator kinematics is the basis for obtaining the equations of dynamics, ie. manipulator motion equations of as a function of the forces and moments which act upon the manipulator. The dynamic model availability is useful for mechanical structure design, actuator selection, and management strategy determination and computer simulation of the manipulator movement.
In modern techniques, the emphasis is put on automatics and remote management. Automatics is the future, and it should be aspired to in further investigation. Management can be applied to different systems, whether they are of discrete or continuous type. The emphasis is on test (modeling) systems with feedback and control systems, and finding out how to make them stable. Modeling is a way to show the real system and the theory about that system in the form that can be manipulated. A real system is a separate part of the real world that is of interest to us. The simulation is enabled by various software patents (Matlab, Simulink, Control System Toolbox) that help in result tracking, correction possibilities and validation of the model.

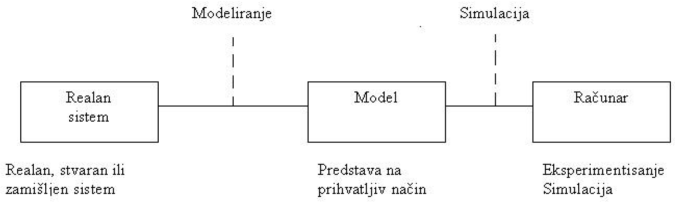


Figure 8. Modeling problem using calculation for robot configuration

Problem solving using calculation for the robot configuration (Figure 8.) can be done by using Matlab / Robotic Toolbox. According to Denavit-Hartenberg notation, any robot configuration can be displayed by defining the following sequence parameters for each of the axes: a_i, α_i, d_i and θ_i. For that purpose, the link command is used in the form: LINK ([alpha A theta D sigma], Convention), taking into account the order, by which the parameters are passed to each axis. The fifth parameter sigma is flag that indicates whether the joint is rotary (sigma = 0) or translational (sigma! = 0).

APPLICATION METHODOLOGY OF MANIPULATOR MODELING

This kind methodology will be shown on the example of a three-axis robot (Figure 9.).

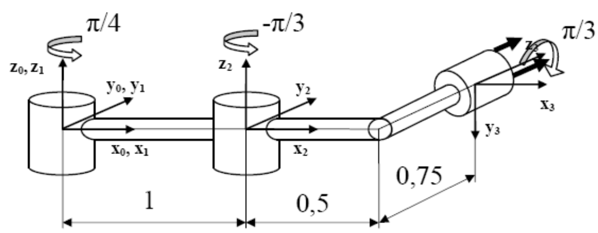


Figure 9. Three-axis robot

Table 1. Denavit-Hartenberg parameter table for the given case

i	α_{i-1}	a_{i-1}	d_i	θ_i
1	0	0	0	45°
2	0	1	0	-60°
3	-90	0,5	0,75	60°

On the basis of the results shown in the table, we can write the transformation matrix {3} of the moving coordinate system in respect to the base {0}-fixed coordinate system.

${}^0\boldsymbol{R}_3$ - Rotational transformation matrix of the moving coordinate system 3, into the fixed 0.

$${}^0\boldsymbol{R}_3 = {}^0\boldsymbol{R}_1 \cdot {}^1\boldsymbol{R}_2 \cdot {}^2\boldsymbol{R}_3$$

$${}^0R_3 = \begin{bmatrix} c_3c_{12} & -s_3c_{12} & -s_{12} & c_{12}a_1 - s_{12}d_2 + c_1a_0 \\ c_3s_{12} & -s_3s_{12} & c_{12} & s_{12}a_1 + c_{12}d_2 + s_1a_0 \\ -s_3 & -c_3 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

After calculating with Matlab, the following matrix is obtained:

$${}^0R_3 = \begin{bmatrix} 0.4830 & -0.8365 & 0.2588 & 1.3842 \\ -0.1294 & 0.2241 & 0.9659 & 1.3021 \\ -0.8660 & -0.5 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

On the basis of the previous calculated matrix, it is possible to present the orientation and position {3} of the moving coordinate system using base or {0} fixed coordinate system.

Thus, {3} coordinate system is, in respect to the base coordinate system, rotated around the Z axis for -15 °. Coordinates of the starting point {3} coordinate system, shown in the reference coordinate system, could be obtained from the following matrix equation:

$$\begin{bmatrix} {}^0x_{3\,org} \\ {}^0y_{3\,org} \\ {}^0z_{3\,org} \\ 1 \end{bmatrix} = \begin{bmatrix} 0.4830 & -0.8365 & 0.2588 & 1.3842 \\ -0.1294 & 0.2241 & 0.9659 & 1.3021 \\ 0.8660 & -0.5 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 1.3842 \\ 1.3021 \\ 0 \\ 1 \end{bmatrix}$$

where:

$${}^0x_{3org} = 1.3842$$
$${}^0y_{3org} = 1.3021$$
$${}^0z_{3org} = 0$$

Calculation with Matlab: xorg = 1.3842, yorg = 1.3021, z = 0

Denavit-Hartenberg parameters are defined using the command "LINK" (angle values $\theta_1, \theta_2, \theta_3$ are set to 0 - zero position of the robot):

```
L{1}=link([0 0 0 0], 'modified')
L{2}=link([0 1 0 0], 'modified')
L{3}=link([-pi/2  0.5  0  0.75], 'modified')
L{1}=link([0 0 0 0], 'modified')
L{2}=link([0 1 0 0], 'modified')
L{3}=link([-pi/2 0.5 0 0.75], 'modified')
```

Using the command "ROBOT", robot configuration is being constructed:

```
r = robot (L, 'romir' )
r = robot (L,'romir')
```

It is possible to draw the defined robot configuration in 3D space by using "PLOT" command and by giving the desired angles $\theta_1, \theta_2, \theta_3$ (Figure 10).

```
plot (r, [ pi/4 -pi/3 pi/3 ])
plot (r, [ pi/4 -pi/3 pi/3 ])
```

q=[pi/4 -pi/3 pi/3]
q=[pi/4 -pi/3 pi/3]

Denavit-Hartenberg matrix (direct kinematics) of the joint tool coordinate system could be calculated by using the command "FKINE" with previous settings of the angle θ_1 , θ_2 , θ_3 values.

T=fkine (r, q)
T=fkine (r, q)
After running the above commands, the following results are obtained:
q = 0.7854 -1.0472 1.0472
R= 0.4830 -0.8365 0.2588 1.3842
-0.1294 0.2241 0.9659 1.3021
-0.8660 -0.5000 0.0000 0.0000
0 0 0 1.0000
R3=[0.4830 - 0.8365 0.2588 1.3842, - 0.1294 0.2241 0.9659 1.3021,
- 0.8660 - 0.5 0 0, 0 0 0 1]

CONCLUSION

Robots were introduced in factories in order to achieve higher productivity. They started from simpler operations and move toward complex ones. Today, the fields of industrial robot applications can be classified into four categories: material transfer and machine handling, processing operations,assembling, inspection.
We are also in contact with the components of technological systems, such as mechanical, pneumatic, hydraulic, electrical, and mechatronic components. Their application is very frequent. Pneumatics is the most widespread for its safety - it cannot cause an explosion or inflammation and damage to the work area or machines, as it is the case with hydraulic machines and systems. In further investigation, we need to acquire knowledge in programming and implementation of programmable logic controllers (PLC).

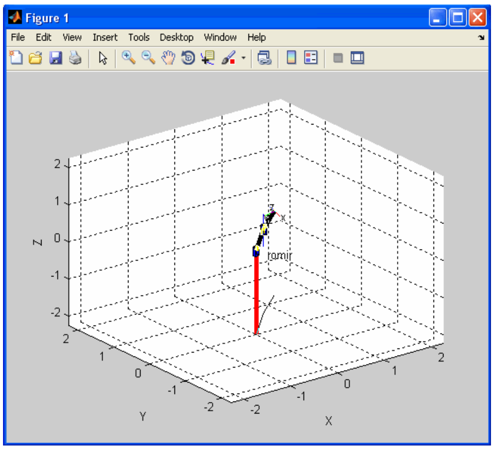


Figure 10. Display of the assigned robot configuration in 3D space

REFERENCES

[1] www.microsoft.co.yu/downlo ad/obrazov anje /pil /Uvod_u_ro b o t ik u .pdf
[2] http://www.ieee.hr/_download/repository/MR_Predavanje_01_UVOD_2006_07_4str.pdf
[3] http://ww w.tfc.kg.a c.yu/tos /PDF/3_7_Mikic.pdf
[4] http://titan.fsb.hr/~zkunica/nastava/studentski_radovi/Tomislav_Perkovic_FSB_dipl_2008.pdf
[5] http://titan.fsb.hr/~zkunica/nastava/studentski_radovi/Hrvoje_Tonzetic_TVZ_dipl_2005.pdf

[6] T. Urina, M. Crneković. Industrijski roboti .kolska knjiga, Zagreb 1990.
[7] Krstulović. Uvod u industrijsku robotiku HZTK, Zagreb 2003.
[8] Mr.sc. Jasmin Velagić, dipl.inž.el., Laboratorija za Robotiku i autonomne sisteme (skripte)
[9] Craig, J. J.: Introduction to Robots, Addison -Wesley Publishing Company, 1989.
[10] Denavit, J.; Hartenberg, R.S.: Kinematic Notation for Lower-Pair Mechanisms Based on Matrices, ASMEJ of Applied Mechanics, 1955.
[11] Dieter W. Wloka: Roboter systeme 1-Teschnische Grundlagen, Springer-Verlag Berlin Heidelberg, 1992.
[12] Craig, J. J.: Introduction to Robots, Addison -Wesley Publishing Company, 1989.
[13] Šurina, T. ; Crneković, D.: Industrijski roboti, Školska knjiga, Zagreb, 1990.
[14] Čohodar, M.; Kulenović, M.; Voloder, A.: Kinematic Modeling of Robot Arm and Analysis its Singularity, The 12th INTERNATIONAL DAAAM SYMPOSIUM "Inteligent Manyfacturing & Automation: Focus on Precision Engineering'', Jena, 2001.
[15] Šurina, T.; Crneković, M.: Industrijski roboti, Školska knjiga - Zagreb, 1990.
[16] www. cont inent a l. com
[17] www. howst uf f works. Com
[18] www. cir cuit cel lar . com

REVERSE ENGINEERING APPLICATION IN CREATION OF 3D CAD MODEL FOR INVESTMENT CASTING OF KNEE IMPLANT

Aleksandar Rajic[1], Slobodan Stojadinovic[2], Eleonora Desnica[2], Dorian Nedelcu[3]
[1]Technical College of Applied Sciences, Zrenjanin, Serbia
[2]University of Novi Sad, Technical Faculty ″Mihajlo Pupin″, Zrenjanin, Serbia
[3]″Eftimie Murgu″ University of Resita, Romania
e-mail: aleksandar.rajic@vts-zr.edu.rs, slobodan@tfzr.uns.ac.rs,
desnica@tfzr.uns.ac.rs, d.nedelcu@uem.ro

Abstract: The paper presents a description of application procedures of Reverse Engineering technology for creation of 3D CAD model of femoral component of total knee endoprothesis based on available meltable wax model for investment casting. Once CAD data record is accepted it presents an information management center for its geometry throughout the lifetime of knee implant component. Thus, in case a change in component construction should be made, it can be managed quickly and consistently made available for all CAx-tools which accompany the product development. The procedure is defined within the work conducted in the international IPA cross-border cooperation project Romania-Republic of Serbia where Reverse Engineering technologies and Additive Manufacturing were studied.
Key words: Reverse Engineering, meltable wax model, investment casting, 3D CAD model, knee endoprothesis

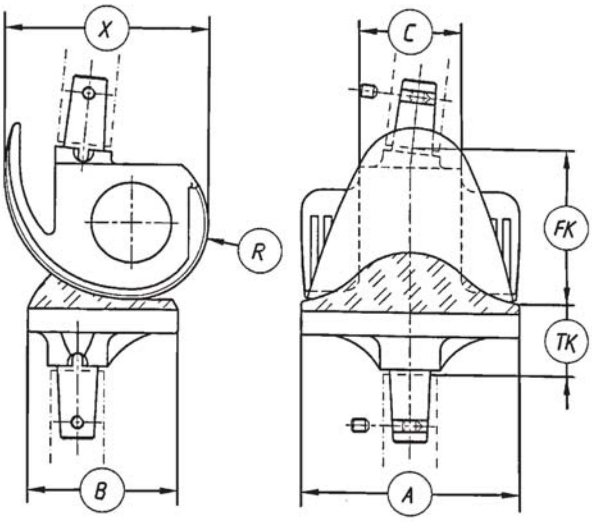
INTRODUCTION

The most recent approaches to technological innovations include technological innovations of products and processes as competition factors as well as the new information and flexible manufacturing technologies having new properties. Modern development and design of new products and technologies is based on CAD/CAM/CAE technology application.
Additive Manufacturing technologies is the most frequently used name for a technology family (Rapid Prototyping - RP, Rapid Tooling - RT, Rapid Manufacturing - RM and Reverse Engineering - RE) which are used for development of physical objects directly from three-dimensional 3D CAD model.
When the application of AM technology started in investment casting, the parts produced within the first AM systems were applied as meltable wax models in order to shorten the time and costs of casting. AM processes application in investment castings one of the widest used applications. Economic benefit which the AM meltable models provide is reduced to individual and small series production due to high AM material costs.
The latest researches in technology of development of AM meltable models are redirected to development and application of Rapid Tooling technology which ensures fast development of tools/molds for meltable wax models development in investment casting. The name Rapid Investment Casting (RIC) is RP and RT techniques application in investment casting. Additive Manufacturing technology is optimal for the process of custom implants. These are the reasons why RP and RE technologies have such an important role in medicine, [5].

INVESTMENT CASTING OF METAL IMPLANTS

The main feature of technological process of producing cast products by investment casting is to inject under pressure an easily melted model mass in tools made of metal or other material: after solidifying in the tool the mass assumes the shape of a cast piece. The injecting system is made in other tool. The model of cast piece is joined to the injecting system model after it has been removed from the model tool. Since the models are of small dimensions, more models are joined for one injecting system which makes a wax sprue. Several layers of suspension are applied on the prepared wax sprue, which form a solid shell after drying. The shell is made by melting the model assembly and is then put into special boxes and sprinkled with sand or grains.
The box containing the shell is heated in a furnace to a relatively high temperature and then is cast. After cooling down the cast pieces are removed from the shell and then detached from the injecting

system and cleaned. If necessary, thermal treatment of cast pieces is performed. Investment casting is used for making cast pieces of ferrous, non-ferrous and light metals.
Metal orthopedic implants made of meltable models are partial knee endoprothesis and Fig. 1 shows main dimensions of joint i.e. knee based on which implant are made. The material of metal implants is CoCrMo alloy.



Size	A mm	B mm	C mm	FK mm	X mm	TK mm	R mm
middle/right	65	45	30	46	62	22	23
middle/left	65	45	30	46	62	22	23

Figure 1. Main dimensions of joint/knee

Investment casting of metal implants consists of the following operations: development of the cast piece drawing, meltable model tool design, model structure melting, meltable model development by injection, disjoining of tools, model assembling into a model, coating of wax sprue with ceramic suspension, wax melting out and roasting of ceramic shells, metal implants casting.

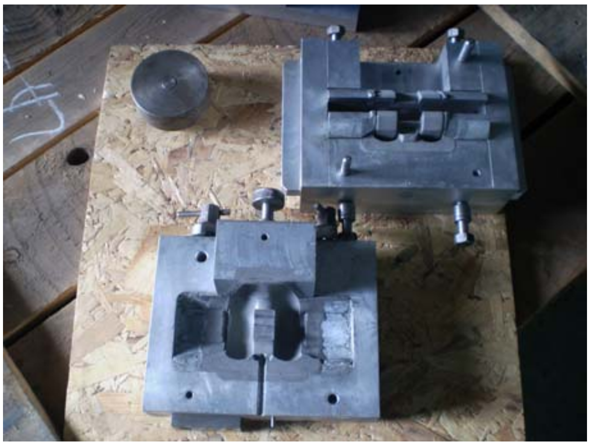


Figure 2. Tool for meltable implant model

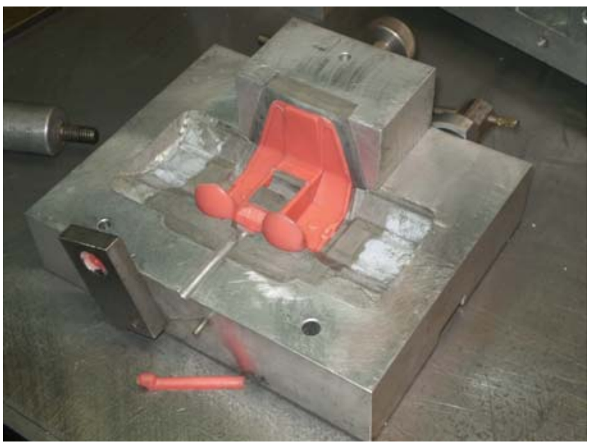


Figure 3. Dissembled tool with meltable wax model

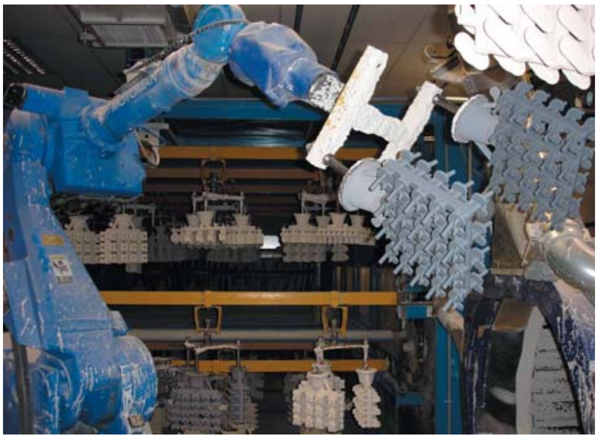


Figure 4. Coating of model sprue

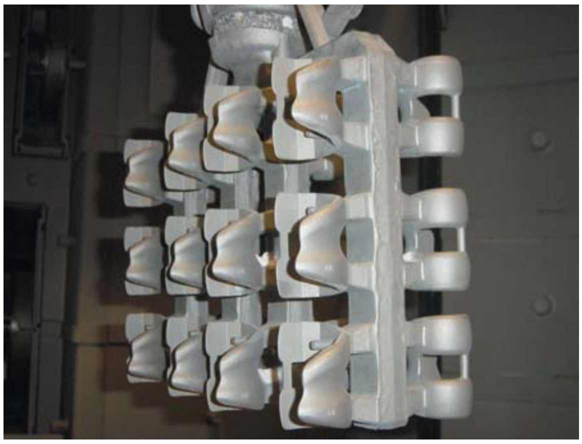


Figure 5. Finished knee implant metal cast piece

DEVELOPMENT OF METHOD FOR REVERSE ENGINEERING OF KNEE IMPLANT MELTABLE MODEL

This part of the paper development of method for reverse engineering of knee implant meltable model is shown; the method will include 3D scanning of the present standard meltable model, treatment of point cloud and formation of 3D mesh model which may later be defined by parameters. The obtained result is creation of 3D CAD model in software package SolidWorks.
Non-contact 3D scanning OptiNum and software packages Numisoft, Geomagic Wrap and Rapidform XOR are used for development of the method, while 3D CAD solid model of implant meltable model will be developed in SolidWorks.
Phases of obtaining 3D CAD model:

1. Generating the point cloud by 3D scanning Noomeo Optinum and Numisoft software
2. The obtained point cloud processing and conversion into mesh model in Geomagic Wrap software
3. Mesh model processing and transfer into neutral CAD format in Rapidform XOR software
4. Model import and conversion into 3D CAD solid model in SolidWorks software.

REVERSE ENGINEERING - 3D SCANNER NOOMEO OPTINUM

The 3D Scanner Noomeo Optinum is a portable scanner that connects to the acquisition system via USB 2.0 with autonomy offered by the battery included in the configuration. The scanner uses technology "Vision based self positioning", the point cloud acquisition is performed by successive multiple photographic images, through a CCD sensor with resolution 1024x768 pixels, which can take up to 500,000 points/image.
The scanner dimensions are 230 mm x 230 mm x 80 mm and the weight is less than 2 kg. The volume of the scanned objects fall in 10 cm3 ÷ 1m3, the minimum purchase size is 1 cm.
Noomeo Optinum scanner technology combines structured light, which allows instant capture of the geometry through the deformation analysis of repetitive light projected onto the object, with 2D image processing, leading to the scanner position to the object concerned and capture its texture. Thus, by 2D image processing, the autoposition is calculated, which eliminates the need for markers and the light flow provides additional information for taking geometry as a cloud of points. The scanner system does not require preparation of items scanned, their installation in a reference system or reference markers.
Fig. 6 shows meltable wax model of knee implant which are produced on semi-automatic presses for wax injection: Var-Flex, Inject-model 35 (Tempcraft, SAD). Material used for production was the wax - W1/1 (Dussek Campbell Limited, London, UK).

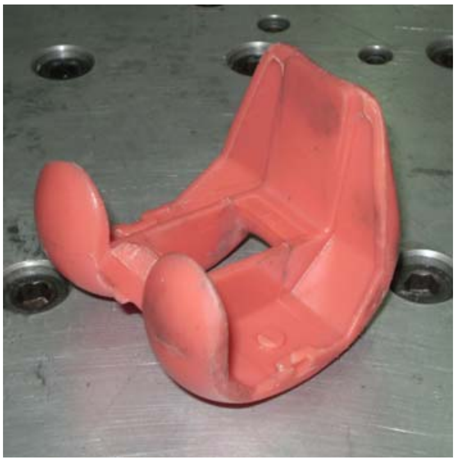


Figure 6. Meltable wax pattern of knee implant

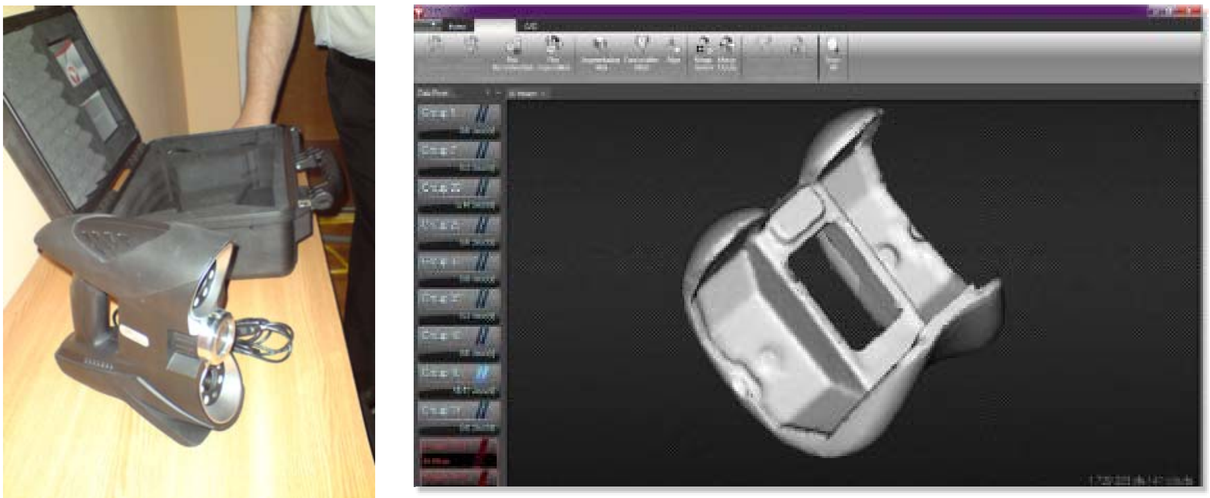


Figure 7. 3D Scanner Noomeo Optinum and generating point cloud in Numisoft softwer (Center for Numerical Simulation and Digital/Rapid Prototyping, University Eftimie Murgu'' Resita, Romania)

PROCESSING OF POINT CLOUD AND GENERATING THE MESH MODEL

Geomagic Wrap software is a software tool for the cloud point transforming of the scan result into a 3D polygonal network (mesh), which can be used in the design, analysis and manufacturing. Geomagic Wrap can process large data sets, collected from different types of scanners, provides opportunities to optimize the scanned data (using remove outliers, reduce noise and other available tools), align and merge multiple scan data sets, create polygon mesh from point cloud data, automatically detect and correct errors in the polygon mesh, detect and create features in the model, repair and sharpen boundary edges, 3D model export in different formats: STL, OBJ, VRML1/2, DXF, PLY and 3DS.

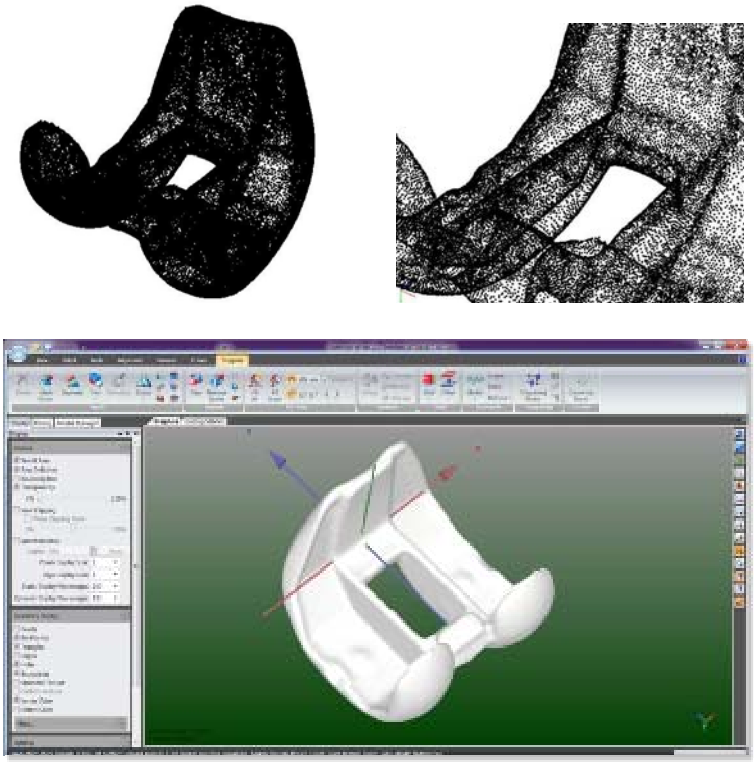


Figure 8. Mesh created in Geomagic Wrap software

PROCESSING OF MESH MODEL

Rapidform XOR software is an Reverse Engineering application that combines CAD with 3D scan data processing, to create parametric, editable solid models of virtually anything scan data sets. Because Rapidform XOR is based on Parasolid kernel, it can generate history - based CAD models with feature trees and export the geometry into the SolidWorks, Pro/E, AutoCAD, CATIA and others native format.

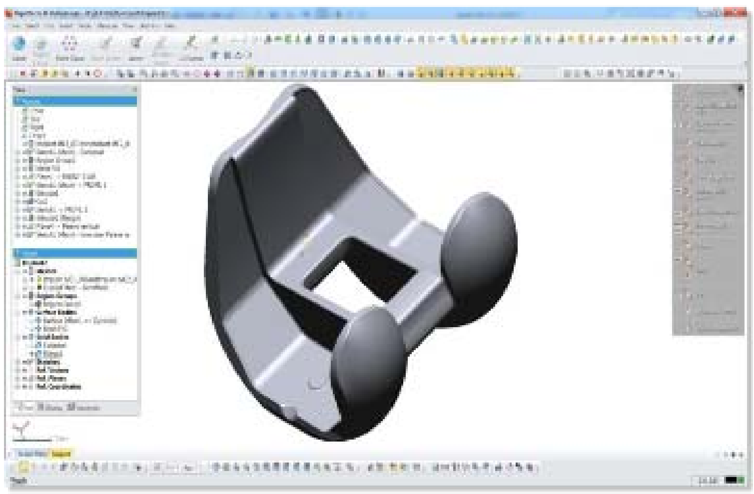


Figure 9. Knee implant geometry recreated in Rapidform XOR software

In the last phase of model adaption in Rapidform XOR software, the knee model is exported in neutral CAD format (STL or IGS) in order to be readable for all leading CAD applications.

IMPORTING MODEL AND CONVERTING IN 3D CAD SOLID MODEL

To generate the 3D CAD solid model of the human knee implant, SolidWorks (CAD) application is selected for its wide range of possibility to operate with mesh and surface models.
SolidWorks is a 3D CAD program that runs on Microsoft Windows and is being developed by Dassault Systèmes SolidWorks Corp., a subsidiary of Dassault Systemes, S. A. (Velizy, France). SolidWorks is a Parasolid-based solid modeler, and utilizes a parametric feature-based approach to create models and assemblies.
There are two methods in SolidWorks for converting scan data to a solid model:

- semi-manual creation: direct mesh referencing
- semi-automated creation using wizards.

The first step in preparing the model is to import the STL or IGS model created in Rapidform XOR software, into SolidWorks program. The imported model is presented in figure 10.

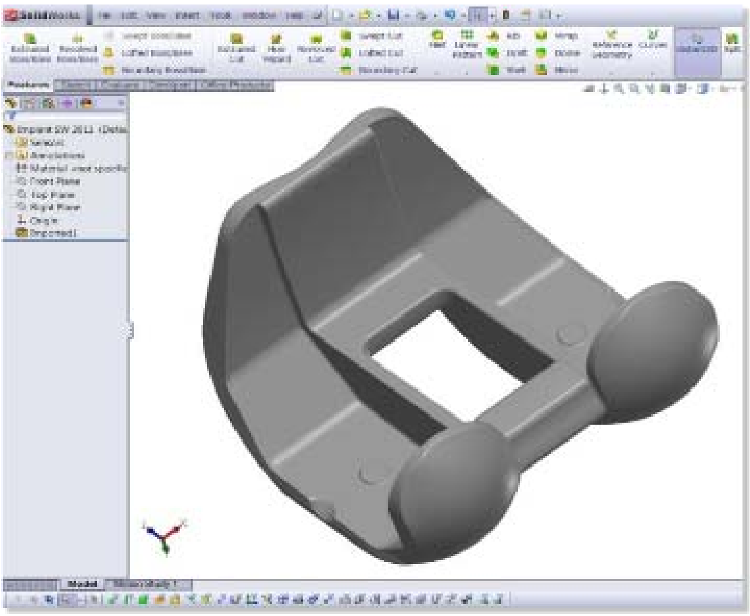


Figure 10. Implant geometry exported from Rapidform XOR software to SolidWorks software

The next step in preprocessing of the CAD model is FeatureWorks software attempts to automatically recognize and highlight as many features as possible. The advantage to this method is the speed at which features are recognized because do not select faces or features. FeatureWorks provides both automatic and interactive feature recognition capabilities. Automatic feature recognition requires no user intervention. If the FeatureWorks software can automatically recognize most or all of the features in model, then we use Automatic Feature Recognition, as shown in Fig. 11.
.

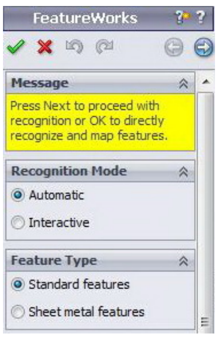


Figure 11. Automatic feature recognition in SolidWorks

As shown in Fig. 12 the obtained model is solid model, which was the aim of the applied method for generating 3D CAD model of knee implant.

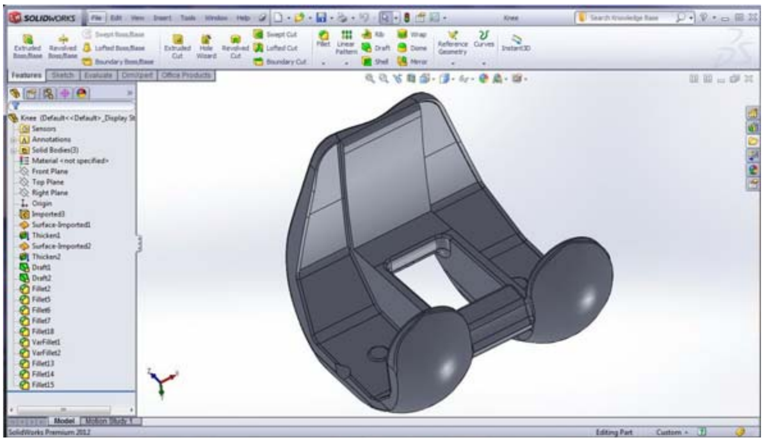


Figure 12. 3D CAD solid model of knee implant

CONCLUSIONS

The main effort of the work was to creat a 3D CAD model of knee implant using a different approach to the usual one. This research was based on 3D scaned data of the wax pattern used in conventional investment casting of knee implant.

Based on the above mentioned observations and claims, a conclusion follows that the presented process of generating the 3D CAD solid model of the knee implant provides quite good results regarding geometry. The method of generating the 3D CAD solid model is not restricted to the medical implants only; it can be used for any other wax pattern.

Such generated 3D CAD model of the knee implant can have various uses, in medicine and technology. The 3D solid model of the knee can be used for the purpose of studying different aspects of stresses, on the knee itself, by finite element analysis. Besides that, the 3D CAD model of the knee can be used to analyse the use of different aspects of implants in surgery of the skeletal system. Also, the model can be used in the process of Rapid Prototyping or Rapid Manufacturing.

Thanks to the scaned data it is possible to make a new implant more suitable for the patient. It could also provide advantageous financial conditions.

REFERENCES

[1] Cheah, C.M., Chua, C.K., Lee, C.W., Feng, C., Totong, K., Rapid Prototyping and Tooling techniques: A review of applications for rapid investment casting, Springer-Verlag London Limited, 2004.

[2] Rajic, A., Development and optimisation of process and systems in investment casting using ″Rapid Tooling″ technology", Master thesis, University of Novi Sad, Technical Faculty ″M. Pupin″ Zrenjanin, Zrenjanin, 2006.

[3] Gibson, I., Advanced Manufacturing Technology for Medical Applications, Reverse Engineering, Software Conversion and Rapid Prototyping, John Wiley & Sons Ltd, 2005.

[4] Rajic, A., Stojadinovic, S., Applying of Direct Metal Laser Sintering (DMLS) process in investment casting, Scientific/professional symposium: Metal and non-metal materials, MNM – 2008, Zenica, Bosna i Hercegovina, 15. – 16. May, 2008.

[5] Rajic, A., Manic, M., Rapid Prototyping technologies in investment casting of metal implants, Journal "IMK-14 - Research and Development", Krusevac, Year 16, Vol. 2, pp. 39-44, 2010.

[6] Gibson, I., Rosen, D. W., Stucker, B., Additive Manufacturing Technologies, Rapid Prototyping to Direct Digital Manufacturing, Springer Science+Business Media, LLC, 2010.

SESSION 8: Biotechnology

BIOTECHNOLOGICAL APPLICATIONS OF PECTINASES IN TEXTILE PROCESSING AND BIOSCOURING OF COTTON FIBERS

Kiro Mojsov[1]
[1]University "Goce Delcev" Stip, Technological-technical Faculty, R. Macedonia
e-mail: kiro.mojsov@ugd.edu.mk

Abstract: This work represents a review of applications of alkaline pectinases in textile processing and bioscouring of cotton fibers, the nature of pectin and pectic supstances, and production of alkaline pectinases from various microorganisms. Over the years alkaline pectinases have been used in several industrial processes, such as textile and plant fiber processing, paper and pulp industry, oil extraction, coffee and tea fermentations, poultry feed and treatment of industrial wastewater containing pectinacious material. The use of enzymes in the textile chemical processing is rapidly gaining globally recognition because of their non-toxic and eco-friendly characteristic with the increasingly important requirements for textile manufactures to reduce pollution in textile production. Furthermore, the use of *pectinases* in conjunction with *amylases, lipases, cellulases* and other *hemicellulolytic* enzymes to remove sizing agents is attractive because enzymes are highly specific and efficient, and work under mild conditions, that results in reduced the use of harsh chemicals in the textile industry, process times, energy and water savings and improved product quality.
Key words: pectinases, application, textile processing, eco-friendly characteristics

INTRODUCTION

Textile processing is a growing industry that traditionally has used a lot of water, energy and harsh chemicals that result in waste streams causing high environmental burdens. With the increasingly important requirement for textile industries to reduce pollution in textile production, the use of enzymes in the chemical processing of fibres and textiles is rapidly gaining wider recognition because of their non-toxic and eco-friendly characteristics. Enzymes were discovered in the second half of the nineteenth centure, and since are routinely used in many environmentally friendly and economic industrial sectors. There is increasing demand to replace some traditional chemical processes with biotechnological processes involving microorganisms and enzymes such as *pectinases, xylanases, cellulases, laccases and ligninases* [3], [5], [10].

Today enzymes have become an integral part of the textile processing. There are two enzyme applications in the textile industry. Firstly, in the preparatory finishing area *amylases* are used for desizing process and secondly, in the finishing area *cellulases* are used for softening, bio-stoning and reducing of pillink propensity for cotton goods. Applications of *pectinases, lipases, proteases, catalases, xylanases* etc., included fading of denim and non-denim, bio-scouring, bio-polishing, wool finishing, peroxide removal, decolourization of dyestuff, etc.

Researchers have tried to apply enzymes into every step of textile wet processing, ranging from pretreatment, bleaching, dyeing to finishing, and even effluent treatment. Some applications have become well established and routine, while some have not yet been successfully industrialized due to technical or cost constraints. A famous example is bioscouring or biopreparation, a process that specifically targets noncellulosic impurities within the textile fabrics, with *pectinases* [27].

For fabrics made from cotton or blends, the warp threads are coated with an adhesive substance know as "size", to prevent the threads breaking during weaving. Although many different compounds have been used to size fabrics, starch and its derivatives have been the most common sizing agent. Starch is widely used as a sizing agent, being readily available, relatively cheap and based on natural, sustainable raw materials [22] . After weaving, the size must be removed again in order to prepare the fabric for dyeing and finishing. This process (desizing) must be carried out by treating the fabric with chemicals such as acids, alkali or oxidizing agents. The chemical treatment was not totally effective in removing the starch (which leads to imperfections in dyeing) and also results in a degradation of the cotton fiber resulting in destruction of the natural soft feel, or hand, of the cotton. However starchbreaking enzymes are preferred for desizing due to their high efficiency and specific action. Using amylase enzymes for the removal of starch is one of the oldest enzyme applications [14]. The use of enzymes such as pectinases in conjunction with amylases, lipases, cellulases and other

hemicellulolytic enzymes to remove sizing agents has decreased the use of harsh chemicals in the textile industry, resulting in a lower discharge of waste chemicals to the environment, improving both the safety of working conditions for textile workers and the quality of the fabric.
Before the fabric can be dyed, the applied sizing agent and the natural non-cellulosic materials present in the cotton must be removed (scouring). Conventionally the scouring process carried out by treating the fabric with caustic soda and sodium hydroxide at 70 °C to 90 °C. The use of traditional strongly alkaline process can have a detrimental effect on fabric weight (g/m^2) and on the environment. Enzymatic scouring makes it possible to effectively scour fabric without negatively affecting the fabric or the environment. Hydrolysis by enzymes such as pectinases promotes efficient interruption of the matrix to achieve good water absorbance without the negative side effect of cellulose destruction. This process is called bioscouring. It breaks down the pectin in the cotton and thus assists in the removal of waxes, oils and other impurities. The optimum temperature is 50-65 °C and pH between 7,5-9,0 [26], [32], [34], [38], [40]. The fabric gives better wetting and penetration properties, making subsequent bleach process easy and resultantly giving much better dye uptake.

Structure of cotton

Cotton is the most important of the raw materials for the textile industry. Cotton grows as unicellular fibre on seeds. The mature cotton fibre forms a highly convoluted flat ribbon, varying in width between 12 and 20 µm. Cotton fibres have a fibrillar structure. The primary wall in mature fibres is only 0.5-1 µm thick and contains about 50% of cellulose. Noncellulosic constituents consist of pectins, fats and waxes, proteins and natural colorants. The secondary wall, containing about 92-95% cellulose, is built of concentric layers with alternatic shaped twists. The layers consist of densely packed elementary fibrils, organized into microfibrils and macrofibrils. They are held together by strong hydrogen bonds. The lumen forms the centre of the fibres. Cotton is composed almost entirely of the polysaccharide cellulose. Chemical composition of cellulose is a linear (1→4)-linked polymer of β-D-glucopyranose. The degree of polymerization of cellulose varies with its source and the processing stage of the cellulosic material [23].
The primary wall is about 1 µm thick and comprises only about 1 % of the total thickness of cotton fibre. The major portion of the noncellulosic constituents of cotton fibre is present in or near the primary wall. Noncellulosic impurities, such as fats, waxes, proteins, pectins, natural colorants, minerals and water-soluble compounds found to a large extent in the cellulose matrix of the primary wall and to a lesser extent in the secondary wall strongly limit the water absorbency and whiteness of the cotton fiber [41]. Pectin is located mostly in the primary wall of the fibre. It is composed of a high proportion of D-galacturonic acid residues, joined together by α(1→4)-linkages. The carboxylic acid groups of some of the galacturonic acid residues are partly esterified with methanol. Pectic molecule can be called a block-copolymer with alternating the esterified and the non-esterified blocks. In the primary cell wall pectin is covalently linked to cellulose or in other plants to hemicellulose, or that is strongly hydrogen-bonded to other components. Pectin is like a powerful biological glue. The mostly water-insoluble pectin salts serve to bind the waxes and proteins together to form the fiber`s protective barrier.

Production of pectinases from microorganisms

Commercial sources of enzymes are obtained from three primary sources, i.e., animal tissue, plants and microbies. These naturally occurring enzymes are quite often not readily available in sufficient quantities for food applications or industrial use. However, by isolating microbial strains that produce the desired enzyme and optimizing the conditions for growth, commercial quantities can be obtained. This technique, well known for more than 3,000 years, is called fermentation. Most of the industrial enzymes are produced by a relatively few microbial hosts like *Aspergillus* and *Trichoderma* fungi, *Streptomyces* fungi imperfecti and *Bacillus* bacteria. Yeasts are not good produces of extracellular enzymes and are rarely used for this purpose. There is a large number of microorganisms which produce a variety of enzymes [7], [15]. Microorganisms producing enzymes of textile important are listed Table 1.

Table 1. Microorganisms producing enzymes of textile important

Microorganisms	Enzymes
1. Bacteria	
Bacillus subtilis	*Amylase*
B. coagulans	*α-amylase*
B. licheniformis	*α-amylase, protease*
2. Fungi	
A. niger	*Amylases, protease, pectinase, glucose oxidase*
A. oryzae	*Amylases, lipase, protease*
Candela lipolytica	*Lipase*
P. notatum	*Glucose oxidase*
Rhizopus sp.	*Lipase*
Trichoderma reesei	*Cellulase*
T. viride	*Cellulase*
Ascomycetes	*α-amylase*
Basidomycetes	*α-amylase*
Aspergillus sp.	*Pectinase, lipase*

The enzymes are inducible, i.e., produced only when needed, and they contribute to the natural carbon cycle. Pectolytic enzymes or pectinases are classified according to their activity on the main polygalacturonan backbone chain [35]. Pectinases comprise a group of enzymes that catalyze the breakdown of substrates containing pectin. Pectinases are classified into three classes: pectin esterases, depolymerizing enzymes (hydrolases, lyases), and protopectinases. Some of the alkaline pectinases from microbial sources are listed in Table 2.

Table 2. Microbial sources of alkaline pectinases, properties and applications

Microorganisms	pH (opt.)	T (opt.), °C	Application	Reference
1. Bacteria				
Bacillus sp. DT-7	8	60	Degumming	Kashyap et al. 2001
Bacillus sp. MG-cp-2	10	60	Degumming	Kapoor et al. 2000
Bacillus sp. NT-33	10.5	75	Degumming	Cao et al. 1992
2. Fungi				
Penicillium italicum	8	50	Food industry	Alana et al. 1991
Aspergillus fumigatus	3-9	65	Degumming	Baracat et al. 1993
Amycolata sp.	10.25	70	Degumming	Bruhlmann et al.1994
Streptomyces sp.QG-11-3	3-9	60	Biobleaching	Beg et al. 2000

Several methos, such as submerged fermentation (SmF), solid-state fermentation (SSF) and whole cell immobilization have been successfully used for alkaline pectinase production from various microorganisms [12], [18]. The production of alkaline pectinase in SmF cultures is reported to be induced by supplementing the production medium with different nitrogen and carbon sources containing pectinaceous substances such as pectin polymer, cheap agricultural residues such as ramie fiber or leaves, citrus pectin, orange peel, wheat bran rice husk, etc. [5], [9],[18], [36].
SSF is the growth of organisms on solid substrates in systems with continuous gas phase and no free-flowing water. Agro-industrial residues such as wheat bran, rice bran, sugarcane bagasse, corncobs, and apple pomace are generally considered the best substrates for processes [6], [28], [30].
For practical applications, immobilization of microorganisms on solid materials offers several advantages, including repeated usage of enzyme, ease of product separation and improvement of enzyme stability [18].

Properties of enzymes used in textiles

1. **Enzyme accelerates the reaction**
   - An enzyme accelerates the rate of particular reaction by lowering the activation energy of reaction
   - The enzyme remains intact at the end of reaction by acting as catalyst
2. **Enzymes operate under milder condition**
   - Each enzyme have optimum temperature and optimum pH i.e. activity of enzyme at that pH and temperature is on the peak
   - For most of the enzyme activity degrades on the both sides of optimum condition
3. **Alternative for polluting chemicals**
   - Enzymes can be used as best alternative to toxic, hazardous, pollution making chemicals
   - Also some pollutant chemicals are even carcinogenic. When we use enzymes there is no pollution
4. **Enzyme acts only on specific substrate**
   - Most enzymes have high degree of specificity and will catalyse the reaction with one or few substrates
   - One particular enzyme will only catalyse a specific type of reaction. Enzymes used in desizing do not affect cellulose hence there is no loss of strength of cotton
5. **Enzyme are easy to control**
   - Enzymes are easy to control because their activity depends upon optimum condition
6. **Enzymes are biodegradable**
   - At the end of reaction in which enzymes used we can simly drain the remaining solution because enzymes are biodegradable and do not produce toxic waste on degradation hence there is no pollution

APPLICATIONS OF PECTINASES IN TEXTILE PROCESSING

Textile industry uses various chemical agents in the different wet processes. These chemicals, after their use, cause pollution in the efluents, some of them are corrosive that could damage equipment and the substrate. However, by introducing enzymatic processes an environment friendly production can be ensured. The serious wastewater pollution caused by conventional textile finishing has oriented the research towards application of enzymes in textile wet proceses. One of the oldest technology being used today is based on *amylase*-catalysed hydrolysis of the starch size. The advantage of these enzymes is that they are specific for starch, removing it without damaging to the support fabric. An amylase enzyme can be used for desizing processes at low-temperature (30-60 ºC) and optimum pH is 5,5-6,5 [13]. In the last two decades several other enzymatic processes have also been developed for the different wet processing of textile goods in wide-ranging operations from cleaning preparations to finishing processes. *Cellulases, hemicellulases* and *pectinases* (hydrolyses) acting on native cellulosic fibres (cotton, flax, hemp, jute, etc.) became the target enzymes in textile bioprocessing.

Recent results indicate that certain enzymes may be used effectively in the cleaning procedure of cotton. The scientific interest in this process is reflected in the number of papers published during recent years describing biopreparation results obtained, using various enzymes from different sources. But enzymatic biopreparation of cotton represents a fairly new approach and is still mostly in the development stage.

Pectinases catalyse the degradation of pectin. The total degradation is resulted by the harmonized work of several enzymes with different activities. These enzyme are in synergism with each other. There is a nondepolymerase in pectin degrading enzyme system: *pectin esterase*. This enzyme catalyses the cleavage of ester bond of poligalacturonan, as a conseqvence the degree of esterification decreases. Free carboxyl group and methyl alcohol are produced in the reaction [2]. *Polygalacturonase,* which is a depolymerase enzyme, catalyses the cleavage of $\alpha(1\rightarrow4)$ bonds in pectic polymer chain, releasing water and reducing groups at the chain ends. *Exopolygalacturonase* works at the end of the chain, while *endopolygalacturonase* works randomly within the chain [2].

Transeliminase or shortly *lyase* (depolymerase) catalyses the cleavage of α(1→4) bonds in polygalacturonan chain without releasing water and creating a double bond between the C4 and C5 athoms. Endo and exo enzymes work within or at the end of the chain, respectively, similar to the *polygalacturonases* [37].
Cellulases catalyse the degradation of cellulose. All *cellulases* have an identical chemical specificity towards the β(1→4) glycosidic bonds, but they differ in terms of the site of attack on the solid substrates (*exoglucanase* and *endoglucanase*). These enzymes catalyse the hydrolyses of the glycosidic bonds by general acid catalysis [20]. *β-glucosidases* cleave cellobiose and other soluble oligosaccharides to glucose, which is an importan step since cellobiose is an end-product inhibitor of many *cellulases* [20].
Xylanases catalyse the hydrolysis of xylan, the major constituent of hemicellulose. Xylans are heteropolysaccharides with a homopolymeric backbone chain of (1→4)-linked β-D-xylopyranose units. Two types of *xylanases* are distinguished, one is a non-branching, which does not liberate arabinose, while the other is a debranching, which liberates arabinose from the side chain substituents in addition to cleaving main chain linkages. *Endo*- and *exoxylanase* work within or at the end of the chain, respectively [21].

APPLICATIONS OF PECTINASES FOR BIOSCOURING OF COTTON FIBRES

Biopreparation of cotton

Scouring is removal of non-cellulosic material present on the surface of the cotton. Raw cotton contains about 90 % of cellulose and various noncellulosics such as waxes, pectins, proteins, fats, lignin-containinig impurities and colouring matter. The goal of the cotton preparatory process is the remove the hydrophobic and noncellulosic components and produce highly absorbent fibres that can be dyed and finished uniformly. In the conventional energy and chemical intensive process concentrated sodium hydroxid solution and additional hydrogen peroxide and sodium hypochlorite solutions are applied for removing the impurities from greige cotton. The mild reaction conditions offered by enzymatic treatment provide an environmentally friendly alternative. Pectinases, cellulases, proteases and lipases have been investigated most commonly and compared to alkaline scouring.
In generally cellulase and pectinase are combined and used for Bioscouring. In this pectinase destroy the cotton cuticle structure by digesting the pectin and removing the connection between the cuticle and the body of cotton fibre whereas cellulase can destroy cuticle structure by digesting the primary wall cellulose immediately under the cuticle of cotton. But at present, the only commercial bioscouring enzyme products are based on pectinases. Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) of enzymatic scouring process are 20-45 % as compared to alkaline scouring (100 %). Total Dissolved Solid (TDS) of enzymatic scouring process is 20-50% as compared to alkaline scouring (100%). Handle is very soft in enzymatic scouring compared to harsh feel in alkaline scouring process. Enzymatic scouring makes it possible to effectively scour fabric without negatively affecting the fabric or the environment. It also minimises health risks ence operators are not exposed to aggressive chemicals. Bioscouring process provides many advantages, such as reduced water and wastewater costs, reduced treatment time and lower energy consumption because of lower treatment temperature. Moreover, the weight loss in fabric is reduced, and fabric quality is improved with a superior hand and reduced strength loss. [31].

Bioscouring with pectinases

Pectinase, as the name suggests, hydrolysis pectins that are present in cotton as a non-cellulosic impurity. The best kinds of pectinase are those, which can function under slightly alkaline conditions even in the presence of chelating agents. Such enzymes are called "alkaline pectinases". Most conventional pectinases are usually inactive under these commercially useful conditions, their optimum activity lying in the slightly acidic region.
Bioscouring is a process by which alkaline stable pectinase is used to remove pectin and waxes selectively from the cotton fibre. Unlike the traditional alkaline scouring, this process is substrate-specific and does not alter the cellulose component. The treatment here is also rather lower than that of

the high-temperature alkaline scouring. The bioscouring however does not swell or remove the seed coat fragments called motes. This can be beneficial when scouring for the "natural look", because of the mote and colour retention in the cotton fabrics scoured with this process, pastel or light shades need to be bleached prior to dyeing, but medium to dark shades can be dyed directly after bioscouring. Some of the researchers have reported that pectinase treatment alone results in adequate wettability [11], [17], [25], [38], [39], however, others have found only a little improvement in water absorbency [16]. Yachmenev and his co-workers obtained better absorbency and whiteness after the treatment with alkaline pectinase than with acidic pectinase [40]. During the pectinase treatment the pectin content of cotton fibre can be decreased by about 30 %. Removal of pectin results in lower amounts of waxes on the cotton surface and subsequently in improved water absorbency of the fabric, which supports the hypothesis of chemical linkage between pectin and waxes. The enzymatic treatment has no effect on the tensile strength [11]. Pectin acts as a sort of cement or matrix that stabilizes the primary cell wall of the cotton fibres. The enzymes will degrade pectin during incubation, thereby destabilizing the structure in the outher layers.The weakened outher layers can be removed in a subsequent wash process [29]. Pectinase treatment modifies the morphology of cotton fibres. After pectinase treatment the fibre surface becomes perforated at first, an further treatment results in cellulose fibrils protruding from the surface of the fibre [24].
Waxes have a melting point about 70 °C, therefore during pretreatment they melt and disperse into the treatment bath or they are redistributed on the fibre surface and the thickness of the fabrics increases. The bioscouring of cotton using pectinase enzyme with multiple mixed surfactant and organic solvent has also been investigated. Three mixed surfactants used were: C12-14 syntetic alcohol with ethylene oxide 5 mol; C12-14 syntetic alcohol with ethylene oxide 9 mol; Coconut alcohol with ethylene oxide 18 mol; The natural product D-limonene has been used as an organic solvent to improve the extraction of wax. It has been found that the addition of small amounts of non-ionic surfactants in the bioscouring solution greatly enhances the effectiveness of the removal of cotton wax without inhibiting the activity of pectinase [33].
Novozymes, Bayer and Dexter Chemical Corporation have introduced an enzymatic alternative for scouring woven and knitted cotton fabrics in the textile industry on the basis of an alkaline pectinase (Dextrol Bioscour 3000) produces by a genetically modified *Bacillus* strain. For cotton knits, enzyme is added in this step. The temperature is brought to 57 °C and held for 10 minutes. This is the actual bioscour part of the procedure. The bath is then heated to 95 °C to melt and emulsify waxes and held for 5 minutes. The scour is followed by at least one 80 °C rince before proceeding for dyeing. The later modifications include reducing the time used for rinsing by skipping the drain step and going directly to another flow wash. Among other modifications, at 50 °C rinse prior to the bioscour process has proved to be effective in helping remove knitting oils and reducing foam levels. For cotton woven fabrics, batch process, pad-batch bioscour as well as continuous bioscouring have also been suggested. The bioscouring process results in textiles being softer than those scoured in the conventional sodium hydroxide process [29].

Recipe for conventional alkaline scouring process

Sodium hydroxide, 20 %

Non-ionic surfactant, 2 g/l

Wetting agent, 1-2 g/l

Temperature, 100 °C

Time, 60-90 mins

Liquor ratio, 20 : 1

Recipe for enzymatic scouring using pectinase

Pectinase, 7-8 g/l (in acetate buffer solution)

pH, 4.0

Temperature, 40 □C

Time, 45 mins

Liquor ratio, 50 : 1

CONCLUSION

Pollution free processes are gaining ground all over the world. Enzymes emerging as the best alternative to the polluting textile processing methods. Enzymes also saving lot of money by reducing water and energy consumption which ultimately reduce the cost of production.
Biotechnology offers a wide range of alternative environmentally-friendly processes for the textile industry to complement or improve the conventional technologies. The use of various enzyme is in the early stages of development but their innovative applications are increasing and spreading rapidly into all areas of textile processing. These enzymatic processes are gives the similar results as that of conventional methods The textile industry can greatly benefit from the expanded use of these enzymes as highly specific and efficient, non-toxic, environmenatally friendly compounds, work under mild conditions (pH, temperature) with low water consumption that results in reduced the use of harsh chemicals in the textile industry, process times, energy and water savings and improved product quality. The conventional alkaline scouring carried out with hot caustic soda is unquestionable an energy, water and chemical-intensive process.
Biopreparation of the cellulosic fibres is an enzyme-aided process by which the noncellulosic "impurities" (waxes, pectic substances, proteins, lignin-containing and colouring materials, etc.) are removed mainly by pectinase rich enzymes.
Advances in enzymology, molecular biology and screening techniques provide possibilities for the development of new enzyme-based processes for a more environmentally friendly approach in textile industry. It seems that in the future it will be possible to do every process using enzymes.

REFERENCES

[1] Alana, A., Liama, M., Serra, J.L., Purification and some properties of the pectin lyase from *Penicillium*. FEBS Lett, Vol. 280, pp.335-350, 1991.
[2] Bailey, M.J., Pessa, E., Strain and Process for Production of Polygalacturonase, Enzyme and Microbial Technology, Vol.12, pp. 266-271, 1990.
[3] Bajpai, P., Application of enzymes in the pulp and paper industry, Biotechnology Progress, Vol.15, pp.147-157, 1999.
[4] Baracat, M.C., Vanetti, M.C.D., Araujo, E.F.D., Silva, D.O., Partial characterization of *Aspergillus fumigatus* polygalacturonases for the degumming of natural fibres, J Ind Microbiol, Vol.11, pp.139-142, 1993.
[5] Beg, Q.K., Bhushan, B., Kapoor, M., Hoondal, G.S., Production and characterization of thermostable xylanase and pectinase from a *Streptomyces sp*. QG-11-3, J Ind Microbiol Biotechnol, Vol.24, pp.396-402, 2000.
[6] Blandino, A., Iqbalsyah, T., Pandiella, S.S., Cantero, D., Webb, C., Polygalacturonase production by *Aspergillus awamori* on wheat in solid-state fermentation, Applied Microbiology and Biotechnology, Vol.58, pp.164-169, 2002.
[7] Boyer, P.D., The enzymes,3rd ed., Academic Press, Inc., New York, Vol.5, 1971.
[8] Bruhlmann, F., Kim, K.S., Zimmerman, W., Fiechter, A., Pectinolytic enzymes from actinomycetes for the degumming of ramie bast fibers, Appl Environ Microbiol, Vol.60, pp.2107-2112, 1994.
[9] Bruhlmann, F., Purification and characterization of an extracellular pectate lyase from an *Amylocota sp.,* Applied and Environmental Microbiology, Vol.61, pp.3580-3585, 1995.
[10] Bruhlmann, F., Leupin, M., Erismann, K.H., Fiechter, A., Enzymatic degumming of ramie bast fibers, Journal of Biotechnology, Vol.76, pp.43-50, 2000.
[11] Buchert, J., Pere, J., Scouring of cotton with Pectinases, Proteases and Lipases, Textile Chemist and Colorist&American Dyestuff Reporter, Vol.32(5), pp.48-52, 2000.

[12] Cao, J., Zheng, L., Chen, S., Screening of pectinase producer from alkalophilic bacteria and study on its potential application in degumming of ramie, Enzyme and Microbial Technology, Vol.14, pp. 1013-1016, 1992.

[13] Cavaco-Paulo A. & Gübitz G. M., Cambridge:, Textile processing with enzyme, Woodhead Publishing Ltd, ISBN 18557366101, 2003.

[14] Ciechańska D., Kazimierczak J., Fibres & Textiles in Eastern Europe, Vol.14, No 1(55), pp. 92-95, 2006.

[15] Fersht, A., Enzyme structure and mechanism, San Francisco: Brenda, W.H., The comprehensive enzyme information system, 50–2. ISBN 0-7167-1615-1 , 2007.

[16] Hartzell, M.M., Hsieh, Y-L., Enzymatic Scouring to Improve Cotton Fabric Wettability, Textile Research Journal, Vol.68(4), pp.233-241, 1998a.

[17] Hartzell, M.M., Hsieh, Y-L., Pectin-Degrading Enzymes for Scouring Cotton, In ACS Symposium Series 687 (eds. Eriksson K. and Cavaco-Paulo A.) Washington, D.C.,pp.212-227, 1998b.

[18] Kapoor, M., Beg, QK., Bhushan B., Singh, K., Dadhich, K.S., Hoondal, G.S., (2001). Production and partial purification and characterization of a thermo-alkali stable polygalacturonase from *Bacillus sp.* MG-cp-2, Process Biochemistry, Vol.36, pp.467-473.

[19] Kashyap, D.R., Vohra, P., Soni, S.K., Tewari, R., Degumming of buel (*Grewia optiva*) bast fibers by pectinolytic enzyme from Bacillus sp. DT7, Biotechnol Lett, Vol.23, pp.1297-1301, 2001.

[20] Koivula, A., Linder, M., Teeri, T.T., Structure-function Relationships in *Trichoderma* Cellulolytic enzymes, In *Trichoderma* and *Cliocladium* Vol.2 Enzymes,Biological Control and Commercial Applications (eds. Harman G.E. and Kubicek C.P.), Taylor&Francis, pp.3-23, 1998.

[21] Kulkarni, N., Shendye, A. and Rao, M, Molecular and Biotechnological Aspects of Xylanases. FEMS Microbiology Review, Vol.23, pp.411-456, 1999.

[22] Lange, N.K., Textile Chemist and Colorist, Vol.29, pp.23-26, 1997.

[23] Lewin, M., Pearce, E.M., Handbook of Fibre Chemistry, Marcell Dekker Inc., New York, 1998.

[24] Li, Y., Hardin, I.R., Treating Cotton with Cellulases and Pectinases: Effects on Cuticle and Fibre Properties, Textile Research Journal, Vol. 68(9), pp.671-679, 1998a.

[25] Li, Y., Hardin, I.R., Enzymatic Scouring of Cotton-Surfactants, Agitation, and Selection of Enzymes Textile Chemist and Colorist, Vol. 30(9), pp.23-29, 1998b.

[26] Losonczi, A., Csiszar, E. Szakacs, G. and Kaarela, D., Bleachability and Dyeing Properties of Biopretreated and Conventionally Scoured Cotton Fabrics, Textile Res. J., Vol.74(6), pp.501-508, 2004.

[27] Lu, H., Insights into Cotton Enzymatic Pretreatment. International Dyer, No.4 10-13, ISSN 0020 – 658X, 2005.

[28] Maldonado, M.C., Saad, A.M.S., Production of pectin esterase and polygalacturonase by *Aspergillus niger* in submerged and solid state systems, Journal of Industrial Microbiology and Biotechnology, Vol.20, pp.34-38, 1998.

[29] Nierstrasz, V.A., Warmoeskerken, M.M.C.G., Process Engineering and Industrial Enzyme Applications. In Textile Processsing with Enzymes (eds. Cavaco-Paulo, A., Gűbitz), Woodhead Publishing Ltd, Cambridge, England, pp.129-131, 2003.

[30] Pandey, A., Selvakumar, P., Soocol, C.R., Nigam, P., Solid state fermentation for production of industrial enzymes, Current Science, Vol.77, pp.149-162, 1999.

[31] Pawar, S.B., Shah, H.D., Andhorika, G.R., Man-Made Textiles in India, 45(4), pp.133, 2002.

[32] Rajendran R, Sundaram SK, Radhai R, Rajapriya P., Bioscouring of cotton fabrics using pectinase enzyme its optimization and comparison with conventional scouring process, Pak J Biol Sci., Vol.14(9) pp.519-25, 2011.

[33] Rossner U, Melliand Textilberichte, Vol.74, pp.144, 1993.; Li Y H and Hardin I R, Textile Chemist and Colourist, Vol.29, pp.71, 1997.

[34] Sawada, K., Tokino, S., Ueda, M. Wang, X.Y., Bioscouring of cotton with pectnase enzyme, Journal of the Society of Dyers and Colourists, Vol.114 (11), pp.333-336, 1998.

[35] Sakai, T., Sakamoto, T., Hallaert, E., Vandamme, E.J., Pectin, pectinase and protopectinase: production, properties, and applications, Advances in Applied Microbiology, Vol.39, pp.213-294, 1993.

[36] Said, S., Fonseca, M.J.V., Siessere, V., Pectinase production by *Penicillium frequentans*, World J Microbiol Biotechnol, Vol.7, pp.607-608, 1991.

[37] Sakamoto, T., Hours, R.A., Sakai, T., Purification, Characterisation and Production of Pectic Transeliminases with Protopectinase Activity from *Bacillus subtilus,*Biosci. Biotech. Biochem., Vol. 58(2), pp.353-358, 1994.

[38] Tzanov, T., Calafell, M., Guebitz, G.M. and Cavaco-Paulo, A., Bio-preparation of cotton fabrics, Enzyme and Microbial Technology, Vol.29, pp.357-362, 2001.

[39] Traore, M.K., Buschle-Diller, G., Environmentally Friendly Scouring Processes, Textile Chemist and Colorist&American Dyestuff Reporter, Vol.32(12), pp.40-43, 2000.

[40] Yachmenev, V.G., Bertoniere, N.R. and Blanchard, E.J., Effect of Sonication on cotton Preparation with Alkaline Pectinase. Textile Res. J., Vol.71(6), pp.527-533, 2001.

[41] Yamamoto, R., Buschle-Diller, G., Takagishi, T., Eco-friendly processing of cotton: application to industrial manufacturing. In: Proceedings of the American Chemical Society National Meeting, April 2001, San Diego, Calif. ACS, Washington D.C., 2001.

EXPERIENCES WITH BIOMASS ENERGY CONVERSION USING DRY FERMENTATION TECHNIQUE

Ján Gaduš[1], Jozef Bajla[1], Štefan Jančo[1], Tomáš Boďo[1]
[1]Slovak University of Agriculture in Nitra, Faculty of Engineering, Slovak Republic
e-mail: Jan.Gadus@uniag.sk

Abstract: In the paper the authors present their experiences obtained during an experiment with biomass energy conversion using dry fermentation technique. As an example they present results on the utilization of the straw cattle manure for the biogas production by the dry fermentation technology. The authors discuss weaknesses and strengths of the dry fermentation technique and compare them with the conventional – wet fermentation technique. A part of the paper is also a short description of an operational industry-scaled biogas production facility.
Key words: dry fermentation techniques, energy conversion, biogas, biomass

INTRODUCTION

Biogas facilities utilizing anaerobic digestion of wet organic substances and collecting the produced gas belong to so-called low-potential energetic sources. At the same time these technologies help also to reduce emission of damage gasses from all kinds of organic wastes.
Dry methane fermentation is an innovative anaerobic digestion technique to treat solid biomass and bio-wastes. Dry fermentation is a series of processes in which micro-organisms break down biodegradable material in the absence of oxygen. This process utilises renewable sources as a feedstock to produce a methane and carbon dioxide rich biogas suitable for energy production. The nutrient-rich solids left after digestion can be used as a fertiliser and compost. Almost any organic material can be processed with the dry fermentation. This includes biodegradable waste materials such as municipal waste, grass clippings, leftover food, sewage and animal waste. Although dry anaerobic fermentation offers great advantages like utilization of wastes in their produced forms, high organic loading rate, no liquid effluent and comparable biogas production with wet fermentation, commercial dry anaerobic digestion is scarcely used so far.

PRINCIPLES OF ANAEROBIC DIGESTION

Anaerobic digestion has been utilized by man for many years to treat sewage sludge [5]. Before anaerobic digestion, the organic material in the sludge also automatically decay due to the biological activities of the extensive existence of microorganisms in the sludge, producing offensive, odorous and reduced end products such as fatty acids, mercaptans and amines. After anaerobic digestion, the digestate consists of an odor free residue with appearance similar to peat. Methane produced by the anaerobic digestion process is a clean, carbon dioxide (CO_2) neutral and renewable energy that can be consequently used to produce heat and electricity. Further more, anaerobic digestion seems to be a very cost-effective method that makes it possible for sewage sludge to use farmland as a safe and permanent outlet destination with positive effect, i.e. the digestate, which has retained plant nutrients such as nitrogen (N) and phosphorus (P), can be recycled as fertilizer and soil conditioner back to the farmland and thus it keeps these natural nutrients recycled within a closed loop ecosystem, and remains or improves the soil structure.
Anaerobic digestion is a multiple bio-process, in which four main steps can be identified [4, 7], namely hydrolysis, acidogenisis, acetogenisis and methanogenisis, involving six major distinct processes. Proposed reaction scheme for this 4-step anaerobic digestion model of biomass adapted from [4] is presented in Fig.1. Percentages indicate substrate flow in the form of chemical oxygen demand (COD) or methane (CH_4) equivalents. Numbers in the circles identify different processes. Each step involves a specific group of microorganisms. To obtain a stable and efficient process all four reaction steps need to function, as the processes are connected.

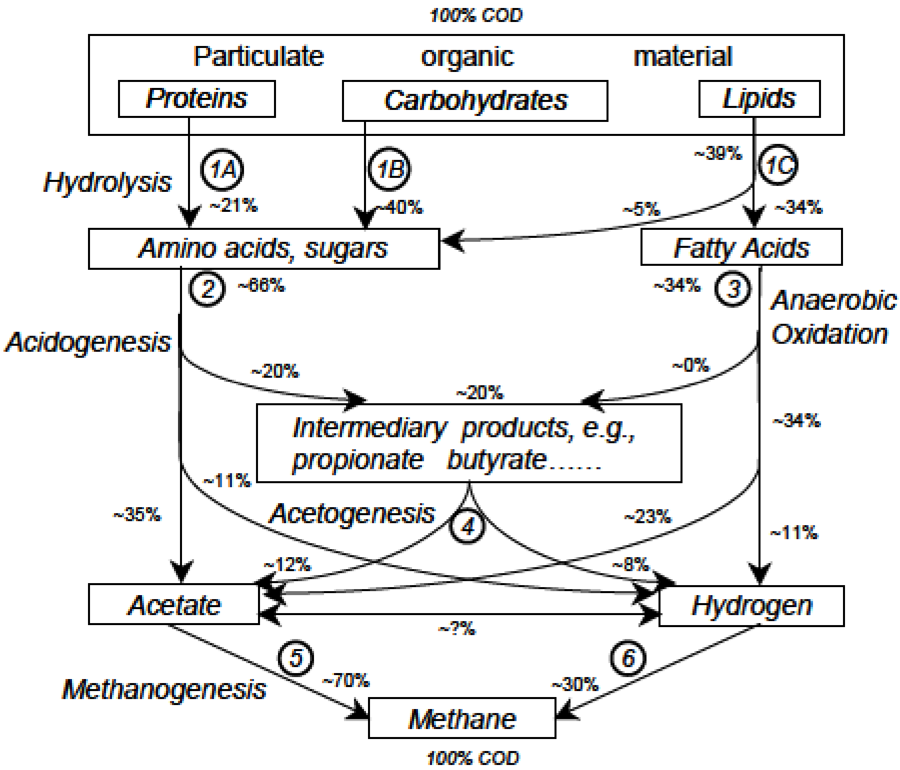


Figure 1. Scheme of the 4-step anaerobic digestion model

Total solids (*TS*), volatile solids (*VS*), total and soluble chemical oxygen demand (*COD, SCOD*) are common parameters measured in the incoming substrate at digestion facilities. If the fractions of fat, protein and carbohydrates are known, the theoretical methane yield can be determined using the Buswell formula (eq. 1) [2].

$$C_nH_aO_bN_c + \left(n - \frac{a}{4} - \frac{b}{2} + \frac{3c}{4}\right)H_2O \rightarrow \left(\frac{n}{2} - \frac{a}{8} + \frac{b}{4} + \frac{3c}{8}\right)CO_2 + \left(\frac{n}{2} + \frac{a}{8} - \frac{b}{4} - \frac{3c}{8}\right)CH_4 + cNH_3 \tag{1}$$

The methane production capacity can be expressed thus as $\left(\frac{n}{2} + \frac{a}{8} - \frac{b}{4} - \frac{3c}{8}\right)$ mole per mole organic compound $(C_nH_aO_bN_c)$. If combining the Buswell formula with the oxygen demand of the organic substance, the theoretical methane production potential per unit of COD can be determined. The oxygen demand can be expressed by equation 2.

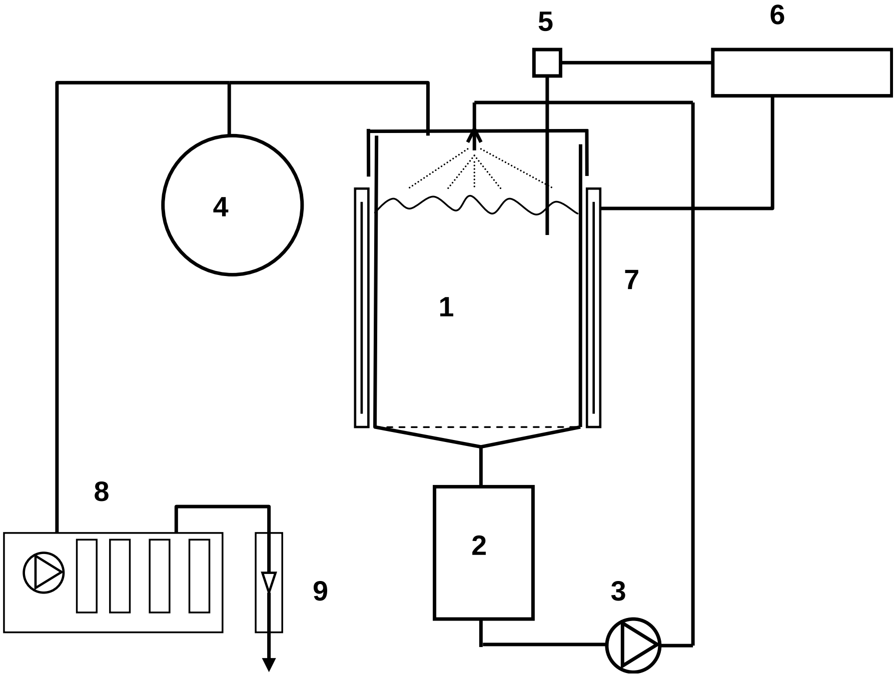
$$\left(n + \frac{a}{4} - \frac{b}{2} - \frac{3c}{4}\right) \text{mol } O_2 \text{ per mole organic substance} \tag{2}$$

MATERIAL AND METHODS

To test suitability of various biomasses for dry fermentation purposes, an experimental equipment was designed by research workers of the Research Centre for Renewable Energy Sources at the Slovak University of Agriculture in Nitra.

The objective of the experiment was to optimize the dry fermentation process by varying parameters (e.g. percolation period) to increase the biogas production and methane content, and to minimize

retention time. The influence of the process parameters was observed through an analysis of substrate, percolate, fermentation residue and biogas during the dry fermentation.
The key part of the designed experimental equipment was a cylindrical double-cup tank of 80 l volume. A general scheme of the equipment showing its main parts and the percolate and biogas flow is presented in Fig. 2.



1 – fermentor
2 – percolate tank
3 – percolate pump
4 – gasholder
5 – temperature sensor
6 – temperature controller
7 – heating of fermentor
8 – biogas analyser
9 – flowmeter

Figure 2. Scheme of the experimental equipment

Measurement of the Biogas Parameters
Measured biogas parameters were:

- CH_4 (% Vol) – methane volume percentage,
- CO_2 (% Vol) – carbon dioxide volume percentage,
- O_2 (% Vol) – oxygen volume percentage,
- H_2S (ppm) – hydrosulphide volume,
- V_{BP} ($l.d^{-1}$) – daily biogas production.

Analysis of the biogas composition was done once a day by a gas analyser MADUR. The biogas production ($l.day^{-1}$) was measured once a day, too and it was done by a laboratory flowmeter (Fig.2).
Measurement of the Substrate Parameters
The substrate parameters were determined from the percolate taken from the fermentor. There were recorded following parameters:

- pH level – measured by a pH – probe,
- substrate temperature Ts (°C) – measured by a temperature sensor integrated in the pH – probe.

A view on the configuration of the experimental equipment for dry fermentation with a flexible gas holder and measurement of the produced biogas volume and composition is presented in Fig. 3.

Figure 3. Configuration of the experimental equipment for dry fermentation

RESULTS AND DISCUSSION

The tested substrate consisted of 45 kg straw cattle manure. The experiment was carried out from 2. 2. to 15. 4. 2012, i.e. its duration was 74 days. Basic parameters of the used straw cattle manure were: dry matter content 32.52 %, pH value 7.11. Percolate for biomass wetting was taken off from the biogas plant fermentor in volume of 7 litres and its parameters were: dry matter content 4.2 %, pH value 7.4, temperature 39.5^o C. During the whole run of the experiment, mainly the biogas production (l.day^{-1}) and biogas composition were assessed (Fig. 4). To measure the biogas composition the analyser MADUR was used. More detailed record of the biogas composition changes during the experiment is presented in Fig. 5.

One of the main advantages of the dry fermentation is so-called batch way of feeding. Batch way of feeding means that the substrate is fed into the fermentor at once and then during the whole period of its stay in the fermentor it does not fill up. The biomass is only wetted by the percolate which is added from an external source at the beginning of the feeding, and during the operation it is filled up with substrate own sap. This ensures a very short start-up time of the fermentation process as it is seen in Fig. 3. The methane content reached 53.59 % already on the eighth day. Beginning from the eighth day its content was above 50 % and such values were registered even until the end of the experiment. The highest methane content, which was 68.73 %, was registered on 17th day of the experiment duration. Within the whole 74 day experiment duration there was produced 1,762.25 litres of the biogas, what meant its average production 23.81 litres per day.

As an optimal interval of the biogas production by the means of the dry fermentation technologies for the given input material, proved by the experiment results (max. production $V_{BP} \rightarrow$ max, max. methane content $CH_4 \rightarrow$ max), seems to be the period from 6th to 40th day of the fermentation process.

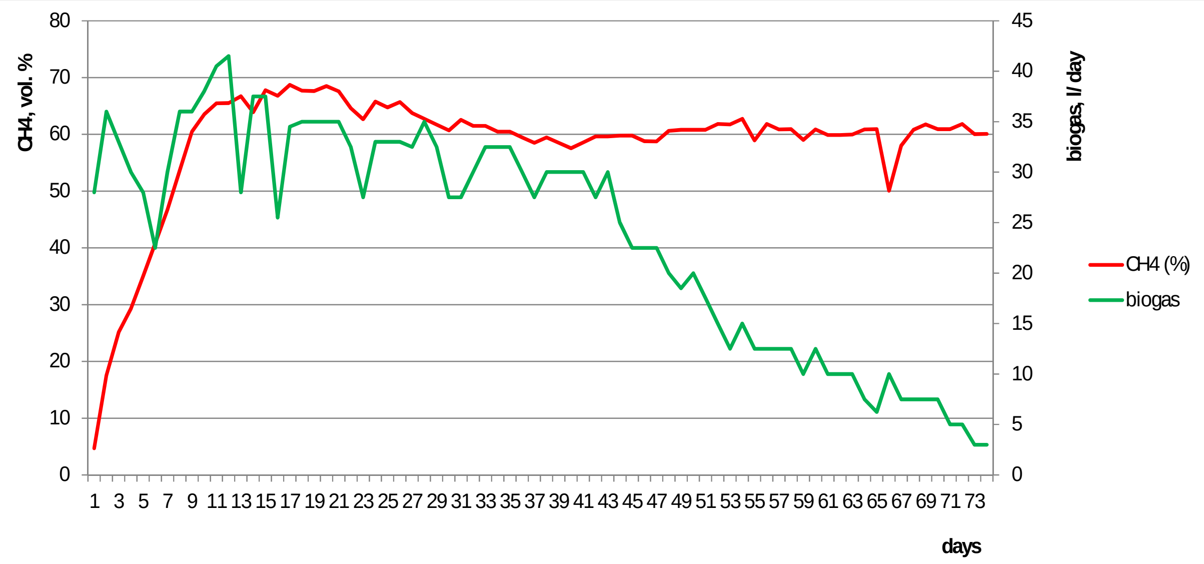


Figure 4. Values of biogas production and methane content during the fermentation process

To ensure a continuity and stability of the biogas production in the case of dry fermentation technology more fermentation tanks are necessary. These have to be filled in successive steps with time distance given by the time of the biomass stay in fermentor and by the number of the tanks/fermentors.

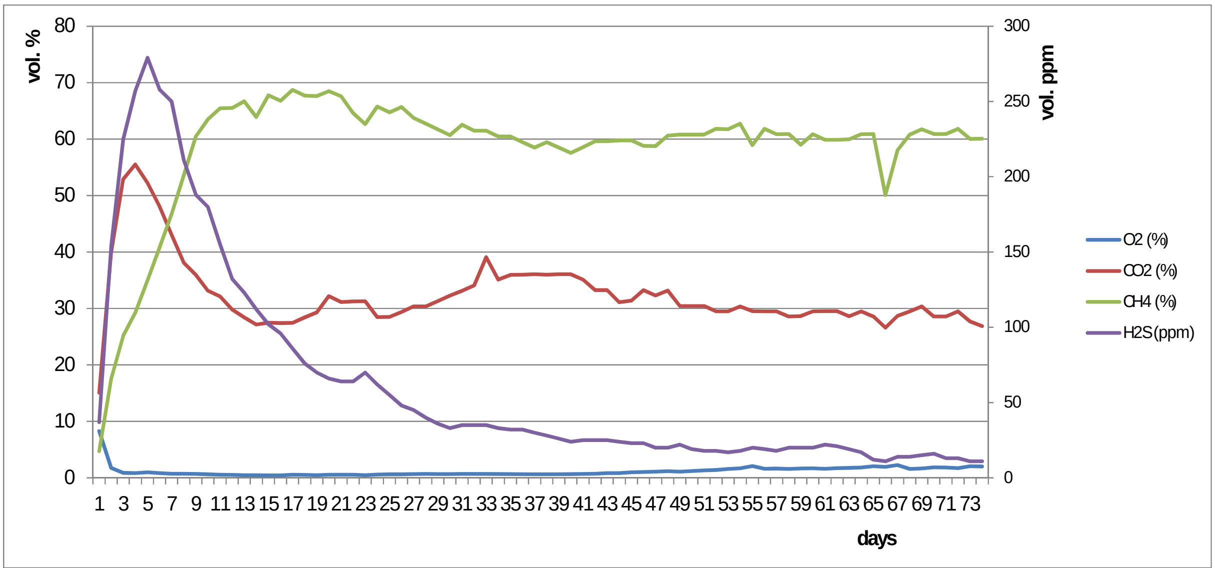


Figure 5. Oxygen, carbon dioxide and methane content in the produced biogas

Following the good experiences obtained during the experimental facility operation, the first equipment for dry fermentation in Slovakia was designed and manufactured (Fig. 6). The equipment is of a container type, inside with two fermentation boxes made from anti-corrosive steel. The boxes are isolated, closed with gasproof doors and equipped with a heating system built in the floor and wall area. Internal dimensions of a box are: 6 096 x 2 556 x 2 482 mm, what means a volume of 38,67 m^3. A common amount of the input substrate in the box (one batch) is 28 t, with the dry mater content within 25 – 35 %. The fermentation boxes are filled batch oriented once per 30 – 40 days depending on the input biological material composition. The second box is filled with a time delay 15 – 20 days. This time shift ensures certain stability of the biogas production. After the new material delivery into the box (app. ¾ of its volume) and closing the box, the material is sprayed by the percolate, which is stored in an isolated tank. This process runs automatically, in computer controlled periodical time intervals. Keeping the temperature at the level 40 ^{o}C ± 1 ^{o}C, periodical spraying by the percolate and ensuring the anaerobic environment create in the fermentor suitable conditions for the methanogenisis bacteria evolution and biogas production.

Figure 6. Dry fermentation container facility

In Europe, the anaerobic digestion of municipal solid waste (MSW) utilizes one-stage systems corresponding to 90 % of full scale plants. In these systems, the reactions take place simultaneously in a single reactor. These systems have simple designs, suffer less frequent technical failures and require smaller investment. There are several new approaches about the efficiency improvement of semi-dry anaerobic digestion and dry digestion process (20 – 35 % TS) of organic wastes. Conventional anaerobic digesters require feed material with total solids content below 10 %. Modern systems can deal with > 20 % total solids content in the feed. Anaerobic digestion in semi-dry (total solids content of 10 – 20 %) and dry conditions is considered capable of producing an inert bio-solid product with higher methane production.
Compared with wet anaerobic digestion, dry anaerobic digestion has several advantages, such as compact digester with high organic loading rate and energetically effective performance. This process also results in a lower production of leachate and easier handle of digested residues that can be further treated by composting process or be used as fertilizer.
One of the most important factors affecting anaerobic digestion of organic solid waste is temperature. Anaerobic digestions can be developed at different temperature ranges including mesophilic temperatures (approximately 35 ºC) and thermophilic temperatures ranging from 55 ºC to 60 ºC. Conventional anaerobic digestion is carried out at mesophilic temperatures (35 – 37 ºC), mainly because of the lower energy requirements and better stability of the process. Operating in the thermophilic temperature range is interesting because it may lead to faster reaction rates, higher gas production, and higher rates of the destruction of pathogens and weed seeds than the mesophilic temperature range.

CONCLUSION

Anaerobic digesters induce the processes of fermentation and anaerobic digestion and provide a mechanism for capturing the released by-product, biogas. Traditional digesters are classified as wet fermentation systems. They typically use high moisture waste streams, like manure, as input and add large amounts of liquid to facilitate movement required by this system. Dry fermentation technology uses numerous waste streams, such as municipal solid waste and industrial food processing waste. In this way it eliminates the need to mix the input material and to add any liquid components. The dry

fermentation technology has specific advantages over the wet fermentation systems in many situations and provides customers with increased flexibility and profitability.
The experiment results showed that the tested biomass – straw cattle manure is applicable as a very suitable for biogas production based on the anaerobic dry fermentation technology but to obtain more objective results and to optimize the fermentation process it is necessary to continue in these experiments and to repeat them more times.
In Slovakia due to a new law on support of renewable energy sources and highly effective combined production, adopted in June 2009, we are witness of intense building-up new conventional biogas plants. This legislation adjustment has created better conditions for investors in the field of renewable energy sources. One of the effective possibilities for agricultural companies seems to be just the utilization of the dry fermentation techniques.

ACKNOWLEDGEMENT
The paper was prepared with a financial support provided by the APVV Agency within the projects: APVV VMSP – 0063 – 09 *Využitie biomasy z obnoviteľných zdrojov na energetické účely* (Utilization of the biomass from the renewable sources for the energy purposes) and APVV SK-CZ-0099-11 *Výskum výroby bioplynu z netradičných biologicky rozložiteľných materiálov* (Research of the biogas production from unconventional biologically decomposable materials).

REFERENCES

[1] Andreas, H., I.: Untersuchung zu In- und Outputströmen bei der Restabfallvergärung und Vergleich mit der Kompostierung, diploma theses, Höxter: Universität – Gesamthochschule Paderborn, 1998.
[2] Buswell, E. G., & Neave, S. L.: Laboratory studies of sludge digestion. Illinois Division of State Water Survey , 1930, Bulletin no. 30.
[3] Dohányos, M. et al.: Anaerobní čistírenské technologie. Brno: NOEL 2000, 1998.
[4] Gujer, W., Zehnder, A. J. B.: Conversion process in anaerobic digestion. Water Science and Technology, 1983, Vol. 15, 127-167.
[5] Hamzawi, N., Kennedy, K. J., McLean, D. D.: Anaerobic digestion of co-mingled municipal solid waste and sewage sludge. Water Science and Technology, 1998, Vol. 38, No. 2, 127-132.
[6] Jandačka, J., Malcho, M.: Biomasa ako zdroj energie. Žilina: 2007.
[7] Madigan, T. M., Martinko, J. M., Parker, J.: Brock Biology of Microorganisms (10th ed), 2003, Pearson Education, Inc., Upper Saddle River, New Jersey.
[8] Mockaitis, G.: Anaerobic whey treatment by a stirred sequencing batch reactor (ASBR): effects of organic loading and supplemented alkalinity. In: Journal of Environmental Management. London, 2006, v. 79, n. 2, p. 198-206.
[9] Váňa, J.: Biomasa pro energii a technické využití. Biom.cz, 25.3.2003. In: http://biom.cz/index. shtml?x=129197.

ANALYSIS OF BIOENERGY PRODUCTION FROM MISCANTHUS GROWN ON DEGRADED AREA OF LANDFILL OF PRELIĆI, ČAČAK

Snežana Dragićević[1], Milan Plazinić[1], Goran Dimić[2], Zorica Plazinić[3]
[1]University of Kragujevac, Technical Faculty, Čačak
[2]PUC „Komunalac“, Čačak
[3]Technical School, Čačak
e-mail: snezad@tfc.kg.ac.rs

Abstract: This paper looks at the possibility of establishment of biomass production of Miscanthus grown on degraded area of Prelići landfill, Čačak, and the analysis of results obtained over the first growing period. The objective of this study was to investigate the possibility of using biomass for heating PUC 'Komunalac', Čačak where gas and electricity are currently used for the purpose. Using biomass collected from degraded areas could reduce dependence on thermal energy suppliers. Additionally, the establishment of biomass on degraded landfill areas could ensure economic and environmental benefits for the community.
Key words: biomass, Miscanthus, energy fuel

INTRODUCTION

RS Energy Development Strategy by 2015 ('Official Gazette' 35/05) promotes and encourages projects in the field of renewable energy sources (RES) so as to reduce energy dependence and promote rational use of fossil fuels. Local municipalities and their activities are very important for the application of this strategy. Having recognised the importance of reducing energy dependence, the town of Čačak has given the support to some energy efficiency projects. The Strategy of Sustainable Development of the town of Čačak is another document that helps to reduce energy dependence and is in agreement with the Biomass Action Plan. PUC 'Komunalac' Čačak, founded by the town of Čačak, have elaborated the project 'Establishment of biomass on degraded area of Prelići landfill' and the town of Čačak and Ministry of Environment have supported this project.
The idea of biomass production on degraded soils is based on the fact that the energy from these energy resources is pure energy. Providing pure energy by new technologies is realized through a zero carbon emission along with much lower sulphur dioxide and nitrogen oxide emissions.
As it is generally known, biomass is renewed faster than fossil fuels and its growth is easily controlled, though its quantities are limited. Active use of biomass residues, primarily forest resources, can damage the environment and induce landslides, soil erosion, etc. The potential for the use of biomass in our country has not been sufficiently explored, therefore it is necessary to establish biomass plantings but not to the detriment of food production acreages.
PUC 'Komunalac' Čačak has been allotted by the town of Čačak to manage the landfill of Prelići. The landfill (280,000 m^2) was initiated in 1973. The formation of the Regional Landfill 'Duboko' has provided conditions for closing down the Prelići landfill and has initiated re-cultivation of the entire surface for other purposes. The principal idea of the management board of PUC 'Komunalac' Čačak was to establish biomass production on the landfill, reduce the dependence on suppliers of fuels currently used for heating and, finally, cut down energy costs. Fuel prices are on the rise daily, the delivery is uncertain often depending on movements on the European and global markets. On the other hand, there is the consensus about the importance of active participation in environmental protection.

MATERIAL AND METHODS

Energy plantings

Energy plantings have a positive effect on environment and ecology in general as they serve as a means of rebuilding the degraded areas, re-cultivation of landfill Prelići in this particular case. Heat value of energy crops is high, ranging 15–20 MJ/kg dry weight, while heat value of lignite-coal is about 10.5 MJ/kg.

The economy of energy plantings targets to a 20-year exploitation period. The technology of establishment of these plantings is cheaper than the one used to exploit other forms of renewable energy such as waterpower plants, solar panels or wind generators. Globally, there are a number of energy crops cultivated. Characteristics of some biomass products from energy crops are given in Table 1.

Table 1. Major characteristics of biomass products originating from energy crops (TENBIORE project 2011)

Agricultural by-products	Annual average yield (t d.m./ha)	Water content at the harvesting time (%)	Theoretical energy output (GJ/ha)
Hemp	5-15	50-60	128-270
Giant reed	15-35	50-55	240-600
Miscanthus	15-25	15-20	260-440
Switchgrass	10-25	15-20	174-435
Poplar	8-20	50-60	144-360
Willow	10-15	50-60	178-276
Robinia (Black locust)	10-13	50-60	128-270

The criteria for the selection of an energy plant for planting establishment include as follows:

- Annual biomass yield;
- Moisture content at harvest time;
- Economic component of establishing and maintaining crops;
- Ecology and environmental protection.

The comparison of the given energy plants parameters and best growing practices recommend Miscanthus x giganteus as a favourable energy plant.

Planting establishment of Miscanthus x giganteus

Miscanthus x giganteus plant is a perennial, fast-growing hybrid grass that is native to Asia. It originated from the crossing of Miscanthus x Sacchariflours (diploid) and Miscanthus sinensis x (tetraploid).

Figure 1 Biomass fuel and Miscanthus Pellets (8 mm)

In its appearance, Miscanthus X giganteus resembles Johnson grass and Italian cane. However, Miscanthus reaches even up to 4 metres in height, developing vigorous foliage as well as parenchyma inside the tree which gives it strength. Plants develop from rhizomes or underground rhizomes which do not spread uncontrollably into adjacent areas. It is recommended that planting establishment be at soil temperatures lower than 10°C, i.e. April or early May, in Serbia [1]. If planting establishment is too early there is a risk of late frost damage, if planted too late, it may result in plants die back. Given low temperatures during dormancy, it is recommended that plants are planted deeper or covered with a protective layer of straw [2]. Growing period is from early April, while harvesting is in mid-February or early March the following year, as humidity is lowest over that period.

The following aspects of Miscanthus X giganteus render it an environment-friendly crop [3-5]:

- Increases soil fertility and through the root system provides uptake of water and harmful substances from the deeper areas of the soil;
- Improves morphological and microbiological soil properties;
- Being a perennial plant it allows the accumulation of plant layer;
- Its vigorous foliage provides habitat for birds and mammals not being a competitive food crop;
- has zero CO_2 emission.

It was observed that rhizomes-propagated Miscanthus X giganteus is less prone to frost damage compared to micropropagated Miscanthus x giganteus. Optimum planting density is 1 to 2 plants per m^2. Crop growth is initially slow due to low resistance to cold. Fully grown crop grows up to a 3–4 m height by the end of growing period, whereas the annual dry matter yield ranges from 10–30 t/ha, varying by agro-environmental conditions. Growing period is between the latest spring and the earliest autumn frosts [6-8].

As plants grow, the aboveground biomass is growing faster in all aspects from the third growing period onwards. Full potential of Miscanthus is achieved from second to fifth leaf, depending on climatic conditions. Typically, maximum yield is reached in the second year in the southern EU countries, and the fifth in northern ones.

Quality and quantity of biomass of Miscanthus x giganteus is closely associated with harvesting time. Late September and early November is the period of maximum biological production. Over this period, the crop has high moisture content (about 60%) therefore is not suitable for storage and use (burning bales, briquette production, etc). Additional artificial drying of biomass raises final production costs. Delayed harvesting lowers the content of moisture and unfavourable components, improves quality of biomass burning, consequently leading to aging of leaves, shedding of plant tops and yield decrease.

The European Miscanthus Productivity Network reported on yields ranging from 7.7 to 26.3 t/ha in three-year old crops [9].

With regard to storage of harvested plant material, moisture content is a very important factor. High moisture content can promote development of mildew and mould leading to spontaneous burning in storage. Analyses show that Miscanthus can be safely stored after drying down to 15% moisture in open field or in a ventilated warehouse. If complete drying in the field is not available, additional drying is needed immediately after harvesting (if moisture content exceeds 25%), or during storage (if moisture content is up to 25%), if there is ventilation. At moisture contents in excess of 25% without ventilation the risk of spontaneous self-burning of stored plant material is possible [10].

Figure 2. Current state at the planting site of Prelići landfill

Energy crops and biomass plantations have been established on several locations with different soil characteristics and altitudes for the research and promotion (Table 2).

Table 2. The list of Miscanthus trial planting sites

No	Planting site	Surface (acre)	Number of rhizomes	Altitude (m)	Planting orientation	Germination percentage (%)
1.	Prelići landfill	2	120	242	W-E	80-90*
2.	Zablaće	2	250	230	S	80
3.	Gornja Gorevnica	1	120	317	S-E	80-90
4.	Rošci 1	1	380	593	S-W	80
5.	Rošci 2	2		762	-	-
6.	Slatina	2	250	263	W	60-70
7.	Trbušani	2	250	257	S-W	80

** die back of individual plants at a plot part*

Figure 3. Miscanthus photographed on 14 June, 2012 at Gornja Gorevnica site

With regard to the facts above, the location of the Prelići landfill is of particular importance for the project. Analysis of the other locations revealed that Miscanthus should not be grown at altitudes exceeding 593 meters, e.g. at Rošci 2 site no rhizomes were successfully grown. The locations above also differ in soil characteristics therefore soil analysis on these locations was done and compared with that of Prelići landfill. The comparison of the results showed that additional fertilization to increase yields is not required on the latter. Additionally, soil analyses and theoretical data infer that Miscanthus is tolerant of a wide range of pH values, but also suggest that optimal pH ranges between 5.5 and 7.5 [11].

RESULTS AND DISCUSSION

Based on the computed lower average yields of Miscanthus in the amount of 340 t/ha for a 20-year exploitation period, the total of 600t/ha replaces 250 tons of coal and 280,000 litres of oil or 280,000 m^3 of gas for heating. In winter time, PUC 'Komunalac' Čačak uses electricity and gas for heating their business premises. The average annual consumption of gas for heating the administration building amounts to 12,000 m^3. Based on the anticipated yield of Miscanthus, it can be used as a gas substitute for a period of about 24 years. Extending Miscanthus plantings from 2 to 4 acres would ensure heat supply to all the Administration building premises where gas is used as energy, as well as to another sector of the PUC 'Komunalac' which currently uses storage heaters. The planned extending of plantations would ensure significant saving of conventional forms of energy for heating.

Planting establishment cost for research purposes and transition into the second stage of heating by processing into briquettes or pellets is 2,725 €/ha (all costs included). Expanding plantations from current 2 acres planted with Miscanthus rhizomes would be brought out of its own resources in the years to come.

Table 3. Costs of supply of material and equipment for planting Miscanthus

No	Description	Value (€) with VAT*
1.	Rhizomes supply (0.17 Eurcent/com)	2,404.35
2.	Herbicides and treatments	166.6
3.	Tools, equipment and fuel cost for watering and transport of workers	153.33
Total (per ha)		2,724.28

** 1 € =117 RSD*

The internal rate of project profitability is 20%, which implies that the project is cost effective, the rate being higher than the interest rates on the market. Refund period is 7 years. The economic component of the project, computed by dynamic criteria, shows that the project is economically viable.
Using biomass energy can provide significant energy saving because of daily rise in price. Also, lower use of fossil fuels will allow for their longer use, which is an important issue given their ever decreasing supply. In this manner, future generations would be enabled to use this energy source, which is in accordance with energy efficiency and the requirement for the proper management of energy resources.

CONCLUSION

This paper looks at possible usage of biomass aimed at reducing the dependence on energy suppliers and utilization of fossil fuels. Additionally, the objective of the paper was to investigate the ways of increasing energy efficiency and sustainable development PUC 'Komunalac' Čačak and the town of Čačak, as the founder of the Company. Using biomass provides the decrease in greenhouse gas emissions and Kyoto Protocol greenhouse gases. Results obtained and analysis of all planting establishment costs as well as projected costs for 20 year-period of crop cultivation revealed that the production of Miscanthus, as biomass energy source, is feasible and economically acceptable.
The study found that there are certain problems in the establishment of energy crops plantings in the territory of the landfill – substantial die back of plants was observed, which is the indicative of existing activities within the landfill. Similarly, severe drought during growing period does not favour plant growth. A heavy dependence on water supply was also evidenced because the landfill soil is composed of various animal, communal and industrial wastes which make it quite porous. These facts call to attention when estimating yields, as no precise conclusions can be made at this point.

REFERENCES

[1] Clifton-Brown, J.C., The iмportance of teмperature in controlling leaf growth of Miscanthus in teмperate cliмates,. Dissertation, University of Dublin, Trinity College, Dublin, 1997.
[2] Eppel-Hotz, A,, Jodl, S., Kuhn, W., Marzini, K., Münzer, W., Miscanthus: New cultivations and results of research experiмents for iмproving the establishмent rate, In: Biomass for Energy and Industry**,** Proc. 10th EU Bioenergy Conference, Wurzburg, Germany, pp. 780–783, 8-11 June 1998.
[3] Semere, T., Slater, F.M., Ground flora, small mammal and bird species diversity in miscanthus (Miscanthus × giganteus) and reed canary-grass (Phalaris arundinacea) fields, Biomass and Bioenergy, Vol. 31, No.1, pp. 20-29, 2007.
[4] Semere, T., Slater, F.M.,Invertebrate populations in miscanthus (Miscanthus×giganteus) and reed canary-grass (Phalaris arundinacea) fields, Biomass and Bioenergy, Vol. 31, No.1, pp. 30-39, 2007.

[5] Bellamy, P.E., Croxton, P.J., Heard, M.S., Hinsley, S.A., Hulмes, L., Hulмes, S., Nuttali, P., Pywell, R.F., Rothery, P., The impact of growing miscanthus for biomass on farmland bird populations, Biomass and Bioenergy, Vol. 33, No.2, pp. 191-199, 2009.
[6] Pude, R., Franken, H., Diepenbrock, W., Greef, J.M., Ursachen der Auswinterung von einjährigen Miscanthus-Beständen, Pflanzenbauwissenschaften, Vol.1, No.4, pp. 171–176, 1997.
[7] Clifton-Brown, J.C., Long, S.P., Jørgensen, U., Miscanthus productivity. In: Miscanthus — for Energy and Fibre (Eds. Jones MB and Walsh M), James & James (Science Publishers), London, ISBN 1-902916-07-7, 2001.
[8] Clifton-Brown, J.C., Neilson, B., Lewandowski, I., Jones, M.B., The мodelled productivity of Miscanthus × Giganteus (Greef Et Deu) in Ireland, Industrial Crops and Products, Vol. 12, No.2, pp. 97–109, 2000.
[9] Christian, D.G., Riche, A.B., Yates, N.E., Growth, yield and mineral content of Miscanthus × giganteus grown as a biofuel for 14 successive harvests, Industrial Crops and Products, Vol. 28, No.1, pp.320-327, 2008.
[10] El Bassam, N., Huisмann, W., Harvesting and Storage of Miscanthus. In: Miscanthus for energy and fibre (Eds MB Jones and M Walsh), James & James, London, pp. 86-108, 2001.
[11] DEFRA, Planting and growing Miscanthus. Best Practice Guidelines (for Applicants to Defra's Energy Crops Scheмe), Rural development programme, England, 2007. http://adlib.everysite.co.uk/resources/000/023/838/miscanthus-guide.pdf (online Oct 2012)

IMPROVING THE QUALITY OF LANDFILL GAS IN COGENERATION SYSTEMS

Milena Todorović, Biljana Milutinović, Dragan Pavlović, Pedja Milosavljević
University of Nis, Faculty of Mechanical Engineering, Niš, Serbia
e-mail: milenatod1@yahoo.com

Abstract: The creation of landfill gas is one of the undesirable consequences of waste disposal in landfills. The components of landfill gas: methane (CH_4) and carbon dioxide (CO_2) are the gases that cause the greenhouse effect and it is necessary to reduce their emission in the atmosphere. One way is to use landfill gas as a fuel in cogeneration systems, due to high proportion of methane in landfill gas. In this paper it is presented the current solutions that could increase the concentration of methane in landfill gas, and thus its energy value, and also the separation of carbon dioxide from landfill gas for further use. These methods will increase the amount of electricity and heat energy produced from 1 m^3 of landfill gas, as well as more efficient use of landfill gas.
Key words: landfill gas, methane, carbon dioxide, cogeneration

INTRODUCTION

The rapid technological development and population growth are the main causes for increasing generation of solid waste [6]. Regardless of the efforts that are made to reduce the amount of waste that is generated, it is still a significant amount of solid waste that is disposed at landfills every day. One of the problems that arise as a result of the solid waste disposal is the creation of the landfill gas.
Considering that the composition of landfill gas is in largest amount are methane and carbon dioxide, gases that elicit the greenhouse effect, great efforts has been made to reduce their emission in the atmosphere. These efforts go in two different directions: one is that using different treatments of the waste it can be reduced the amount of landfill gas generated at the landfill [4], and the second is to use landfill gas as an energy source [7], [12].
In this paper it is given an overview of the existing and currently used solutions where the landfill gas is used as fuel, with special emphasis on systems for cogeneration and the analysis of solution for improving this system, and also better utilization of landfill gas.

THE PROCESS OF CREATING LANDFILL GAS

Landfill gas is being produced during the natural process of bacterial decomposition of organic matter contained in municipal solid waste. Process that contribute the formation of landfill gas are bacterial decomposition, volatilization and certain chemical reactions. Since municipal waste mainly is consisted of organic waste (food, garden waste, textiles, wood and paper products), the bacteria that are present in the landfill, decompose the waste.
During the creation, landfill gas passes through four stages [14]. The composition of landfill gas is being changed during each stage of decomposition. Considering that landfill usually accept waste in the period from 20 to 30 years, at the same time different waste parts are present in the different stages. Stages through which waste is during the decomposition are following (figure 1):

- Stage I – aerobic stage;
- Stage II – anaerobic stage, non-methane;
- Stage III – anaerobic, methane, volatile, non-stable;
- Stage IV – anaerobic, methane, stable.

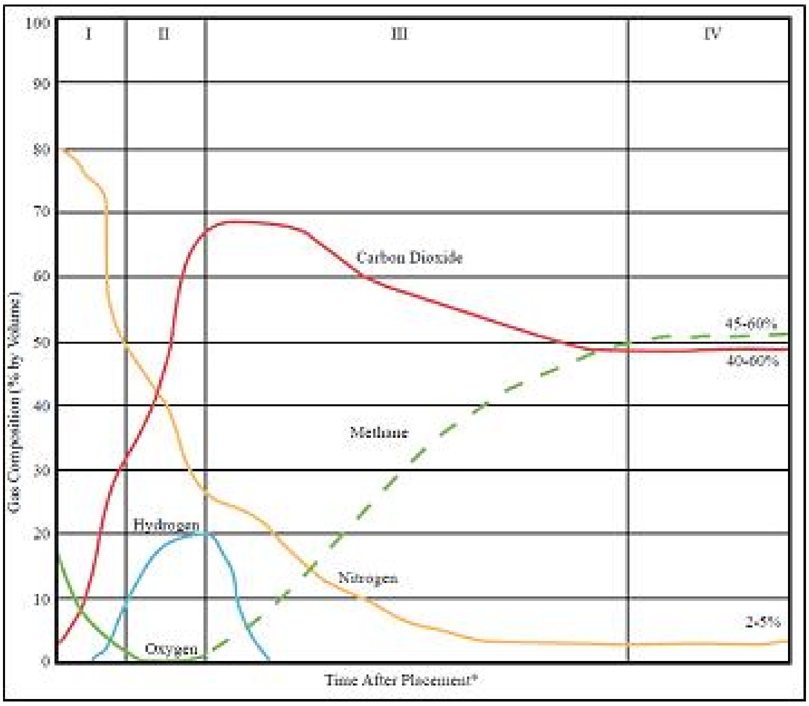


Figure 1. Stages of the creation of landfill gas, Source: EPA 1997

The landfill gas is consisted of the large number of components that are methane and carbon dioxide in the largest amount. In the table 1 it is presented a typical composition of landfill gas.

Table 1. Typical composition of landfill gas, Source: Tchobanoglous, Theisen, and Vigil 1993; EPA 1995

No.	Component	Percentage contribution (% by volume)
1.	Methane	45 – 60
2.	Carbon dioxide	40 – 60
3.	Nitrogen	2 – 5
4.	Oxygen	0,1 – 1
5.	Ammonia	0,1 – 1
6.	Non-methane organic compounds	0,01 – 0,6
7.	Sulfides	0 – 1
8.	Hydrogen	0 – 0,2
9.	Carbon monoxide	0 – 0,2

Essential data that is often used when the comparation of the plant for landfill gas utilization is being made is the degree of landfill gas extraction per tone of waste for a year (m^3/t). Exact amount extracted landfill gas is usually not known, but is estimated with different methodologies, because it depends on many factors, such as: composition and quantity of waste that is deposited, waste age, temperature, moisture content, etc. Landfill gas production generally reaches a maximum after three to eight years of waste disposal, and then declings over the years.

LANDFILL GAS UTILIZATION

The fact that landfill gas has a high energy value, which varies depending on the source within the 4,1 – 6,2 kWh/m^3 [13], led to the fact that it starts to be used for energy production [8], [5].
There are many different types of plants for landfill gas utilization. System for landfill gas utilization consists of the system for extraction and the system for utilization.
The system for landfill gas extraction consists of vertical or horizontal perforated pipes. Gas is pumped from the landfill by pump or compressor, and then is being implemented in the system for landfill gas utilization.
It been developed so far several different types of systems for landfill gas utilization for energy purposes [11], [15], [1]:
Gas engines – most common usage of landfill gas as a fuel in gas engines, which drives generator and produce electricity.
Gas boilers – Another common method is gas usage in the gas boiler to produce hot water or steam, which can be used for space heating or as process heat. If gas is used in boiler or gas engine, it is not necessary to do gas treatment, except for the removal of solid particles.
Direct use of gas – Gas is directly used in brickyards, where in their furnaces instead of natural gas, is directly used landfill gas. Second possibility of direct use of landfill gas is the production of cement.
Landfill gas as natural gas – For usage in some plants is done landfill gas purification on the level of the natural gas, which is known as methanization. As a result, the gas may be distributed through the distribution network of natural gas. In this way, it saves plant for landfill gas utilization, but it is required large investments in plants for gas treatment. This gas can be used and to drive vehicles with engines adapted for the use of natural gas.
Evaporation of seepage water – Treatment of seepage water is one of many environmental problems, when it comes to landfill operation. Evaporation of seepage water is one of the most practical direct usage of landfill gas when it is off-site disposal presented and the seepage water treatment. The basis of the evaporation system is to use landfill captured at certain location as an energy source for water evaporation and organic components combustion in seepage waters. Evaporation of seepage water can be carried out together with other systems for landfill gas utilization.
Fuel cells – Fuel cells are devices in which electricity is generated directly from chemical energy. They are very similar to batteries, but they will never be discharged until there is enough oxygen and fuel supply. Landfill gas, or hydrogen produced from gas, it can be used in fuel cells. The system has been tested in the U.S., where there are plants that produce 25 kW and 250 kW. Investment costs for such systems are still high.
Cogeneration systems – The most famous use of landfill gas is in cogeneration systems, where gas engines powers an electric generator and thus generate electricity, which also utilize waste heat resulting from the cooling of water and engine oil, and gas heat. Installations also include gas engines 350 and 1200 kW.
For power plants over 4 MW, in some cases, gas or steam turbines are used. The largest built plant has steam turbine, and its power is 45 MW [9]. In recent years, the landfill gas is used in small gas turbines (known as microturbines) is also used for power generation of 30 kW. Generally, increase in installed capacity decline specific investment costs.
For gas combustion it is used gas Otto and diesel engines. Gas Otto engine has power of 20 kW up to 8 MW. Gas diesel engines are produced to higher power. When landfill gas is used, it is used 10 to 20% of diesel fuel (in energy share).
Plants that use landfill gas began to develop in 1975 in the USA. Shortly after that in Europe has begun implementation of landfill gas for energy generation and now the number of such plants is bigger than in the USA. Today there are about 1150 plants that use landfill gas for energy production, of which are about 730 in Europe and 350 in the USA. The total capacity of all plants is nearly 3930 MW. Although the United States does not have a large number of plants, there are the largest plants built in capacity [15].
The largest plant for landfill gas utilization is in Denmark, was built on Odense landfill in 1997. Extraction system is consisted of 160 vertical wells and the network of over 25 km gas pipeline connected with 4 measuring pumps and regulation modules. Gas is over 4 km long pipeline pumped

into the cogeneration plant, which is consisted of three units of gas engine/generator. Electrical power is 900 kW each, and thermal 1.300 kW.

Another example of landfill gas utilization for generating electricity and reducing emissions of methane is located in Slovenia, at the city landfill in Ljubljana and has been achieved by building of thermal power plant with four engines that are running on landfill gas [9].

COGENERATION SYSTEM

Cogeneration is the simultaneous process and co-generation of electricity (or mechanical) and thermal energy. Depending on primary production, there is electricity (the primary electricity and secondary heat production) and industrial cogeneration, and heat cogeneration (the primary heat production and secondary electricity production). Besides them there is trigeneration where, in addition to electricity and heat, and cooling energy products. In all cases, the ultimate goal is to achieve higher efficiency of input energy (fossil and nuclear fuels, solar and geothermal energy, etc). The process of cogeneration is also known as "combined production of heat and electricity - CHP.

In the world are developed different systems for cogeneration: steam turbine engines, screw steam engines, ORC (Organic Rankine Cycle) process, Stirling engines, hot air turbines, gas engines, gas compression ignition engine, gas turbine, microturbines, etc.

Cogeneration system with gas engine

The gas engine is an internal combustion engine for fuel gases - natural gas, landfill gas. Gas engine drives a generator to produce electricity. Through the heat exchanger, the heat energy received from the water that cools the engine lubricating oil, and the exhaust gases. Cogeneration is achieved by utilization of waste heat of lubricating oil, cooling water from a cooling water circuitry in the system 60/90 º C, and the heat is used for heating and for domestic hot water. Also, the waste heat of exhaust gases have a temperature of about 500 º C, the steam boiler used in various purposes. Biogas must be initially purified from particles and hydrogen sulfide, for prevention of corrosion.

Combined use of electricity and heat is possible to achieve a high efficiency ("eta" el = 40%, "eta" term = 43%). This means that from 1 Nm3 of landfill gas (Hu = 5kWh/Nm3) gets 2 kWh of electrical energy and 2.15 kWh of thermal energy. The advantage of this system is the high electric efficiency and disadvantages are the high investment and the need for higher government incentives for electricity produced to be worthwhile investments.

Cogeneration system with gas turbine

The system consists of the following parts: compressor, combustor and turbine generator. The compressor is used to suction of ambient air and its compression. In the combustion chamber, the fuel is mixed with compressed air and burns, after which combustion products (which are on high pressure) expands in the turbine, which is coupled to a generator of electricity.

The waste heat of the combustion products in the cogeneration system can be used in the heat exchanger to heat the water which is transported to the external customer. Since the temperature of exhaust gases is very high (about 480 º C), the heat can be used for heating and boiling water for steam turbine.

Power of gas turbines is from 500 kW to 250 MW. Electrical efficiency for gas turbines ranged from 22 to 36% and heat 48 to 39%. The total efficiency is in a range of 70 to 75%, and specific value depends on the particular technological solutions and ways of utilization of thermal energy.

Specific investments in cogeneration plants with gas turbine is 600 € / kW to about 1350 € / kW. Maintenance costs for the plant are of a certain size of 0.31 to 0.70 €c / kWh. General overhaul of gas turbines is required after 25,000 to 50,000 hours of work.

The advantages of this system are: high reliability, low emissions, there is no need for cooling, high temperature of exhaust gases. The disadvantages are: the low level of efficiency at low loads, potential delays and high maintenance costs, high cost of investment, poor features in variable load.

METHODS FOR INCREASING THE QUALITY OF LANDFILL GAS

Increasing the proportion of methane in the landfill gas

Since the energy value of landfill gas is 4.1 – 6.2 kWh/m3 (14.7 – 22.32 MJ/m3) and the energy value of methane is 35 MJ/m3 [4], by increasing the proportion of methane in landfill gas increases its energy value per m^3. Generally, the amount of methane in the landfill waste depends on the percentage of moisture in the waste because the proportion of methane increases with increasing moisture [3]. Landfill gas can be treated with various technological processes in order to increase the proportion of methane. One of the treatments is with wet scrubbers, where the characteristic of carbon dioxide that can be dissolved in water is used in order to extract it from landfill gas. With this procedure the proportion of methane in landfill gas can be increased to 95 - 98% [10].

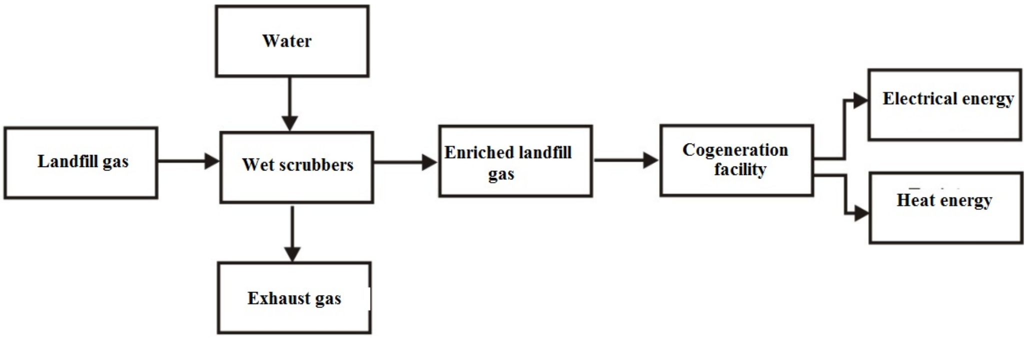


Figure 2. Cogeneration system with previously treated landfill gas

Landfill gas is first dried and then is imported into a reservoir where is compressed to the pressure of 10 - 30 bar. The reservoir water is sprayed from the top of the column at a temperature of 10 ° C, and the landfill gas at the bottom of the column is running from the tank and importing into another tank in which the pressure is 0 - 0.3 bar. The exhaust gas is discharged from the tank, and the enriched landfill gas is leaded up to the cogeneration system.

Separation of carbon dioxide from landfill gas

The components of landfill gas, methane and carbon dioxide are changing aggregate state at different temperatures and pressures. Methane becomes liquid at -160 ° C at atmospheric pressure, while carbon dioxide passes into the liquid state at -78 ° C at atmospheric pressure. This means that carbon dioxide can be extracted from landfill gas at increased pressure. Separated carbon dioxide can be removed first when the landfill gas is imported in cogeneration system and can be used for other purposes (for example in the food industry, in the welding process, the production of dry ice, etc.).

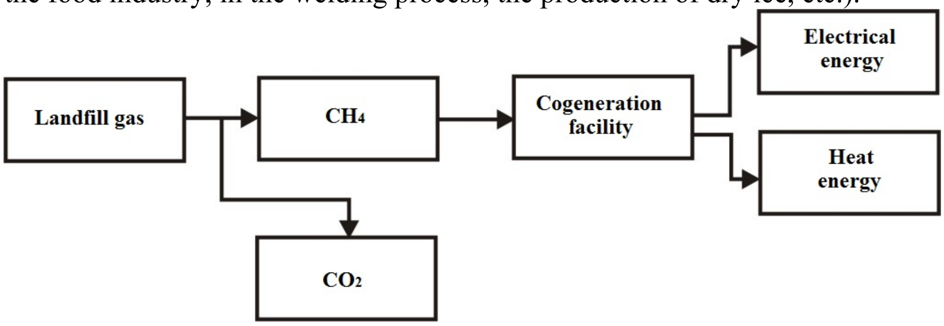


Figure 3. Cogeneration system with landfill gas with previous separation of carbon dioxide

Average investment costs per kW of installed power capacity of cogeneration systems with landfill gas [15] are given in table 2.

Table 2. Average investment costs per kW of installed power capacity

	Investment costs (€ / kWe)
System projecting	190 – 270
Extraction system	150 – 300
Collection system	150 – 230
Cogeneration system	600 – 1350
Total	1 090 – 2 150

The price of electrical energy in Serbia from renewable energy is 8.5 - 9.2 €c / kWhe [1], and the cost of heat energy, without maintenance costs and administration is 3.5 - 5 €c / kWhe [9].
Electrical efficiency for gas turbines is 22 - 36%, and the heat efficiency between 48 -39%, giving a total efficiency of 70 - 75%. From 1 m^3 of methane, depending on the type of cogeneration system may be obtained from 2.5 - 3.7 kWh of electricity and about 3.4 kWh of heat energy. [4].
If we analyze landfill with the annual disposal of 24 000 t waste, the amount of landfill gas generated ranges between 80 - 200 m3/t of waste, and the amount of methane which is generated annually is 1.92 million m^3 whose energy value is 18.816 million kWh. From this amount of methane is obtained 5.76 million kWh of electricity and 6.528 million kWh of heat energy.

TECHNO - ECONOMIC ANALYSIS

Increasing the proportion of methane in the landfill gas

Previous analysis refers to the cogeneration system which uses landfill gas where the proportion of methane ranges from 55 - 65%. If we increase the proportion of methane, by treating landfill gas in a wet scrubber where it gets gas containing methane of 95 - 98%, it is assumed that the system efficiency increased to 80 - 85%, as shown in table 3.
Table 3. Comparison of cogeneration system

	Cogeneration system with landfill gas (methane, 55 - 65%)	Cogeneration system with landfill gas (methane, 95 – 98%)
Energy value of landfill gas	15-23MJ/m^3	30-34MJ/m^3
The total electrical energy generated	5 760 000 kWh	7 526 000^e
The total electrical heat generated	6 528 000 kWh	8 467 000^e

^{e} – assumed values

Cost of facilities for the treatment of landfill gas with water, using a wet scrubber, is 15 € C/m3 of landfill gas, which in the case of the previously discussed landfill is € 288 000.

Table 4. Cost of facilities for the treatment of landfill gas with water

Cost of facility	15 €c/m^3
Cost of facilities for the considered landfill	288 000 €
Price of electrical energy	8,5 – 9,2 €c/kWhe
Price of heat energy	3,5 do 5 €c/kWht

Separation of carbon dioxide from landfill gas

The amount of carbon dioxide that is generated is from 30 - 80 m3 / t of waste, and for the considered case of the landfill annually is approximately 1.32 million m3, or 2 600 t of carbon dioxide. Investment costs for facilities of landfill gas compression and separation of carbon dioxide are 3 000 €, while labor costs range from 25 - 70 € / t of separated carbon dioxide [16].

Table 5. Costs separation of carbon dioxide from landfill gas

Amount of carbon dioxide	2 600 t
Investment costs	3 000 €
Labor costs	25 – 70 €/t carbon dioxide
Market price of carbon dioxide	15 €/t

CONCLUSION

One of the negative consequences of waste disposal is creation of landfill gas whose components, methane and carbon dioxide are greenhouse gases, so it is necessary to reduce their emissions in the atmosphere.
Reducing emissions of methane and carbon dioxide in the atmosphere can be achieved by using of landfill gas for energy purposes in order to obtain electricity and heat in cogeneration systems.
Procedures to increase the share of methane in landfill gas, as well as previous separation of carbon dioxide from landfill gas, leads to its more efficient use.
When is considered the fact that the proposed methods can increase the proportion of methane in the landfill gas, which is used in cogeneration system, at 95 - 98% and that the separated carbon dioxide can be sold, it can be concluded that the investment in equipment for the treatment of landfill gas is profitable.

REFERENCES

[1] Agency for energy Republic of Serbia, Online: http://www.aers.org.rs/
[2] Beaujardiere, C., Numbers (4-2010), Online: http://archive.cityofpaloalto.org/
[3] Bekmuradov, V., Landfill gas extraction and purification technologies, Ryerson University, Digital Commons @ Ryerson, Theses and dissertations, paper 288, 2008.
[4] Bockreis, A., Steinberg I., Influence of mechanical-biological waste pre-treatment methods on the gas formation in landfills, Waste Management, Vol. 25, pp. 337-343, 2005.
[5] Bove, R., Lunghi, P., Electric power generation from landfill gas using traditional and innovative technologies, Energy Conversion and Management, Vol. 47, pp. 1391–1401, 2006.
[6] European commission – Eurostat, Online http://ec.europa.eu/environment/waste/
[7] Gohlke, O., Efficiency of energy recovery from municipal solid waste and the resultant effect on the greenhouse gas balance, Waste Management and Research, Vol. 27, pp. 894–906, 2009.
[8] Luoranen, M., Horttanainen, M., Feasibility of energy recovery from municipal solid waste in an integrated municipal energy supply and waste management system, Waste Management and Research, Vol. 25, pp. 426–439, 2007.
[9] Provincial Secretariat for energy and mineral resources, Faculty of technical science Novi Sad, Study of possibility of using waste for energy production (waste to energy) in the territory of Vojvodina and Republic of Serbia, 2008.
[10] Rasi, S., Lantela, J., Veijanen, A., Rintala, J., Landfill gas upgrading with countercurrent water wash, Waste Management, Vol.28, pp. 1528–1534, 2008.

[11] Ritchie, S., McBean, E., Assessment of operations and design strategy controls to improve landfill gas utilization opportunities, Canadian Journal of Civil Engineering, Vol.38, pp. 519–529, 2011.
[12] Tolis, A., Rentizelas, A., Aravossis, K., Tatsiopoulos, I., Electricity and combined heat and power from municipal solid waste; theoretically optimal investment decision time and emissions trading implications, Waste Management and Research, Vol.28, No.11, pp. 985–995, 2010.
[13] US Energy Information Administration (EIA), online http://www.eia.gov/
[14] US Environmental Protection Agency (EPA), online http://www.epa.gov/
[15] Willumsen, H., Number and types of landfill gas plants worldwide, LFG Consult, Presented in the World Bank, 2004.
[16] http://www.iea.org/techno/essentials1.pdf

BMW MANUFACTURING FACILITY IN SPARTANBURG, THE ROLE MODEL OF LANDFILL GAS UTILIZATION

Biljana Milutinovic, Milena Todorović, Dragan Pavlović, Pedja Milosavljevic
University of Nis, Faculty of Mechanical Engineering, Niš, Serbia
e-mail: draganpavlovic10369@gmail.com

Abstract: Components of landfill gas: methane (CH4) and carbon dioxide (CO2) are the gases that cause the greenhouse effect and it is necessary to reduce their emission in the atmosphere. In order to reduce the emission of Landfill gas in the atmosphere many companies are starting to use this gas in their facilities. One way is to use landfill gas as a fuel in cogeneration systems, due to high proportion of methane in landfill gas. One of the largest automotive company in the world BMW started to use landfill gas in 2003 in his manufacturing plant in Spartanburg in South Carolina, USA. This paper presents an example of landfill gas utilization in cogeneration system in BMW's manufacturing plant in Spartanburg in USA and also shows environmental and economic benefits of this utilization.
Key words: Landfill gas, Cogeneration, Sustainable Energy, BMW Spartanburg

INTRODUCTION

As we move through the second decade of the 21st century, it's becoming more crucial than ever for us to think about our impact on the environment. The environment has been part of BMW's focus for years, though, as can be seen from the construction of the BMW Spartanburg plant in 1993.
The plant's design included an over 15 km long pipeline between the plant and the nearby Palmetto Landfill. This pipeline conveys recycled methane gas which provides 50% of the plant's total energy and helps reduce overall energy costs. In addition, 17,000 tons of greenhouse gases are spared from the atmosphere. In this paper will be presented Spartanburg BMW plant as role model for efficient use of recycled methane gas to save energy and reduce costs.

SUSTAINABLE BUSSINESS PRACTISE

Sustainable business practice focuses on the social responsibility and environmental contribution of business, as well as, the financial viability of the company [10]. For many years, profit maximization seemed like the only concern of the company. Time has shown that other factors such as quality, environmental protection and social responsibility may be equally important considerations for business. Sustainability is the term being used to capture this focus on multiple goals. Sustainability is often described as attention to a "triple-bottom-line"—"profits, planet, and people." [1]"Profits" refers to financial return or financial profit. "Planet" refers to environmental concerns such as pollution, resource depletion, or global warming. "People" refers to issues of social justice or equity and social responsibility. Thus sustainability, as it is being used today, refers to more than environmental protection.
According to Peter Drucker, "Every single social and global issue of our day is a business opportunity in disguise." [6]. This approach suggests "that adopting sustainable practices is not an obligation for businesses—it's a contemporary differentiator, a foundation for success. It promises to lead businesses to surprising new discoveries, stronger profits, and greater significance to society." This is another reason to be interested in sustainable business cases.

LANDFILL GAS UTILIZATION

Landfills produce landfill gas (LFG) as organic materials decompose under anaerobic (without oxygen) conditions. LFG is composed of approximately equal parts of methane (CH_4) and carbon dioxide (CO_2) with trace concentrations of other gases, including non-methane organic compounds (NMOCs). The combustibility of methane can be both an asset and a liability to a landfill owner: an asset when the gas becomes a source of energy recovered from LFG; and a liability when subsurface

migration of LFG results in accumulations of methane gas in structures, and because LFG emissions can increase the potential for the greenhouse effect. LFG can be used instead of conventional fossil fuels [2].
To create awareness and promote the use of this wasted resource, The EPA created the Landfill Methane Outreach Program (LMOP) in 1994 as a means of converting landfill methane gas into a clean-burning, cost-effective, useable energy. When landfill gas is used to generate energy, it reduces dependency on fossil fuels and NO_X emissions. It also reduces sulfur dioxide, a primary contributor to acid rain, and carbon-dioxide, a heat-trapping gas that contributes to global warming.
According to the EPA, approximately 60 percent of the solid waste generated in the United States is disposed of in more than 2,100 landfills. More than 330 of those landfills recycle the methane gas they produce to generate heat or electricity. More than 500 landfills flare or burn the gas to get rid of it [13].

The Industry's Beginnings

The LFG recovery industry started in California in the early 1970s. The first project was at the Palos Verdes Landfill in Los Angeles County, where the extracted LFG was upgraded to pipeline quality gas [5]. Several LFG-to-energy projects have been operating in California for about 15 years. From the late 1970s until the mid-1980s, LFG recovery for use as an energy source was supported by favorable energy prices, and projects were implemented in most regions of the country. From the late 1980s to the present, however, LFG developers have experienced lower energy prices, stiff competition, and additional regulation. Nevertheless, projects have continued to be implemented.

Environmental and Economic Benefits

Small landfills (less than 0.5 million tons) and old landfills generally cannot support LFG-to-energy projects. Medium sized landfills (0.5-3.0 million tons) are capable of supporting projects only in the 500 to 2,000 kilowatt (kW) range. Traditional conversion technologies (primarily internal combustion engines) in this range may not be cost-effective at current low energy prices without special pricing supports [3], [12]. They also may be difficult to permit, because they produce a significant amount of nitrogen oxides (NO_x) and carbon monoxide (CO).
Capturing the environmental and economic benefits associated with LFG resources requires conversion technologies that neutralize environmental damage associated with landfill sites, and at the same time produce salable energy at marketable prices. At present, electricity purchase prices are depressed due to excess electric capacity and the current low prices of primary fuels. Increased LFG recovery depends on low cost conversion technologies capable of producing electricity at prices that electric utilities are willing or required by regulation to pay [7].
The reduction in environmental emissions due to an energy project may eventually have a monetary value in the marketplace as an off-site emission reduction (OER) item. For example, the Massachusetts Department of Public Utilities (DPU) has required the consideration of externalities in utility decision-making since 1988. Environmental externalities are incorporated in integrated resource planning and competitive bidding. In 1992, the DPU established monetary values for emission reductions, and the Department of Environmental Protection proposed regulations regarding emission averaging, banking, and trading. The potential sale of OERs by LFG projects would help underwrite associated capital investments and operating costs, thus making such projects more economically attractive [9].

The Industry Today

Using LFG as an alternative fuel source may become more attractive to developers and investors for several reasons. Increases in fossil fuel costs, government support of LFG-to-energy projects, and costs of complying with environmental regulations all play a role. For example, landfill owners can offset a portion of the cost of complying with federal and state regulations for control of air emissions by selling the landfill byproduct, LFG. The required pollution control measure thus can improve the economics of LFG recovery [8].

BMW LANDFILL GAS UTILIZATION

In 2001, BMW Manufacturing Co., LLC initiated a project to use methane gas that is naturally generated within the Palmetto Landfill to power four onsite turbines and “cogenerate” electricity and hot water for the manufacturing plant in Spartanburg, South Carolina [11]. The Palmetto Landfill, owned and operated by Waste Management, Inc. (WMI) and located near Spartanburg, contains approximately 10 million tons of refuse. It is permitted for a total of 16 million tons of refuse. Decomposition of this refuse generates a substantial amount of gas that is composed of approximately 50% methane and 45% carbon dioxide. The other 5% is comprised of primarily nitrogen, oxygen and other trace gases. Before this project was implemented, this gas was collected and burned in flares located at the landfill in an effort to reduce odors and methane gas emissions. The gas offers a source of "green" (e.g. renewable, nonpolluting) energy that will last as long as the landfill waste continues to decompose–through 2030 and beyond.
This landfill gas project consists of collecting, cleaning, and compressing the landfill gas and then transporting it through 15 km long pipeline to the BMW plant [14]. This is the longest pipeline ever built for landfill gas, as most are between 5 and 10 km in length. In the BMW plant the gas is further compressed, filtered, and then delivered to four gas turbines. These cogeneration units produce electricity and hot water for the plant’s operations. This project is unique in that it is the first to generate electricity and recover thermal energy at an industrial site remote from the landfill itself. Construction on the landfill gas-to-energy project began in July 2002 and was completed in December 2002. It became fully operational in March 2003.
The landfill gas-to-energy project is unique in many ways. It starts with the collection and scrubbing at the landfill, which usually doesn’t take place in other landfill projects. The gas separated from the actual trash and then the excess water is taken out by dehydration system that brings the gas to a dew point level that is specified. By removing the moisture and impurities that are in landfill gas, the obtained gas has very high quality. That is very important because water in the gas can damage equipment of the plant. Another difference in this plant is that the electricity is co-generated and also the hot water. Most landfill gas projects generate just electricity at the landfill. Here the gas comes directly to the plant — to the four turbines —so every kilowatt-hour that is generated, the company don’t have to purchase. Finally, the pressures that are run are unique. Typically, other systems run between 55 to 80 kPa. In plant is compressed up to 1000 kPa.
It is said that BMW’s landfill gas-to-energy project returns profits to the bottom line, and gives the company a guaranteed supply of gas, at a guaranteed price, for the next 20 years. Another reason is that the cost of landfill gas is approximately half the cost of natural gas. It made perfect financial sense, and will result in a substantial savings to BMW on an annual basis and over the terms of the contract. It has been reported that BMW will save at least 780,000 € a year or at least 15.500 million € over the 20 year term. The instability of natural gas pricing is another factor that led to a desire for landfill gas. Natural gas traditionally costs €9.25 to €10.6 per MWh. In early 2003, natural gas prices rose to as high as € 26.3 a MWh. BMW uses, on average, 31,066 MWh per month. The most BMW will pay over its 20 years is €10.6 per MWh.

Environmental benefits

This landfill gas project was formally adopted as an environmental improvement program in 2002 as one of the requirements of BMW’s environmental management system. Using landfill gas as an alternative energy source reduced area carbon dioxide emissions by 42,000 tons in 2003, which equates to more than 149 million km driven per year by the average automobile. Furthermore, the project recovered sufficient energy to heat the equivalent of 13,500 homes per year during the same timeframe. The use of this renewable energy source provides more than 25% of BMW’s energy needs while lowering the area’s carbon-dioxide emissions and reducing its dependence on non-renewable fossil fuels. In fact, it is estimated that this project will reduce the plant’s natural gas consumption by 450 million Nm^3 over the next 20 years and by avoiding 55,000 tons of carbon dioxide emissions each year. It will result in cleaner, healthier air for everyone to breathe. This landfill gas project supports BMW’s sustainability strategy, specifically by means of conserving natural resources and minimizing environmental impact. For its efforts, BMW Manufacturing Co., LLC has won several national and state environmental awards, including the 2003 South Carolina Governor's Pollution Prevention Award, EPA's Green Power Award, and EPA's Landfill Methane Outreach Program (LMOP) Project of the Year award.

Some of the facts of the BMW Landfill-Gas-Project

- The energy provided by recycled methane gas will supply 25 percent of its energy needs.
- A 15 km pipeline was built to utilize the gas from Palmetto Landfill to BMW. The project is unique in the fact that most other landfill gas projects create energy at the landfill and send through wires.
- This landfill project is the only project that co-generates electricity and hot water for use at an industrial location remote from the landfill.
- Landfills are the largest man-made methane source in the United States. Methane is produced as trash decomposes. It is a greenhouse gas when released into the air and contributes to local smog conditions.
- BMW is able to improve local air quality by lowering regional emissions of greenhouse gases (methane and carbon dioxide).
- The landfill gas-to-energy project will reduce carbon dioxide emissions equivalent to driving 169 million km per year or more than 4,000 times around the earth.
- The landfill gas-to-energy project will recover sufficient energy to heat the equivalent of 10,000 homes per year.
- Ameresco designed, built and owns the pipeline, gas processing and gas compression facilities, as well as manages the overall operations of the project.
- Waste Management, which owns and operates the Palmetto Landfill, has been developing landfill gas-to-energy projects for more than 15 years and currently supplies landfill gas to 69 gasto-energy projects in 21 states.

PROJECT OVERVIEW TODAY

The new system, which is nearing completion, will include two new highly-efficient gas turbine generators capable of producing 11,000 kilowatts (kW) of electricity. These two new co-generation turbines will replace four older, less-efficient turbines. The new turbines have the capability to increase electrical output from 14% up to almost 30% of the plant's current electrical demand. While the new turbines double the overall electrical output using the same amount of methane gas, through electrical and hot water generation over 60% of the plant's total energy requirements continue to be provided by methane gas produced at the nearby landfill [4].

In addition to adding larger turbines and heat recovery boilers, BMW will integrate a new specialized treatment system to remove siloxanes from the methane gas (a compound common to landfill gas and potentially destructive to gas turbines). Two of the four original 1,200kW gas turbine engines will remain in place to serve as a back-up for the new system.

BMW's original landfill gas project was implemented in December of 2002 and supported by Ameresco, Inc. the original project developer, and Waste Management Inc., operator of the Palmetto Landfill located in Wellford, SC. The initial infrastructure allowed for collecting, cleaning, and compressing methane gas from the Palmetto Landfill near Spartanburg, SC, transporting it through a 15 km long pipeline to the BMW plant, compressing and then using it to power four gas turbine generators [16].

To date the landfill gas project has saved BMW an annual average of €3.89 million in energy costs and over 60% of the plant's total energy requirements are provided by landfill gas. With the addition of the new turbines, this project will return an additional average annual cost savings to BMW of up to €1.5 million and reduce carbon dioxide emissions by approximately 92,000 tons per year.

BMW CONTINUE TO BE ENVIRONMENTALLY FRIENDLY

Last year BMW Manufacturing has announced the launch of the first phase of an integrated program of work with the intent to validate the economic and technical feasibility of converting landfill gas into hydrogen. If successful, the follow-up phases of the project will provide infrastructure for using this hydrogen to fuel the company's entire fleet of material handling equipment [15].

The first phase of this million dollar, multi-phase project will be funded by SCRA (South Carolina Research Authority). A unique collaboration of partners from various government energy agencies and other public and private sponsors will work together on future phases. The project team will include BMW, Advanced Technology International (a subsidiary of SCRA), the Gas Technology Institute, Ameresco, Inc., and the South Carolina Hydrogen and Fuel Cell Alliance.

This project expands upon BMW's commitment to sustainable energy development. Since 2003, methane gas has been collected, cleaned and compressed from a local landfill and used to power more than 50% of the BMW plant's total energy requirements. In 2009, the company invested €9.34 million in its landfill gas program to further improve overall efficiency. Implementation of the program has reduced CO_2 emissions by about 92,000 tons per year and saves about €3.89 million annually in energy costs.

In September 2010, BMW completed installation of a hydrogen storage and distribution area within the existing Energy Center at its North American manufacturing plant in South Carolina. The company is using hydrogen fuel cells to power nearly 100 material handling vehicles in the plant's new 111.484 m^2 assembly facility that produces the new BMW X3 Sports Activity Vehicle. Success of this new project will allow BMW to transition from the pilot-scale system into a full-scale system capable of supporting the largest single-site deployment of fuel cell material handling equipment in the world.

"This project allows testing of valuable technology to determine if using locally-sourced hydrogen in our fuel cell equipment can provide the necessary performance needed to expand our hydrogen fuel cell fleet," said Josef Kerscher, President of BMW Manufacturing. "In the spirit of continuous improvement, we are always pursuing additional, sustainable methods of capturing renewable energy, including our existing source of landfill gas."

"This landfill gas-to-hydrogen project at BMW will seek to demonstrate a first-of-its-kind solution that will serve as a model for other private sector companies," said SCRA CEO Bill Mahoney. "Projects like these further the Knowledge Economy of South Carolina, and I am delighted to be working, together with our partners, to launch this important project on the grounds of a major South Carolina manufacturer. I am confident that this solution to combine renewably-generated hydrogen with clean, efficient fuel cell technology will improve productivity, reduce environmental pollutants and relieve electrical power demand from the grid and am optimistic that it will be replicated nationally."

In addition to using hydrogen to power material handling equipment, BMW is participating in two projects with the US Department of Energy (DOE) to develop efficient storage of hydrogen for use in future motor vehicles. Collaboration with the Lawrence Livermore National Laboratory on a project to produce and store cryo-compressed hydrogen is ongoing, as well as a DOE project to efficiently store hydrogen via a liquid organic carrier. These projects are part of a portfolio of innovative concepts that are intended to enable industry to achieve long range zero-emissions vehicles on the roads across America.

CONCLUSION

One of the negative consequences that follow the development of the industry is the increased pollution of environment. So today, one of the crucial issues for humanity is how to preserve the environment and to reduce a greenhouse effect.

There are plenty of examples of using the landfill gas in cogeneration systems and this work shows an example of the BMW plant which can serve as a role model to other companies. As can be seen 60% of the BMW's plants energy requirements are provided by landfill gas and the site has reduced carbon dioxide emissions by 92,000 tons per year. This is the good example of merging the environmental and economic benefits.

REFERENCES

[1] Bisoux, T., The Socially Responsible Cirriculum, BizEd, pp 22-30, 2008.

[2] Bockreis, A., Steinberg I., Influence of mechanical-biological waste pre-treatment methods on the gas formation in landfills, Waste Management, Vol. 25, pp. 337-343, 2005.

[3] Bove, R., Lunghi, P., Electric power generation from landfill gas using traditional and innovative technologies, Energy Conversion and Management, Vol. 47, pp. 1391–1401, 2006.

[4] Case study: BMW Manufacturing Co., 11 MW Landfill Gas CHP System, U.S. Doe Southeast Clean Energy Application Center.

[5] Comparative Analysis of Landfill Gas Utilization Technologies, SCS Engineers, Reston, Virginia, 1997.

[6] Cooperrider, D., Sustainable Innovation, BizEd, pp 32-38, 2008.

[7] Gohlke, O., Efficiency of energy recovery from municipal solid waste and the resultant effect on the greenhouse gas balance, Waste Management and Research, Vol. 27, pp. 894–906, 2009.

[8] Harbison, G., Getting the True "Green" Benefit of Renewable Fuels, Energy Engineering, Vol. 104, No. 2, pp 58-65, 2007.

[9] Luoranen, M., Horttanainen, M., Feasibility of energy recovery from municipal solid waste in an integrated municipal energy supply and waste management system, Waste Management and Research, Vol. 25, pp. 426–439, 2007.

[10] Rook, S., Sustainability: Landfill methane to energy – three south Carolina upstate projects, Palmetto Business and Economic Review, Vol. 12, pp 24-28, 2009.

[11] Stamoulakis, D., Bridwell L., BMW's approach to glabal warming and environmental management: Corporare Social Responsibility or Greenwashing, Competition Forum, Vol. 7, No.1, pp 98-106, 2009.

[12] Tolis, A., Rentizelas, A., Aravossis, K., Tatsiopoulos, I., Electricity and combined heat and power from municipal solid waste; theoretically optimal investment decision time and emissions trading implications*,* Waste Management and Research, Vol.28, No.11, pp. 985–995, 2010.

[13] http://www.epa.gov/

[14]http://www.bmwusfactory.com/news-center/press-releases/2010/bmw-charity-pro-am-presented-by-synnex-corporation-partners-with-waste-management-to-make-tourney-greener/

[15]http://www.bmwusfactory.com/news-center/press-releases/2010/bmw-manufacturing-introduces-hydrogen-fuel-cell-material-handling-equipment/

[16]http://green.autoblog.com/2009/06/11/bmw-expands-landfill-methane-electrical-generation-at-spartanbur/

SESSION 9: Reengineering and Project Management

ABILITY OF MANAGERS FOR CRISIS MANAGEMENT IN SME's

Vlado Medaković[1]
[1]University of East Sarajevo, Faculty of Mechanical Engineering, East Sarajevo
e-mail: vlado.medakovic@gmail.com

Abstract: Since the enterprise have been existing, crisis of enterprise is well-known. Researches in area of possible appearance in small and medium size enterprises, and sciense enterprise management which is crisis, have large significance when we talk about survival those enterprises, apropos possible prevention their bancrot. We can see that theory is mostly dedicated to enterprises repairing. The early symptom in sight of crisis and prevention latent crisis of enterprise are pointed up. Crisis management and analysis of strategy for turn out from the crisis, as we can see in thisis paper, expand views and enable giving certain recomendations for appliance in practice.
Key words: Small and Medium size Enterprises, Enterprising management, Crisis management

INTRODUCTION

The bankruptcy of small and medium enterprises all over the world, ranging between 50% and 60% in the first year of operation (start-up)[2]. The causes of bankruptcy are different, not the existence of the mission, vision and strategy to the poor product range, marketing, and poor organizational structure. The main reason for bankruptcy, the company's poor management, ie. management incompetence and his inability to recognize the threats facing the company in the early and transitional stage of its existence.
In theory and practice, we often encounter the dilemma of demarcation functions of entrepreneurs and managers. Of course there are differences, however, this distinction depends on the quantity of the enterprise in various companies, or by way of corporate management. In any case, it is impossible to imagine the company's operations outside of the chain (Owned - Market - Entrepreneurship - Management)[1].
Max Weber advocated the view that bureaucratic organization is an ideal type of organization. He, however, was aware of the possibility of abuse of power in the modern organization. Misuse of power may be internal, when participants are exploited or neglected or are not otherwise involved in the organization of public goods and services. Pathology of the modern business organization is struggling with one another and with the problem. As it seems these problems are based on the abuse of power.
Problems that affect the individual participante include alienation, inequality and prenormiranost or ritualism. Alienation can be defined as a subjective feeling of weakness or self-alienation or objectively as a condition under which workers are losing control over the products of their labor or the value they have created. Since the time of Adam Smith onwards, the researchers examined the consequences of organizational involvement, and in particular, the employment of individual participants - the ways and forms of employment in the organization and management efficiency.
In the Republic of Srpska and Bosnia, Serbia, Croatia segregation in employment is made on the basis of belonging to a political party or a privileged group. At the organizational level segregation of jobs in origin, or membership in a group is not just alienation but ill highly criminal society and its institutions.
All organizations providing benefits to external audiences - consumers, customers, citizens - as a condition for its continued existence. Use of this audience requirements vary according to the nature of the organization, they may include direct payments for goods or services received, indirect support in the form of taxes and normative support in the form of goodwill and legitimacy. The response to the needs of external audiences is a concern for all types of organizations, especially those that are external users and/or people connected as primary users. Since the private sector is expected to respond to economic signals - for example, the decline in business because customers are looking for better quality and lower prices. However, the decentralization of ownership and control, and encouraging managers still do not answer the wishes of customers.

THE CRISIS OF THE LIFE CYCLE COMPANY

Stage of development of small business is the most important period in the life cycle of the company, and this is the period in which the most common crisis companies, even in 60% of cases[2]. At this level of growth, the company may either continue to grow and begin to use the profits to block roads or restricting its growth. Some companies survive only during development. Usually, but not always, the development phase begins in the second year of business and takes about two years. The following scenario, shown in Fig. 1. helps to understand the life cycle of a competitive firm and a sense of each stage of the cycle.

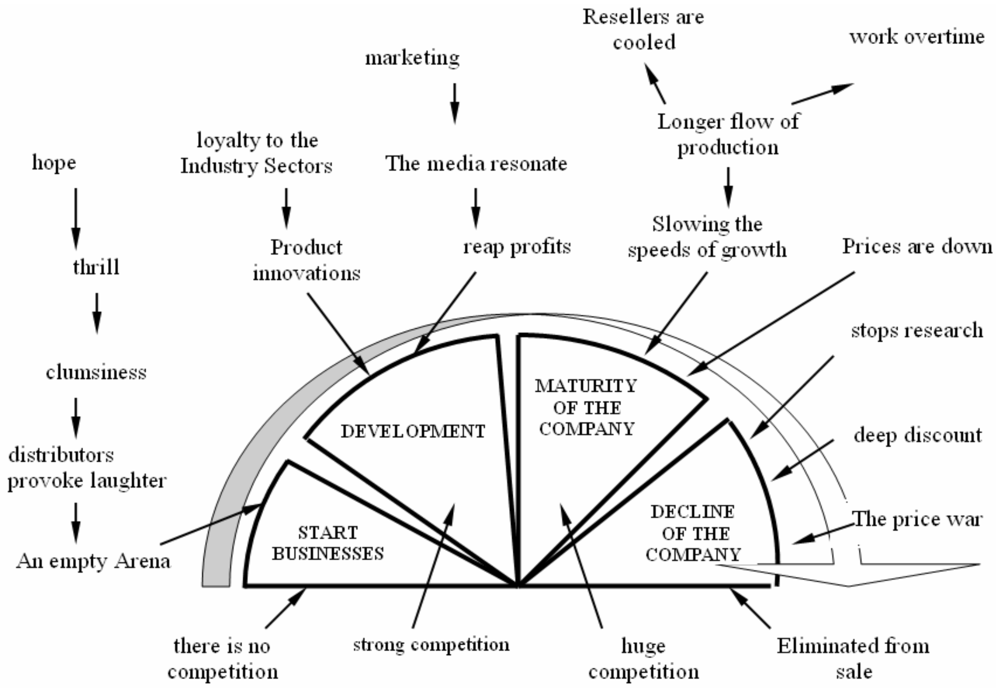


Figure 1. Crisis scenario life cycle of the company[2]

In the embryonic stage, the market is exciting, euphoric naive collision with the truth, that causes laughter, a high failure rate and a lot of negotiation. Price is experimental. The sales volume is low, because the market is very small and the production and marketing costs are high. Dealers are difficult to find, and the sellers are looking for a huge margin. Profit is a risky and speculative. Shrewd entrepreneur, however, can be approximated assess the "core markets". The competition has not yet emerged.

Growth phase was identified as product innovation, strong acceptance of products, beginning loyalty industry, the promotion that "bursting" through the media, the price is indicative. Product innovation continues. Distribution becomes all important. Resellers who were "laughing" during the initial phase now loudly complaining of product distribution. Strong competition, excited scent of money entering the market arena as find the group of target customers superior profits shows signs of growth.

Stage of maturity has been marked as the peak number of customers and generating zero modification. The design is focused on production differentiation rather than product promotion. Competitors are now blinded, they give impulse even when the speed slows shelves. Production is extended, so that firms can exploit the full advantage of capital equipment and management experience. Resellers anticipate rapid collapse, the growing cold products. Investing in advertising is growing compared to the competition. Prices are falling slowly. Any competitor who enters the market, it is now or dumb or over-confident, or both. Once the market becomes hot, it pervades the breath of depression. Decay phase is marked as extreme depression in the market. Competition is becoming desperate. Promotion disappears. Price war continues. Relentless fight for what is left of the core market. Reseller is impossible to find "they disappeared."

The crisis the company largely depends on the vested interests and political interaction between, the influence of organizational and adhokratije anarchy and chaos, and ultimately self-organization. The politicians are competing with each other in order to obtain a favorable status as an entrepreneur dynamic forces in the private sector, which searches for profitable projects by offering goods and services in a competitive market depends on supply and demand. Today we are seeing that political power has an increasing impact on small businesses and the entrepreneurs. With the support of policy and interest groups are trying to provide the best possible position and as quickly become favorites in their industry, and to provide power.

EMPIRICAL STUDIES OF CRISIS IN THE SMALL AND MEDIUM ENTERPRISES IN THE MUNICIPALITIES OF PODRINJE

Complete information about the characteristics of a set gives only statistical list. Since the census requires a lot of time to create a large cost, it is replaced by the sample, which is part of the basic set and chosen without bias, ie. objective and whose purpose is to provide a reasonably accurate information about the characteristics of the entire sample set from which it originates.
To be credible conclusions about the characteristics of the basic set, we make based on the sample, the sample should be representative, that should be their composition similar to a basic set.
The study was conducted in the Republic of Srpska, closer location from which the sample is appropriate Podrinje region or territory following municipalities of Bratunac, Srebrenica, Zvornik, Višegrad and Foča. Investigations were carried out in the business at this location, whose random sample I came up. The sample companies are: companies face - singular and partner companies, a capital company: joint stock companies and cooperatives.
Research on this topic, not only in the Podrinje region, but also in the Republic of Srpska and Bosnia and Herzegovina are very rare or not implemented at all, so it is difficult from the standpoint of patients eligible and unpopular, mainly due to fear of public presentation of certain data.
The sample is formed by 40 enterprises, which by their nature, organization, number of employees, total annual income, be representative and fully meet the requirements set out in the order of this paper.

RESULTS AND DISCUSSION

The survey covered 34 enterprises whose legal form of organization singular - a partnership firm, then we have 4 companies that are organized as a corporation and two enterprises that are organized as a agricultural cooperatives.
The number of managers is 9 women and 31 men. In order guaranteed discretion of managers, their age will not be shown here, and the age of the company is classified into several categories, as shown in Fig. 2.

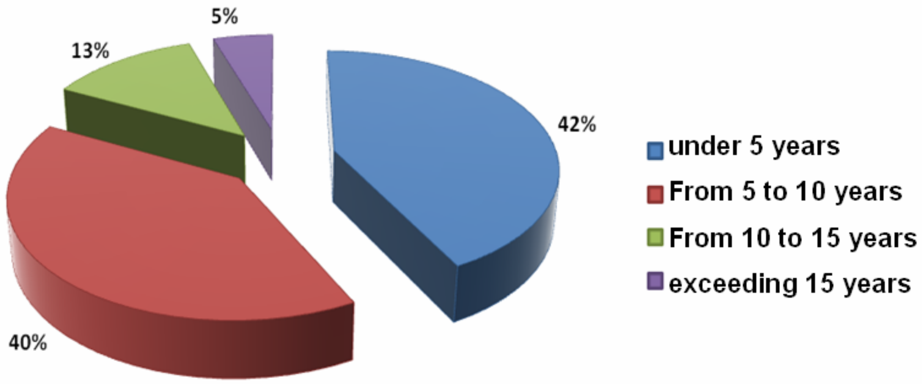


Figure 2. The age of enterprises[1]

It is obvious that small and medium-sized enterprises in the region of Podrinje fairly young, because the representation of companies under the age of 5 years 42%. Therefore subject to all the influences, both external and internal factors of instability.

Activities of companies that are the subject of the research are presented in Fig. 3.

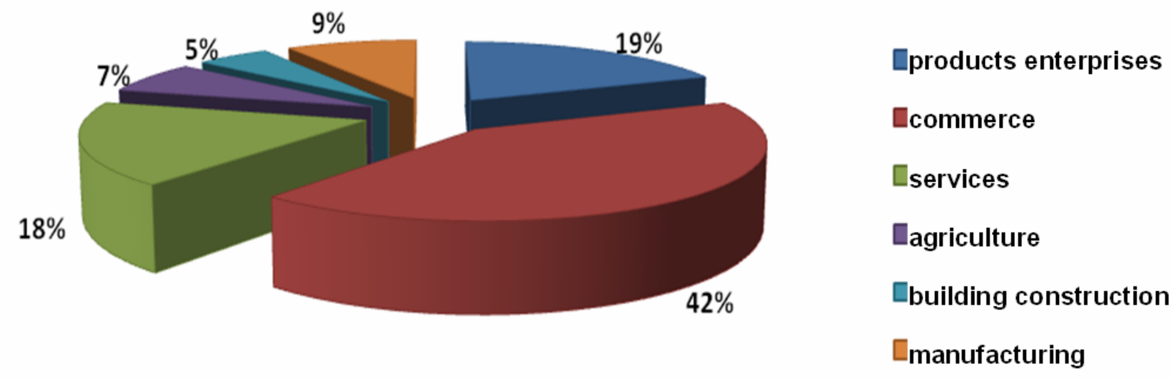


Figure 3. Activities of the company represented[1]

Generally given the third graph, conclusions can be drawn that a large number of companies engaged in commerce (42%) and that there is market saturation and competition is getting stronger, and those who want to survive have to adapt to that situation or reorient to a different activity. In the future business of the company in the field of services, or the provision of services in all areas of social, technical, educational, health, and so on., Tend to increase and the majority of small businesses will be exactly the service of character.
The survey covered enterprises employing different number of workers, as shown in Fig. 4, where one can see four intervals of number of employees and the percentage of workers employed in small and medium-sized enterprises.

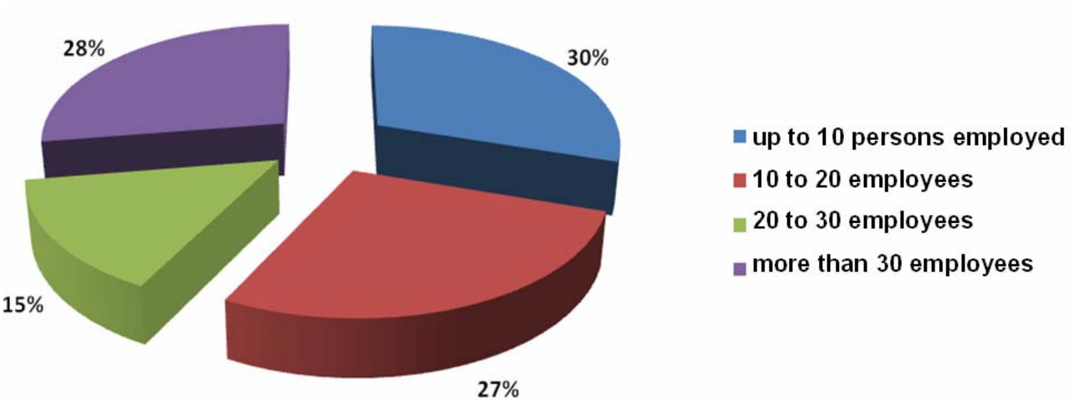


Figure 4. **N**umber of employees in small and medium-sized enterprises[1]

Based on Figure 4 it can be concluded that a substantial number of small companies, 30% employ less than ten workers, indicating that a significant number of micro enterprises participating in the small and medium-sized enterprises.
As far as managerial experience, analysis of the survey can be concluded that included managers from small and managers with extensive experience. In Fig. 5. management experience has shown that is divided into three categories, time intervals Conducting managers.

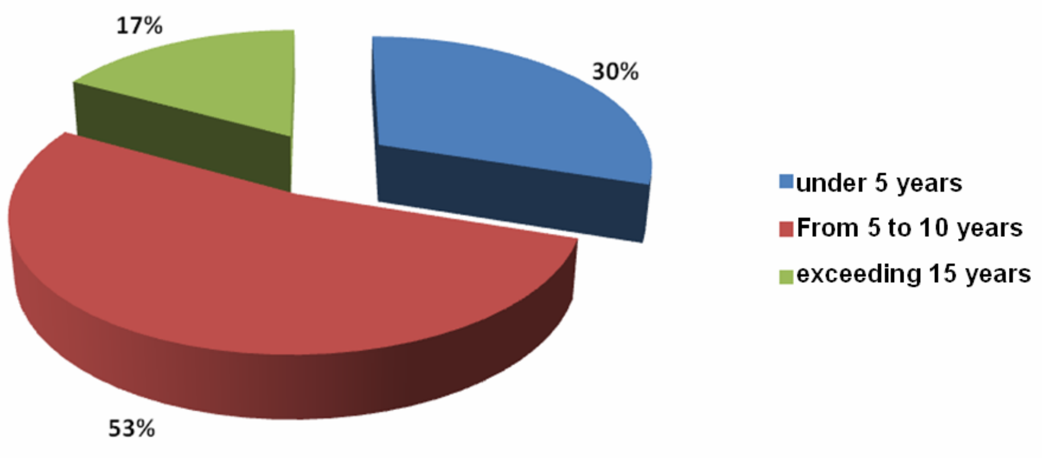


Figure 5. Years of managerial experience[1]

The percentage of 30% of managers with experience of 5 years indicates that just recently there was a rapid development of the private sector and the emergence of small and medium enterprises of different industries.
The third part of the survey effectiveness and creativity has a psychological test that is related to the effectiveness and creativity of managers.
This test demonstrates the extent to which managers have the ability to manage the crisis and which companies are the characteristics that are dominant in their personalities.
The analysis is presented Fig. 6 which displays the points depending on years of managerial experience, where we also had a manager is that the three groups. Manager with experience of 5 years, then a group of managers with experience of 5 to 15 years and a group of managers with over 15 years experience.

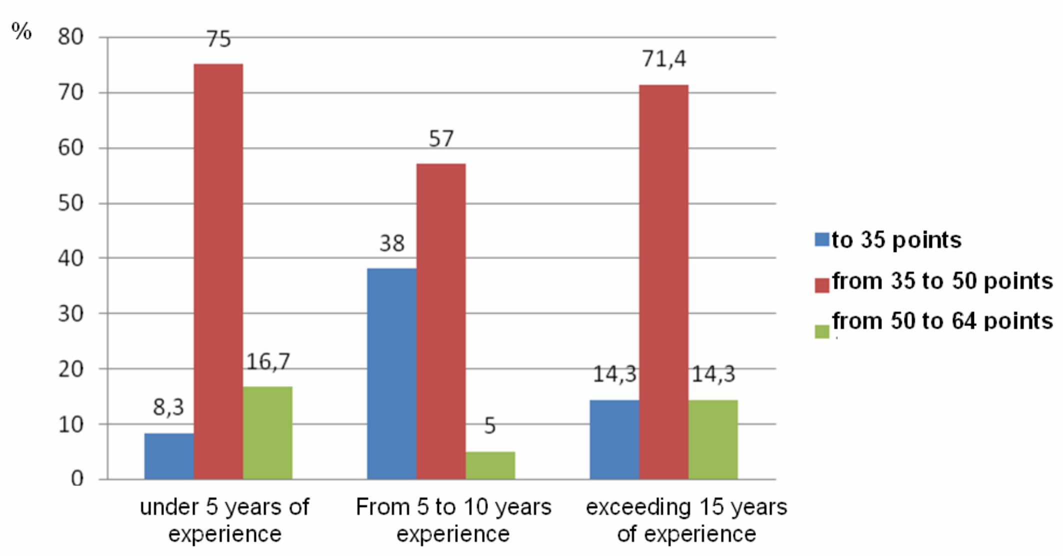


Figure 5. Procentuala ability to manage a crisis managers in small and medium-sized enterprises[1]

With Figure 5 that at first glance conclude that years of managerial experience are crucial when it comes to crisis management in small and medium-sized enterprises.
We see that in all three groups, which were formed on the basis of years of managerial experience, the number of points in the interval from 36 to 50 represented a large percentage, it gives us hope that the managers of small and medium-sized companies willing to venture enterprise management which threatens crisis or is already in crisis.

Managers with experience of 5 to 15 years are less involved in monitoring and comprehensive changes that were "put to sleep" in their work, and would for that reason you should pay more attention to innovation in leading companies.

CONCLUSION

We are aware that the environment in which companies operate is becoming more dynamic. Today we live in a time of faster, complex and unpredictable changes, all of which significantly affect the operations and management services. Response to rapid changes in the environment have become more discontinuous character, which asks managers of companies to achieve major shifts in the short term.

Empirical studies have been conducted on the territory of the Republic of Serbian shown that small and medium-sized enterprises in a number are in crisis and that the necessary use of such knowledge and skills of crisis management.

Corporate Responsibility (owners of small and medium enterprises) as well as manager of the Republic of Serbian is at a high level as well as the temptation of finding the right path out of the crisis in which we find ourselves. If we lose way and start to be afraid of new technology, new types of managers, voice of other developed countries and cultures, then inevitably remain in the vicious circle of crisis. Managers who are able to bring to the organization a passion for change and a competitive spirit can count on the future.

REFERENCES

[1] Medaković, V., Razvoj modela za upravljanje krizom u malim i srednjim preduzećima, magistarski rad, FTN Novi Sad, 2008.
[2] Jojić, R., Božić, R., Preduzetništvo za novi vijek, Srpsko Sarajevo - Priština, 1998.
[3] David, R. F., Strategic management, Fifth Edition, Prentice – Hall International, Inc., Englewood Cliff, New Yersey, 1995.
[4] Ford, D. J., The Management of Organizational Crisis, Business Horizont, May/June 1981.
[5] Senić, R., Krizni menadžment, Beograd, 1996.

BASIC ASPECTS OF LEAN CONCEPT

Kiril Kosev[1], Živan Bojić[1]
[1]NIS Petrol EOOD, Sofia, Bulgaria
e-mail: kiril.kosev@nis.eu

Abstract: LEAN concept of busines conduct is sum of methods and technics aiming to decrease a much as possible all the production activities losses, as well as all the other processes in the company.This will eventually lead to: system eficiency increase, quality improvement, decrease of expenses, wastage elimination and increase of health and safety of work environment. In order LEAN concept to have full efect, it is necessary to develop continuing development philosophy of production processes and elimination of the unnecessary expenditure. LEAN methods and technics are not comlicated, but they demand absolut devotion of all empoyees.
Goal of this paper is to show importance and advantage of LEAN philosophy by analysing LEAN concept.
Key words: Lean koncept, Lean menadžment.

INTRODUCTION

Consistency and comprehensiveness of change due to a number of factors: globalization and liberalization of the way of doing business, new technologies and technical achievements, altered and new customer needs, which all require continuous adjustment and business improvement. In changed market conditions companies are forced to conform their operations to the requirements of customers. Customer demands are crucial for the functioning of market, and market ability of the company. Striving for continuous improvement of work processes especially emphasized in Japan after World War II (with the help of American Scientists Deming, Juran and others) resulted in approaches called Kaizen, Just-In-Time and Kanban which, along with others, have become widely accepted approach in modern business enterprises toward improvement of companies called LEAN concept.
LEAN as a term is defined by two professors from MIT (Massachusetts Institute of Technology) Vomak James and Daniel Jones in 1992 in the book "The Machine that Changed the World." Writing of the book was initiated by a six-week stay in TOYOTA Plant in Japan where they had seen the buseiness miracle that was not destabilized by recession or changes in oil prices at the global level that prevailed in the 80-ies and set back almost all U.S. companies.

DEFINITION OF LEAN

LEAN is a word that comes from the English language and in our terminology is used in the field of organization and management. This word translates as: skinny, slim. "LEANNESS term can be translated as" thinness "and process flow at the necessary minimum level of all elements, or the business process that in good health reaches the predifined goal". Analogy LEAN means "slender" factory that minimizes losses during the manufacturing process, a set of methods and techniques that aim to reduce as far as possible all losses incurred during the production and all processes in the company. [1]
According to some authors, lean manufacturing and an adaptation of mass production in which the work is carried out with less time, space, labor, equipment, and significantly achievement of quality finished products. Other authors add that it is only the lean vision of what we want to achieve, and we use Kaizen in order to achieve that vision. [6]
Initially LEAN terminology was tied exclusively to manufacture. After several years of trying to introduce the concept of LEAN manufacturing processes only in the U.S. automakers, it led to the conclusion that such a thing is impossible. For LEAN to have full effect company-wide philosophy of continuous improvement of production processes and elimination unnecessary costs should be introduced. It is necessary that everyone, from top management to the workers at the plant, know the essence of Lean and are committed to its implementation. Then we are already speaking about lean enterprise, and not just about the LEAN production elements. Professor Zelenovic in our first term

"lean manufacturing", widen the term "lean economic activity," which is "a certain approach on the use of all resources at the necessary minimum, to achieve the projected quality and impact in the overall process of business in all industries and all industrial, financial, social and state structures". [1]

PRINCIPLES OF LEAN CONCEPT

The purpose of introducing the lean concept of production is to reduce unnecessary costs in all areas of production. There is a view that consumers should not pay unnecessary costs of production (workers' unnecessary activities, scrap materials, unnecessary inventory). Manufacturing companies need to constantly seek perfection, which requires radically reduced costs and improved operations. It can be achieved only if it satisfies the four principles which are shown in Table 1.[3]

Table 1. Principles of lean concept

Principles	**Characteristics**
Principle of individual value	Determined by the consumers themselves. It is necessary to apply Poterov value chain concept that looks at two groups of activities. The first group of activities includes: procurement of raw materials to finished products, distribution, marketing and servicing. The second group includes the activities: production, design and distribution..
The principle of identifying trends	Through all the activities in the production that create value
The principle of the design of flow values	Through the elimination of unnecessary costs (by reducing inventories, production stoppages, errors, and streamline manufacturing operations
Principle of pull scheduling	All activities must be conducted in accordance with the requirements of consumers (from supply through production to distribution).

Other authors as the most important principles of Lean business stress: loss of recognition, standardization of processes, continuous flow, pull system, the quality of the source and continuous improvement (striving for excellence).
Systematized overview of LEAN approach in the process of improving business processes was given by professor Zelenovic through 14 principles of automotive company TOYOTA grouped into four areas :

- **philosophy of approach** - designed on the principle of thinking in the long term and the ability to anticipate events;
- **Process approach** - developed in the process of constant discovery problem, implement the "drawing", balancing the flow, stop the process because of quality problems and the use of reliable equipment;
- **employees and partners** - respect for customers and suppliers, developing teamwork, fostering participants in the implementation of LEAN approach and help in the further advancement of education;
- **Troubleshooting -** based continuous learning process (system KAIZAN) approach and go and see, I order to help understand the situation

ADVANTAGES OF LEAN CONCEPT

The most important advantage of using LEAN concepts, according to some authors, is the applicability to the small and medium enterprises in emerging precisely structured in phases. Young and educated people are willing to adopt new ideas, because they are not burdened with traditional ways of thinking. They are able to define goals, develop tools, through the generous support of top management and the availability of information reflecting best practice. In this way, the development of the concept will be a challenge for all employees, and not a source of stress and frustration.[1] [5]
By other authors LEAN's advantage is in "directing company management mechanisms for finding out the procedures for the exercise of the projected effects of the minimum investment, including efforts to educate the collective respect for our company and its approach of work, our customers and our suppliers, and our environment / market" The diversity of application LEAN concept should be noted compared to traditional concepts and its advantage over the continued analysis of the production process in order to eliminate any unnecessary costs, which is expressed by the desire of companies (top management and employees) to be effective (Table 2).

Table 2. Differences between classic concepts and lean concepts

Elements	Traditional concepts	Lean concept
Company goals	Win over competitors	Take-over customers
Management culture	Manage the problems	Prevent problems
Priorities	Results	Results and processes
Procedures	Statical	Dynamic
Employees	Expenses and trouble	Potencial and possibilities
Machines/ equipment	Expensive, specialized	Small and highly flexibile
Problem solving	Who is to blame? Crisis	What is solution? Resource of improvement

Source: Regodić, D. I drugi (2009) „Lean production system and reaction of supply chain“, *Ingeneer management,* p. 215. From www.scribd.com

In practice, there are two kinds of perceptual management: process-oriented management and results-oriented management. It can be said that Japan is a process oriented company, while the U.S. company is results-oriented. In general, the lack of results in the U.S. and Europe, regardless of the employee's effort, lead to poorer grades and lower income and status. Individual contribution is valued only by concrete results. Manager, by definition, must be interested in the results and this is not disputed. However, if you examine the behavior of successful managers in successful companies that will lead to conclusion they are process-oriented managers.Results Lean as a concept and a process-oriented management thinking are:

- Better discipline
- Better time management
- better communication and respect between manager-employee
- Development of skills of employees
- participation and involvement of workers in new projects
- increased morale and a positive atmosphere in the company. [6]

---

[1] Trkulja, Z., (2011) *Implementation of lean concept by exelency of platform production, Operational management in function of sustanable growth of Serbia* 2011-2020., VIII Meeting of businessman and scientists

These findings have resulted in the company's competitiveness in the market and hence higher profits, which in part has to invest in growth companies, and reward the successful work of other employees in the company.

CONCLUSION

Lean manufacturing is a management method that originated in Japan in response to an increasingly demanding customers, but also to get shorter and shorter product life cycle. LEAN is a set of methods and techniques that aim to reduce as much as possible against all losses incurred during the manufacturing process and all processes in the company. This is achieved: by increase system eficiency , improving of quality, reducing of costs, eliminating waste and increasing safety in the workplace. To have full effect company-wide philosophy of continuous improvement of production processes and eliminate unnecessary costs should be adjusted, as LEAN concept is a journey, not a destination. Perfection does not exist, but it should be pursued.From previous exposure can be clearly concluded that companies that operate under the concept of LEAN have a greater chance of success and that is why we will in the future pay more attention to it, until the business without it is no longer possible.

REFERENCE

[1] Zelenović, D. (2011) Inteligent business conduct – basic technology of serious society, Prometej, Novi Sad
[2] Šingo, Š, (1995) New japanese production phylosophy, Novi Sad, Prometej
[3] Banjanin,M., Banjević, K. (2003) Filisofia Just-in Time
[4] Emiliani, R.I. (2006) Origins of lean management in America The role of Connecticut busine, Journal of Management History, Vol. 12, No 2, ppt 167.
[5] Trkulja, Z., (2011) Implementation of lean concept by exelency of platform production, Operational management in function of sustanable growth of Serbia 2011-2020., VIII Meeting of businessman and scientists
[6] Imai, M, (2008) Kaizen – Key of japanese business, Beograd, Mono i Manjana.

ROLE OF MAINTENANCE IN PRODUCT OF LIFECYCLE MANAGEMENT

Slavica Prvulović[1], Ljubiša Josimović[2], Dragiša Tolmač[1]
[1]University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
[2]Polytechnic school, Požarevac, Serbia
e-mail:prvulovicslavica@yahoo.com

Abstract : This paper presents the role and importance of maintenance from the standpoint of product lifecycle management. Also, it presented a framework for the management of activities that shows the cycles in the product life cycle. In this framework, we have identified the technical issues of maintenance and the role of perceived improvements in process technology maintenance. From this point of view, the role of maintenance redefined as the primary method for product lifecycle management.
Key words: maintenance, life cycle, product.

INTRODUCTION

In consideration of maintanence covers a wide range of activities that are implementing different technologies, technological progress has affected the maintenance of the different ways. It is well known that the maintenance is a need. However, maintanence have a negative image and sometimes regarded as a necessary evil. But, as a paradigm for progress in production towards the realization of a sustainable society, we should recognize the changing role of maintenance. To achieve this goal, product lifecycle management is becoming a key issue. In this context, the role of maintenance needs to be redefined as the primary means of managing the life cycle [9, 10, 12].
In consideration of the role of maintenance in managing the life cycle, one should know that there are close links between maintenance activities and other phases of the product life cycle, such as design, production, and end of life. These relationships create the need for the integration of technology and information throughout the entire product lifecycle by providing more efficient maintenance. A attention to maintenance could facilitate the transformation of the company from manufacturing provider's to the service provider's, with maintanence as a great service.

MATERIAL AND METHODS

Product life cycle and maintanence activities

The objective of maintenance is to preserve the condition of products so as to fulfill their required functions throughout their life cycle [7, 11]. Maintenance is executed to compensate these gaps by means of treatment or upgrading, as shown in Figure 1.

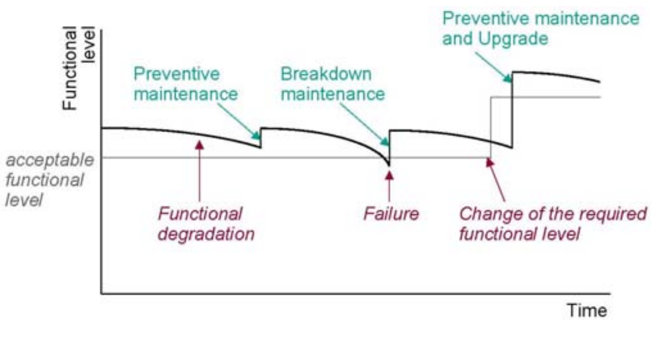


Figure 1. Maintenance activities

For this purpose, maintenance should involve the following activities:

- **Maintainability design**: improving design based on evaluating maintainability in the product development phase and providing the design data for maintenance strategy planning and maintenance task control.
- **Maintenance strategy planning**: selecting a maintenance strategy appropriate to each part of the product.
- **Maintenance task control**: planning and execution of maintenance tasks based on the chosen strategy.
- **Evaluation of maintenance results**: evaluation of the results of maintenance, it is necessary to determine whether they are suitable strategic planning for the maintenance and upkeep of the task control.
- **Improvement of maintenance and products**: improving control of maintenance task, maintenance, strategic planning, and even the design of products based on the assessment results of maintenance.
- **Dismantling planning and execution**: planning and execution of dismantling at the end of the product life cycle.

In life cycle maintenance, we have to manage the activities listed above in an effective way throughout the life cycle of the product. For this purpose the following issues should be considered.

- **Adaptation to various changes during life cycle**: during product life cycle there could be various changes in the required functions, in the operating environment, in the operating conditions and in the product itself. Maintenance management should be flexible enough to adapt to these changes, because maintenance methods depend on these factors.
- **Continuous improvement of products**: in general, it is impossible to design a perfect product. Therefore, maintenance should include a mechanism for continuous improvement of products based on the experience and knowledge acquired during the life cycle.
- **Integration of maintenance information**: for effectively manage of maintenance, all information associated with maintenance should be integrated in such a way that it is available from any phase of the life cycle.

A framework for life cycle maintanence

For fulfilling the requirements of life cycle maintenance described above, effective execution of a P-D-C-A (Plan- do- Check- Action) cycle is essential. For this purpose, the framework for life cycle maintenance shown in Figure 2 has been proposed [10]. In this framework, maintenance strategy planning plays a key role.

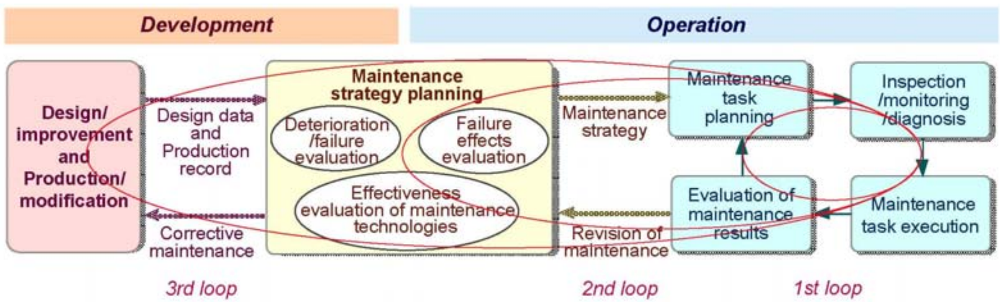


Figure 2. Framework for life cycle maintenance

This planning involves selecting the strategy of maintenance among various options, such as BM (breakdown maintenance), TBM (time- based maintenance), and CBM (condition based maintenance), based on the evaluation of potential problems which could occur during operation, as well as evaluation of failure effects and effectiveness of maintenance technologies.

Maintenance strategy planning serves as a bridge between the product development phase and the operation phase. It obtains design data and production records from the development phase, and determines the maintenance strategy for each component of the product. These strategies are passed on to the operation phase, where maintenance tasks are planned in terms of procedures and schedules based on them. After maintenance tasks, which include inspection, monitoring, diagnosis and treatment, are executed, the results are evaluated by comparing between the actual condition of the product and what is anticipated when the maintenance strategy was selected [5, 8]. If there are discrepancies, the information is fed back to the maintenance strategy planning, where the maintenance strategies are revised based on re-evaluation of potential problems taking the actual data into account. If corrective (interventive) maintenance is needed, the information is further fed back to the development phase where improvements and modifications of product design are performed.

As seen in Figure 2, there are three feedback loops. The first is the loop of maintenance task management in the operational phase, which consists of maintenance task planning, task execution and assessment of maintenance results. This is the loop for controlling routine maintenance work. The second loop includes maintenance strategy planning. By means of this loop, the maintenance strategies can be improved based on the observation of actual phenomena and knowledge accumulated during the product life cycle. The third loop includes product development. This loop is essential for continuous improvement of the product during the life cycle.

These three loops provide effective mechanisms for adapting maintenance strategies to various changes such as those in the operation conditions and environment, and also for continuously improving products.

As pointed out above, maintenance strategy planning plays a key role in life cycle maintenance management. Maintenance strategies are categorized in terms of three factors: criteria for providing treatment, opportunity of maintenance task executions, and type of treatment, as shown in Figure 3. Among these options, a maintenance strategy is selected for each component based on two kinds of evaluations: technological evaluation and managerial evaluation, as shown in Figure 4.

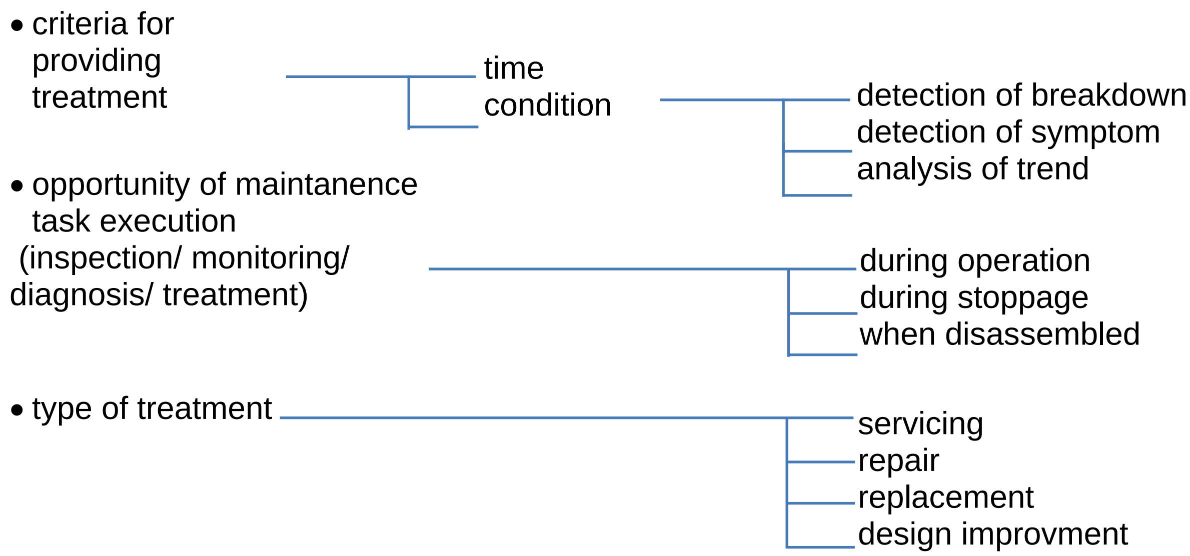


Figure 3: Categorizations of maintenance strategies.

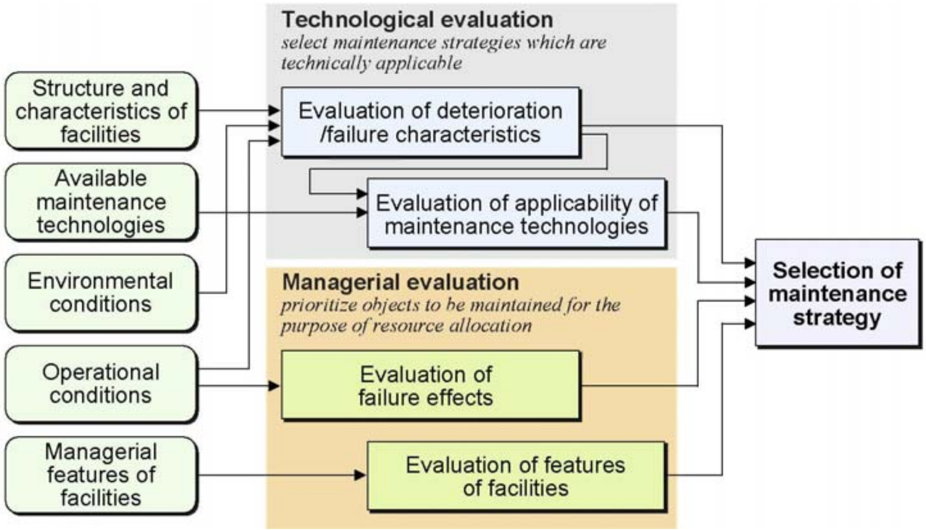


Figure 4. Factors for determining maintenance strategies

Two major factors should be considered in the technological evaluation. The first factor involves the characteristics of deterioration and the resultant functional failures, which should be analyzed in the deterioration and failure analysis. The other factor is the applicability of maintenance technologies (In this paper, deterioration refers to physical and/or chemical processes, such as wear, fatigue and corrosion that change the conditions of product components. Deterioration may induce changes in the behavior of the product.).

While technological evaluation and managerial evaluation are independent of one another, they must be integrated to obtain maintenance strategies which are consistent and effective for the system as a whole. Figure 5 shows the general procedure for this purpose. The principle underlying the procedure is to allocate maintenance resources to minimize the expectation of total loss due to potential failures of the system. Then, technically feasible strategies and effects of the failure of each component are evaluated for each component. Probability of failure depend on expectations of loss due to failure, and then of the maintenance strategy.

Maintanence task execution

Maintenance tasks are categorized into three: identification of conditions of products, which include inspection, monitoring and diagnosis; middle-of-life treatment; and end-of-life treatment. Identification of the product condition is one of the major maintenance tasks, not only for condition-based maintenance but also for diagnosis in the case of breakdown maintenance [2, 3, 6]. The purposes of the task are:

- to check product integrity
- to detect symptoms or failures
- to analyze cause of failures or symptoms
- to predict the future trend of the condition

Terms such as inspection, monitoring, diagnosis and prognosis are used to represent these activities. While inspection implies observation and understanding of current status, diagnosis and prognosis involve analysis of causality and anticipation of the progress of deterioration and functional degradation. On the other hand, monitoring implies continuous or periodic observation of the product condition for detecting symptoms or failures. In any case, the activity consists of three phases: sensing, processing, and judging.

A variety of techniques are applied to each phase. In thesensing phase, various physical and chemical parameters are observed by means of a wide range of sensing technologies. In the processing phase, when the sensory data is obtained as time series data, various signal processing techniques are applied for extracting features, which indicate the status of the product conditions [10]. Chemical analysis

techniques, such as lubrication analysis and wear particle analysis, are also used in the processing phase.
In the judging phase, the features extracted from the signal are interpreted to determine whether they indicate deterioration and/or functional degradation. In many cases, difficulties of monitoring and diagnosis come from a lack of such information. To cope with this problem, various technologies have been applied. In particular, technologies of knowledge engineering are extensively applied as promising methods, such as rule-based reasoning, modelbased reasoning, case-based reasoning, and neural networks. Many diagnostic expert systems have so far been developed based on these technologies [1, 4, 13].
However, there are still various issues to be resolved for reliably performing monitoring, diagnosis and prognosis under practical conditions.
Maintenance treatment methods vary by situation and conditions of product. Execution of treatment requires skills and knowledge. Therefore, the maintenance personnel should be provided with guidelines to improve the work efficiency. For this purpose, it consider using virtual reality and tele-service technology.
One of the means to improve the efficiency of the execution of maintenance tasks is to automate operations. To this end, they developed various types of robot maintenance.
In addition to the technologies supporting each phase of the product life cycle, we need technologies for the evaluation and management of the total life cycle. LCC (Life Cycle Costing) and LCA (Life Cycle Assessment) are the primary methods for evaluating the entire product life cycle. In many cases, maintenance centered life cycle, where product functions that are maintained for a longer period through maintenance has an advantage in life cycle cost and also in environmental impact [12].
Another important issue in life cycle maintenance management is to provide an information infrastructure in order to share product and maintenance data throughout the life cycle. This includes product life cycle data management, malfunction data collection and MP (Maintenance Prevention) data management [9].

CONCLUSION

This paper described the role of great importance in the maintenance product lifecycle management. Apart from the fact that maintanance have a negative image, because it requires additional cost and delay in machinery and equipment, and this paper describes a positive side maintenance, which refers to the fact that if the maintenance effectively implemented at each stage of the product life cycle, it can have a positive impact on the overall lifetime of the product .This fact indicates that the maintenance carried out effectively extend the lifetime of the product, which is cheaper and cost- effective of new products.

REFERENCES

[1] Chen, L., Bender, P., Renton, P., El-Wardany, T., Integrated Virtual Manufacturing Systems for Process Optimisation and Monitoring, Annals of the CIRP, vol.51/1, p. 409-412, 2002.
[2] Feldmann, K., Goeringer, J., Internet based Diagnosis of Assembly Systems, Annals of the CIRP, vol.50/1, p. 5-8, 2001.
[3] Hirschmann, J., Fault detection and diagnosis of the electromechanical drive units the automation technology, Managing Innovative Manufacturing (MiM 2002) Conference Proceedings, p. 179-181, 2002.
[4] Majstorovic, V.D., Expert Systems for Diagnosis and Maintenance: The State-of-the-Art, Research Report, No. 24/03, Mechanical Engineering Faculty, Belgrade, p. 1-21, 2003.
[5] Prvulović, S., Tolmač, D., Radovanović, Lj., Methods for validation of technical systems on PK 'Kostolac' technical diagnostic procedures, Tehnička dijagnostika, vol. 4, br. 3-4, p. 54-58, 2005.
[6] Prvulović, S., Živković, Ž. Tolmač, D., Quality products and diagnostics as the foundation of a successful company, Tehnička dijagnostika, vol. 6, br. 3, p. 27-32, 2007.
[7] Prvulović, S., Tolmač, D., Radovanović, Lj., Management application of innovative ideas and proposals in the enterprise, Tehnika - Menadžment, vol. 59, br. 1, p.13-16, 2009.

[8] Suh, J., Kumara, S.R.T., Mysore, S.P., Machinery fault diagnosis and prognosis: applications of advanced signal processing techniques, Annals of the CIRP, vol.48/1, p. 317-320, 1999.
[9] Takata, S., Hiraoka, H., Asama, H., Yamaoka, N., Saito, D., Facility Model for Life-Cycle Maintenance System, Annals of the CIRP, Vol.44/1, p.117-121, 1995.
[10] Takata, S., Life Cycle Maintenance Management, Computer-Aided Maintenance, edited by Lee, J., Wang, B., Kluwer Academic Pub., p. 209-230, 1999.
[11] Westkaemper, E., von der Osten-Sacken, D., Product Life Cycle Costing Applied to Manufacturing Systems, Annals of the CIRP, vol.47/1, p. 353-356, 1998.
[12] Westkaemper, E., von der Osten-Sacken, D., The Method of Life Cycle Costing Applied to Manufacturing Systems, Production Engineering 7, Nr. 1., p. 135-138, 2000.
[13] Zhou, Z.D., Chen, Y.P., Fuh, J.Y.H., Nee, A.Y.C., Integrated condition monitoring and fault diagnosis for modern manufacturing systems, Annals of the CIRP, vol.49/1, p. 387-390, 2000.

MANAGEMENT OF NATURAL RESOURCES AND PARADIGM OF SUSTAINABLE DEVELOPMENT

Slobodan Cvetanović[1], Igor Mladenovic[1]
[1]University of Niš, Faculty of Economics, Serbia
e-mail: slobodan.cvetanovic@eknfak.ni.ac.rs, igor.mladenovic@eknfak.ni.ac.rs

Abstract: The possibility of exhaustion of natural resources indicates one of the most pronounced challenges of the global economy long-term development. The concept of economic growth based on the neoclassical approach has manifested irreparable constructional weaknesses. In this context, analyzed question of natural resources sustainability, regardless of whether it is about the concept of weak or strong sustainability, cannot provide satisfactory answers. Insistence, at any cost, on the economic growth without taking into account the sustainability of natural resources can have many negative socioeconomic consequences. Therefore are necessary qualitative changes in the management of development in order to channel the functioning of the world's economy in a way that respects the demands of the sustainability of natural resources. On the theory plane, the answer of world's economy to the threat of unsustainable use of natural resources implies a new approach to the treatment of natural equilibrium, an approach that starts from the premise that the ultimate goal of economic activities is the quality of life improvement, and not making a profit regardless of the price paid by nature.
Key words: natural resources, weak sustainability, strong sustainability, the concept of reserves, the concept of flows.

INTRODUCTION

In recent times, economists while talking about natural resources identify this category with the expression – natural capital. (4) Although certain objections can be made regarding this approach, this paper will make no distinction between complex of natural capital and natural resources. This despite the fact that the content of natural capital consists of natural resources, renewable and non-renewable natural resources, the environment and the country as a factor of production in agriculture. (2, page) "Natural resources have multiple uses in the economy, starting with the production of the most diverse products relevant to everyday life, all the way to obtaining electricity, growing different crops, and the like. They are all over the place, but because of growing human needs, natural resources are quickly exploited. Different components of nature occur as natural resources, depending on the approached level of the technology development, economic possibilities and the viability of use, and level of exploration." (2, page).

This paper firstly elaborates the relevant knowledge of sustainable development complex as a new paradigm. There follows an analysis of the concept of funds (reserves) and concept of flows in the management of natural resources. Finally an attempt of the two approaches synthesis was made in designing the management of natural resources in the context of the key messages of sustainable development paradigm.

ABOUT THE PARADIGM OF SUSTAINABLE DEVELOPMENT

Sustainable development in short, means development that defines the current consumption in a way that does not threaten the abilities of future generations to meet their own needs (9). During the seventies of the previous century, in the debate between theorists of economic growth on the one hand, and environmental economists, on the other hand, in the epicentre was the concept of limits of growth (5). Given the limits of the use of natural resources and natural capacity to absorb waste and pollution, many researchers held the view of the inevitable reduction of production based on the massive use of natural resources.

According to the opinion of economic researchers, economic growth causes increased pollution, already these are bad market signals that occur due to negative externalities emitted by the market. Therefore, their internalization through instruments of economic policy is an important contribution to environmental compatibility and economic criteria requirements to production and trade. In the context of economic analysis, it is indicated that strong enough substitution, of environmentally-intensive, by less intensive activities, leads to the solution of problem. Complex of technological changes has potentially an important role in overcoming the scarcity of natural resources.

The models that were used to predict the limits of growth are dominantly based on the extrapolation of data concerning long-time paths, without consistent theoretical foundation. By changing the assumptions, the results are simply modified, or corrected. Therefore, in modern economic theory models that are conceptually consistent and realistic are preferred.

The concept of sustainability was originally applied in the use of forest resources. This is the result of circumstances that the commercial principles of forest management can often be in conflict with environmental goals. Although it is generally possible to internalize some of the social costs in management of forest resources, for large areas of private or public forests, market profitability is a key principle of natural resources management (8, p. 331). Forest management is sustainable if the forest fund, over time, remains undiminished in quantitative and qualitative terms.

The concept of sustainability can also be applied to other renewable natural resources. However, the problems of defining sustainability arises when the principle is applied on the total of natural resources and when their use is linked to the economic growth. Then, by its actuality, imposed are the following questions: What is the allowed substitution of certain types of natural resources? Is it possible, at the global level, to compensate the reduction in quantity and quality of a renewable natural resource, by improving the quality of other renewable natural resource? What is the allowed substitution of natural, work created capital? Can the disappearing of oil reserves, for example, be replaced by the knowledge about solar energy? Can the reduction of coal reserves be substituted by increased knowledge in the field of utilization of wind energy? What are the expectations of the future development of science and technology? And finally, what are the expected preferences of future generations?

THE CONCEPT OF FUNDS (RESERVES) IN THE MANAGEMENT OF NATURAL RESOURCES

According to the concept of funds, sustainability is achieved if the amount of natural resources, which must be precisely defined, does not diminish over time. Various arguments go in favour of applying the funds concept in management of natural resources. Firstly, this approach eliminates the problem of uncertainty and question of sustainability of natural resources work created by the production inputs. Secondly, reversibility of certain natural resources is different, often once lost critical reserve of natural resources can never again be recovered, and so on. Therefore, it is necessary to have undiminished stocks of known forms of natural resources. This, especially, because the effects of natural limits and irreversibility can significantly limit substitutability of certain forms of natural resources, regardless of their sustainability criteria. Thirdly, the effects of economy scale, due to the loss of critical size of certain types of natural resources, are not known.

In the context of the key aspects of the natural resources management consideration of questions of their sustainability with the funds concept, widely used terms are weak and strong sustainability. ***The concept of weak sustainability*** starts from the view by which certain types of natural resources are substitutes to certain extent. So, according to this concept, the structure of natural resources is not, but their own funds are important. The concept allows exhaustion of natural resources, assuming that they are compensated by investing in the development of other factors, thus providing increase of reserves of natural resources, and also providing stocks growth by work created factors. In the literature is known Hartwick's rule, which determines sustainability in terms of non-decreasing consumption of humanity over time. Under this rule, the consumption may remain constant, or increase, whilst decreasing the non-renewable resources, if the rent of such resources is reinvested in reproducible capital (9).

The concept of weak sustainability was, in a certain sense, represented by economists of neoclassical school, who treated natural resources and work created production inputs as substitutes in production. Supporters of such thinking are a kind of "technological optimists", because, implicitly and explicitly, they are of the opinion that the development of science and technology will always offer adequate substitutes after the point of exhaustion to the moment of available reserves of natural resources. In other words, this concept emphasizes the importance of the total capital for future of economic development, whilst not believing, that the question of particular kinds of capital matters. By Robert

Solow, economic development is likely to be sustained, despite the expenditure of non-renewable resources in the past, if reduced reserves of resources are compensated by increased quantity and quality of physical capital and also accumulated intellectual capital. (7, pp. 141-149) The premise, on which Solow has based this view, represents the view that preferences of future generations are unknown, and it is therefore impossible to judge about the degree of usefulness of some forms of natural resources for the future generations. So Solow believes that sustainability does not imply an obligation to leave the world exactly how it is found. The possibilities to lead a decent life should be saved.

The distinctive attitude to the concept of weak sustainability is that the entire rent from exhaustion of non-renewable resources should be allocated to the growth of generated capital funds, in order to compensate for the natural resources used. To be able to maintain a constant consumption, in terms of the growing use of non-renewable natural resources, there is a need for unlimited rate of substitution of different types of capital. Although this rule was applied by many countries when deciding on investments in various types of capital, there was no precise qualification of the funds necessary to invest, neither the relation between investments of the private sector and investments that are supposed to be the guarantor of undiminished consumption of natural resources in the future (8, p. 145). Therefore, this approach completely ignores the fact that the destruction of certain types of natural resources, which are of essential importance for the entire ecosystem, continuously questions its balance, with a number of negative repercussions that not even nearly can be eliminated by increased funds of work created capital.

It is reasonable to assume that the private owner will always make calculation that less valued natural resource substitutes more expensive resource. Also, this concept suggests that the consumption of natural resources goes to the sectors which are largest, actually sectors which based their existence largely on human capital. State intervention in the context of weak sustainability, is necessary in cases when:

- private landowners does not accept the full ecological value of natural resources,
- property rights over natural resources are not precisely regulated,
- private property owners do not take into account long-term effects (erosion of soil, for example),
- it comes to public goods,
- it is about the non-renewable resources (extinction of particular species of living organisms, limited water supplies in arid areas) (8, p.145).

The concept of strong sustainability assumes that all types of capital (physical, natural, human, and social) are primarily complementary. Therefore, it begins with the assumption that each kind of capital is necessary for social and economic development and as such is irreparable. Representatives of strong sustainability concept in the literature are often described as technologically pessimistic, since they consider the work created and natural capital as complementary in the production process. In this regard, any increase in population and consumption creates unsustainable pressure on natural resources.

The key message of strong sustainability concept is that possibilities of the substitution of different types of capital are significantly less than it is commonly thought. Therefore, development should not lead to a reduction in certain types of capital. Analogous to that fact, the reserves of natural capital must not be reduced over time (1). Sustainable development is the development that ensures sustainable yields.

Weak sustainability implies that any form of natural resources may be exhausted, if there is a possibility to replace it with other forms of capital, such as capital created by human hands. Strong sustainability of capital, however, requires that the reserves of natural capital must not be reduced. Here we must make a distinction between the requirements for the preservation of all natural resources, and the requirement for preservation of the total reserves of natural capital, which leaves room for various forms of substitution.

The application of theoretical principles of strong sustainability in practice means consideration of the two rules of use of renewable natural resources. Firstly, the rate of use should be equal to the rate of regeneration (renewal). Secondly, the loss rate emissions should be equal to the natural assimilative capacity of the ecosystem. For non-renewable natural resources, the problem is quite different. Any kind of positive rate of exploitation will lead to exhaustion of limited reserves. However, it should be noted that the effect of exhaustion of certain reserves is of no importance to the well-being, or at least not in direct relation with all the natural resources. This may mean that the utility remains constant even with the reduction of certain reserves of resources, while there are a few (very specific) resources that do not affect the utility. In many cases, the "quasi-sustainable" use of non-renewable resources can be achieved by limiting the rate of their spending onto the rate of creation of renewable substitutes.

In some areas, where are of importance irreversibility and high uncertainty, concept of reserves could be applied in the form of so-called minimum standards of the state of nature. The usefulness of such standards may be explained by the following arguments:

- with a reduction in the ecology quality, the future economic costs of production and consumption can rise sharply,
- option of intact environment value increases with income, e.g. increases the willingness for payment of the existing possibilities of enjoyment or use of the natural environment,
- reduction of the amounts of environmental damages from the current level to a certain environmental standard can bring great benefits,
- more information about the ecological damage will be available in the future.

THE CONCEPT OF FLOWS IN THE MANAGEMENT OF NATURAL RESOURCES

The exclusive concentration on the criterion of natural resources reserves is not adequate, since it does not take into account the economic dimension of the problem, especially because it ignores the intertemporal efficiency request. According anthropocentric approach to economic theory, it is about the welfare of human beings, which must be in the centre of theoretical thinking. In the context of the elementary logic of economic science, development is sustainable when the members of future generations find themselves in good or better situation than those of the present generation, as measured by individual wealth. From the anthropocentric point of view, the concept of flows is the appropriate approach to assessing the sustainability of each individual form of capital, and in this context, the sustainability of natural resources, or natural capital. However, it should be noted that the use of some forms of natural resources follows the irreversible ecological damage, as well as the express risks for the balance of the environment associated with the effects of such damages. In these situations, a further reduction in natural resources funds implicitly carries big risks, and hence the need to take good care. These funds of natural capital can be, in the analysis of sustainable development, defined as "safe" minimum standard, which should enable the achievement of goals such as long-term economic growth or sustainable growth of wealth. If, in these cases, environmental policy focused on preserving funds of natural resources, is leading to desired effects, then it is at the same time achieved sustainability in terms of the concept of flows.

Observing the wealth category, it can be concluded that the greater the number of environmental areas with uncertain and irreversible effects, it is more important to have a minimum standard in natural resources. In this sense, the concept of reserves becomes more important when the uncertainty, regarding the priorities of future generations, is seen as an important social issue. Therefore, if we take into account the specific characteristics of the natural resources, it is useful to supplement the goal of wealth non-reduction of different generations, with the requirements related to the state of the environment. Higher probability of irreversibility and more pronounced uncertainty in terms of overall damage makes the minimal standard for reserves of certain natural resources a more rational instrument of management of natural resources in the light of the requirements for achieving sustainable forms of production and consumption.

In the theory of economic growth, the concept of sustainability can be more clearly expressed by the aggregate production function and utility function. By using this analytical tool, it can be seen that the flows are not independent of funds, since they have an impact on the production and consumption possibilities. However, in exceptional cases, both concepts are leading to the same results. It may also be noted that the concept of flows corresponds to the concept only under the assumption that it is possible to find an adequate measure of the total capital.

In the theory plane, the analysis of the sustainability of natural resources, by using the concept of funds, is predominantly based on Valrasian model of economic equilibrium. It is quite clear that the implementation of this model in the analysis of the sustainability of natural resources has no significance without modifications, which question its essence. In short, the concept of sustainability is assuming changeability of consumer preferences and intense technological change on the supply side. Therefore, the effective management of natural resources must take into account the corrections, both market inefficiency and ineffectiveness of the state, which are caused by external effects, overflow effect, the results of "imperfect" state decisions, ignorance, uncertainty, reluctance to take over the risk.

Basically, there are two different types of external effects that are important for long-term growth of wealth: positive externalities which, by the new growth theory, have a positive effect on the long-term accumulation, and negative externalities, that lead towards expression of a number of ecological imbalances in production and consumption. Questions of limitations of renewable and non-renewable natural resources in the production and consumption only complicate the treatment of sustainability in the management of natural resources.

Sustainability determined in terms of a requirement that the wealth of individuals is not reduced in the long term can only be analyzed by using the concept of flows. The three-dimensional concept of sustainable development that includes the achievement of economic, social and environmental objectives, among other things, implies the existence of an appropriate institutional framework.

In neoclassical models of economic growth emphasized is the importance of the rate of growth of income and consumption. Conclusions of different models points to the wealth, or to the optimal solutions for consumption and growth. Now, however, even the variables that are related to the ecology must be added to theory. Practically, this means that the quality of the environment, i.e. the exploitation of natural resources, must be included in the utility function which expresses the wealth.

SYNTHESIS OF THE CONCEPT OF FUNDS AND FLOWS IN THE MANAGEMENT OF NATURAL RESOURCES

The standard notion of category development concerns raising the total production and consumption per capita and also covers aspects such as environmental quality, income distribution, and so on. Thus, the utility function now includes not only the possibilities of consumption but also quality of environment. In a dynamic sense, the ultimate goal of sustainable growth normative theory is long-term development of broadly defined individual uses. However, due to the simplifications in the constitution of the growth model, only a relatively small number of variables can be taken into account in every new model. This corresponds to the methodology of economics; there is no need to analyze all aspects of the development at once (ceteris paribus clause).

Modern economic activities must not jeopardize the resilience of natural environment and its capacity for regeneration. Therefore, the question of the sustainability of natural resources, need to be perceived in the context of providing equal opportunities for present and future generations. Although the negative repercussions of resources degradation are manifested in global relations, we believe that its key causes are in the fact that the global economy functions at the national level.

There are three different paths of growth that characterize the long-term development. The first is the production that is achieved when all the sizes and prices in the economy are determined in the free market, regardless of the externalities. Such result is marked as a solution of "private optimum." Models of the free market are calculated with economic growth that has been achieved without adjustments by the state in terms of negative externalities in the field of ecology.

If, with instruments and measures of economic policy are corrected positive and negative externalities, the optimal path of growth could be obtained. Here the epithet "optimal" means maximizing the utility of the present generation. This model is called the decision of "social optimum". The difference between private and social optimal path of growth occurs due to the existence of externalities. In expression of economic inefficiency, this difference causes a loss in the social richness of the present generation. Practically, the externalities lead to wealth growth rate that is lower than the optimal growth rate.

Sustainable growth path are characterized by undiminished wealth over the long term, which corresponds to the aspect of intergenerational distribution. However, private and social paths of optimal growth can be both sustainable and unsustainable. The first option refers to the case when both the private and social optimal paths are of sustainable growth, i.e. located in the area of sustainable growth. Internalization of external effects leads to a greater increase in wealth over the long term, which by itself is a desirable goal. In another variant, the private optimal path is in the area of unsustainable growth. With internalisation of external effects and by valuation of externalities according to the priorities of the present generation, the sustainability is already achieved. This means that environmental policy, which is created for the current generation, carries, at the same time, the development which is suitable for future generations. The most unfavourable case is a third option, where none of the paths is not in the area of sustainable growth, i.e. even the path of the social optimum does not meet the requirements of sustainability. Here is not enough just to make a correction of externalities, but much more stringent measures are needed in order to achieve sustainable development.

Determining factors of sustainability in the context of growth theory refer to the negative externalities in the field of ecology, and to the use of renewable and non-renewable natural resources. With the help of these additional elements, different growth paths can be analyzed more thoroughly. Optimal paths of growth are unsustainable if, for example, in the long-term, use of natural resources can be replaced by other factors of development, but during the time available natural resources are available in smaller and smaller quantities. Also possible is a situation whereby certain forms of natural resources, which are important for the production, are naturally renewable but are excessively used by the current generation. In this case, unsustainable development is also likely.

In discussions about the sustainability of natural resources, often can be heard opinion that, because of the "fairness" of the current generation, social decisions should ensure equal treatment in the coming generations. This, however, does not automatically mean dedication that the state should compensate myopia of individuals with discount rate correction. Things are not so simple. Lowering the discount rate has, in some cases, undesirable effects, while in other cases that is simply not necessary for the sustainability of natural resources. The low or zero discount rate can lead to a high rate of investment that current generations cannot stand. Also, a low discount rate, with reduction of natural resources and increasing pollution, does damage to future generations, assuming that the accumulation of total capital has the pollution effect which is not internalized. From a macroeconomic point of view, it is not possible to have a real insight into the well-being of future generations, based on the needs of the present generation. You cannot have a correct assessment of discounting validity of future well-being if we do not know anything specific about the possible paths of economic growth.

Neoclassical school economists assume a high degree of natural resources substitution by other factors of production. They directly compare the material benefits of growth with the costs of the environment. However, gross domestic product that economists use to measure the performance of the economy is not a good indicator of measuring sustainability. For that reason in recent years as a measure of sustainability appears the index of net national welfare for which, however, there is still no uniquely accepted methodology for its calculation. Simply put, the net national welfare could be defined as the total annual production of market and nonmarket goods, less the total costs of externalities associated with these products and amortization of capital used in production (all types of capital). At the same, economists approximately estimate amortization as the resources rent. However, this concept raises many discussions, particularly relating to the use of natural resources and in particular the problem of discounting.

Standard theory of economic growth does not question the limits of growth production. Conversely, the concept of sustainability indicates the imperative of keeping account of the macroeconomic scale. Instead to calculate with dynamic growth rates in the future, these rates are now observed through the prism of environmental load (of country, region and ultimately the world as a whole) (3).

The issue of natural resources sustainability, although is not new, it was only in recent decades that began to arise more attention by economic theorists. The problem of pollution of the environment began to manifest with the expansion of industrial production. Almost all of the traditional, classic industries have appeared, and now appear as major polluters of the environment. Many technological solutions, which are accepted as economically expedient and technically feasible today, are put under the spotlight of sustainability as a new paradigm of development.

One can speak of a kind of contradiction between technological changes and particular aspects of sustainability. Many innovations, which seemed to have a positive effect on economy, brought the

extremely negative consequences for the environment. Fact is that even the numerous measures that were taken by the state and specific pollutants, failed fully to eliminate the negative effects caused by the industry. On the other hand, the price of pollution of the natural environment is too high and cannot be recovered even with large outlays that government and private companies set aside for remediation of negative environmental consequences.
Existing and potential contaminants are indeed present, so even strict environmental standards set by the state are not enough, nor the sanctions that are taken against the violators. However, the fact is that today is taken much more care of the ecological side of individual investment projects than it was before. Also new, high technologies are neutral with respect to environmental issues, because they do not contribute to the pollution of the human environment. With further development of science, we should expect further reductions, if not even elimination, of the negative environmental consequences.

CONCLUSION

Neoclassical growth theory focuses on the analysis of the quantitative relationship between the output and input, and static concept of allocative efficiency. In this context, the analyzed relationship of natural resources management and the sustainable development paradigm, regardless of whether it is about the concept of weak or strong sustainability cannot provide satisfactory answers. The insistence, by all means, on economic growth, can also have many negative socioeconomic consequences.
Management of natural resources must start from respecting imperatives of adaptive capability of the economy in terms of continuous flux of the entire environment, and in this regard the natural environment. The growth of the world economy is the result of its adaptation to the impacts of the environment. Logically, even the environment itself adapts to the impact of global economic growth, thus contributing to its change. Excessive use of natural resources in generating global economic growth, threatens to become the cause of its collapse.
work.

REFERENCES

[1] Barbier, E., Markandye, A.: The Conditions for Achiving Envirenmentally Sustainable Development, *European Economic Review*, Vol.34. pp. 659/669, 1990.
[2] Cvetanović, S., Mladenović, I.: Kapital u teoriji rasta i razvoja, Ekonomski fakultet, Niš, 2011.
[3] Daly, H.: Elements of Environmental Macroeconomics, u Constanza, R. (ed) 1991. *Ecological Economics: The Science and Management of Sustainability*, Columbia University Press, New York.
[4] Drašković, B.: Ekonomija prirodnog kapitala, Institut ekonomskih nauka, Beograd, 1998.
[5] Meadows, D. H., et al.: The Limits to Growth, Universe Books, New York, 1972.
[6] Solow, R.: On the intertemporal Allocation on the Natural Resources, *Scandian Journal of Economics* 88, 1986.
[7] Harris, J.: *Ekonomija životne sredine i ptirodnih resursa*, DATA STATUS, Beograd, 2009.
[8] Hartwick, J.: Intergenerational Equity and Investing of Rents from Exhaustible Resources, *American Economic Review* 66, 1977.
[9] WCED, *Our Comon Future,* OUN an Oxford University Press, New York, 1987.

APPLICATION OF THE QFD METHOD TO OPTIMIZE THE DESIGN OF FASHION CHLOTHING

Danijela Paunović[1], Gordana Čolović[1]
[1]Beograd The College of Textile-Design, Technology and Management
e-mail: vspaunovic@gmail.com

Abstract: High frequency market changes caused by global competition in clothing industry have conditioned production-business systems (PBS) to set permanent production goal: short delivery terms, high quality of clothing products and price which is acceptable on market. Modern design in conditions of JIT, QRS and LEAN concepts requires an optimal time when designing and redesigning the clothes. On example of jeans pants optimization is made for time spent on designing, pattern making and virtual sewing. If the ''voice of the user'' is taken into consideration as one of most important factors in quality management, application of the method of Quality Function Deployment – QFD initiates and enables the right kind of information for adequate decision making and correctly positions PBS
Key words: fashion design, QFD, optimization

INTRODUCTION

In the modern fashion industry's most successful manufacturers are those that have organized professional teams for the design and marketing, as dictated by the cycle of current fashion and easily introduce new fashion designs, thus surprising the competition. Higher application of informatics technology and knowledge management brought to new ways of planning and clothing production techniques in order to create high quality clothing product. Producers of clothing products should, therefore, choose business strategy for adaptation to changes in the surrounding, to study without fail and implement TQM approach for strategic management, as well as QFD method for efficient reaching of goals of clothing products improvement. In clothing industry which must realize high quality flexible product, place and role of QFD method in the framework of the QMS quality loop has for a goal achievement of precisely defined level of quality which suites users' demands. For the first time in our clothing industry suggested method is applied in the example of female denim trousers. The influence of fashion dictated by fashion designers everywhere in the world is very important for the design of garment products. Process design would not be necessary that there is no need for the product and its sale. Without the successful design, as important components of quality garment products, he would not have found its place in the market.
The research process of creating new designs and quality clothing products includes determining the actual needs of customers. The process of creative designers improve the concept of research interest includes design, customers and profits and contemporary design tends line geometric form and aerodynamic surfaces loaded requirements and mass production. This is not the case with the fashion industry dictates that a large number of different styles and models with unlimited structural parameters of the textile surface are made of wear.[1]

PHASES OF THE QFD METHOD

Implementation of the QFD method in clothing industry is represented through 4 principles of work in 4 phases [2]:
- phase1 – translates buyer's demands into product characteristics,
- phase2 – translates product's characteristics into characteristics of parts
- phase3 – translates characteristics of parts into manufacturing technology and
- phase4 – translates manufacturing technology into technical, instructions.

Forwarding information from one organizational unit to another (marketing, development, technology, production) through four "houses of quality" (Mizuno & Akao, Japan, 1979), in which demands ("What") turn into characteristics of product/service, part of product/service or process ("How"), with following technical target values and their correlations in experimental part on example of female denim trousers led to:

■ Reduction of product designing time.
■ Improvement of clothing product quality (the exact quality as customer demands is offered).
■ Reduction of total cost of designing and production.
■ Plans and programs of workers' training especially on critical places.
■ Definition of work procedures.
■ Documentation and quality management system.

When questions of clothing product buyers' are analyzed through poll and claims on female denim trousers, list of buyer's wishes are formed (WHATs). It can be divided into:

1. Basic (primary, expected, unspoken-understood, "must be").
2. Derived (secondary, spoken, "might be").
3. Exhilarating (tertiary, unspoken-pleasantly surprising, "it would be nice, if it existed").

Basic WHATs are integral part or function of clothing product, and rarely increase buyers' satisfaction – he seldom even thinks of them. But, in the case of unfulfilment (shortage or malfunctioning) quickly follows the buyers' disappointment with the product. For example: zipper is not working, size is not adequate, etc. Derived WHATs are usually determined through market research. Buyers' satisfaction grows with the level of fulfilment.

Exhilarating WHATs increase buyers' satisfaction, although he wouldn't be unsatisfied even without them. It is not expected from PBS to make breakthroughs on the market with such innovations. With maturing of the product, exhilarating WHATs can pass into basic. For example denim trousers that women are wearing: they were very excited with them in the 70's, (during hippie revolution), while today they are obligatory clothing article for women.

HOWs

Producer defines group of quality elements which realize WHATs (buyer's demands), while each of HOWs "attacks" one or more of WHATs, and for every WHAT there is at least one HOW.

HOWs are methods or techniques of "translation" of the buyer's voice into criteria for estimate of shaping, for example, WHAT are a "comfortable clothing product (denim trousers)", and appropriate four HOWs demands are on: pattern making, prototype, design and size. Typical HOWs may be: length, width, height, thickness of cloth, volume, features of material, etc.

HOWMUCHs represent feasibility limits of HOWs and targeted values of HOWs (qualitative elements) for every HOW one HOWMUCH.

To create criterion for the testing of successfulness, this is usually obtained through market research, typical HOWMUCH measures importance of HOWs, product designing, or group of targeted values.

HOWs contain extremes –permissible target values, positive or negative.

WHYs

Similar to WHATs and HOWs, group of WHYs is also a vector that describes relative importance of clothing product, in relation to world class products or the best in their class.

If the quantitative WHYs are multiplied with WHATs, and summarized, measure of total satisfaction of buyer is received. Example: WHY is vector of relative importance in relation to buyer's demand for a world class product of the main competitor (for example Levi's denim pants, or some relevant denim pants producer).

If the product is intended for a larger number of groups of buyers, like USA, Asia, Europe, Japan etc, the list of WHYs must include these groups and their relative demands, because WHYs are names of competitors, competitors' products, segments of market which describe instantaneous market conditions.

WHYs can be also used for evaluation of decisions for the future product [3].

RESULTS AND DISCUSSION

Design, as a thought process involves the creation of products and begins with the idea, intuition and reason. The reality is complex and elaborate structure activities, which include:

• Identification of needs;
• The initial concept of how to meet those needs;
• Development of initial concept;

• Analysis to determine whether the concept and the extent to which meets requirements;
• Preliminary prototype form;
• Construction of forms;
• Implementation of various quality control procedures;
• Sale of its value to the consumer;
• Provision of feedback from users.

Market research should obtain the right information on customer satisfaction and their reactions to the proposed garments, in order to obtain a basis for business in the future, define the objectives and strategy of a company. Phenomena and laws of modern production line - the market must be kept under control.

In order to obtain relevant data marketing research has been performed through poll and claim of buyer of denim trousers. Results were systematized, photographed and analyzed and as such prepared for the first phase of transformation of the buyer's voice into characteristics of the product. Analysis has been carried out with the QFD method in the framework of PBS 1 and partially in the framework of PBS 2 through 4 phases based on the part of planning and construction preparation. Each of these phases is represented through matrixes presented as houses of quality. For the first time, this method was applied on the example of PBS in domestic clothing industry. On Figure 1 were shown the house of quality made on the basis of comparison of PBS 1 and PBS 2, as well as on the basis of the buyer's evaluation of given product in order to answer the questions HOW to satisfy the buyer's needs and improve the quality and features of clothing product.

Phase1:

● Through analysis of houses of quality on the basis of marketing research it has been established by priorities what buyers really want.

● On the basis of performed SWOT analysis data of comparison of similar PBS on the basis of production of female denim trousers were included. [4]

● On the basis of reported buyers' claims (from sales facilities of analyzed PBS) were established most frequent claims with statistic method and possibility of their elimination.

● On the basis of buyer's demands in the field of WHAT were given buyer's demands received through market research. Buyer's demands are systematized. In the field of HOW are given product characteristics. Their numeric significance is established and for each is a separately given amount in percentage. In the first place is the fashion trend, while behind the fashion trend there are factors of organoleptic characteristics of denim trousers.

● Correlation has been established between the degrees in which dimensions of HOW support dimensions of WHAT. Grades were given from 1 to 9, i.e. were presented in known symbols.

● Numeric significance of some quality characteristics has been established, but it was not possible to establish whether dimensions of HOW with highest absolute value would really add to market success of the product.

● Between characteristics of HOW and WHAT conflicting goals can exist, therefore it has been established in the matrix of the roof that such kind of problems may occur during realization of technical rules.

It is very difficult to compare two or more PBS because of the protection of privacy, but the comparison has been carried out and graded with grades from 1 to 5 where characteristics were spotted, given in diagrams in houses. (There are two moments in which QFD is used: when a new clothing product is being developed and when the existing one is being improved. When we are developing new clothing product we establish what it that is good at the competition or wrong is. While we are improving already existing product of our own service we ask users how they would grade certain characteristic of our product compared to competition. This gives us the possibility to improve characteristics of clothing product which are essential for the user, and where we are worse than the competition. Strategy of PBS 1 is to design clothing product better or at least on the same level as competition with which it compares itself (benchmarking).

The coordination of fashion designers' solution of ideas, possibilities to prepare construction, objective analysis of technical-technological possibilities of firms and management teams gives a chance to get to the strategy that will bring expecting placement and sale of goods on a fashion market for a long time in merciless completion that exist in fashion industry.

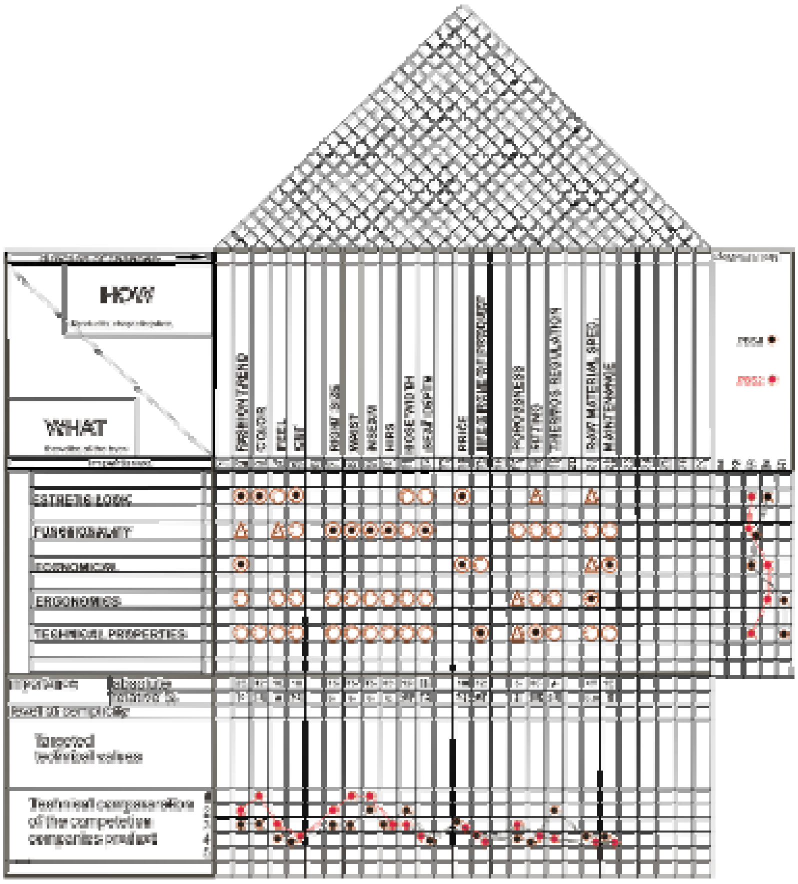


Figure 1. House of quality-phase and establishment of significant characteristics of the product

Phase 2:

- In the second phase are established characteristics of the parts of clothing product.
- Critical characteristics of parts are included in the field as dimensions of HOW with analysis from the FMEA method [5]. Degree of correlation has been performed and on the basis of it two targeted critical areas on female denim trousers were defined, such as: waist, side seams and slit.

Phase 3:

For each individual critical part all operations of fabrication were analyzed and its established influential critical parameters. Characteristics of parts have moved out of house 2 into field of WHAT, and in the field of HOW technology of fabrication is shown.

Highest level of complexity by the sequence of critical parameters of the process have, arranged by sequence: sewing and finishing technologies (stone washing, finishing, designing by laser…), fabrication of pattern making and prototypes (making of sample), marker cutting, fabric lay, bundles marking.

As a result of QFD analysis significance of some HOWs is received. Today we still compare ourselves with chosen raw model and competition, in order to see if we are better or worse in that category. If we are worse, it is necessary to establish if that is important and must improve ourselves. If we are similar to the competitors, and category is not too important, we will keep the existing state.

Phase 4:

Matrix of establishment of procedures is provided for the next process of research which after application of all mentioned methods uses data from the third house. Goal is to get:

1. Preventive measures for production process.
2. Such plans for providing quality, that "the voice of the buyer" is really implemented in the product and his characteristics.
3. Optimal number of working instructions and instructions for work.
4. Application of appropriate standards (SRPS ISO).

CONCLUSION

Quality control between phases is introduced in every segment of construction preparation in a classic way and in computing system. Technological operations performed by workers on previous machines are controlled. Fabrication of female trousers is followed through all the phases of manufacturing and through every technological operation till finishing processing and packing, in order to increase percentage of error discovering. Priorities risks factors are established. Potential errors according to priority are ranked. It was provided for introduction of quality system, application of new SRPS ISO standard of sizes, ISO for stitches and kind of seams, training of workers and team responsibility.
In order to alleviate the process of designing and manufacturing of clothing products as one of the solutions it is necessary to use, besides QFD method, CFD methodology enables communication for engineers and comparative work during stages of PD^3 (Product Design, Development & Delivery) process in order to secure quality and integrity of clothing product [5].
Based on the results and conclusions of individual can be stated justification of investment in new software packages that allow:
•Humane, easier and faster operation.
•Reduce employee fatigue.
•Increase production of quality garments.
• Reduce delays, errors and failures.
•Shortening the time of making clothes.
•Reduced cost per unit of product
In addition to automation of production processes and reduce costs in the market perceived the advantages of CAD and other technologies.

REFERENCES

[1] Paunović, D., Đuričić, M., Savanović, G., Primena FMEA u odevnoj industriji, ICDQM, 10. Međunarodna konferencija, Beograd, 2007.
[2] Edwin, B. D., Quality Function Deployment for Large System, NASA Langley Research Center, Hampton, 1996.
[3] Đuričić, M. R., Menadžment kvaliteta, ICIM, Kruševac, 2006.
[4] Paunović, D., Čolović, G., The application of SWOT analysis in designing of garments, Menagement, Volume 37, pp (71-77), Belgrade, 2005.
[5] Prasad, B., Journal of Engineering Design, Volume 11, 2000.
[6] Colovic, G., Management of Technology Systems in Garment Industry, Woodhead Publishing Limited, Cambridge, Oxford, New Delhi, 2010.
[7] Colovic, G., Strategic management in the garment industry, Woodhead Publishing Limited, Cambridge, Oxford, New Delhi, Philadelphia, 2012.
[8] Hayes, B., Measuring Customer Satisfaction, Press, 1997.

THE EFFECT OF STRATEGY ON THE DEVELOPMENT OF AN ENTERPRISE

Jelena Vojnović
Higher School of Professional Business Studies, Novi Sad, Serbia
jelena.vps@gmail.com

Abstract: In order to achieve the goals of the operations of an enterprise, in the conditions of increasing market instability of existing operations, a prerequisite for existence and success are well-planned and implemented strategies of the enterprise. Strategy, as a theory of organisational business, defines strategic choice between alternative strategies, assuming that the enterprise will achieve its goals and react efficiently to changes in its environment. This paper will considers the impact on enterprise development strategy and types of strategy.
Key words: strategy, the effect of strategy, types of strategy, low cost.

INTRODUCTION

A strategy should enable the realisation of previously defined goals of the enterprise, taking into account the effect of factors from the external and internal environment. Formulating a strategy represents a phase in the process of strategic management. Formulating a strategy includes harmonization of opportunities and threats in the external environment and internal possibilities and intentions.
Every strategic business unit which competes on a particular market or market segment can consider an infinite number of strategies. A strategy implies independent activities in the battle against competition, suppliers, buyers and substitutes. Development of a strategy is a continual step-by-step process, keeping in mind that collision between phases of strategic analysis and strategic implementation is possible. Accordingly, this can imply experimenting, learning and consulting for those participating in the changes. The fundamental criterion for choosing a strategy is "comparative advantage". Comparative advantage is a consequence of cost control, and cost control is enabled by the control of cheaper resources, positional rent, superior technology and good managing.

STRATEGY OF BUSINESS UNITS

A. The notion and definition of strategy

A strategy is a specific way in which a particular enterprise begins the interaction with its environment. A strategy should enable the realisation of previously defined goals of the enterprise, taking into account the effect of factors from the external and internal environment. Adequate organisation is a prerequisite for coherent and successful strategy. Strategy affects organisation, but organisation affects strategy, too.

A strategy determines:[1]
- the relation with the environment
- the structure of the business portfolio and the competition portfolio
- the treatment of the competition
- the methods
- the desirable level and type of flexibility

Characteristics of a strategy:[1]
- initiating and managing changes
- holistic approach to resources
- balancing the interests and values of internal and external stakeholders
- focusing on synergy

B. Formulating a strategy

Formulating a strategy represents a phase in the process of strategic management. Formulating a strategy includes harmonization of opportunities and threats in the external environment and internal possibilities and intentions.

Formulating a strategy also includes establishing the mission and long-term goals, the analysis of opportunities and threats generated by the general environment, establishing the attractiveness of the branch using the analysis of competition forces, identifying the sources of competitive advantage, the analysis of internal environment and distinguishing doable options.

The process of formulating a strategy shows:[1]

- how the enterprise assessed its opportunities and dangers
- how it understood strategic situations
- how it identified ways and methods

Accordingly, the process of formulating a strategy should include:

- a strategic analyses of the environment and possibilities of the enterprise, which should result in identification of strategic understanding of the situation,
- an exploratory-creative phase

The process of formulating a strategy is based on the SFO approach. That is a conceptual frame, in which, based on the SFO triangle, a correlation between opportunities and dangers is made, along with the relation of enterprise with them and directions and methods of concrete action.

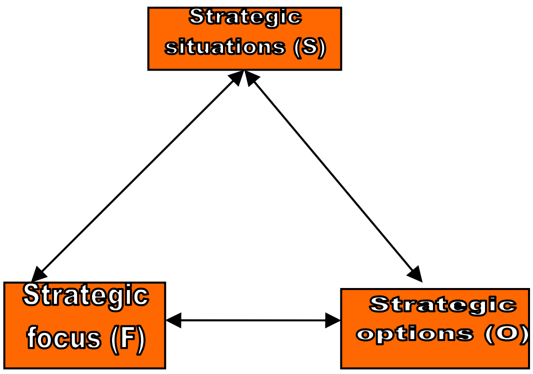


Figure 1. Formulating a strategy according to the SFO approach

TYPES OF STRATEGIES

There are many different classifications of strategies, but this section will focus on the following classification:

- strategies of intensive effort
    a. possible strategies of growth
    b. strategy of market penetration
    c. strategy of market development
    d. strategy of product development
- diversification strategies
    a. related diversification strategy
    b. unrelated diversification strategy
- stabilisation and withdrawal strategy
- generic business-level strategies
    a. enterprise strategy
    b. business strategy

A. Generic business-level strategies

Enterprise strategy

Enterprise strategy covers several markets or several branches of the given activity. The focus of this strategy is on balanced exploitation of the resources and possibilities of the enterprise in order to maximize the value (synergistic effect).

Business strategy is oriented towards one market or one branch of the activity. The focus of this strategy is on creating and maintaining competitive advantage.

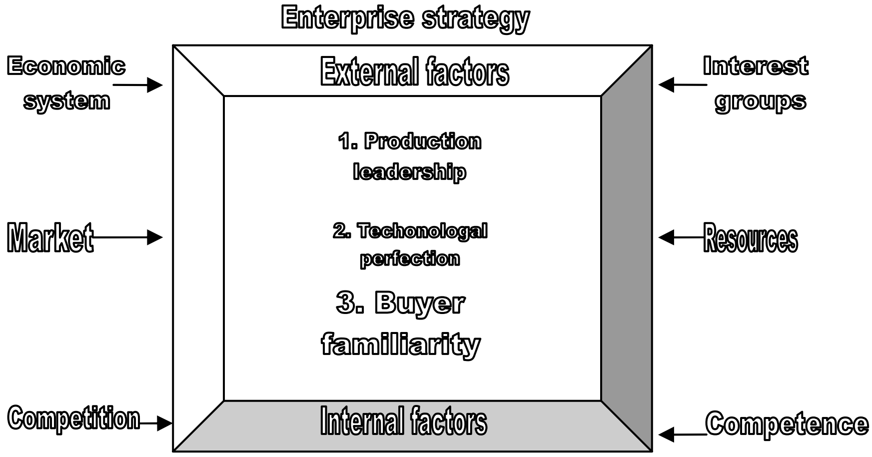


Figure 2. Elements of an enterprise strategy

The fundamental criterion for choosing a strategy is “comparative advantage”. Comparative advantage is a consequence of cost control, and cost control is enabled by the control of cheaper resources, positional rent, superior technology and good managing.

Development of a strategy is a continual step-by-step process, keeping in mind that collision between phases of strategic analysis and strategic implementation is possible. Accordingly, this can imply experimenting, learning and consulting for those participating in the changes.

An enterprise has to grow in order to survive. Growth is a prerequisite for its existence. As its primary goal, growth needs the enterprise to provide it with new possibilities for growth. Accordingly, growth can be healthy, slow and cancerous. Healthy growth is the kind of growth which brings value. Continual growth implies increasing sales and an opportunity to make use of advantages of the effects of cost economy in order to decrease costs per unit of product, and, therefore, make a profit and increase value. Starting from the criterion of growth
potential, types of enterprise strategies can be identified which are shown in figure 3.

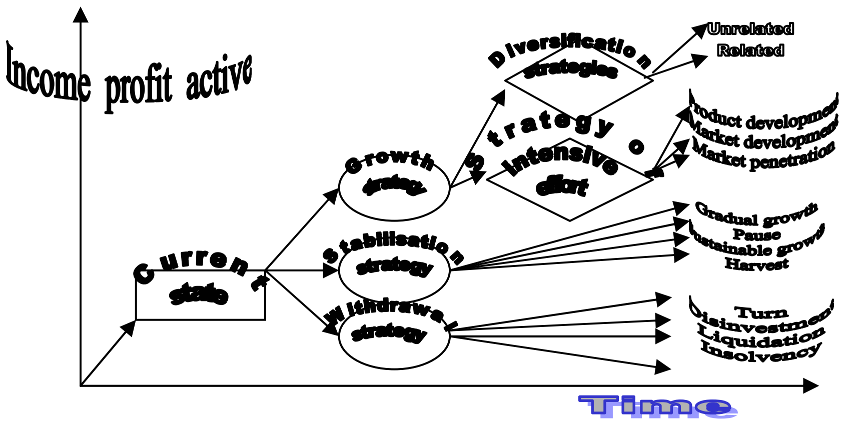


Figure 3. Enterprise strategy

Every strategic business unit which competes on a particular market or market segment can consider an infinite number of strategies. A strategy implies independent activities in the battle against competition, suppliers, buyers and substitutes.

Competition environment of an enterprise is represented by the branch or industry. The branch represents a group of enterprises whose products are similar or connected with each other, as well as with the market where those products are sold. According to M. Potter, the profitability of a branch is affected by so-called "competitive forces".

The greatest profit is made in branches with moderate influence of competitive forces, while branches with extreme influence of competitive forces suffer from profitability crisis. Figure 4 shows that competitive forces of a branch comprise existing participants, producers, substitutes, buyers, suppliers, as well as every enterprise whose intention is to enter that particular branch.

Figure 4. Competitive forces of a branch

The ground for determining the relative position of an enterprise in its branch is represented by permanent competitive advantage. There are two basic sources of competitive advantage:

- low costs
- differentiating

Strategies which are based on the abovementioned sources of competitive advantage are called "generic" because any enterprise can apply them, regardless of its size and performances, including non-profit organisations. A strategy is also affected by competitive coverage, that is, the width of target markets (mass market or narrow target).

Cost advantages and differentiating are consequences of the enterprise's ability to meet competitive forces in a better way than its competition. Combining sources of competitive advantage with market goals leads to four generic strategies, shown in figure 5:[2]

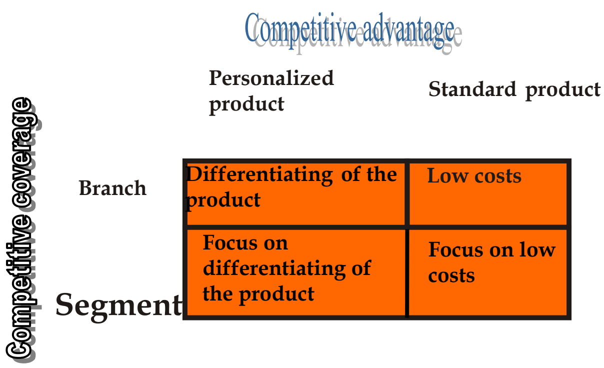


Figure 5. Generic strategies

A. Low cost strategy

Costs are an important factor which affects the creation of competitive advantage based on both prices and differentiating. Accordingly, low costs are one of the sources of competitive advantage of an enterprise. When choosing a strategy, every competitor has to take into account its cost position. Low costs lead to creating value, in which way threats caused by competitive forces are diminished.

There are many reasons why different competitors which produce the same product have different costs, and some of them are:

- difference in the capacity size caused by the scope economy effect
- learning curve effect
- positional rent
- technological change

Cost economy is heavily influenced by the organisational structure, management concept and reward system. According to this strategy, costs are monitored by cost drivers. They are structural determiners which affect the costs of an activity. An enterprise which has a lower cumulant of the costs of an activity from the value chain than its competitors has a cost advantage.

Main cost drivers:[3]

- Scope economy: refers to decreasing costs per unit which is achieved by an enterprise increasing the number of activities. These economies determine the way in which an enterprise can distribute its costs, fixed and redundant, to several things, and where the scale of activity provides the enterprise with other advantages (more successful bargain with suppliers).
- Business economy: it is realised where the competencies of a firm are in accordance with those that are needed relative to the number of product markets.
- Experience advantages: enterprises which have a relatively big share on the market, based on their experience, gain advantages faster than their competition.
- Management efficiency: enterprises which aren't subject to strong competition pressures can suffer from so-called "X-inefficiency". X-inefficiency refers to cost increasing which can come about if an enterprise is protected from the full flurry of competition market. It can also come about in situations where a particular enterprise has an almost monopolistic position of supplier.
- Low cost level: some enterprises have the possibility of having the advantage of lower costs than the competition because they have access to cheaper raw materials. Many advantages depend on the location, lower costs of work force, cheaper energy, lower social benefits.

There are three steps in the cost analysis:[3]

- The first step in the analysis of cost drivers is the allocation of funds and business costs onto the activities in the value chain. Every activity in the value chain is connected to costs and funds via turnover of funds and capital investments.
- The second step is disaggregation of generic activities of the chain to discreet activities of respecting requests. Disaggregation is done until the following situation is reached: one activity, one cost driver.
- Third step: allocation of funds and costs onto discreet activities. Allocation of funds is done via bookkeeping value, or via change costs. Allocation of costs and funds onto activities leads to value chain which shows the distribution of costs. It is necessary to divide costs of every activity into: raw materials and intermediate goods, work force, capital investments.

Figure 6 gives an insight into cost-decreasing zones. Raw materials and intermediate goods usually cost more than it was assumed because of safety stocks. Another reason for decreasing costs could be the classification of activities into direct, indirect and those which secure quality, which leads to doubling of costs.

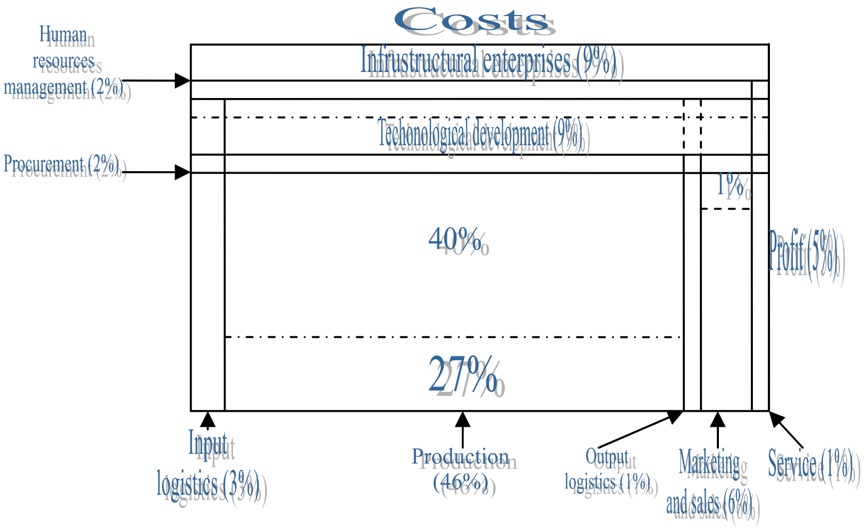


Figure 6. Cost distribution per activity

Cost advantage comes about if the cumulant of costs of all the activities in the value chain is lower than the cumulant of costs of the competition. Strategic value of cost advantage exists if it is permanent. Accordingly, the permanence of cost advantage exists if the sources of the cost advantage are unusual or difficult to imitate. There are also drawbacks to the strategy of low costs: [4]

- Too intensive orientation towards one or several activities from the value chain – in every activity in the value chain costs should be re-examined and organisationally conditioned costs should be decreased or eliminated.
- All competitors purchase the same inputs.
- The strategy can also be applied by other competitors – this will cause intensive competition on the same market for the same extent of demand.
- Lack of priorities based on differentiating – gaining advantage with low costs also assumes application of the strategy of differentiating which consists in making a risk in the product which is assessed by buyers as special quality.
- Advantage decreasing when buyers get an insight into the structure of selling prices – the insight of buyers into the components of selling prices and cost structure can cause a decrease in the demand of the product.

Relative cost position is a consequence of the relative position in relation with cost drivers of every activity in the value chain and the structure of the value chain in relation to competitors. The strategy of cost decreasing can be achieved in two ways:

- Cost driver control – the principle of a control exception is applied, meaning that control is only carried out in relation to cost drivers which affect the activities in the value chain.
- Reconfiguration of the value chain – changes of the value chain should enable savings of costs per individual activity, not affecting the value for buyers.

B. Differentiating strategy

Differentiating strategy is a business-level strategy which is used in order to gain competitive advantage by decreasing the degree of added value in relation to other competitors. Differentiating leads to competitive advantage and an above-average real value. This strategy provides a price level above average costs.

Gaining a permanent competitive advantage requires unusual differentiating, as well as high costs for its imitation. According to M. Potter, the basis of differentiating are the following characteristics:

- characteristics of the product
- the connection between business functions
- timing

- location
- production programme
- connections with other enterprises
- reputation

There are two groups of techniques that are used to formulate a differentiating strategy:

- positional maps – an inductive technique of differentiating criterion determination. Positional maps are analysis techniques of accepted similarities of an approved set of products. When applying them, it is necessary to interview buyers using questions about the similarities of products which are sold on the same market. The main point is to identify a small number (2-3) of product characteristics which can be used to generate a matrix (for example, examining similarities of 10 cars of middle high class: Ford, Chevrolet Lumina, Mercedes 300E, etc.)
- regression analysis of price determiners – it is a deductive technique of determining the criterion of differentiating. It consists in testing a hypothesis using methods of regression analysis in order for one or more price determiners to lead to differentiating. This technique can be explained by using an example from car industry. The factors that affect the price of a product: engine positioning, travel cockpit, the size of the car body, accepted quality, acceleration and safety. The price of a car is a dependent variable in a multiple regression of the form:

$$b_0 + b_{1,}atribute_1 + b_{2,}atribute_2 + b_{i,}atribute_i = P_i \quad (1)$$

P_i = the price of the car
$Atribute_i$ = criterion of the attribute j for the product i
b_i = regression coefficient which measures the impact of the attribute j on the price of the product and which is controlled by the other attributes of the product

This regression model assesses the impact of every attribute of a product on the price of the product.

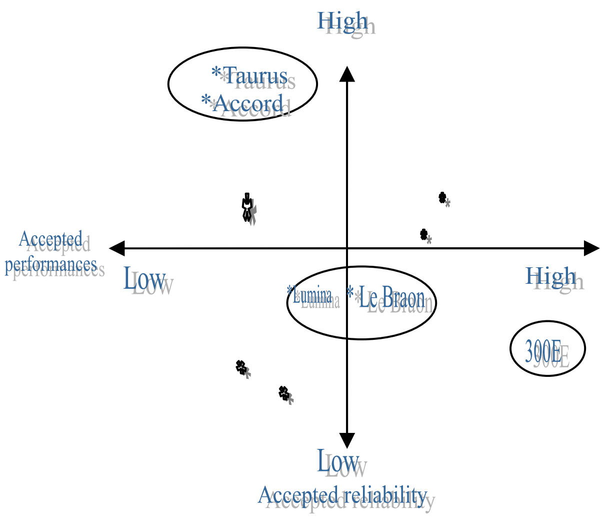


Figure 7. Positional map

As any other strategy, this one also has its drawbacks:

- uniqueness which doesn't have a value – it is not enough to only produce unique products – they should also have a value for buyers
- too much differentiating – differentiating should be implemented to the extent which buyers want

- high premium price – too much differentiating of the product leads to a high differential price, which can be considered too high by buyers, which makes them consider the products made by the competition
- Differentiating can also easily be applied by the competition – differentiating strategy can only be successful in a period until the competition manages to create a product of the same quality
- Weakening of brand identification through broadening of production line – the brand of a product can be endangered if in the production line there are products of lower quality and a lower price
- Buyers and sellers can have different perceptions of differentiating – products which an enterprise considers differentiated aren't necessarily perceived in the same way by a buyer. Accordingly, buyers won't accept a product with high price, but only with a low price, which will make the profit of the enterprise decrease.

C. Focusing strategy

While the strategies of cost management and differentiating are oriented towards achieving goals on the branch market, focusing strategy is oriented towards a particular narrow market which an enterprise aims to serve. All functional strategies in the enterprise are defined bearing this in mind. The basic assumption of the focusing strategy is that the enterprise is able to serve a narrow market more effectively and more efficiently than those enterprises that compete on the entire market. The enterprise achieves that with either differentiating in order to meet the needs in a better way or with lower costs in serving the market or in both these ways.

Focusing strategy means that an enterprise uses its basic competence in order to meet the needs of a special group of consumers in one branch. Competitive advantage is created on the target market segment although the enterprise doesn't have a competitive advantage in the entire branch. As in the strategy of cost management and differentiating, the enterprise, when it wants to apply the focusing strategy, has to be able to complete some primary and supporting activities in a way that is competitively superior.

All three generic strategies have some risks. The first one is not achieving the intended strategy, and the second one is that the competitive advantage which is brought about doesn't erode with the branch evolution. With this strategy, the risks are:

- differentiating costs between a competitor which targets the wide market and the one which targets a narrow market are broadened, so the cost advantage is eliminated in serving the narrow market or the differentiating which is brought about with the focusing strategy is diminished
- the difference among desired products or services between the narrow and entire market is narrowed
- competitors find sub-markets within the target narrow market and focus in a better way than the enterprise.

Conditions in which enterprises orient towards a focusing strategy are the following:

- the enterprise disposes of sources and abilities to serve only one or a couple of segments
- the enterprise doesn't have a wide production programme
- the enterprise isn't one of the biggest in the economy and doesn't intend to become one, either
- the enterprise is very specialised and competent (human resources-wise, technologically, in research and development)
- the enterprise is small and oriented towards entrepreneurship

The enterprise has to study the attractiveness of particular market segments. Their attractiveness is usually assessed by their size, rate of growth, intensity of competitive forces on the market segment, profitability of the segment, the importance of the segment for other main competitors, as well as the harmony between the abilities of the enterprise and the needs of the segment. It is crucial that the segment isn't extremely important for other enterprises, as well as for the enterprise to ensure appropriate loyalty of buyers.

CONCLUSION

The effect of strategy on the sustainable growth and development of an enterprise, on its competitiveness degree, especially in the unstable conditions of economy in crisis, is extremely important because strategies are subject to re-examining and adapting, depending on the kind, degree and intensity of changes. Some solutions which show the effect of a strategy on the competitiveness of an enterprise delegate key responsibility for achieving and preserving sustainable competitiveness to strategic management. Continual monitoring and re-examining of the state in context, analysis of impact, re-examining of intention in order to confirm the choice of a strategy which has already been made or to choose another adequate strategy which includes solution of the problems brought about by instabilities and changes, are a prerequisite for the success of the projected segmentation and building a realistic attitude of an enterprise towards its future.

REFERENCES

[1] J.Todorević, D. Đuričin, S. Janošević, “Strategijski menadzment”,Belgrade 2003.
[2] D. Đuričin, S. Janošević, D. Kališanin, “Menadzment i strategija”,Belgrade 2010.
[3] K. Bouman,” Strategija u praksi”, Novi Sad 2003.
[4] K. Jakovčević, “Upravljanje troškovima”, Faculty of Economy, Subotica, 2008.

SESSION 10: Process Management and Energy Efficiency

ENERGY AND MATERIAL OPTIMISATION OF A CORN BRAN DRYING PLANT

Sofija Miškov[1], Ivona Radović[1], Mirjana Kijevčanin[1], Dragiša Tolmač[2]
[1]University of Belgrade, Faculty of Technology and Metallurgy, Belgrade, Serbia
[2]University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
e-mail: ivonag@tmf.bg.ac.rs

Abstract: Many materials that are in every-day use in various industrial processes as ready to use products or semi-products require moisture removal. As processing and industry production are growing on a daily basis, low price demand is increasing, while at the same time the energy price is increasing. Intensive growth in the last decade of 20th century, in line with the contemporary lifestyle and consumption of semi-prepared meals has resulted in increased production of dried food. In corn industry, drying is one of the essential processes and the biggest energy consumer. There is a need for optimisation of drying process, which could result in reduction of costs associated with energy consumption, introduction of heat recuperation and possible process improvement. In this work the optimization of the corn bran pneumatic dryer was performed. The obtained results were compared to literature data. The intention of the study was to identify the key variable influencing the thermal efficiency of the analysed drying plant.
Key words: Corn bran, Pneumatic Dryer, Thermal efficiency, Energy optimization

INTRODUCTION

Dryers are major energy consumers in corn industry. As energy price is on the rise, the objective is to reduce energy consumption. This may be achieved by extracting the energy from exhaust streams and reusing it for pre-heating or recycling it for another use. Knowing how dryers affect different process parameters would give better understanding of possible improvements [1].

Corn grain consists of a cap, germ, endosperm and bran. Germ is a central part of a grain and is rich with oils. Cap seals a corn grain. Endosperm consists of a protein part, gluten, and starch granules [2].

The processing of corn for food use requires one of two milling techniques: dry-milling or wet-milling. Corn dry-milling involves the traditional milling of clean, tempered grain to separate its component parts: endosperm, germ and bran. The major purpose of dry-milling is to recover the endosperm fraction for use as corn grits, meals and flours, while the germ may be harvested for oil. Corn bran, however, currently has low value and is often used for animal feed alone or in combination with corn germ cake or meal. Wet-milling of corn involves first steeping the grain in water and sulphur dioxide. During this process, the moisture content increases to about 450 g kg^{-1} and the kernels are softened to facilitate separation of the components: starch, gluten, fiber and germ. The profitable products of wet-milling are the starch (endosperm) and oil (germ) from the corn kernel. Co-products of wet-milling include corn fiber, corn gluten and steeping solids, which are sometimes combined and sold as corn gluten feed. Both corn bran and corn fiber are mainly composed of the pericarp (bran); however, corn fiber also contains cell wall material from the endosperm, which is not contained in corn bran [2].

After the conveyance, corn is elevated and dried in a stream of hot air. After that the corn is sent for storage until it goes to steeping plant, for about 48 hours. Wet corn separation starts in the steeping plant. Wet separation is based on different specific densities. Products separated in this way have to be dried before storage or packaging.

MATHERIAL AND METHODS

Drying is a process of moisture removal; it can be natural or managed through a unit operation, where heat and mass transfer occur simultaneously [1,3-5].

Beside mass minimization and preservation of natural characteristics, the purpose of drying, a complex technological operation is to improve natural characteristics of the material in order to get products with better structural, physical and chemical properties.

In plants for corn processing in Serbia, pneumatic (flash) dryers are usually used for the corn bran drying. A schematic diagram of a typical pneumatic dryer is shown in Fig. 1.

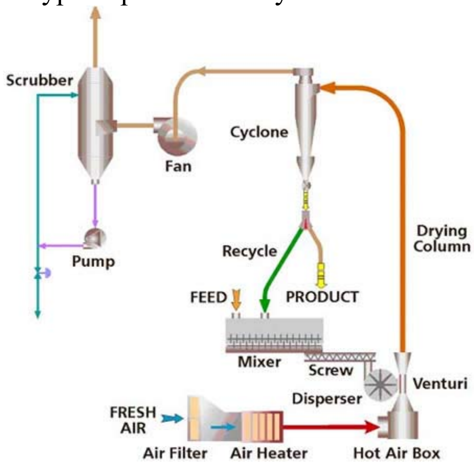


Figure 1. Schematic diagram of a pneumatic dryer

Hot air produced by indirect heating or direct firing is the most common drying medium in these systems. In direct flash dryers, the gas stream transports the solid particles through the system, and makes direct contact with the material to be dried. This gas stream (drying medium) also supplies the heat required for drying and carries away the evaporated moisture. Following the drying column, material falls through a cyclone while hot, unsaturated process fluid leaves cyclone on the top. One of the features of these types of dryers is a relatively short contact time between the hot air and the particulate materials (0.5–10 s) at the drying section. Because of this the material temperature always stays low in the drying process [1].
In this work the pneumatic corn bran dryer was analysed. Energy and material optimization of the drying process was performed by using the Simprosys 2.2 software developed by Simprotek Corporation. Simprosys is a Windows based software package specifically designed for the heat and mass balance calculations of drying and evaporation process, or combined evaporation and drying process. It is efficient for both designing and optimisation, no matter which type of drying or evaporation is explored.

RESULTS AND DISCUSSION

A flowsheet of a corn bran drying process is presented in Figure 2. Ambient air passes through a gas heater where it gets heated. The wet particles consisting of wet corn bran, corn steep liquor (CSL) and of a recycled stream (mat 6) are fed into the hot gas stream at the dryer entrance.

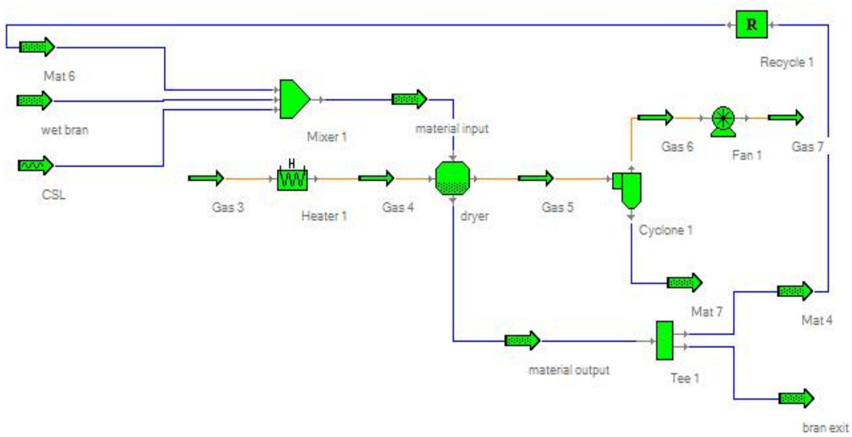


Figure 2. Flowsheet of a corn bran drying process

Process parameters necessary for the optimisation of the corn drying process (Fig. 1) are presented in Table 1.

Table 1. Process parameters used in Simprosys optimization

Parameter		Value
Wet bran mass flow rate	kg h^{-1} db[a]	3130
CSL mass flow rate	kg h^{-1} db	540
Recycled stream mass flow rate	kg h^{-1} db	6173
Wet bran moisture content	kg/kg db	0.62
Dry bran exit moisture content	kg/kg db	0.12
Material input moisture	kg/kg db	0.30
Material output mass flow rate	kg h^{-1} db	7890
Moisture evaporation rate	kg h^{-1}	2030
Bran exit mass flow rate	kg h^{-1} db	1578
Pressure	kPa	101.325

[a] dry basis

The objective of this work is to compare the parameters calculated by Simprosys software package with the literature data [7-10]. The comparison between these two sets of parameters is presented in Table 2. The thermophysical properties of raw material and air necessary for the calculations are taken from the literature [11,12].

Table 2. Parameters of the industrial corn bran drying plant

Energy drying parameter		Values literature parameters [7-10]	Values of calculated parameters
Dryer inlet air temperature	[˚C]	425	370[a]
Evaporable water quantity	[kg h^{-1}]	2030	1775
Total heat quantity	[kJ h^{-1}]	7956000	9475200
Drying heat power	[kW]	2210	2632
Energy specific use	[kJkg $^{-1}$]	3919	-
Drying air quantity	[$m_n^3h^{-1}$]	19452	19452
Specific quantity of evaporable water	[$kgm^{-2}h^{-1}$]	49	-
Specific quantity of evaporable water	[kg $m^{-3}h^{-1}$]	315	-
Dryer outlet air temperature	[˚C]	110	182[b]
Thermal degree of utilization	[%]	74	74

[a] Maximum possible temperature that can be set in Simprosys calculation
[b] Calculated for the option of the material output temperature of 280ºC

From the results given in Table 2 it can be concluded that in the process performed in the literature, requirements for the drying heat power are lower than those calculated with Simprosys, while the evaporable water quantity is higher. This implies that the process performed in the literature [7-10] is more energy efficient than the process simulated with Simprosys.
In addition, it was observed that the outlet air temperature, as well as the thermal efficiency is directly dependent on the outlet material temperature of the dryer as shown in the Fig. 3. As the outlet material temperature raises both the outlet air temperature and thermal efficiency decrease.

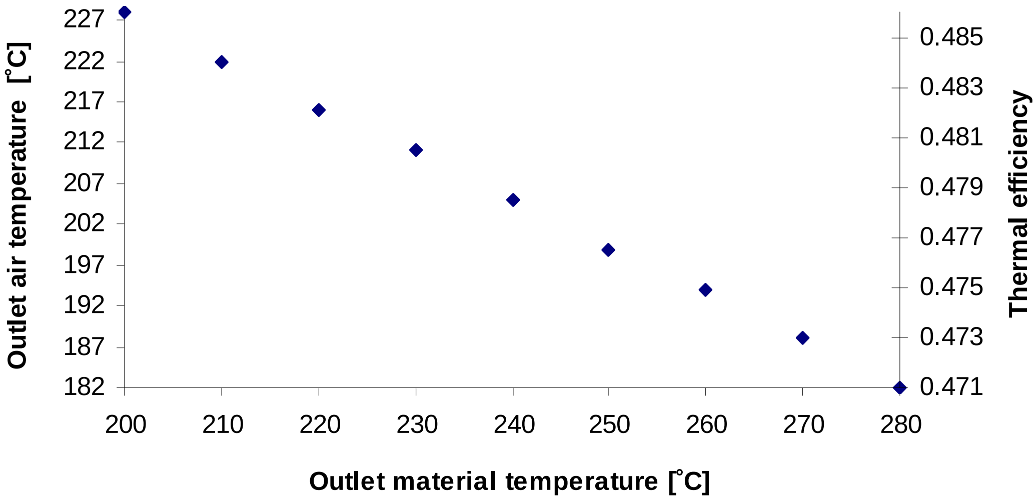


Figure 3. Changes of the outlet air temperature and thermal efficiency vs. outlet material temperature

This work also considered a correlation between the overall thermal efficiency or quantity of evaporable water and the amount of recycled material stream. Fig. 4 represents changes of the outlet evaporable water quantity and thermal efficiency vs. ration between recycled and exit material stream. It is well known that by means of recirculation of a drying material drying time would be shortened [1]. As it can be seen from Fig. 4 both the thermal efficiency and the amount of evaporable water are increasing with a raise in reflux ration.

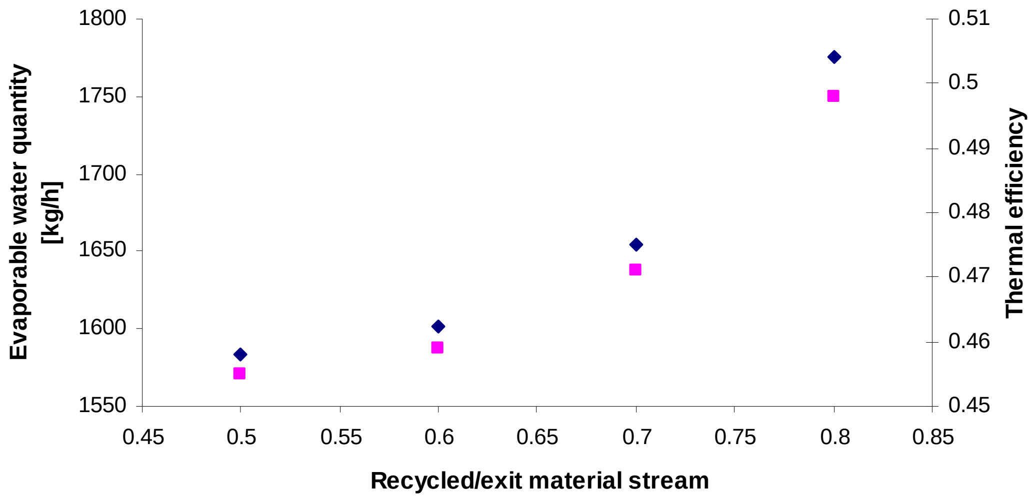


Figure 4. Changes of the outlet evaporable water quantity (♦) and thermal efficiency (■) vs. ration between recycled and exit material stream

As the drying process uses ambient air as a drying medium, the consumption of heat directly depends on the ambient air temperature. Fig. 5 shows the correlation between the specific heat consumption necessary for the drying process and air temperature during different working seasons. As expected, the heat consumption is the lowest during the summer months.

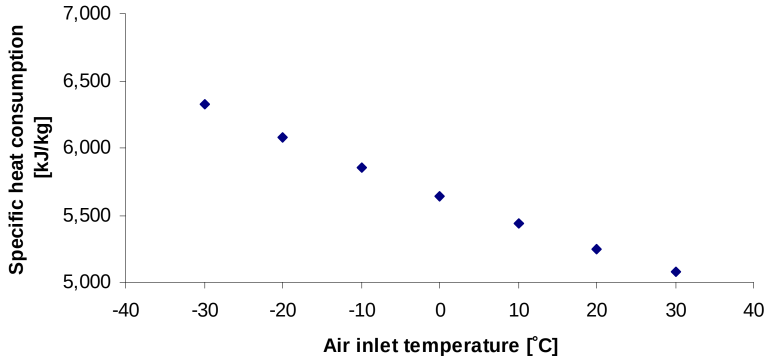


Figure 5. Changes of the specific heat consumption vs. air inlet temperature

CONCLUSION

In this work the performance of the corn bran drying process in the pneumatic dryer is evaluated using the Simprosys software package. The calculation results are compared to the parameters obtained in the literature. Additionally, the effect of the amount of the recycled stream on the overall process thermal efficiency was examined. The results indicate that in the process described in the literature requirements for the drying heat power are lower than those calculated with Simprosys, while the evaporable water quantity is higher.

The variation of the ration between recycled and exit material stream results in increase of evaporable water quantity and the overall thermal efficiency.

Since the exhaust air is at high temperature, the future work could be focused on evaluation of the technical feasibility of residual air heat reuse.

REFERENCES

[1] Mujumdar, A. S., Handbook of Industrial Drying, Third Edition, Taylor & Francis Group, London, 2006.

[2] Rose, D. J., Inglett, G. E., Liu, S. X., Utilisation of corn (Zeamays) bran and cornfiber in the production of food components, J. Sci. Food Agric. Vol.90, pp.915–924, 2010.

[3] Valent, V., Sušenje u procesnoj industriji, Tehnološko-metalurški fakultet, Beograd, 2001.

[4] Tolmač, D., Uvod u teoriju sušenja, Tehnički fakultet “Mihajlo Pupin”, Zrenjanin, 2007.

[5] Tolmač, D., Lambić, M., Racionalizacija potrošnje energije u sušarama sa pneumatskim transportom materijala, Časopis za procesnu tehniku i energetiku u poljoprivredi / PTEP, Vol.4, pp.29-31, 2000.

[6] Reddy, B. S., Chakraverty A., Equilibrium Moisture Characteristics of Raw and Parboiled Paddy, Brown Rice, and Bran, Drying Technology, Vol.22, pp.837–851, 2004.

[7] Tolmač, D., Prvulović, S., Lambić, M., Radovanović, Lj., Energetska efikasnost konvektivnog sušenja, (UDK: 66.041:536.2), Savremena Poljoprivredna Tehnika, No.1-2, pp. 19-25, Naučno društvo za poljoprivrednu tehniku, Novi Sad, 2008.

[8] Tolmač, D., Blagojević, Z., Prvulović, S., Tolmac, J., Radovanovic, Lj., Experimental study on drying kinetic and energetic characteristics of convection pneumatic dryer, FACTA UNIVERSITATIS (Mechanical Engineering), Vol.8, No.1, pp.89-96, 2010.

[9] Tolmač, D., Prvulović, S., Radovanović, Lj., Effect of Heat Transfer on Convection Dryer with Pneumatic Transport of Material, FME TRANSACTIONS, Vol.36, No.1, pp.45-49, (ISSN 1451-2092), 2008.

[10] Tolmač, D., Josimović, Lj., Prvulović, S., Dimitrijević, D., Experimental and Numerical Studies of Heat Transfer and Kinetic Drying of Convection Pneumatic Dryer, FME TRANSACTIONS, Vol.39, pp.139-144, 2011.

[11] Interne skripte tehnologije skrobarstva u IPOK-u, Zrenjanin, 1997.

[12] Vulićević, D., Tehnološke operacije - dijagrami, nomogrami, tabele, Tehnološko-metalurški fakultet, Beograd, 2002.

SUSTAINABLE USE OF ENERGY IN EUROPE

Dragan Škobalj[1], Sonja Lukić[2]
[1]Vujić Valjevo, Valjevo, Serbia
[2]University of Niš, Faculty of Occupational Safety, Niš, Serbia

Abstract: The aim of the energy-supply strategy for rhe European Union must be to ensure the well-being of its citizens and the optimal functioning of its economy, providing a countinuous supply of energy at prices that are as low as possible for citizens and companies and in a way that is compatible with sustainable-development objectives. Two lines of development are necessary so that Europe can securely access energy resources to nourish intelligent future growth that is sustainable and inclusive according to the terms of the „Europe 2020" strategy. Southeastern Europe faces a new crisis in the supply of electricity, which is the result of nearly two years of drought periods. With our conventional energy resources becoming scarcer, we should therefore use this critical momentum to gradually shift to a low-carbon society. Our initiatives for the development of new and renewable energy sources and for reaching a high level of energy efficiency serve this objective.
Key words: energy-supply, economy, sustainable-development, renuwable energy resources, low-carbon society.

INTRODUCTION

The European Union is consuming more and more energy and importing more and more energy products. Community production is insufficient for the Union's energy requirements. As a result, external dependence for energy is constantly increasing.

The dramatic rise in oil prices which could undermine the recovery of the European economy, caused by the fact that the price of crude oil has tripled since March 1999, once again reveals the European Union's structural weaknesses regarding energy supply, namely Europe's growing dependence on energy, the rule of oil as the governing factor in the price of energy and the disappointing results of policies to control consumption. Without an active energy policy, the European Union will not be able to free itself from its increasing energy dependence. If no measures are taken, in the next 20 to 30 years 70 % of the Union's energy requirements, as opposed to the current 50 %, will be covered by imported products. This dependence can be witnessed in all sectors of the economy. For example transport, the domestic sector and the electricity industry depend largely on oil and gas and are at the mercy of erratic variations in international prices. Enlargement will exacerbate these trends.

In economic terms, the consequences of this dependence are heavy. It cost the Union some EUR 240 billion in 1999, or 6 % of total imports.

In geopolitical terms, 45 % of oil imports come from the Middle East and 40 % of natural gas from Russia. The European Union does not yet have all the means to change the international market. The European Union's long-term strategy for energy supply security must be geared to ensuring, for the well-being of its citizens and the proper functioning of the economy, the uninterrupted physical availability of energy products on the market, at a price which is affordable for all consumers (private and industrial), while respecting environmental concerns and looking towards sustainable development.

Security of supply does not seek to maximise energy self-sufficiency or to minimise dependence, but aims to reduce the risks linked to such dependence. Among the objectives to be pursued are those balancing between and diversifying the various sources of supply (by product and by geographical region). The European Union now has to face new challenges characteristic of a period of profound transition for the European economy.

In the decade to come, investments in energy, both to replace existing resources and in order to meet increasing energy requirements, will oblige European economies to arbitrate among energy products which, given the inertia of energy systems, will condition the next 30 years. The energy options exercised by the European Union are conditioned by the world context, by the enlargement to perhaps 30 Member States with different energy structures, but above all by the new reference framework for the energy market, namely the liberalisation of the sector and environmental concerns.

THE SECURITY OF EUROPE'S ENERGY SUPPLY: CONTINUOUS ADAPTATION

The aim of the energy-supply strategy for rhe European Union must be to ensure the well-being of its citizens and the optimal functioning of its economy, providing a countinuous supply of energy at prices that are as low as possible for citizens and companies and in a way that is compatible with sustainable-development objectives.
What is more, the European Union is faced with a profound period of transition. In the decades to come, massive investments will be necessary in the filed of energy and in energy infrastructure in particular. This should put the European economy on a new path, towards growth with low emission of greenhouse gases.
The objectives of the energy-climate package adopted in 2008 for renewable energies are essential in this regard. Not only are renewable energies low in carbon but above all, they are mostly produced locally, in Europe, and therefore strengthen of security of supply in circumstances that would otherwise see the share of primary energy imported into Europe increase.
Two lines of development are necessary so that Europe can securely access energy resources to nourish intelligent future growth that is sustainable and inclusive according to the terms of the „Europe 2020" strategy.
Primarily, it is advisable to go further in implementing the internal market for energy. The markets for electricity and gas are still far from functioning as integrated markets at the European level. For example, it is striking that only 3% of the electricity produced in Europe is traded beyond the borders of a member state. We are now in a situation where national and regional markets are juxtaposed rather than having a real integrated market at the European Union level.
We also need to complete the functioning of the integrated market in this field. This is the only way of being physically able to ensure that all citizens and companies will have access to natural gas under the best conditions, even in case of sudden shockes to one of the sources of supply on entry to the European Union.

Figure 1. Electricity supply infrastructure

Following the gas crisis of 2009, the security of gas supply came into force on 2 December 2010. The implementation of measures covering mechanisms for handling crises, particulary concering the standard on infrastructure.
Secondly, the necessary physical infrastructure should be put in place to allow the conceptual, legislative and regulatory development of integrated markets to provide optimal security of supply. This is true in the filed of electricity, gas and other sources or transmitters of energy.
In 2010, the European Commission adopted a strategy on priority infrastructure for 2020 and beyond for the development of European networks, which identified 10 priority corridors on the electricity, gas and oil sectors and for the installation of intelligent networks. Major investments will be necessary over the next 10 years, particulary in transport and storage.
The European Council has adopted new measures. These measures aim to make possible the implementation of projects in the European interest. EU wish through measures to improve and accelerate the procedures for authorising new infrastructure.

At a time when both national budgets and private lending are in difficult situations, this immediately rises the problem of knowing which player will make such massive investments in infrastructure.

A NEW CRISIS IN THE SUPPLY OF ELECTRICITY IN SOUTH EASTERN EUROPE

Southeastern Europe faces a new crisis in the supply of electricity, which is the result of nearly two years of drought periods. Summer electricity consumption growth is currently successfully covered by imports from Slovenia, Hungary and Bulgaria in part, and if the drought continue, due to low water levels of rivers and reservoirs, the region would be in the fall and winter could face serious problems in the regular supply of electricity, which would led to an increase in the price of electricity on the regional and international markets.

Traders indicate that the continue of drought will result with the inevitably rise in electricity prices at the regional, international market, which will further burden state power utilities that need to import the missing energy. How serious is the situation became clear last week when Romanian Hidroelectrica, who is one of the largest regional exporter of energy, due to low water levels in the reservoirs referred to the force majeure and canceled all contracted sales for export. Balkan additionally burdens the record low water level of the Danube and other major waterways in the region are facing a very negative hydrological assessments.

In mid-July, electric economy of Bosnia and Herzegovina, also one of the leading regional energy exporter, has announced that production from hydropower in 2012. were lower by as much as 42% from 3280 GWh as part of the plan. In the first half of the year, the production of hydroelectric power plants covered only 18% of total production. It is expected that total production EPBiH in 2012. would be 20% lower than in 2011, partly due to the plant maintenance of 215 megawatt power plant in Tuzla, mostly due to the prolonged dry period. Bosnia and Herzegovina is the only exporter of electricity in the Western Balkans, and even 40% of the energy produced by hydroelectric plants.[1]

An additional load was a major overhaul of thermal power plants in the region, as in the second quarter of the year which results with the higher production of hydropower facilities and additional drain reservoirs. Hydropower production in the region in period of six months from October 2011. by March 2012. was the lowest in last 15 years - produced a total of about 11 terawatt hours of energy, as much as 56% below average, this is a regional problem because Balkans produce more than 25% of the energy in hydropower plants. Total energy production in the first six months of this year in the region is 16% lower than last year, while in the case of Bosnia and Herzegovina is lower by as much as 50% compared to the annual average

THE NECESSITY OF ENSURING THE SECURITY OF EUROPE'S ENERGY SUPPLY

In the past, energy security was understood as deference against supply disruption and price instability. Maintaining stability and predictability was paramount. Today, energy security policy is no longer only a question of protecting existing energy supplies. The unrest in Libya and disaster in Japan are the most recent indicators for radical changes currently occurring in global energy markets. This calls for a strategy for managing global energy market dynamics without energy security concerns. In fact, we know that a safe, secure, sustainable and affordable energy supply is crucial to Europe's economic and strategic interests as a global player.

The Libyan case shows that political turnoil in some impotrant oil and gas producing countries could lead to supply shortages in Europe. Nevertheless, sucurity of supply issues have so far been addressed mostly on national level. While security of supply is ulitmately the responsibility of Member States, at a time of crisis, with events in Libya putting the world on alert, energy security calls for quick and decisive political leadership by the EU. The EU must come together to defend its enegry security in a strategy based on political consensus, mutual solidarity and full market integration.

The internal energy market today is fundamental and most effective tool to provide security of supply. Only a fully functioning market is able to take adequate corrective measures in case of a disruption. During the gas crisis in January 2009, there was enough gas on the European market. But because of

[1] http://www.e-novine.com

market anomalies and lack interconnections it could not flow to those places where demand for it was the higest. Also substantial investments are planned to increase connections between EU Member States, including investments funded by the European Energy programme for Recovery (EEPR). The need for an improved and modern infrastructure network has become a major issue and will condition the success of the EU energy integration.

Today, the EU has the world's largest regional energy market of 500 million people. It accounts for one fifth of the world's energy use. It is also the world's biggest economic trading block. Every time that the EU has spoken with one voice, results followed as shown by the gas supply crisis of 2009. Europe needs a mechanism to coordinate its efforts and send coherent messages to her main partners. The integration of energy markets with our neighbours is an impotrant step, but our international relations must go further and should aim at establishing strategic partnerships with key partners.

Following the tragic events in Japan, the Commision has agreed with all Member States to jointly assess the consequences, together with national nuclear safety authorities, nuclear power plant. In particular it has been decided to organise in the coming months specific stress tests in all Member States. But the events in Japan also prove that the global energy system is entering a phase of unpredictable transition with potentially far-reaching implications for the next decades. The EU's energy system must therefore go through a deep transformation in the way to generate, transport, distribute and consume energy, in particular electricity.

The EU's conventional energy resources becoming scarcer, therefore, it should be used this critical momentum to gradually shift to a low-carbon society. The initiatives for the development of new and renuwable energy sources and for reaching a high level of energy efficiency serve this objective. Europe has currently some of the world's best renewable energy companies and research institutes and the numerous research activities to find new, more efficient ways of producing and using energy, is undertaken. The main challenge today is to accelerate market uptake of technologies. It must be demonstrated that sustainable energy technologies which contribute to ensuring the security of energy supply are viable, costeffective and good for the environment and economy.

EU ENERGY CONSUMPTION

Total energy consumption

Energy consumption decreased slightly in 2007 compared to 2005 and 2006. In 2007, gross inland energy consumption in EU-27 was 1 806 Mtoe while it was 1 826 Mtoe in 2005 and in 2006. 2007 provides further confirmation that growth of energy consumption has stopped. 2007 consumption, down by 1 % from 2006, is comparable to the 2003 level (1 803 Mtoe). Final energy consumption has followed the same trend, decreasing by 1.5 % from 2006. In 2007, total final energy consumption was 1 158 Mtoe while it was 1 176 Mtoe in 2006. 2007 final consumption remained slightly below the 2003 level.

According to preliminary data, a slight decrease in gross inland energy consumption in 2008 (0.9 %) contrasts with the moderate increase in GDP of 0.9 % between 2007 and 2008. This could, to a certain extent, provide a further confirmation of decoupling of energy consumption and economic growth.

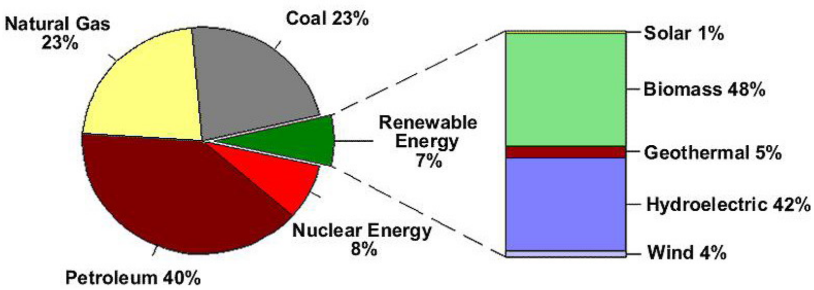


Figure 2. The percent of energy resources

Gross inland consumption and energy mix

Oil remained the most used energy source in the EU in 2007. However, for the second consecutive year, gross inland consumption of oil has dropped and according to 2008 monthly aggregated data, a further 1.5 % contraction occurred. In 2007, it accounted for 657 Mtoe, down by 2.4 % year-on-year, which was comparable to 2000 consumption. As for its share in the EU energy mix in 2007, oil accounted for 36.4 %, down by 0.5 percentage point (hereafter pp) with respect to 2006. In 1990, oil accounted for 38.1 % with 633 Mtoe. As in the case of oil, consumption of gas and nuclear energy decreased slightly in 2007 respectively for the second and third consecutive year. Gas consumption, totalling 432 Mtoe in 2007, fell by 1.3 %, to slightly below the 2004 level. Nuclear energy consumption fell by 5.5 %, to 241 Mtoe which is slightly below the 2000 consumption. Gas remains the second most used energy source in the EU in 2007 with a stable share in the energy mix of 24 %. The share of nuclear energy is down by 0.6 pp, from 14 % to 13.4 % of the energy mix in 2007. It remains the fourth energy source in the EU gross inland consumption. In 2008, the consumption of natural gas increased (2.7 %) while for nuclear energy further decline could be observed (0.9 %).

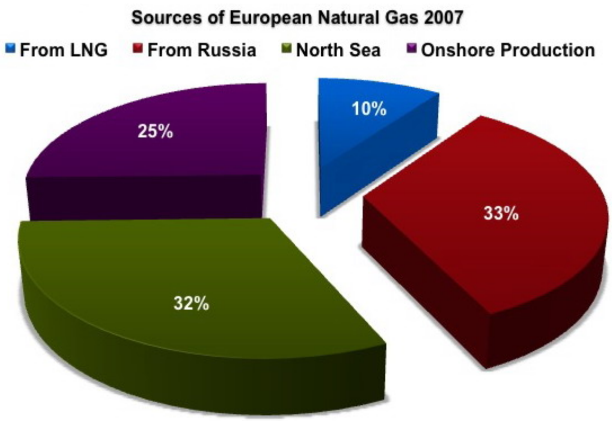


Figure 3. The European energy supply: a ntural problem

- **One kilowatt-hour**
    - ✓ is consumed in six hours by the average EU citizen;
    - ✓ creates around 420 g of CO_2 (with the current EU electricity mix);
    - ✓ is produced by a big wind power plant in one second during a strong breeze.
- The average EU citizen **drives** 30 km to get to work , which involves the consumption of two litres of petrol and the emission of 5.5 kg of CO_2.

THE BEST ENERGY IS THE ENERGY WE DON'T CONSUME

Today the EU depends on imports for 55 percent of its energy supply. Because of increasing demand on world markets, rising energy prices, and repeated occurrences of political instability in major energy-producing regions, the question of how we can meet Europe's energy needs both reliably and affordably is more urgent than ever. Diversifying our suppliers and establishing energy partnerships with oil-and-gas producing countries is one key side of the equation. The other crucial side is this: we have to focus more intensively on new ways to improve the alignment between supply and demand within Europe itself. Among other things, this means accelerating our efforts to expand the use of renewable energy and to upgrade power grids, but most of all, this means: We have to boost energy savings and energy efficiency.
This is no easy task, but it's necessary, and it's worth it! If we use energy efficiently and establish smart framework conditions at both the European and national level, we can achieve all of our primary energy policy goals: economic viability, security of supply, and environmental comatibility. In this way, we can succeed in our efforts to further decouple economic growth from energy consumption – and this is a key precondition for maintaining and enhancing the dynamism of European industry.

The path toward greater energy efficiency involves major challenges, but there is also major potential for improvement in this area, praticulary in the building and transport sectors. But Europe isn't starting from scratch here.

One good example of a market-oriented and non-bureaucratic measure is the European Commission's proposal – contained in its 2011 Energy Efficiency Plan – to enhance the transparency of the energy services market by publishing market analyses and by providing end users with information on available services and offers. Compulsory rules must remain the exception and must always stay within the boundaries of what is economically feasible. In any case, it is absolutely necessary to avoid the adoption of overly rigid energy consumption rules that slow down growth and investment in Europe.

Right now, the 27 member states are at highly divergent stages of development when it comes to energy efficiency, and this is one of the biggest challenges we face in our efforts to adopt European rules to improve energy efficiency. And the differences are not just between old and new member states: rather, there are major differences in the priorities and intensity of existing national energy efficiency policies, in national legal frameworks, in funding and support programmes, in the awareness levels and energy consumption habits of businesses and private households, and not least in construction methods and climatic conditions. Some member states can point to decades of experience in this policy field, while others are now just starting to catch up. We have to take these differences into account as we move forward. Furthermore, these differences provide clear proof that it is essential to divide tasks and responsibilities between the EU and the member states in a way that makes sense and is truly workable. The member states must retain the necessary flexibility to shape policy.[2]

Some investments in energy efficiency pay for themselves within a realitively short period of time. For example, turning off appliances and equipment instead of leaving them in stand-by mode can save the average household 100 euros per year in electricity costs. In assition, replacing older household appliances with new ones can generate substanial enegy savings

For example, in recent years Germany has gained positive experience with programmes that offer energy-related advisory services to small and medium-sized businesses and that provide suport for energy efficiency building retrofits. To this end, an Energy Efficiency Fund have established in Germany. This Fund finances support measures for consumers and businesses, such as programmes to promote the market deployment of energy-efficient generic technologies and to foster the implementation of energy management systems. It also provides funding for cutting-edge power plant technologies as well as smart power lines. In addition to programmes like these, we should also look at exiting EU financing schemes – such as the structural funds – to determine whether they can also be put into action toward our goal of improving energy efficiency.

One thing is clear: top-down energy efficiency policies will not succeed. The risk of boosting energy efficiency must be tackled at all levels – by the European Union, the member states, and society at large.

PREPARING THE UNION TO COPE WITH THE NEW ENERGY CRISIS –WHAT STRATEGIES?

Europe is faced with new challenges related to the unstabile situation in the global energy market. The EU needs a well-prepared and long-term power industry development strategy. In order to achieve the objectives of the European energy policies specified in the Treaty of Lisabon, the member states have to cooperate.

The external energy policy of the EU is going to be one of the top priorities. Poland is of the opinion that the Union will not be capable of maintaining its position in the global market or cooperating effectively with its global partners if it does not manage to fully implement a strong and coherent external energy policy.

Further expansion of the Energy Community (in particular, the accession of the EU's neighbors) would contribute greatly to Europe's energy safety. It should become a priority for the next 10 years.

---

[2] Michael, J. (ed.) *Greening the Millennium? The New Politics of the Environment*, Oxford: Blackwell Publisher, 1997.

The Energy Community Treaty has proved its suitability and effectiveness and it should be treated in terms of a basis for the EU's dialogue with its partners.
Investments aimed at completing the construction of the natural gas internal market should be seen as the basic requirement for the EU's energy safety. Both the conclusions stemming from the 2009 gas crisis and later experiences show that it really pays off to develop natural gas grids linking the EU member states.
The structure of energy production raw materials in the Union is not going to change drastically in the near future. Coal will not stop being the basis of the Community's energy safety, and that is why the EU regulations should also take into consideration the development of technologies deployed to extract energy from our own sources.

HOW TO GUARANTEE THE SECURITY OF ENERGY SUPPLY IN EUROPE?

The EU energy policy has to securely supply energy to all 500 million European citizens. To complete the internal energy market, the EU has to enhance security of supply, to enable the integration of renewable energy sources, to upgrade and modernize electricity grids and to ensure the interconnection and interoperability between Member States' (MS) energy infrastructure as well as the integraton between trans-European energy network with the energy infrastructure of the neighbouring countries.
The third energy package established the framework to develop the Pan-European energy infrastructure. The ten year investments plan should not only provide flexibility to the internal energy market and increase the security of supply, but will identify the needs for further investments in order to remove the energy island.
The EU's dependency on gas imported from third countries is above 60%. The consumption of gas imported from Russia is three time higher in the EU-12 than in the EU-15. Therefore, a diverified portfolio of physical gas sources and routes, a fully interconnected and bi-directional gas network as well as enhanced storage capacities and enhanced infrastructure for liquefuel (LNG) and compressed natural gas (CNG) within EU are needed. In this context, the Black Sea Region (BSR) is of geostrategic importance, in particular for energy security and the diversification of EU energy sources and of energy supply routes, given its proximity to the Caspian Sea, the Middle East and Central Asia. Therefore, we stress the European added value and the importance of the Southern Gas Corridor as a means of enhancing the EU's security supply.
The interconnections between Member States' national gas infrastructure should not only include projects which are pure „reverse flow projects", but also ones which contribute to the improvement of European security of supply.
The EU should urgently develop Pan-European smart grid, able to use the electricity produced locally or regionally from renewable sources and integrated within the required infrastructure for the use of electric or hybrid-vihicles. This requires better interconnections between the national electricity grids of the Member States.
In order to reduce EU's dependency on energy products imported from third countries which are traditional partners, the EU should be more focused and should invest more in energy efficiency measures. The improvement of energy efficiency of the building sector as well as of the transport sector will reduce primary energy consumption and CO_2 emissions. Therefore, the upgrade of urban district heating and cooling networks as well as the introducion of smart metering should be part of EU priorities and should be properly reflected and supported by the current and future financial perspectives.

CONCLUSIONS

We will achieve greater energy efficiency only on the basis of efficient individual measures. For this reason, it should be a matter of course that we regularly review such measures at the European level and critically examine their effectiveness.
There's no time to delay. If we want to achieve our 20 percent reduction target by 2020, we have to get businesses and private households on board as well. To do this, though, we should place a priority on economic incentives, not on compulsory measures. The businesses and citizens must take their own

responsibility and initiative, because there are powerful arguments for investing in energy efficiency. Such investments normally pay for themselves quickly through reduced energy consumption. This must be clearer to the public. For this reason, it is crucial for the member states and EU institutions to provide information on energy consumption that is both easy to uderstand and readily available.

However, other investments – such as energy-efficiency building retrofits – will rarely be undertaken if no financial incentives are provided. So it's clear that we won't be able to achieve our energy efficiency targets in the total absence of government funding and supprot measures. We have to overcome the financial hurdle of costly initial investments and set targeted incentives to get citizens and businesses on board for higher energy savings. In turn, their investments will help other branches of the economy, such as plant construction, the skilled crafts and installation services.

REFERENCES

[1] Atkinson, A.B., Comparing poverty rates internationally; lessons from recent studies in developed countries, World Bank Economic Review,5,3-22., 1991.
[2] Balassa B., The Theory of Economic Integration, Irwin, Homewood, Illinois, 1961.
[3] E. Bridge, Analysis of coupling solutions for the CWE region and Nordic market, final version, September 2009.
[4] IEC 64100-21 Wind turbines – Part 21: Measurement and assessment of power quality characteristics of grid connected to wind turbines, Edition 2.0, 2008.
[5] Stabiliry Pact Watch Group: Arrested development, energy efficiency and renewable energy in the Balcans, 2005.
[6] Michael, J. (ed.) Greening the Millennium? The New Politics of the Environment, Oxford: Blackwell Publisher, 1997.
[7] World Bank, Global Economic Prospects and Developing Countries, The World Bank, Washington, 1994.
[8] Web sites: http://www.e-novine.com
http://www.euractiv.rs
http://www.ks.undp.org
http://rs.seebiz.eu
http://www.biogassrbija.com
http://ec.europa.eu
http://www.energy.eu

SOLAR ENERGY IN SERBIA - POTENTIAL, APPLICATION AND DEVELOPMENT

Miroslav Lambić[1], Erika Tobolka[1]
[1]University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
e-mail: lambicmiroslav@yahoo.com

Abstract: The paper presents the potential of solar power in Serbia. The possibility of using solar thermal and photovoltaic systems, are given. Especially, prominent justification and energetic effects (saving) the use of solar energy in the process of heating water (in households and industry). The effects of using solar energy for heating houses and other buildings, are given. It also contains recommendations for a more intensive use of solar energy in Serbia. Recommendations are given solar system suitable for implementation in Serbia.
Key words: solar energy, potential, possibilities for application, development, Serbia

INTRODUCTION

From the energy sector point of view, solar radiation presents a resource that is available for use and the substitution of considerate quantities of conventional energy forms. Its limited use is caused by technological and economical problems. It is a huge energy source with which demand for the energy can be covered for a very long time.
Solar energy can have a significant place in energy sector of a country because it presents renewable and inexhaustible energy resource. Not the same attention to renewable energy resources is paid everywhere in the world. We can freely say that relatively small number of countries - the ones most developed - pays more attention to this issue. It is interesting that the energy technologies based on the use of solar radiation are being developed the most in technologically and economically powerful countries. There are several reasons, from which the most important are strategic, economical and ecological factors.
Solar energy is, ecologically seen, clean energy whose energy technologies in application do not pollute the environment. It presents a resource that each country has available, without being import-dependant. It is especially significant fact that the plants for solar energy use can be constructed immediately next to the consumers - without significant investments into infrastructure. With technical means solar energy simply is transformed directly into heat and, directly or indirectly, into electricity, which enables fast application in all energy processes. The use of solar energy in all segments of energy consumption is in significant increase in many countries of the world today.
The use of Renewable Sources of Energy (RES) and with them of solar energy, contributes to more efficient use of our own potentials in producing energy, decrease of "green-house effect" emissions, decrease of the import of fossil fuels, development of local industry and creating new jobs.
By passing a Directive on Measures of Encouragement for Energy Production by Using Renewable Sources of Energy, with the decision of the government of Republic of Serbia, pre-conditions to start more intensive use of transformed solar energy in households and economy of Serbia have been established.

POTENTIAL

From practical solar energy use point of view, important is the quantity of energy that reaches some surface during a day. This quantity depends on the latitude, season, orientation of receiving surface and meteorological conditions. The first three factors are of geometrical character and there are calculation methods of their precise determining. However, meteorological conditions are a variable factor and reliable data can be reached only by measuring during many years. For the use of solar energy data on middle daily sum according to months of a year, as well as data on average temperatures for the same periods are important. A great role in the use of solar energy have the shape, the size of the buildings, orientation, materials used and other. Also the environment is important, if there are shades from other buildings and other.

Having in mind that the Sun's energy, from the technical-exploitation point - is energy resource of renewable feature (transformed solar energy which is conducted from the receiver of solar energy (RSE), is permanently being in the process of renewal, in the conditions of radiating solar energy), we cannot speak of an energy resource as in other cases of non-renewable sources of energy. This resource depends on insolational conditions, size and characteristics of SEC (previously listed factors) and the time span of exposure of RSE to radiating solar energy.

The Sun, as a source of energy, has very stable effect and intensity of radiation until it reaches the Earth's atmosphere. The decrease of this radiation in the Earth's atmosphere under the most favorable conditions goes within limits of 23,9 to 28,3%. But, except for yearly, monthly and daily changes of the intensity of solar radiation on a certain surface of the Earth, the changes appear depending on meteorological conditions of the atmosphere, as well as the angle of arriving rays onto the Earth, or the surface they reach.

The energy of radiation that reaches some surface on the Earth depends mainly from the duration of sunshine. Insolation depends on the latitude and season. The difference in time from dawn till sunset gives the time of insolation duration to which horizontal and uncovered surface is exposed. This for Serbia equals to around 15 h - in summer and 9h-in winter. Real duration of insolation is significantly shorter due to the appearance of clouds and fog, and also depending on the conditions of atmospheric pollution at the monitored area. It differs for surfaces that are set horizontally, vertically, or at a certain angle relating to the surface of the Earth. Energy inflow of solar radiation is not proportional to insolation duration. Meaning that a part of the energy is lost by going through the atmosphere due to oxygen, ozone and CO_2 absorption. The loss is greater as the Sun is closer to the horizon. Next to that, radiation energy scatters in its passage through the atmosphere, and the biggest loss happens immediately after the sunset. So, the overall radiation that reaches the Earth's surface consists of immediate - direct and indirect - diffuse radiation, which is a part of scattered radiation energy. Because of all this the strength of radiation that reaches some surface, and which could be energy useful, considerably varies during the day, and its changes depend on the season and the position of the radiated surface.

Very often the energy of radiation is presented as the energy that reaches the surface of the Earth during the day, of course during the time of insolation.

The strength of solar radiation varies during day, month and year. Its value depends on geographical position, conditions of the atmosphere and other. All this points to a great variability of solar radiation strength. Still, these changes are slight (less than for example the change of the strength of the wind), and they can be foreseen with bigger or smaller exactness, because the rhythm of these phenomena is familiar (dawn and dusk). The intensity of available radiation we cannot predict utterly precisely. As a source of energy, solar radiation is more suitable than - for example the wind - concerning the predictability of the phenomenon, but it is less suitable because there is no radiation at night and it is less intense during winter when energy consumption is bigger. Plants can function only during daily cycles, which does not coincide completely with the rhythm of energy demand. Additional plants have to be built, or to ensure the accumulation of energy, by which the providing of consumers would be secured even at night or in worse conditions of insolation.

The greatest participation in getting the energy via solar collectors have direct and diffuse radiation, whose intensity changes during the year, depending on the change of seasons. naturally the most of solar energy is achieved during summer months when the intensity is the strongest. The maximum of solar radiation happens in June, and minimum at the end of December and beginning of January. During the duration of a day generally, the biggest radiation reaches the Earth at noon when the position of the Sun in the skies is the highest and the trajectory of passing solar radiation through the atmosphere is the shortest.

The number of sunny hours in Serbia goes from a bit less than 2.000 hours up to 2.300 hours. According to "*Valentin Energie Software -TSol Pro 4.5*" and *PVGIS programu - Photovoltaic Geographical Information System (JRC - European Commision*) the average annual value of global radiation for horizontal surface is between 1.300 kWh/m^2 on the north of Serbia and 1.600 kWh/m^2 on the south of Serbia. This shows that on the same source, the average yearly value of sun radiation over a horizontal area for the territory of Serbia is around 1.450 kWh/m^2.

The average daily energy of global solar radiation on horizontal surface at the territory of Serbia goes from 1,2 – 1,6 kWh/m^2 during January, and from 6,15 - 6,95 kWh/m^2 during July. At the territory of Serbia, the annual average of daily solar radiation energy on the horizontal surface is 3,5-4,3 kWh/m^2.
According to meteorological measuring made in the span of 30 years in ex Yugoslavia, the values of radiating energy on some horizontal surface are larger from estimation values (according to *Valentin Energie Software -TSol Pro 4.5*) for about 9 to 12%.
In geographical conditions of Serbia, the energy that reaches a horizontal surface of 1 m^2 creates values of minimum 1.270 to maximum - 1.580 kWh/yearly. This is equal to the quantity of heating energy, that is possible to get by burning approximately 160-180 m^3 of natural gas.

POSSIBILITY OF USING

Solar energy provides various possibilities for application. Contemporary solar systems provide the use of solar energy during whole year.
The application of solar energy with thermal conversion is used in practice for:

- Heating of sanitary water in houses, apartments, hotels, hostels, students dormitories, retirement homes, kindergartens, restaurants, sporting facilities and everywhere where the need for sanitary water heating exists.
- Central or individual heating of sanitary water for settlements that are connected to the distribution of hot water from city heating plants in the periods when they do not work.
- Heating swimming pools in the houses and sporting/recreational centers.
- Heating water or other fluids in industrial processes.
- Heating greenhouses (glass or plastic) in agriculture.
- Pre-drying and drying of agricultural and industrial products.
- Distillation of water for industrial purposes.
- Heating facilities as additional means in the periods when there are not enough sunny days.
- Producing electricity on the basis of heat conversion of solar radiation (steam turbines).
- In processes of space cooling.

In residential buildings there are two types of solar heating energy systems: the ones used specifically for water heating and those which next to it provide general heating (combined systems). Solar/thermal energy systems for consumable water heating are designed in such a manner to have dominant role during the warmer part of a year for consumable water heating. During winter season hot water is provided with boilers that usually function on electricity or indirectly from conventional heating system in the building, and during sunny days it is supported by thermal energy system. This means that around 60% of yearly needed energy for heating consumable water can be achieved by solar thermal energy systems.
Efficiency of transformation of the system for heating sanitary water, from collector to solar water heater, in classical collector types, goes from 35 to 55%.
With solar combined systems (with larger number of solar collectors) in certain measure the heating of facilities during autumn and spring months is provided. In this way, with optimum planned plant - installation, solar energy can provide 20 to 30 (40)% of overall energy need of the building, depending on how well it is insulated and what degree of heating we aim to. With specially designed buildings - houses, with application of combined heating the energy demands of the building of up to 50 to 90% can be covered.
This resource depends on insolational conditions, size and characteristics of SEC (previously mentioned factors) and the exposure time to SEC - from one square meter of SEC around 500 do 800 (kWh) of heating energy can be achieved yearly, which is closely equivalent to heating energy that is achieved from 50 to 80 liters of oil.
In winter period, in our area, overall energy effect of solar radiation is less than in summer, but still efficient enough for use. So, for example, from commercial types of solar collectors, in heating season, it can be produced - per square meter and per day - energy of (depending on the month and location) 1,2 to 3,0 [kWh].

In the heating season it is possible to achieve solar radiation of around 360 [kWh] of heating energy from one square meter of SEC.
In the heating season it is possible to achieve solar radiation of around 360 [kWh] of heating energy from one square meter of SEC, that is to say around 11.000 [kWh] from the surface of 30 [m^2].
Since the temperature of warmth in solar collector (with recommended speeds of current) in winter period goes mostly from 40 to 60 - maximum 80 [°C], it is clear that with the systems of central hot-water heating in the period of lowest temperatures, they can not be used as necessary. But if external conditions are more favorable, that is, when external temperature is around 0 [°C] and more, the possibility for using the heat from SEC is larger. Then boiler installation functions mostly with the temperatures of 60/45 [°C].
This means that the best effects for heating family houses and apartments can be achieved in transitional periods. Even this contribution is very significant. If in the system of hot-water heating, under-floor heating with floor panel is applied, which functions with lower temperatures, the effects of warming will be even better. The best effects are achieved by applying air system of heating. Energy effects of solar systems with heating houses or apartments depend on more factors, among which the right and optimum planning has the top role. Thermal characteristics of under-floor heating directly influence the quantity of heating loss, and with this the needs for heating energy.

DEVELOPMENT OF APPLICATION

In the field of heating conversion of solar radiation there are several roads open for developing, research and innovation. The development in the are of thermal use of solar energy is not so connected with the expensive equipment, which is the case with photovoltaic conversion. Systems for concentrating solar radiation, hybrid systems (combination of heating and photo-voltage conversion), air collectors, integration of existing, or new components, into buildings, application in distillation and desalinization of water, pasteurization in food industry, drying in agriculture and storing heating energy - are just one part of the program which is possible to develop by available potentials in Serbia.
The present policy, connected to the decision about granting significant monetary means for recovery and development of science in Serbia, points to the opportunity for a part (at least 1%) of these means to be spent for applicable solutions in the area of renewable energy resources, where special attention should be paid to solar energy.
To make the use of solar energy more intense in Serbia, there should be a favorable business climate for the development of domestic solar equipment industry, on the basis of our own research and development. In present conditions it is even possible to produce the equipment of suitable quality and of lower prices in comparison to imported one.
It is necessary to set as a goal to have all needs for heating water up to 80°C in residential buildings and industrial processes met by using solar energy. In this way the building industry would be encouraged to deal more seriously with this source of energy. It is also necessary to encourage developmental and innovational activities in technology and solar equipment production, which will bring domestic industry to bigger efficiency and lower prices. In this we must also not forget continuous promoting, advertising of the use of solar energy, where a big role should be played by NGOs and media.

JUSTIFICATION OF USE

Solar energy is very attractive and economically justified for use for water heating and for the heating of households, industrial and other facilities. Four reasons why Serbia should enlarge the application of solar energy is:

- Over 55% of overall energy is used in households in Serbia in the form of electrical energy, from which a great part for heating the sanitary water.
- Cost-cutting for heating sanitary water of around 60 to 70 percent is achieved yearly, which leads to unloading the house budget.
- The employment in the process of research, production, assembling and maintenance of solar equipment is raised.

- By achieving considerate application of solar energy we get closer to suggestions of the European Union on the use of renewable energy resources where the Sun has a large role.

At this point for Serbia it is more justified to encourage the use of solar radiation energy for producing thermal and electrical energy in the domain of households, industry and some areas of agriculture because of smaller investments. This policy would, among the rest, be useful for the development of domestic economy as well employing the population in the field of clean energies. Lon-term viewed, the future of transforming solar radiation is in PV technology and its integration with other branches of technology, which is in accordance to the attitudes, plans, and also the present condition in the European Union and other economically leading countries of the world.

CONCLUSION

From the economical point of view, the price of electricity derived from solar energy continuously is falling as a result of technological advancement and mass production growth, while it is expected for fossil fuels to become significantly more expensive in near future. At this point for Serbia it is more justified to encourage the use of solar radiation energy for producing thermal and electrical energy in the domain of households, industry and some areas of agriculture because of smaller investments. This policy would, among the rest, be useful for the development of domestic economy as well employing the population in the field of clean energies. Lon-term viewed, the future of transforming solar radiation is in PV technology and its integration with other branches of technology, which is in accordance to the attitudes, plans, and also the present condition in the European Union and other economically leading countries of the world.

From economical perspective, on the basis of independent comparative tests, the most efficient are systems for heating sanitary hot water. This is confirmed also by comparative tests done for monitored and tested houses. In this comparison, mainly attained power was taken into consideration (yearly saved energy, the degree of usability, the quantity of hot water), also work and maintenance, ecological aspect and energy amortization, safety and simplicity of assembling. From comparative tests we can conclude that great investment costs are 2 to 3 times bigger with combined systems than with the systems anticipated just for the heating of sanitary water. With the support for heating the space it has some economical pay off but only with low-temperature heating systems (e.g. under-floor heating) and houses with small heat loss.

Although in winter time energy effect of solar radiation is lower than in summer, it is still very significant for the use of solar heating in houses, as a support to some other energy on the system of central heating, where it can cover around 45% of free heating energy for houses and around 75% for heating of sanitary water. The best effect using solar energy for solar heating of family houses and other residential and business spaces can be achieved in transitional periods with energy efficient heating systems, under-floor and wall heating systems, with low-temperature heating systems. Still, due to variability of radiating power of solar radiation during the day, month and year, the installation of solar heating that would provide entire house heating during the whole winter season cannot be implemented, and that is the reason why solar systems for solar heating are combined with some of different sources of energy where some other form of energy is used: liquid fuel, gas, electricity, solid fuel and similar.

Solar systems bring significant savings thanks to which derived energy is, so to say, used for free, after the pay off of the starting investment. The life span for quality systems is 25-30 years. Still, it is not possible to generally establish the time for pay back of the investment for solar system, because it depends on many factors, as for example the type and manufacturer of the collector and accessories, the way of preparation sanitary water and heating till present, the price of heating, natural gas or other fuels and similar.

Without the support of a foreign country the time for pay off is rather long in order to build, simultaneously with solar systems, modern, more efficient practical systems. Thinking about investing into solar collectors is, because of that, most suitable with replacing or reconstructing the obsolete and inefficient, or rather expensive heating systems (e.g. electrical heating) as well as in the case of new construction.

Over 55% of overall energy is used in households in Serbia in the form of electrical energy, from which a great part for heating the sanitary water. By using solar energy we can achieve the cost-cutting for warming sanitary water of around 60 to 70 percent yearly.

Serbia has the potential of producing energy annually - 700 to 900 and more (depending on the system efficiency, working mode and other) kWh/m^2 of solar thermal collector, which is more than in the countries that have the reputation in solar energy use. 3,3 kWh of energy could be produced in Serbia daily, and it would be used in most efficient manner in tourism, health care sectors as well as households, mainly for water heating.

Huge savings could be accomplished if every household would have at least one unit of solar collector by which sanitary consumable water would be heated. Seen in the framework of the country's electro-energy system, this would present quite a load shedding for the system.

Especially interesting group of consumers are numerous industrial, tourism, sporting, medical, military and other facilities. It is known that these facilities spend considerable amounts of electricity derived from burning solid, liquid and gas fuels for heating sanitary or technological water. This could be easily accomplished by using very simple systems for solar energy use.

Energy crisis and acute atmospheric and environment pollution have influenced broader possibilities of use, thermal and photoelectric effect of solar energy. In this direction the technologies have been developed, practical solutions and application of these systems designed. In winter period the overall effect of solar radiation is less that in summer, but still significant for use in the systems of heating houses - as a support to heating. In this way it is possible to cover up to 45% of thermal energy for heating houses, 70% - for heating sanitary water and up to 100% for additional heating of water in swimming pools.

Still, due to variability of radiating power of solar radiation during the day, month and year, the installation of solar heating that would provide entire house heating during the whole winter season cannot be implemented, and that is the reason why solar systems for solar heating are combined with some of different sources of energy where some other form of energy is used: liquid fuel, gas, electricity, solid fuel and similar.

According to the results of research done by European association "INTERATOM", the price of heating water for a household with flat solar collectors - in areas where there are more than 1,600 sunny hours yearly (and that is entire Europe), even today it is 1:1 in comparison with other systems of water heating.

As an illustration, with a simple calculation of the time for paying off the investment, an example that suits one part and way of preparing sanitary hot water in a family house, can serve the purpose. Needed investments are 15 - 25 EUR/m^2 - 900 do 1.500 EUR respectively, per household. Lower values relate to cheap solar collectors and simpler installations, and higher to more expensive systems with complex installations with heat-exchangers, system for emergency circulation of working fluid and automatic regulation of work.

The effects with heating consumable sanitary water in the period from April till October, from the aspect of coverage are 80% out of needed energy, and in the period from October till April, this coverage is 30%.

The life span for quality systems is 25-30 years (except for the boiler for drinking water and circulation pumps), and that is the reason why solar collectors are good investment for the future and less dependent on the price rises of classical fuels. Still, it is not possible to generally establish the time for pay back of the investment for solar system, because it depends on many factors, as for example the type and manufacturer of the collector and accessories, the way of preparation sanitary water and heating till present, the price of heating, natural gas or other fuels and similar. Without the support of a foreign country the time for pay off is rather long in order to build, simultaneously with solar systems, modern, more efficient practical systems. Thinking about investing into solar collectors is, because of that, most suitable with replacing or reconstructing the obsolete and inefficient, or rather expensive heating systems (e.g. electrical heating) as well as in the case of new construction.

Researches and commercial application in the area of technologies for the use of solar energy in the processes of heating and producing electricity have as a result in the previous decades enough indicators and practical experiences - so it could be said that these technologies, mainly, have outgrown basic research and experimental phase, and have achieved significant degree of practical application and commercial maturity. Of course, this does not mean that further researches in the direction of conquering new, more efficient, more technologically advanced and more efficient solutions, suitable for wider and further application in practice in everyday life and work, are not needed - as well as the systems reliable enough and efficient enough in the sense of use in various processes of heating (water, space and other), pre-drying and drying (of agricultural and industrial products), production of electricity for everyday use and similar. It can be concluded that the world solar industry, even today, has available reliable technologies and long-standing experience of practical application. In this sense the systems for the use of solar energy for various lower temperature processes (to 100 ^{0}C) are acceptably reliable, efficient and commercially mature. That, above all, relates to the use of heating effect with lower-temperature conversion of solar radiation into heat - for the needs of sanitary water heating for the consumption (in all segments of use - from households, tourist facilities, establishment buildings to industry), technical water (in agro-industrial and industrial processes) and other.

The use of lower-temperature solar plants (solar collectors) in the processes of pre-drying or drying of agricultural products or in industry - of industrial products (processes that demand working temperatures of up to 100 ^{0}C) is practically applicable - whether directly - by pre-heating of the drying agents (air and other gases) - in air collectors, or indirectly - by solar collectors with liquid working medium. It must not be forgotten that low-temperature solar systems (collectors) provide preheating in high-temperature processes. Because in all processes - whether they are low or high-temperature - the heating is done from some lower temperatures (temperature of the environment) to some, technologically needed temperatures.

Systems for photoelectrical conversion of solar radiation into electricity are far more suitable for broader use in practice. This also relates to smaller systems with accumulators of electrical power where electricity is stored (in other words the excess of produced electricity) during the day - when there is not enough solar radiation (night and day - in cases of extreme cloudiness). Solar systems where produced electricity is kept in accumulators, consists of solar cells, regulator for charging the accumulator and accumulator. With this system an inverter for converting direct current into alternating current is also added. The second type of the system is based on joining the photo-voltage system - via converting the inverting system - directly to power network (without the accumulator of electricity). Solar systems for producing electricity that are joined to the city's network, consist of solar cells (modules), converters of direct into alternating power (inverters) and electricity meter.

Thise system, on the contrary to the power plants with concentrating mirrors, can use also diffuse radiation for producing electricity. The quantity of produced electricity with diffuse radiation is of course less from the one produced during direct exposure to solar radiation. The advantage of these types of solar power plants is in the possibility of type building of systems with high and low power. These are simple systems (usually built without the possibility of changing the angle or turning). And as static systems work efficiently and reliably enough. They are easy to manage and maintain. The price per Watt of installed power for these power plants goes from 2 to 3 Euros. Today in the world, commercial power plants of this type are common and work, where limits per exposure to the Sun and intensity of solar radiation mainly do not exist (for average conditions). Since photo voltage systems produce direct transformation of solar radiation into electricity - these systems do not have (static) movable mechanical subsystems that are important for function and maintenance.

The conditions of installation and other conditions for areas in Serbia are suitable for building and exploitation of these kinds of plants. These are systems that, through up till present researches and exploitation reached full maturity and needed reliability in work. Further researches connected with the enhancement of energy efficiency and lowering the initial costs for photovoltaic panels are continuing, where the application of the reached technical solutions does not present a problem.

Having previously mentioned in mind, and in the framework of this study - presented and explained - it can be concluded that for the needs of various energy consumers in Serbia, today application is, recommended, compatible and reliable enough and techno-economically (and ecologically) justified for:

1. Low temperature solar systems (with flat thermal collectors) in the processes of heating sanitary and technical water for consumption in households, institutions, tourism industry, health care, industry and everywhere where there the need for heating (or pre-heating) of various fluids exists.

2. Photo voltage conversion systems for producing electricity - from small power (mini-plants) to middle and larger power.

Heating solar systems are mostly used for heating sanitary water, heating technological water , water in pools and other. It is possible to use them also as a support to heating various facilities - houses, halls and other, but this application is more suitable for buildings that use low temperature systems of heating (under-floor, ceiling or wall) and that are well insulated, meaning that their temperature losses are on the level of low energy buildings. In climatic conditions of Serbia the application of solar technologies is combined with other sources of heating for providing enough quantity of heat in the conditions of less insolation or absence of insolation (in the evenings, mornings, at night, in winter etc.). The water for the needs of heating, heated by solar collectors can be also used in systems of central heating or central heating provision (CHP). Generally viewed, solar energy can cover 50 -70 % of yearly needs for the energy for heating water in households, in summers and transitional periods,so to say, entirely, while during winter it is enough for pre-heating of cold drinking water. Except in the field of apartment building and family houses building, public infrastructural institutional buildings (hospitals, sanatoriums, schools, hotels), present further potential sphere in application of solar heating plants. Good application of solar installation can be found with heating open and closed swimming pools, small buildings of power-maintenance services, public institutional buildings (customs, military installations and other), restaurants, agricultural companies and especially for the heating of consumable water in agricultural industry, food industry and other.

Serbia has available resources of solar energy on a level quite above the European average, with favorable season schedule. Its efficient and long-term use is necessary to be elaborated in the shortest period coming. To intensify the use of solar energy in Serbia, a favorable climate for the development of domestic industry should be created. In present conditions as well, equipment of suitable quality could be produced in small batches and of a suitable price, less than of that from the import.

The application of solar energy presents good way to lower the consumption of electricity everywhere where it is possible. No matter the starting investment into solar installation is relatively high (almost 500 euros for one kW of installed power), it pays off to invest because it will have safe and certain market. If in this price we calculate everything that simultaneously accessorize well planned and organized work, such as research, development, production, marketing, creating professional, scientific and production staff, conquering new technologies, export of the biggest part of production, raising the employment in basic and following fields of work - then the price is quite lower, and a positive energy and economy effect is reached.

Entirely viewed, in Serbia, the application of solar energy for heating sanitary water or space is largely negligible. The same can be said for other areas of possible application. The reasons for existing condition in Serbia are: ignorance about the application of renewable sources of energy, small amount of information on the plans and conditions in Europe, about our future obligations in the circles of decision-makers, as well as in population being uninformed of the possibilities of applying solar energy, the price of the equipment, energy and financial effects. Also, the problem lies in very low material standard of Serbia's population, as well as in relatively low price of electricity, which automatically leads to the fact that electricity is not being rationally spent. The production of domestic equipment is expensive due to import dependence for materials and small, not formed yet, market.

Not less important is the economical effect of the development of new industries of manufacturers and providers of technologies in the area of renewable energy sources. On the basis of European Federation study on the use of solar energy (ESTIF) the use of solar energy has incomparably more advantages in functioning in comparison to fossil and nuclear energy. On 1.000 GWh of delivered primary energy there are 90 new jobs in energy sector based on coals, 72 jobs in nuclear energy sector and even 3.960 jobs in solar energy sector. Creating projects, making, installing and maintaining solar systems, which differ from others, since the energy source is not centralized on one place, but provides opportunities for work in all the regions, is included in this number. So, if we think about limited storages of brown coal, renewable sources of energy are the only domestic, basic, energy sources for the future. By using renewable sources of energy Serbia can get tens of thousands new jobs for qualified personnel, and in the future it will not be afraid or become someone else's cheap labor in other parts of the world.

REFERENCES

[1] Lambić, M.: Energetika, Tehnički fakultet "M. Pupin", Zrenjanin, 2003.
[2] Lambić, M.: Solarna tehnika, Srbija solar, Zrenjanin, 2004.
[3] Lambić, M.: Solarna energetika, Srbija solar, Zrenjanin, 2006.
[4] Lambić, M. i dr.: Solarni atlas Vojvodine - studija, Izvršno veće AP Vojvodine, Pokrajinski sekretarijat za energetiku i min. sirovine, Novi Sad, 2011.
[5] Radosavljević, J., Pavlović, T., Lambić, M.: Solarna energetika i održivi razvoj, Građevinska knjiga, Beograd, 2004.
[6] Weiss, W., Mauthner, F.: Solar Heat Worldwide, SHC, International Energy Agency, 2011.

BPMN & INTOUCH HMI SOFTWARE: A CASE STUDY OF MODELING THE FLOW MEASUREMENT SYSTEM AND DEVELOPING SCADA APPLICATION IN OIL AND GAS INDUSTRY

Jasmina Obradović[1], Mirjana Prvulović[1], Marko Ristić[1]. Milorad Kočić[1], Ljiljana Radovanović[2], Marina Milovanović[3]
[1]Institute Goša, 35 , Milana Rakića str., Belgrade, Serbia
[2]University of Novi Sad,Technical Faculty "MihajloPupin", Zrenjanin, Serbia
[3]Faculty of real estate management, Union University, Belgrade, Serbia
e-mail: jasmina.obradovic@institutgosa.rs, mirjana.prvulovic@institutgosa.rs, marko.ristic@institutgosa.rs, milorad.kocic@institutgosa.rs, milovanovicmm@gmail.com

Abstract: The Business Process Modelling Notation (BPMN) is an increasingly important standard for the graphical representation of business processes. The improvement experienced in BPMN, opens an opportunity to show one very specific flow measurement process in Oil and Gas industry and at the same time show execution of the same process using Supervisory Control And Data Acquisition (SCADA) systems. The first part represents brief description of BPMN graphical tools and explanation the main purpose of the SCADA application. Second part is dedicated for modeling of sub-processes: „Preparation of measuring place“and „Entering data into a SCADA application“. The benefits of modelling by BPMN notation are simplicity, clear visualization and visibility of business process. Software support represents a great contribution to the business process precision. Our work contributes to new observation and modelling of complex business processes in the Oil and Gas industry by mixing modelling and notation software.
Key words: BPMN, InTouch HMI 10.0., SCADA applications, flow measurement system, Oil and Gas industry.

INTRODUCTION

Over time, new languages and standards for process modeling, and new tools also for their implementation, are developing. One of them is The Business Process Modelling Notation BPMN, standardized modeling notation developed by the Business Process Management Initiative (BPMI) group, together with the Object Management Group (OMG) group. The purpose of modeling is to represent the structure of objects, system or concept, using graphical presentations. Graphical presentations are used in order to make the modeling process brighter.BPMN also includes a key capability: an ability to produce a mapping from the business-oriented notation to an execution language. This creates a new standardized bridge between the business analysis and the IT implementation that was previously handled by ad-hoc methods. BPMN offers a wide range of modelling constructs, significantly more than other popular languages and represents intuitive notation, which is easily adopted and implemented. Many applications use BPMN in different kind of real life scenarios. For example, in area of higher education [1], [2], computer science [3] etc. For that reason, BPMN is the most recognized language for specifying process workflows at the early design steps [3], [4].
In our paper, we use Microsoft Office Visio 2007 for creating BPMN diagrams, in process modelling of flow measurement system for crude oil and petroleum derivates. Business process models are considered as a crucial issue by many enterprises because they are key to maintain competitiveness. Moreover, they are important for software developers, since the developers can capture all the necessary requirements for software design and creation from them. Business process modelling (BPM) is the centre for conducting and improving the process. One of the software that uses mentioned a standard by which is possible to control and optimize processes is InTouch HMI version 10.0. This software package is a very use-full tool for development SCADA (Supervisory Control And Data Acquisition) applications. Its advantage is providing a consistent, intuitive development environment that allows software engineers to build applications quickly and easily. For that reason, our work considers using this software package and SCADA application. SCADA application for sampling system was made according to the main BPMN diagram. InTouch software offers many

opportunities – we can display all the required parameters, decide what the critical situations in the process are and set information about them, do calculations, set different access privileges etc, but on the other hand, the process should not be menaced by some error or inconsistency. That is the second benefit of using BPMN: SCADA designers have clear picture of all actions and situations in the process, so they will spend less time and effort to develop their solution. Also, before starting of a system, it is possible to simulate real life scenarios and improve the BPMN model and application. For example, in our work it is not possible to execute wrong command because certain commands will be disabled depending on the real situations in the process.
The remainder of this paper is structured as follows: in the second section we will give overview of the main graphical representation of BPMN concepts using Microsoft Office Visio 2007 tool. In the same part we will summarize the main issues of using BPMN, human machine interface (HMI) and SCADA application. The third section presents a example BPMN diagram of business sub-processes *„Preparation of measuring place" and „Entering data into a SCADA application" in* refineries parallel with screens in SCADA application. The fourth section contains the most important conclusions of this paper. The fifth chapter represents our future work.

MATERIAL AND METHODS

BPMN graphical concepts

Business Process Modeling Notation has emerged as an important open standard graphic notation for drawing and modeling business processes (Figure 1.), [5], [6]. Its design goals include being readily understandable by all business users, from the business analysts that create the initial drafts of processes, to IT architects and developers that implement and deploy processes, and to business and IT users that manage and monitor those processes.
Microsoft Visio is software that enables creating diagrams by the BPMN specification, including set of patterns, which can be imported into it. **Business process diagram (BPD)** is made by importing BPMN graphical tools into Visio workspace. On the BPMN diagram of the business process we can see the sequence of events in the process and causes that lead to the normal flow and to the unwanted situations. When the modeling of business process is complete, diagram can be saved in various formats: JPEG, XML drawing, AutoCAD drawing, Web page, Windows Bitmap and others.

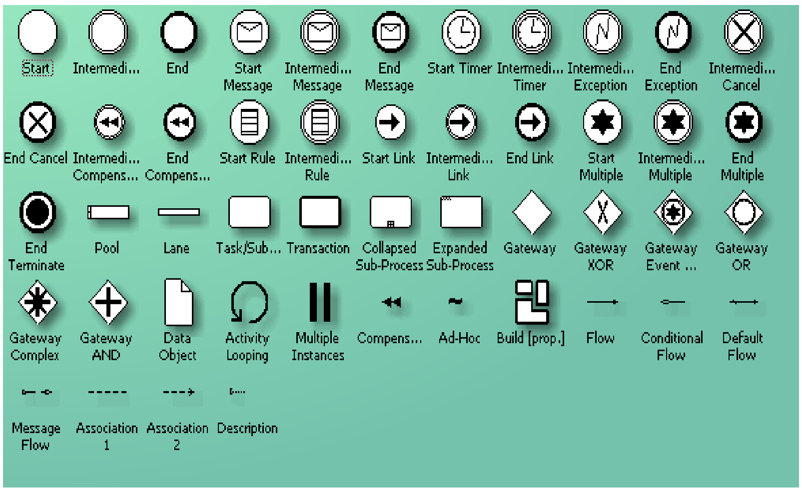


Figure 1. Graphical representation of BPMN concepts using MS VISIO tool

A Business Process Model is a network of graphical objects, which consists of activities and the flow controls that define their order of performance. In BPMN a process is depicted as a graph of flow objects, which are a set of other activities and the controls that sequence them. A BPD is made up of a set of graphical elements. These elements enable the easy development of simple diagrams that will look familiar to most business analysts. The four basic categories of graphical elements are: **Flow objects, Connecting objects, Swimlanes, Artifact.**
Events, Activities and Gateways are **Flow objects**.

Events are used to show that something “happens” during the course of a business process. Events are circular shape. There are three types of Events based on time when They affect the flow: **Start Event, Intermediate Event and End Event** (Figure 1.). Start Event indicates at the beginning of the process, while End Event indicates at the end of the process. An Intermediate Event which affects the process flow can be inserted between them within an activity or a sub-process. That event usually has a cause and effect, ie. “trigger” and result. Start and intermediate events are connected with activities by normal sequence flows, while triggered start and intermediate events are attached to the edge of the activity and they occurs in the case of exception related to the activity.

An activity is work that is performed within a business process. An activity has rectangular shape. The types of activities are: **Process**, **SubProcess**, and **Task** (Figure 1.). The **process** is a set of graphical objects. A **sub-process** is a graphical object within a process flow, but it also can be “opened up” to show another process. A sub-process can be in a collapsed view that hides its details or can be in an expanded view that shows its details within the view of the process in which it is contained. A **task** is an atomic activity that is included within a process.

Gateways can define all the types of business process sequence flow behavior Decisions/branching (**exclusive-XOR, inclusive-OR, parallel – AND, and complex**). BPMN extends the behavior of the diamonds to reflect any type of sequence flow control. Gateways have rhomb shape. Each type of Gateway will have an internal indicator or marker to show the type of Gateway that is being used (Figure 1.).

Connecting objects define the graphical objects used to connect two objects together and how the flow progresses through a process. Types of connecting objects are: **Sequence flow**, **Message flow** and **Association** (Figure 1.). A **sequence flow** is used to show the order that activities will be performed in a process. Types of sequence flow are: normal, conditional and default. A **message flow** is used to show the flow of messages between two entities that are prepared to send and receive them. Two separate Pools will represent the two entities. An **association** is used to associate information and Artifacts with Flow objects. Types of association are: an Association of text annotation and a directional Association.

Swimlanes use to organize the similar types of activities. Swimlanes are: **Pools** and **Lanes** (Figure 1.). A **pool** represents a participant in the process and may be shown as a “White Box,” with all details exposed or as a “Black Box,” with all details hidden. **Lanes** represent a sub-partition within a Pool and will extend the entire length of the Pool. Lanes are used to organize and categorize activities within a Pool.

Artifact shows additional information about a process that is not directly related to the sequence flow or message flow of the process. The types of Artifacts are: **Data object, Group and Text Annotation** (Figure 1.). **Data Objects** provide information about what the process does and generally will be associated with Flow Objects. **Groups** are artifacts that are used to highlight certain sections of a diagram without adding additional constraints for performance. **Text Annotations** use to provide additional information for the business analysts of a BPD.

Traditional automation and control uses hardware interfaces and custom designed algorithms to control a self-contained process. A limited **Human Machine Interface (HMI)** may be part of these distributed control systems. **SCADA** systems provide tools for analyzing, reporting, and fine-tuning those processes and monitoring a variety of plant data including: flows, motor current, temperatures, water levels, voltages, and pressure. Alarms at central or remote sites triggered by any abnormal conditions are propagated to the HMI computer for operator's attention. In addition to alarms, important plant information will be logged in the HMI computer database for reports and trends. SCADA systems and their applications in monitoring and controlling equipment and industrial plants are frequently used in following areas of researches: plant engineering, manufacturing, telecommunications, water and waste control, energy, oil and gas refining and transportation [7]. Our work is focused on one aspect of overall business process – creating and configuring SCADA application in Oil and Gas industry using benefits of BPMN [7]. BPMN is therefore contributed to the development of more efficient SCADA applications for flow measurement systems. In practice, it is important to understand the business process from different aspects: from the aspect of business modeller, IT experts and business analyzer. That leads to the minimizing the potentially errors in the modelling process.

A case study of modeling the flow measurement system and developing SCADA application in Oil and Gas industry using BPMN and InTouch HMI 10.0. software packages

Business process of flow measurement system for crude oil and petroleum derivates is carried out by three independent participants: customer/supplier, refinery and laboratory. The entire business process is taking place in five locations:

1. **Jetty** associated with customer/supplier
2. **Measuring place** in refinery associated with manipulating and maintenance workers
3. **Control room** associated with operator and responsible person who verifies the entire business process
4. **Pump station** associated with the employee who is responsible for pumps control.
5. **Laboratory** associated with specialists who are responsible for product analysis.

Speaking BPMN language, business participants represent Pools. Jetty represents first pool, the second one is Refinery, which has three lanes within it (measurement place, control room and pump station) and third one is Laboratory. All participants in the process have to be informed about current situation and have to be prepared for potential critical situations during implementation of the process. That is the one of the many benefit we can get with BPMN and SCADA application – there is a clear picture of process all over its duration. In our work we managed to create model using BPMN that can be very useful in term of synchronization of participants in the process and in term of making communication between them easier.
Transaction „*Preparation of measuring place*“ takes place in measuring place and handling worker is responsible for it.
Subprocess „ *Entering data into a SCADA application*“ takes place in control room and operator is responsible for it.

Transaction „*Preparation of measuring place*“

The complex transaction „ ***Preparation of measuring place*** “ consists of the following compensating sub-process and activities:

1. If the line is heated, there will be sub-process “heating line”,
2. If there are two directions of flow of the petroleum product, then they will be adjusted using directional valves,
3. If density skid exists, then we will have manual valves on it and manipulating worker will have to set the proper positions,
4. If the sampling process is performed, then the sampler must be suitable prepeared,
5. Safety checks of transmitters and other devices is always performed.

An inclusive decision node is used as part of the transaction because they are running compensatory sub-processes and activities that exist during the transaction. All compensatory sub-processes have their counterparts ie, compensatory activity. Any of compensatory actions may cause interrupting of the measurement of the transaction preparations if some of the failures related to any compensatory sub-process can not be fixed in less than 3h. Maintenance worker is responsible for repairing defects that can occur at the measuring site. An exception flow, Cancel trigger "hooked" on the edge of the transaction, is presented on the graph (Figure 2). Measurement place will be prepared again at 7 am next day.

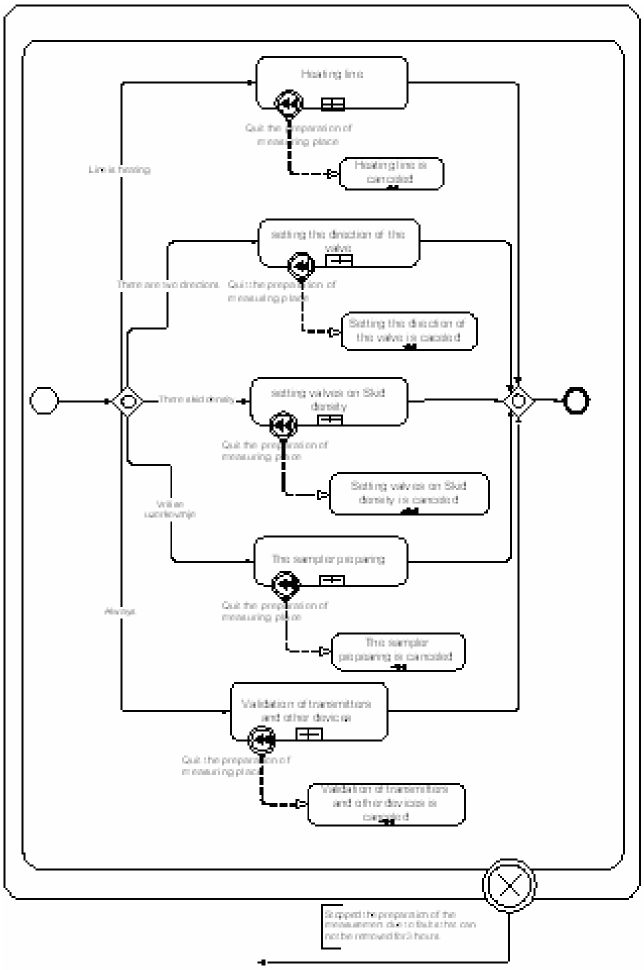


Figure 2. BPMN diagram for „*Preparation of measuring place*" transaction

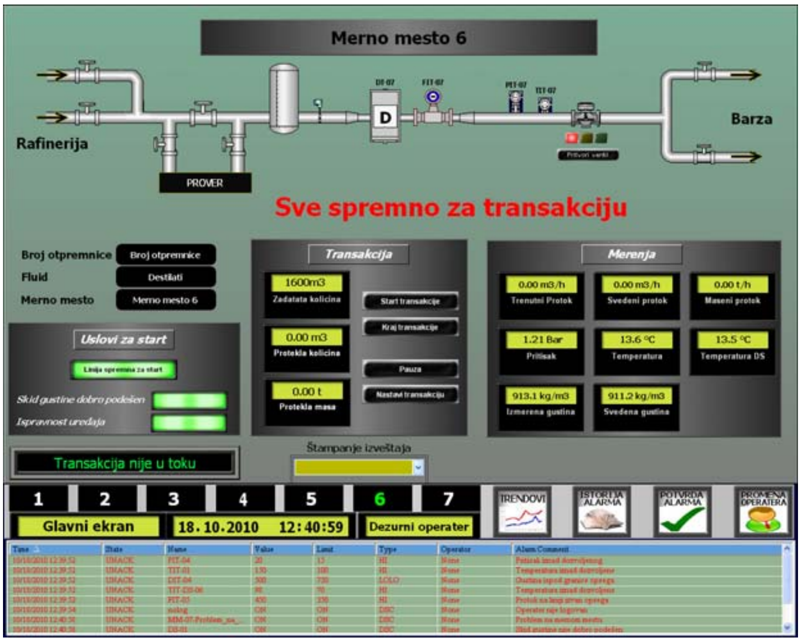


Figure 3. Screen look for measuring place number 6 (the measuring place is ready for the next transaction)

Figure 3. shows screen form of InTouch 10.0. application for the measuring place no. 6th. The operator will enter following data: shipping number, type of fluid (product) and the number of measuring place. Conditions for starting the transaction are fulfilled: quantity is entered, density skid valves are adjusted well, and all devices work correctly. The main three variables are: Batch size, current volume and mass. Transaction can be started, finished, paused and resumed. During the transaction we can monitor the following variables: flow rate, corrected flow rate, mass flow, pressure, temperature, corrected density and measured density.
Subprocesses „*The sampler preparing“ and „ Setting the direction of the valves“* are implemented on the measuring place and handling worker is responsible for it.

Subprocess „*The sampler preparing*“
This subprocess is on a lower level of decomposition of the transaction „*Preparation of measuring place*. It is done by the following steps:

1. Checking the instrumental air supply.
    1.1. If it is ok, then we will check sampler receivers.
        1.1.1. If the sampler receivers are empty, then manipultaing worker will check whether they are placed on the platforms.
            1.1.1.1. if they are placed on the platform, then this sub-process will be finished.
            1.1.1.2. if they are not placed on the platform, then the manipultaing worker has to place them on the platforms and connect it to the air supply, and then the sub-process is finished.
        1.1.2. If the receivers are not empty, then the manipultaing worker will check whether the transaction has already been started.
            1.1.2.1. if the transaction has not been started, the manipultaing worker will empty the receivers and check if they are placed on the platforms.
                1.1.2.1.1. if they are placed on the platforms, the sub-process will be finished
                1.1.2.1.2. if they are not placed on the platform then the manipultaing worker has to place them on the platforms and connect them to the air supply, and then the sub-process is finished.
            1.1.2.2. if the transaction has been started, the manipultaing worker will check if the receivers are placed on the platforms.
                1.1.2.2.1. if they are placed on the platform, the sub-process will be continued normally.
                1.1.2.2.2. if they are not placed on the platform, then the manipultaing worker have to place them on the platforms and connect them to the air supply, and then the sub-process is finished.
    1.2. if the instrumental air supply is not ok, then manipultaing worker has to try to solve this problem.
        1.2.1. If the problem with the air supply instrumental is successfully removed, the manipulating worker will check to see if the receivers are empty for sampling.
            1.2.1.1. If the sampler receivers are empty, then he will check whether they are placed on the platforms.
                1.2.1.1.1. if they are placed on the platform, then this sub-process will be finished.
                1.2.1.1.2. if they are not placed on the platforms, then the manipultaing worker has to place them on the platforms and connect them to the air supply, and then the sub-process is finished.
            1.2.1.2 If the receivers are not empty, then the manipultaing worker will check whether the transaction has already been started.
                1.2.1.2.1. if the transaction has not been started, the manipultaing worker will empty the receivers and check if they are placed on the platforms.
                    1.2.1.2.1.1. if they are placed on the platforms, the sub-process will be finished

1.2.1.2.1.2. if they are not placed on the platform then the manipultaing worker has to place them on the platforms and connect them to the air supply, and then the sub-process is finished.

1.2.1.2.2. if the transaction has been started, the manipultaing worker will check if the receivers are placed on the platforms.

1.2.1.2.2.1. if they are placed on the platform, the sub-process will be continued normally.

1.2.1.2.2.2. if they are not placed on the platform, then the manipultaing worker has to place them on the platforms and connect them to the air supply, and then the sub-process is finished.

1.2.2. If there is a fault with the instrumental air supply that can not be removed within 3h, then the process returns to a higher level of decomposition, ie. the parent process. Therefore the manipualting worker will have to stop the transaction.

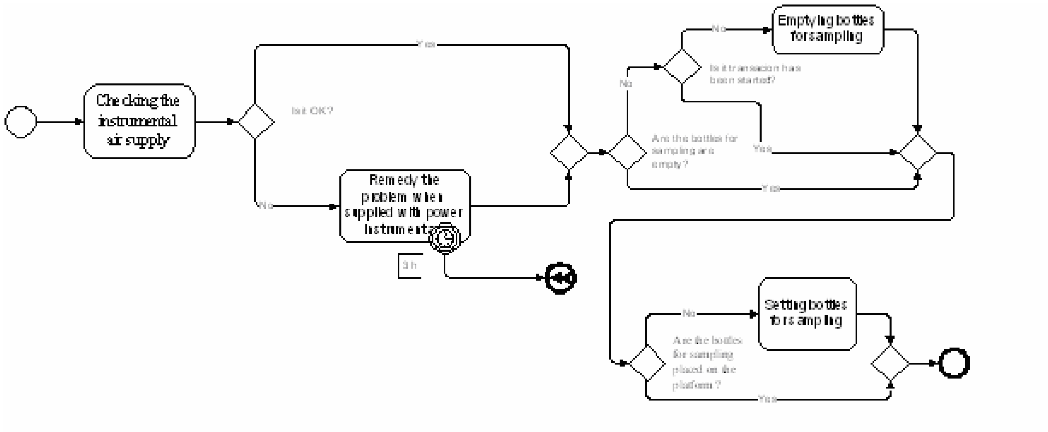


Figure 4. BPMN diagram for „*The sampler preparing*“ subprocess

Subprocess „ *Setting the direction of the valves*“

This subprocess is on a lower level of decomposition of the transaction „*Preparation of measuring place*“. It is done by the following steps:

1. We are checking the direction of the valves.

1.1. If the direction of the valves is OK,then the subprocess is finished.

1.2. If the direction of the valves is not OK, then manipultaing worker will have to try to solve this problem.

1.2.1. If the problem is fixed, the subprocess is finished.

1.2.2. If it is impossible to eliminate this problem within 3h, then the process will be returned to a higher level of decomposition ,ie. the parent process.

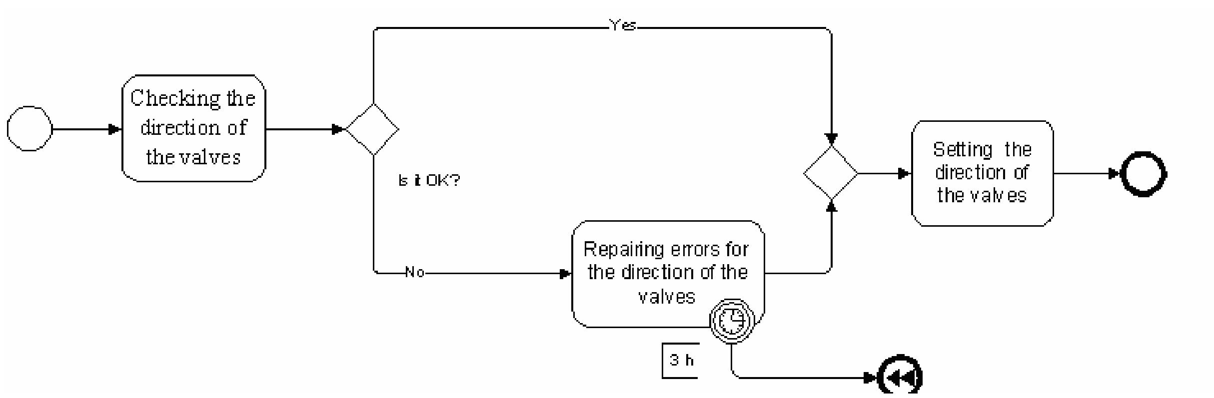


Figure 5. BPMN diagram for „ *Setting the direction of the valves*“ subprocess

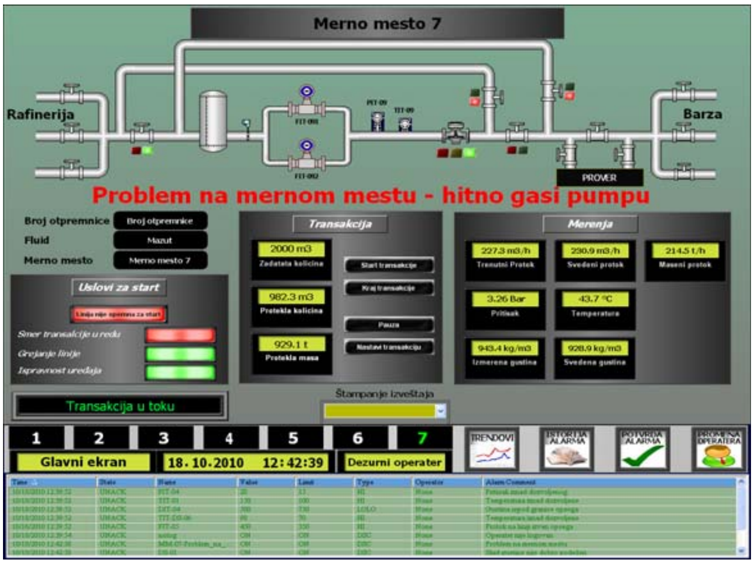


Figure 6. Screen look for measuring place number 7 (problem at measuring place)

Figure 6. shows screen form of InTouch 10.0. application for the measuring point no. 7th where are entered: delivery shipping number, type of fluid (product) and the number of measuring place. The transaction is in progress. Manipulation worker notice „critical situation" during the transaction. Heating at the measuring place is normal and the other devices are working properly. But the transaction is carried out in two directions and there is a problem. The position of manual valves for flow direction is incorrect. Manipulation worker sends a signal to the operator who has to stop the transaction immediately. Also, he has to inform the pump station about this situation. Since the transaction is terminated due to irregularities in the measurement place, the employee will have to execute sub-process „measuring place preparation" again.

Subprocess „ *Entering data into a SCADA application* "

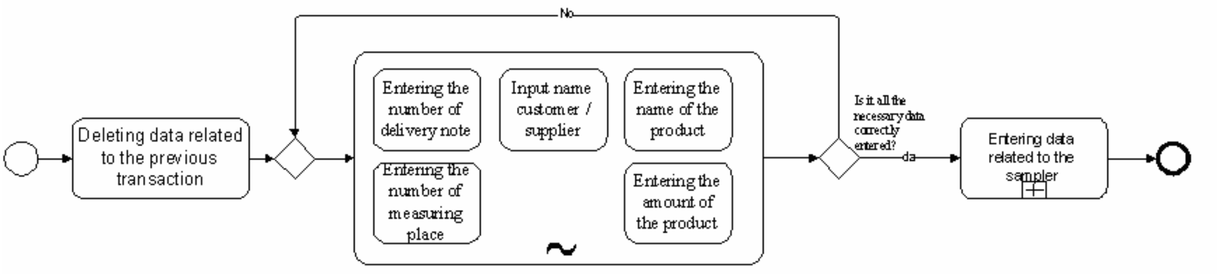


Figure 7. BPMN diagram for „ *Entering data into a SCADA application* " subprocess

Figure 7. shows the decomposition of complex subprocess „*Entering data into a SCADA application*" and operater is responsible for it. It is done by the following steps:

1. At the begining, we must delete all data related to the previous transaction.
2. Second operation is executing „ad hoc activity" which consists of the following activities:
   - 2.1 Entering the shipping number,
   - 2.2 Entering the number of measuring place,
   - 2.3 Customer/supplier name input,
   - 2.4 Entering the product type,
   - 2.5 Entering the amount of the product.

3. Then, the operator will verifying if all the necessary data are entered correctly into the SCADA application .

   3.1. If they are not, the process will be returned one step back to re-enter all the necessary data.

   3.2. If the data are ok, the sub-process is finished.

The main screen created in our work (Figure 8.) represents HMI for the sampling process. It consists of several functional parts: command section on the upper left side of the screen with following commands: set and get system parameters, set and get operational parameters, pre flight check, start and stop, std by and end std by, pause and pause, reset alarms, hardware reset and purging; alarm section in the middle of the screen with following alarms: low instrumental air pressure, low purging pressure, hardware failure, bad command and incorrect receiver selection; section in the lower right side of the screen where the operater in CR can check parameters before start: overall check, level, max sampling frequency, initial gross weight, desired sample volume for both receivers, process parameters on the left side with all data needed for the sampling supervision and finally section for setting system and operational parameters.

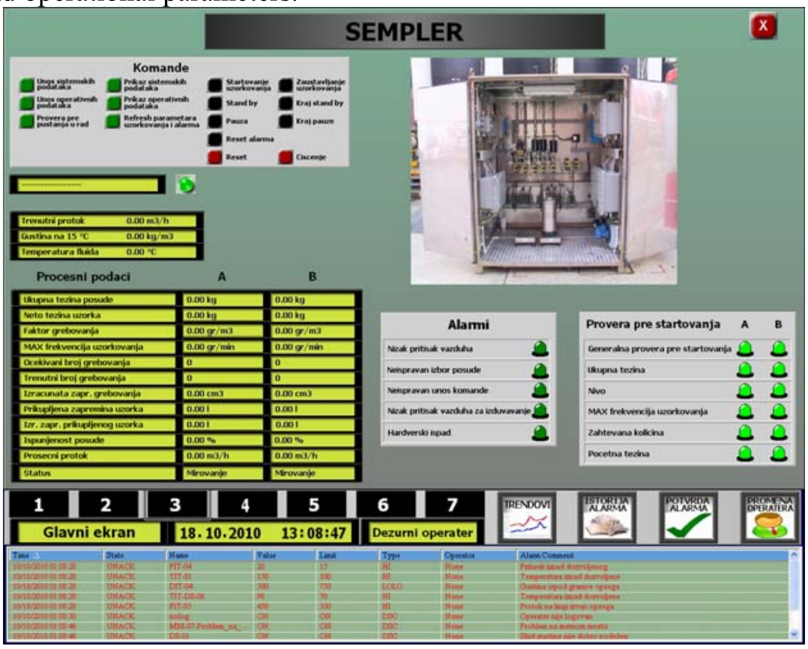


Figure 8. SCADA application for sampling system in refineries – main screen

DISCUSION AND CONCLUSION

BPMN has been used in the different types of studies (education, health, industry etc.) and improved their organizations successfully. For example, it has been used to optimize business processes in the management of higher education [1], [2]. Additionally, in petroleum industry, BPMN enables better understanding of various production processes [8], [9]. Importance in all above mentioned studies is highly successful of usage BPMN notation trough making better and easier organization, implementation and analysis of business processes. Therefore, it can be said that BPMN is universality graphical standard. Our paper is based on very unique and specific real life scenario, too.
Our study resulted in following:

- The goal was to completely formalize semantic for modelling real life situations,
- The developing industry of business process modelling requires various tools, techniques and methodologies and aggravating factor is expensive equipment along with the appropriate trainings in SCADA applications;
- Activities and participants in this process, which are naturally dependent on one another, will be synchronized using the proposed business model;

- We can use this model for simulation in order to prevent errors during process execution before it starts. This is very important because of critical points during the sampling that can threaten the transaction;
- This paper can serve for learning BPMN notation and a better understanding of SCADA applications, also;
- This practical work can use many business analysts from Oil and Gas industry or other kinds of industry.

FUTURE WORK

The improvement experienced in the languages for the business process modelling, especially BPMN, opens an opportunity to show one very specific business process in Oil and Gas industry and at the same time show execution of the same process using SCADA systems. It is very important to understand the business process from different aspects: from the aspect modeller of the process and business analytics and IT programmers. Especially, it is important for business analysis in company in whole world to focused and solve the critical point of view for any real life business process. Software support represents a great contribution to the business process precision. Our work contributes to new observation and modelling of business processes in the Oil and Gas industry by mixing modelling and notation software. Currently, BPM is seldom used, mostly in gas and oil industry, but future work must be oriented to enrich using BPMN in other industries and real life scenarios.

ACKNOWLEDGMENTS

The authors would like to thank the Ministry of Education and Science of Serbia for financial support under the project number TR 34028.

REFERENCES

[1] B. Balbir, O. Samia: BPMN, toolsets, and methodology: a case study of business process management in higher education. In: G. A. Papadopoulos, W. Wojtkowski, (eds.) Information systems development: towards a service provision society. Springer, Boston, MA, pp. 685-693, 2010, ISBN 9780387848099.

[2] A. Ottensooser, A. Fekete, H. A. Reijers, J. Mendling: Making sense of business process descriptions: An experimental comparison of graphical and textual notations, Journal of Systems and Software, Vol. 85, Issue 3, March 2012, pp. 596-606, ISSN: 0164-1212.

[3] S. Nešković, K. Dimitrijević: „Metodološki okvir za razvoj složenih informacionih sistema i integraciju poslovnih procesa“, INFO M, No. 29, pp. 17-21, Beograd, 2009, UDC 004.23, ISSN: 1451-4397.

[4] F. Arbab, N. Kokash, S. Meng: Towards Using Reo for Compliance-Aware Business Process Modeling, Communications in Computer and Information Science, Vol. 17, Part 5, 2009, 108-123, DOI: 10.1007/978-3-540-88479-8_9.

[5] Grosskopf, A., Decker, G., Weske, M. „The Process: Business Process Modeling Using BPMN“, Meghan-Kiffer Press, 2009.

[6] White, S., Miers, D., „BPMN Modeling and Reference Guide: Understanding and Using BPMN “, Future Strategies Inc., 2008.

[7] D. Bailey, E. Wright-Mipenz: Practical SCADA for industry, Elsevier, 2003, ISBN 0750658053.

[8] J. Obradovic: Modeling of Business Process " Transfer Metering Systems for Crude Oil and Petroleum Products" using Business Process Modeling Notation, Faculty of Organizational Sciences- Department of Information Systems and technologies, University of Belgrade, master thesis

[9] J. Obradovic, S. Babarogic, M. Vuckovic, S. Neskovic, M. Milovanovic: Business Process Modeling of transfer metering systems for crude oil and petroleum products using BPMN, Info M – Journal of information technology and multimedia systems, No. 37, 2011, UDC 004:519.8, ISSN: 1451-4397.

IMPLEMENTATION OF ENERGY EFFICIENCY (EE) IN SERBIA WITH REGARD TO THE OBJECTIVES IN THE ENERGY SECTOR UNTIL 2020. AND ENERGY POLICIES OF EU MEMBER STATES

Marija Brković
Public Enterprise for Communal - Housing Jobs „Komunalac", Novi Becej, Serbia
e-mail: marijabrkovic71@gmail.com

Abstract: Energy policy is at the forefront of the purview of the EU, but is increasingly working on forming a common European Energy Policy. Energy is very important (integral) part of the EU Security Strategy and the Serbian sector is integrated through membership in the Energy Community. This paper presents implementation of energy efficiency (EE) in Serbia with regard to the objectives in the energy sector until 2020. and energy policies of eu member states.
Key words: energy efficiency (EE), energy policies, renewable energy

INTRODUCTION - EU ENERGY POLICY [12,13, 14]

Energy policy is at the forefront of the purview of the EU, but is increasingly working on forming a common European Energy Policy. Energy is very important (integral) part of the EU Security Strategy and the Serbian sector is integrated through membership in the Energy Community.
The basis of the Energy Policy of Serbia Europe 2020 Strategy. Everything is done in Europe on the basis of this document.

The base document, with 3 „tracks":
1. „Smart Growth" – knowledge and innovation,
2. Sustainable growth – energy, environment, carbon reduction,
3. Inclusive growth – employment, territorial and social cohesion.

Key topics for the EU: Partnership, Planning and Communication.

5 key objekctives by 2020:
- 20/20/20 by 2020 – energy/climate targets neeed to be met,
- Increasing the employment rate, investment in research and development, reducing poverty and increasing investment in human resources.

Key focus: competitiveness, combating climate change, clean and effective Europe.

Five priorities of the EU:
1. Achieving energy efficiency of Europe,
2. Building a Pan-European integrated energy market,
3. Empowering consumers,
4. Expansion of European leadership – technology, innovation,
5. Strengthening the EU's foreign policy.
6.

The action plan regarding energy Europe 2020
20/20/20 goals established (2007) – 20% increase in energy efficiency, 20% of electricity from renewable energy sources, 20% reduction in CO_2 emissions of greenhouse gases.
Serbian energy policy should be harmonized with the EU acquis communautaire, ie. standards required of countries that are in the process.

Coverage energetic five areas:
- Security of supply, Internal energy market, Energy efficiency, Nuclear energy, Nuclear safety and radiation protection.

In the process of harmonization of key areas are:

- Energy security, Energy efficiency, promoting renewable energy sources, Infrastruktucture and supply, Nuclear energy, Statistics and monitoring.

Republic of Serbia, harmonization and coordinate:

1. Regulations of the Republic of Serbia with the EU law (Acquis communautaire – AE)
- provisions of primary legislation (the Treaties),
- rules of secondary legislation (Regulations, Directives and Decision)

and all of the legal basis for energy.
Of the Stabilisation and Association Agreement ratified September 10 2008th Whatever, and Treaty establishing the Energy Community Treaty ratified by the Parliament of Serbia July 14 2006.

ENERGY EFFICIENCY

As a basis for implementing energy efficiency (EE) in Serbia is a national access Strategy Europe 2020: 20% increase in EE, 20% of electricity from renewable energy sources, 20% reduction of CO_2 and greenhouse gas. EE is the cheapest way to reduces costs for costumers, creating new jobs, including the export industry. It is very important energy chain – from production of energy transmission and distribution through to final consumption.
Economic sectors identified for the implementatin of EE in Serbia are: transport; construction; industry; suply of energy (heat and electricity) and sectors that offer opportunities for the implementation of EE are:
1. Public Sector – Procurement, purchasing, new construction and renovation – Requires a high level of energy performance in cities and communities – that are increasingly used products, vehicles, buildings, works and services that save energy, reduce costs for public bodies heat bills and increase profitability: procurement of goods (equipment ICT), services (energy) and work (renovation of buildings – double the current pace of renovation).
2. Private Industry (Business) buildings – existing and new buildings – Devices and Technology / use of heat – the greatest potential for energy savings lies in the buildings. Focusing on the instruments that started the process of renovation of public and private buildings and improve the results of energy use of components and devices for the household to be used in them. Accelerating the rate of renovation of public buildings through the binding target of consumption and the introduction of criteria for EE in public spending.
3. Industry ESCos/ Energy field (heat and electricity)/ Cogeneration (biomass and waste) – Addressing the loss of heat – the mandatory introduction of regular audits energy. Develop incentives for companies to introduce energy management system as a systematic framework for the rational use of energy.
4. Transportation – Multimodal/fuel mixture – Key area for energy savings. This is a sector that relise heavily on fossil fuels. Activity Improving: the introduction of advanced traffic management systems in all modalities, investment in infrastructure and the creation of a single European area of traffic that would promote multi-modal transportation, intelligent pricing, and efficiency standards for all vehicles in all modalities, and to promote innovation in the automotive industry.
5. Business sector – rewiew of performance/ market opportunities.

RENEWABLE ENERGY

Legal framework: Directive 2001/77/EC - Directive on renewable energy sources- Directive 2003/30/EC – Directive on biofuels. EU objectives in the energy sector by 2020 20/20/20: 20% increase in the share of renewable energy sources in total energy consumption by 2020, 10% larger share of biofuels in total fuel consumption in transport by 2020.
The main policy objectives for renewable energy: competitiveness, security of supply, climate change. Support mechanisms: a clear road map and direction, the market and investor confidence, the impact of consumers.
Member States renewable energy strategy presented to the BOS online learning platform: England, Romania, Bulgaria, Slovenia…. Compare and contrast:
1. Regen SW (England)
2. Sofena (Bulgaria)

England - Regen SW:

- 2020 - Renewable energy sources at the national level - 15% of total consumption,
- Independent, research, and the active advisory organizations - Activity area: business, public sector, communities,

- Provision financial resources - 45% local - grants, contracts, membership fees,project financing, 15% private - membership fees, sponsorship, 15% national -project funding, sponsorship, 25% European - grants, project funding,
- Projects – Supporting farmers and fuelwood producers ⁄ suppliers, - Supportequipment suppliers ⁄ distributors - Increasing renewable heat.

Bulgaria – Sofena

- 2020 - Renewable energy sources at the national level - 15% of total consumption,
- Implemented within the EU SAVE II with partner agencies in the Netherlands and Italy,
- field of activities: The private sector, energy, consumers, municipalities, StateAgency for Energy Efficiency
- Provision financial resources - 10% private - membership fees, sponsorship, 30% national - project financing, grants, contracts, 60% European - grants, project funding.

England - Bulgaria: Renewable energy and energy efficiency, support for local energy planning, information and communication with the public, research and analysis capacity of renewable energy sources: wind, geothermal, solar, hydro…

CONCLUSION

Need to increase communication EE in each sector in Serbia is based on co-ordination, monitoring-monitoring, motivation of consumer, the supply of consumer, change behavior, culture and attitudes of citizens, the liberalization of the market – open access to all energy systems and competitiveness, efficiency in the use of and recycling materials must be of primary importance, Serbian energy Diversification, reducing dependence on fossil fuels, increasing energy networks with neighboring countries, encourage the use of renewable sources, increasing EE through modernization in all sectors, environmental protection.

Factors influencing the identification of similarities and differences among the member states have to do with the "green economy" (job creation, production and export of technology, skills and workforce development, logistics ...) and links with the"national economic policy" (energy safety, production and supply, industry, education, research and development ....) and intelligent energy in Europe - ManagEnergy -(coordination of information between partners throughout the EU, energy efficiency, interactive maps and links, renewable energy sources ....).

REFERENCES

[1] Regulation on establishing the program for realising the energy sector development strategy for the Republic of Serbia until 2015 for the period from 2007 to 2012. (Official Gazzette of the Republic of Serbia, no. 17/2007, 73/2007, 99/2009 and 27/2010)

[2] European Commission – Brussels, 08.03.2011. COM (2011) 109 final Comunication from the commission to the European Parliament, the Council, the European Economic and Social Committee and Committee of the Regions – Energy efficiency Plan

[3] European Commission – Brussels, 10.11.2010. COM (2011) 639 final Comunication from the commission to the European Parliament, the Council, the European Economic and Social Committee and Committee of the Regions – Energy 2020, A strategy for competitive, sustainable and secure energy

[4] European Commission – Brussels, 31.01.2011. COM (2011) 31 final Comunication from the commission to the European Parliament and the Council – Renewable Energy: Progressing towards the 2020 target

[5] Republic of Bulgaria - Ministry of Economy, Energy and tourism – National Renewable Energy action plan draw up in accordance with the template for national renewable energy action plans as set out in Directive 2009/28/EC of the European Parliament and of the Council. Contract No C20006/PORT – 2010-01-01 with the European Bank for Reconstruction and Development 30 june 2010

[6] National Renewable energy action Plan 2010 -2020 (N REAP) SLOVENIA, Ljubljana, July 2010

[7] First national action plan for energy efficiency (2007-2010) - Romanian Energy Efficiency Strategy 2007-2010

[8] UK Energy Efficiency Action Plan 2007

[9] Politika EU u oblasti energetike – Mapa puta EU do 2050 – ka ekonomiji sa niskom emisikom ugljenika, Graham Waddell, Beograd 2011-12

[10] Politika EU u oblasti energetike – Obnovljivi izvori energije, Graham Waddell, Beograd 2011-12

[11] Politika EU u oblasti energetike – Energetska efikasnost, Graham Waddell, Beograd 2011-12

[12] www.seio.gov.rs /

[13] http://www.serbia-energy.com/

[14] http://ec.europa.eu/europe2020/index_en.htm

ENVIRONMENTAL AND FINANCIAL EFFECTS OF SOLAR PANELS

Jasmina Pekez[1], Miroslav Lambić[1]
[1]University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin
e-mail: jpekez@yahoo.com

Abstract: Solar energy forms one of the cornerstones of clean alternate power solutions, and with the difficulties of fossil fuels growing larger by the day, may represent a viable solution to the world's energy problems. Its environmental impact constitutes one of its primary selling points, and the more effectively it can function, the better its chances of supplanting fossil fuels as our main source of energy. Though largely positive, the environmental impact of solar energy can be subtle and its overall effect should be carefully considered as our efforts to explore its potential move forward.
Key words: solar energy, environmental and financial effects

INTRODUCTION

Every day, the sun radiates more energy than all our fuel consumptions but most of this is absorbed by either plants, the ground or the oceans and used as heat energy to keep us warm and keep things alive. Obviously, we are not always going to have solar energy, there will be disasters, rain, cloud, even a shadow can effect the amount of solar energy produced, it is not a stable form of energy. The production of solar panels will require huge factories, silicon, vacuum and lots of heat, despite the fact that you can make a solar panel at home to demonstrate things, it is just inefficient.

MATERIAL AND METHODS

Environmental effects

Solar power is environmentally advantageous because its energy supply never runs out. Sunlight will always shine upon the Earth and, as long as it does, hold energy which solar technology can exploit. Contrast this with fossil fuels such as coal or oil, which need to be mined or drilled and thus have a tremendous environmental impact, even in comparatively safe circumstances. The best thing about solar energy in terms of its environmental effects is that it produces almost no carbon emissions or greenhouse gases. It doesn't burn oil, it doesn't produce toxic waste, and its lack of moving parts reduces the chances of an environmentally devastating accident to nil. Indeed, the only pollutants which factor into solar power are those involved in the construction and transportation of its parts; that ranks it among the cleanest forms of energy on Earth. Implementing solar energy on a large scale would reduce its environmental footprint to a tiny fraction of its current levels. The photovoltaic cells which constitute most solar energy systems are usually made of silicon, one of the most common minerals found on Earth. That means that creating the components is extremely easy, doesn't require mining or drilling in a dangerous locale to produce, and can be acquired without involvement in politically unstable areas such as the Middle East. The environmental effects of this are subtle but, because fewer resources are expended in the acquisition of silicon, its overall effect on the ecosystem is reduced. Cadmium is used in cadmium telluride solar cells as a semiconductor to convert solar energy into electricity. Though used in very small amounts, it is extremely toxic and can build up in a given ecosystem if it isn't monitored. Firms which make this kind of solar cell often instigate recycling programs so that damaged or unusable cells don't inadvertently damage the surrounding environment.

Reduction in Greenhouse Gasses

According to the U.S. Environmental Protection Agency, "the current and projected concentrations of the six key well-mixed greenhouse gases--carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF6)--in the atmosphere threaten the public health and welfare of current and future generations." Of these, carbon dioxide, nitrous oxide and methane emissions are directly tied to the production and burning of fossil fuels, which can be reduced by use of solar power.

Reduction in Other Pollutants

Other pollutants are associated with the burning of fossil fuels. These include the production of nitrogen oxides, which cause respiratory and heart problems, emissions of mercury--a known neurotoxin--and sulfur dioxide, which causes respiratory distress. In addition, the use of nuclear power is problematic in that release of radioactive materials can cause harm for centuries. The use of solar power can mitigate all these problems.

Solar power uses the sun's radiation to generate electricity or heat for buildings. The most common solar power systems use photovoltaic cells or solar thermal arrays installed on the roof of a building, where they have direct exposure to the sun. While solar panel arrays can be expensive to manufacture and install, they create clean, affordable and renewable energy that in time offsets the cost of installation.

Space considerations and ease of maintenance

Solar panels are not as efficient as they could be -- one of the reasons why they have not been widely implemented yet. To capture appreciable amounts of energy, they require a large number of cells, which can take up a considerable amount of space. One practical solution is to mount the cells on a rooftop, which saves a lot of space while still allowing them maximum exposure to the sun. Large-scale solar farms still require a lot of room, however, and trees and bushes can't coexist with them lest they block sunlight from the receivers.

Solar panels operate maintenance free, without the constant attention of an operator. Other sources of power require ongoing efforts to obtain and refine fuel, such as oil drilling and coal mining, or can become dangerous when parts wear or operators make mistakes. For example, solar energy generates power and heat without supervision or ongoing human input.

Economic effects

When you purchase solar panels, you also have to consider the payback period of the system. This is the amount of time it takes the solar panels to pay for themselves. Because you will not be paying for electricity, you have to calculate how much you are saving in electricity costs by owning the panels. Depending on the initial cost of the solar panels, the payback period can vary significantly. In some cases, it takes 10 to 12 years to pay off the panels with the savings. When you have panels professionally installed, it may take longer to repay the initial cost.

Many people who purchase a solar power system have to finance the purchase. In many cases, you can finance the system through the companies that sell the systems. While this can help you get a solar panel system, it may require that you make payments for several years. The size of your monthly payment could be more than what you would have paid in electric bills over the same amount of time. This means the financial burden of purchasing the system will be larger soon after you buy the system.

Besides impacting you individually, solar panels also can have an impact on the economy in general. With more homeowners focusing on buying solar panels, it has created more job opportunities for installers and manufacturers. With government incentives for renewable energy production, many companies are beginning to expand into producing solar panels. By purchasing solar panels, you can have a positive impact on the economy overall. While it may not help you individually right away, the solar power movement in general has the potential to improve the economy.

Barriers to solar energy include traditional cost associated with producing the technology and non-technical issues such as lack of consumer education and awareness about solar energy.

CONCLUSION

Solar energy systems generate no emissions and consume no fossil fuels, making them a clean and renewable energy source. In contrast, the emissions from fossil fuel-based power plants release sulfur dioxide, nitrogen oxide, carbon dioxide and trace amounts of mercury, according to the House Solar Energy website. Solar panels' ability to operate without fuel ensures that no dangerous or ecologically unsound mining or drilling is needed to power solar arrays. But, solar energy have a disadvantages like: solar panels is too expensive, is not stable, requires a lot of space (use up the deserts, but you have to make sure that solar panels does not break or get blown all over the place) and Batteries&Inverters needed for homemade solar energy.

REFERENCES

[1] European Renewable Energy Council (EREC), RE-thinking 2050, A 100 % Renewable Energy Vision for the European Union, 2010.
[2] Lambic, M., Contribution to environmental pollution reduction, Energy technologies, No 1, pp. 22 – 27, 2010.
[3] Abdeen, M. O., Energy, environment and sustainable development, Renewable and Sustainable Energy Reviews, No 9, pp. 2265-2300, 2008.
[4] Demirbas, A. Global Renewable Energy Projections, Energy Sources, Part B, No 2, pp. 212 – 224, 2009.
[5] Ministry of Mining and Energy (MME), Strategy of energy development in the Republic of Serbia until 2015, available from www.mem.gov.rs (accessed on December 2010).
[6] Pekez, J. Radovanović, Lj. Desnica, E. Lambić, M. Increase of exploitability of renewable energy, Energy sources, Part B, paper in print. (2012).
[7] Palz, W. Role of new and renewable energies in future energy systems, International Journal of Sustainable Energy, No 3, pp. 127 – 140, 1994.
[8] Global Energy Survey (GESWorld Energy Council, Korn/Ferry International, London, 2007.
[9] Pekez, J. Lambić, M. Stojadinović, S., Energy characteristics degradation of polymer transparents cover, Metalurgia International, No 6, pp. 47-50, 2012.

ENERGETIC CHARACTERISTICS OF "ACTIVE" SOLAR WALL

Miroslav Lambić[1]
[1]University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
e-mail: lambicmiroslav@yahoo.com

Abstract: In this paper are given the results of research the energetic characteristics of classic and "active" massive solar wall. Through theoretical and experimental researches are established the effects and also are given the mathematical models of the energy balance of the massive wall as solar receiver and heat accumulator. Also, in the paper is presented the energetic characteristics of: Trombe's wall with air circulation, "active" massive wall, "active" massive wall with thermo-insulation and metal absorber on the outside surface of the wall and the comparative survey of temperature change of the back surface of massive wall - during the time.
Key words: Trombe's wall, "active" massive wall

INTRODUCTION

Solar radiation reaches onto Trombe's wall which is painted with mat black or with dark paint one, and covered with one or more glass covers that are on the distance from 2 to 10 cm. Such a wall absorbs heat on the receiving side, that warms it up gradually (increases temperature) and conducts heat to the other inside side (to the room) of the wall. Because of that it can be concluded that Trombe's wall is at the same time a solar collector, a heat storage and a heater.
One of Tromb's wall variants is the solution with the openings near the bottom and near the top of the wall, where hot air flows into the heated room through the upper opening from the receiving area, and the colder air from the room flows into the receiving area through the lower opening. The urging of this process is performed by installing a fan in one of the openings.

TROMBE'S WALL WITH AIR CIRCULATION

At classical massive - Trombe's wall with hot air circulation from the entering zone (the zone between the absorbing wall surface and the transparent) into the heated room, heat balance can be expressed through the balance equation (in accordance with figure 1):

$$\dot{Q}_d = \dot{Q}_k + \dot{Q}_a + \dot{Q}_g \tag{1}$$

One part of the accumulated heat returns - transfer to the heated room, and the other one disappears into the environment - eq. 1.
A new component of the energetics balance is included in the first member of the equation (1) - in the member that includes useful heat;

$$\dot{Q}_k = \dot{Q}_{ka} + \dot{Q}_{kv} + \dot{Q}_{kp} \tag{2}$$

where:

$\dot{Q}_{ka}$ [Wh/h] – is the part of useful heat that is transferred to the massive wall (is accumulated in the massive wall) in time unit;

$\dot{Q}_{kv}$ [Wh/h] – is the part of useful heat that is transferred to the air that circulates from the entering from the entering zone into the heated room, in time unit and

$\dot{Q}_{kp}$ [Wh/h] – is the part of useful heat that is transferred to the heated room transferring heat through the massive wall, in time unit.

Character of temperature curves at the wall of such a type is similar to the curves of classical Trombe's wall without air circulation, only that the intensity of the realized temperatures is lower, taking into consideration that the air flow cools the wall absorbing surface and takes away a heat part directly into the heated room.

- for heat power:

$$\dot{Q}_{kv} = \dot{m}_v \cdot c_p \cdot \Delta T_v \tag{3}$$

- for heat energy:

$$Q_{kv} = \dot{Q}_{kv} \cdot A_z \cdot \tau_v \tag{4}$$

Air circulation with a such a type of Trombe's wall need to be performed only during the sun radiation acting and when the temperature of the wall absorbing surface is higher than the necessary air temperature in the heated room. On account of that with such a wall type must be built in a key that shuts the duct from the entering zone to the heated room.

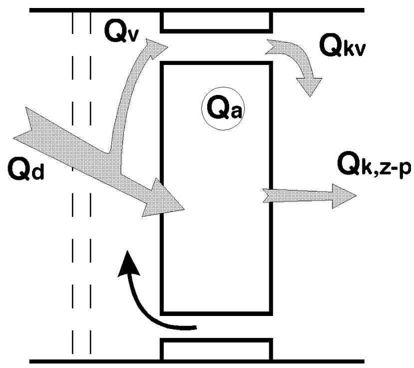


Figure 1. Energy flows with Trombe's wall with hot air circulation from the entering zone into the heated room

More intensive room heating (and lower energy effects of heat accumulation in massive wall) is realized by forced air circulation in the period when sun is shining on the wall. So one get faster heating effects for the room (less delaying in heat transfer from the entering zone to the heated room). In principle, in such cases is built a massive wall of less mass (and thickness) than the wall where there is no forced air circulation.

Because of forced air circulation convection losses increase in the collecting zone of the massive wall (at the same time heat losses are reduced because of lower working temperature of the wall absorbing surface). For calculating convection coefficient between the wall absorbing surface and the first transparent opposite to the wall, one can use next pattern:

$$h_{z-s} = \frac{Nu \cdot \lambda_v}{D_H} \tag{5}$$

where:

Nu – Nuselt's number,

λ_v [W/(mK)] – is the conduction coefficient for air and

D_H [m] – is the hydraulic diameter equal to twofold distance between them)

"ACTIVE" MASSIVE WALL

With "active" massive wall we include wall constructions where the air circulation from the entering zone into the interior of massive wall is enabled - whether it is hollow - with or without special filling of solid material.

Heat balance of the wall with such construction, has the same form as with the previously described types of massive walls. Energy flows are given as a scheme in figure 2.

Way of functioning and basic values of such type of massive wall are described in ref. [25]. Heat losses (that are somewhat lower concerning classical Trombe-s wall) in relation to the equations (6) to (14) - part of the equations concerning heat losses between two transparent covers and between the outside transparent cover and the environment.

Thermal losses from the absorbing wall surface to the environment, can be expressed through the flux:

$$q_g = U_g \cdot (T_{zs} - T_o) = (h_{r,z-s2} + h_{z-s2}) \cdot (T_{zs} - T_s^{"}) = \\ = (h_{r,s2-s1} + h_{s2-s1}) \cdot (T_s^{"} - T_s^{'}) = (h_{r,s1-o} + h_w) \cdot (T_s^{'} - T_o) \quad (6)$$

where:

U_g [W/(m^{2}K)] – is the total coefficient of thermal losses of the massive wall to the environment (from the absorbing wall surface to the environment) that can be expressed in the next form:

$$U_g = \frac{1}{\dfrac{1}{h_{r,z-s2} + h_{z-s2}} + \dfrac{1}{h_{r,s2-s1} + h_{s2-s1}} + \dfrac{1}{h_{r,s1-o} + h_w}}, \quad (7)$$

$h_{r,z-s2}$ [W/(m^{2}K)] – the coefficient of heat transfer through radiation between the absorbing wall surface and the first (inner) transparent (S_2),
h_{z-s2} [W/(m^{2}K)] – is the coefficient of heat transfer through convection from the absorbing wall surface to the first (inner) transparent (S_2),
$h_{r,s2-s1}$ [W/(m^{2}K)] – the coefficient of heat transfer through radiation between the first (inner) transparent (S_2) and the second (outside) transparent (S_1),
h_{s2-s1} [W/(m^{2}K)] – the coefficient of heat transfer through radiation between the first (inner) transparent (S_2) and the second (outside) transparent (S_1)
$h_{r,s1-o}$ [W/(m^{2}K)] – the coefficient of heat transfer through radiation between the second (outside) transparent (S_1) and environment and,
h_{s1-o} [W/(m^{2}K)] – the coefficient of heat transfer through convection (because of air flow - wind) from the second (outside) transparent (S_1) to the surrounding air.

General term for heat transfer through radiation between two parallel surfaces 1 and 2 is the form:

$$h_{r,1-2} = \frac{\sigma \cdot (T_1^2 + T_2^2) \cdot (T_1 + T_2)}{\left(\frac{1}{\varepsilon_1}\right) + \left(\frac{1}{\varepsilon_2}\right) - 1} \quad (8)$$

where:
σ - Stefan-Boltzmann constant (5,668 x 10^{-8} [W/(m^{2}K^4)]) and
ε - the radiation emission coefficient.
If surface of a plate or wall (in this case the outside transparent) turned towards environment (if there is not opposite it near some other parallel surface), then the coefficient of heat transfer through radiation is calculated according to [11]:

$$h_{r,1-o} = \varepsilon_1 \cdot \sigma \cdot (T_1^2 - T_o^2) \cdot (T_1 - T_o) \quad (9)$$

The coefficient of the convection heat transfer between two plates (e.g 1 and 2) with undisturbed air in the gap is calculated according the expression [11]:

$$h_{1-2} = 0{,}82 \cdot \frac{\Delta T^{0,327}}{l^{0,019}} \cdot [1 - 0{,}0018 \cdot (T_m - 283)] \quad (10)$$

that is also important for vertical wall as well as at:

$$1{,}5 \cdot 10^5 < Gr < 10^7; \Rightarrow Nu = 0{,}062 \cdot (Gr)^{0,327} \quad (11)$$

The convection coefficient for vertical wall, too at:

$$1{,}5\cdot 10^4 < Gr < 1{,}5\cdot 10^5; \Rightarrow Nu = 0{,}033\cdot (Gr)^{0{,}381} \tag{12}$$

has the form:

$$h_{1-2} = 0{,}57\cdot \frac{\Delta T^{0{,}381}}{l^{0{,}143}}\cdot \left[1 - 0{,}0018\cdot (T_m - 283)\right] \tag{13}$$

where:
$\Delta T = T_1 - T_2$ [K] - is the difference of surfaces temperatures 1 and 2,
ℓ [cm] – the difference between surfaces (into given empirical expressions this value is brought in [cm]),
$T_m = (T_1 + T_2)/2$ [K] – medium temperature of the surfaces 1 and 2,
Gr and Nu – are Grashof's and Nusselt's number.
The convection coefficient from the outside transparent onto the surrounding air is calculated according to Mc-Adam's pattern [7]:

$$h_w = 5{,}7 + 3{,}8\cdot w \tag{14}$$

where w – is wind velocity in [m/s].

Coefficient of heat losses on account of convection in the entrance zone (between the absorbing wall surface and the first-inside transparent cover) is defined according the equation (5).

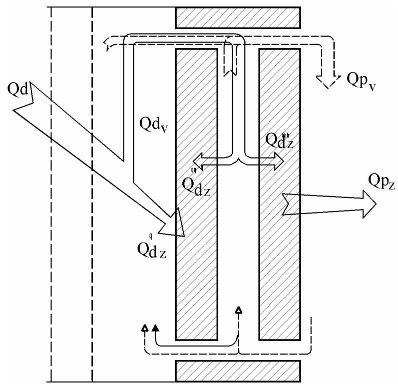


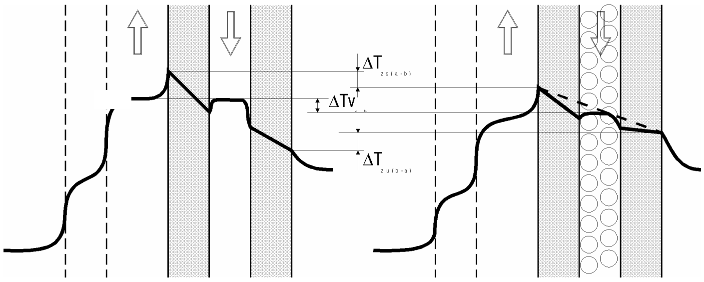
Figure 2. Schematic survey of heat distribution with "active" massive wall

Useful heat is calculated in accordance with equations (2) and (3) - depending on constructive solution and working phase during a cycle. Constructive solution is usually based on the possibility of forced air flow from the entering zone into the heated room (or from the inner chamber of wall into the heated room) - figure 2.

Heat losses from the heated room and wall part nearer the room are less because of the increased thermal resistance of the hollow, and heat utilization during the sun shining may be greater.

Solution that provides only air circulation from the entering zone into the inner chamber (filling of the wall without the possibility that the air may circulate directly-from the entering zone or from the inner chamber into the heated room-is not justified.

Temperature curves of "active" massive wall for the central chamber with solid filling and without it (through it may air circulate) are presented in the figure 3.



a) **b)**

Figure 3. Temperature "curve" of "active" massive wall with central hollow (a) and solid filling (b)

"Active" massive wall with thermo-insulation and metal absorber on the outside surface of the wall

From the view of increasing heat losses, appropriate solution of massive wall is based on application of a special absorber and thermo-insulation over the outside surface of the massive wall. In that case it is necessary that heated air from the entering zone circulates to the inner chamber (with solid filling) or the heated room, so as to provide much quicker and more efficient "transferring away" of heat from the zone where intensive originate heat losses. This solution is somewhat more complex than classical, but heat losses from the heated room and from the wall/filling (accumulated heat), are remarkably reduced. In figure 4 is presented temperature curve at massive wall of this construction.

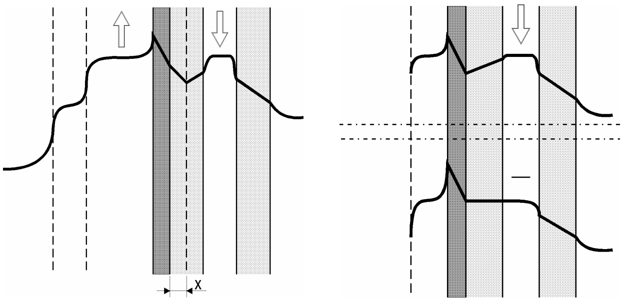


Figure 4. Temperature curve of "active" massive wall with the applicable thermal insulation and metal absorber

Temperature curve that comprise the zone from the absorber to the outside environment, has the profile that corresponds with classical flat absorber of the sun energy* [26]
Coefficient of heat losses by convection from the absorber to the transparent, is defined in accordance with the equation (5). Energy balance for transparent cover, absorber and air may be presented through equations [11]:

$$\left(h_{r,s2-s1} + h_{s2-s1}\right)\cdot\left(T_{s1} - T_{s2}\right) + h_{r,a-s2}\cdot\left(T_a - T_{s2}\right) + h_{v-s2}\cdot\left(T_v - T_{s2}\right) = 0 \quad (15)$$

$$\dot{S} - h_{a-v}\cdot\left(T_v - T_a\right) - h_{r,a-s2}\cdot\left(T_s - T_v\right) = 0 \quad (16)$$

$$h_{v-s2}\cdot\left(T_{s2} - T_v\right) + h_{a-v}\cdot\left(T_a - T_v\right) = q_{kv} \quad (17)$$

where S [W/m^2] – is the solar irradiation (the power absorbed on the unit of the absorber surface).
The useful thermal flux transferred to the air circulating in the entering zone-to the wall interior or to the heated room is [11]:

* Lambic, M. et al.: CONTRIBUTION TO ANALYSIS OF CHARASTERISTICS OF FLAT-PLATE COLLECTORS, Sun Energy, 3 (1981) 1-2, pages 205-211

$$q_{kv} = F' \cdot \left[\dot{S} - U_{ug} \cdot (T_v - T_o)\right] \tag{18}$$

where:

$$F' = \left\{1 + \frac{h_{r,a-s2} \cdot U_{ug}}{h_{r,a-s2} \cdot h_{v-s2} + h_{a-v} \cdot U_{ug} + h_{a-v} \cdot h_{r,a-s2} + h_{v-s2} \cdot h_{a-v}}\right\}^{-1} \tag{19}$$

- is the effectiveness of a solar wall as a solar energy collector.

Coefficient of thermal losses on account of radiation and convection between two transparent plates and between the outside transparent and the environment, are calculated through equations (8), (9) and (10) to (14). Coefficient of heat transfer from the air flow onto the wall surface of the inner chamber or onto the solid filling, is defined in accordance with appropriate equations for convection heat transfer (in accordance with concrete case of filling structure).

According to researches [11] - for providing turbulent flow between two flat plates heated from one part, Nusselt's number is defined according to the pattern:

$$Nu = 0{,}0158 \cdot \mathrm{Re}^{0,8} \tag{20}$$

As a general expression for Nusselt's number at a collector of an arbitrary configuration-with air as working medium, Keis established equation that provides full development of turbulent circulation:

$$Nu = 0{,}022 \cdot \mathrm{Re}^{0,8} \cdot \mathrm{Pr}^{\cdot 0,6} \tag{21}$$

Considering that with the system for thermal conversion of the sun radiation, air circulation ducts are in most cases short (and on account of that one can not achieve full development of circulation), Nusselt's number is determined according Kraic-for laminar circulation in short ducts [11]:

$$Nu = \frac{\mathrm{Re} \cdot \mathrm{Pr} \cdot D}{4L} \cdot \ln\left[1 - \frac{2{,}654}{\mathrm{Pr}^{0,167} \cdot (\mathrm{Re} \cdot \mathrm{Pr} \cdot D / L)^{0,5}}\right]^{-1} \tag{22}$$

Equation (22) is valid for the pipe circulation at L/D<0,0048 and in shallow ducts with the relations L/D<0,0021 Re.

Coefficient of convection heat change may be fixed according to expression (5).

The comparative survey of temperature change of the back surface of massive wall - during the time

At choosing the type of massive wall construction one must consider temperature deflection and the time when maximal temperature of the massive wall back surface appears. In figure 5 is given general comparative survey of temperature change for the back wall surface (to the heated room) of different types during one 24-hour cycle.

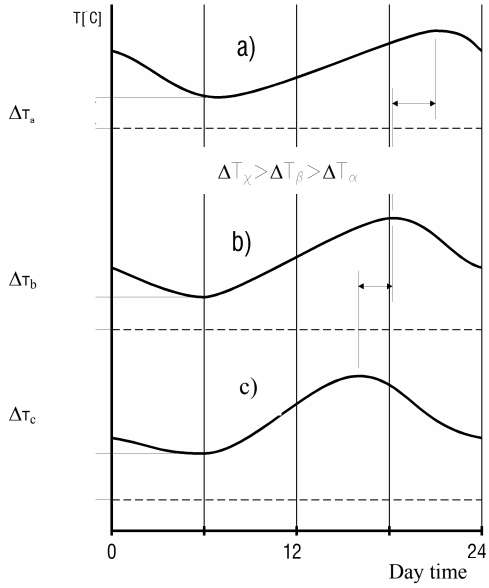


Fig. 5. Temperature change of back massive wall surface of different types during one 24-hours cycle (a-classical passive Trombe's wall, b-"active" massive wall, c-"active" massive wall with applicable thermal insulation and absorber)

CONCLUSION

The passive solar heating systems that are based on using massive (Trombe's) wall with glass covers can, to a significant extent, to provide houses heating and offices at minimal price. Such systems, their essential constructive and working - exploitive characteristics are insufficiently described in literature. This paper is the constribution to better understanding and more detailed study of the subject problems.

REFERENCES

[1] Lambić, M.: The energetic effects of the "active" and "passive" mass wall in the solar heating system, The Conf. Proc.: 28 th congress on air conditioning, heating and cooling, Belgrade, 1997., p. 231-245
[2] Lambić, M.: Energy Balance of Integral Collector within a System of Passive Solar Heating, Conf. Proc. International Conference on Passive Solar Architecture, Bled, 1988., p. 283-287
[3] Lambić, M.: Total Energy Balance of Solar Collector Applied with the Heated Object, Symp. Proc. International Symposium on Solar Energy, Istanbul, 1989., p.10.1-10.6
[4] Lambić, M.: Energetics I, T.F. "M. Pupin", Zrenjanin, 1996.
[5] Lambić, M.; Tolmač, D.: The energetic effects of the "active" and "passive" mass wall in the solar heating system, Conf. Proc.: 28 th congress on air conditioning, heating and cooling, Belgrade, 1997., p. 227- 232
[6] Lambić, M.; Tolmač, D.: Technical Thermodynamics, Tchnical Faculty "M.Pupin", Zrenjanin, 1997.
[7] Lambić, M.: Thermotechnics with energetics, The Univerzity of Novi Sad, Novi Sad, 1998.
[8] Lambić, M.: The experimental researches of massive solar walls effects - report, T. F "M. Pupin", Zrenjanin, 1998.
[9] Lambić, M.; Vragović, I.: The thermo-dynamic analysis of the Trombe's wall stationary model, Conf. Proc.: Scientific-expert workshop: " The Sun energy", Zrenjanin, 1999.
[10]Lambić, M.; Vragović, I.: The non-stationary model of massive solar wall work, Conf. Proc.: Scientific-expert workshop: " The Sun energy", Zrenjanin, 1999.
[11] Lambic, M.: Solar Walls, Technical Faculty M. Pupin, Zrenjanin, 1999.
[12] Lebens, R.M.: Passive Solar Heating Design, J. Wiley & Sons, New York, 1980.

[13] Robert, J.F.; Peube, J.L. and Trombe, F.: Experimental Study of Passive Air-Cooled Flat – Plate Solar Collectors, C.N.R.S. Lab. Energetique Solaire, Odellio
[14] Schepp, B.; Hastie, S.M.: Passive Solar Home, Tab. Books Inc., Blue Ridge Summit, 1985.
[15] Utzinger, D.M. et. al.: The effect of air flow rate in collector-storage walls, Solar Energy, 6(1982.), p. 511-520
[16] Vukadinović, B.: The Energetics Balance of massive "passive" and "active" solar wall, T.F. "M. Pupin", Zrenjanin, 1998.
[17] Lambić, M., Pekez, J.: Karakteristike prirodnog strujanja vazduha kod Trombeovog solarnog zida - za stacionaran slučaj, Hidraulika i pneumatika Br. 1 (2004)
[18] Lambić, M., Pavlović, N., Pekez, J.: Energetska efikasnost upravljanih pumpi, Hidraulika i pneumatika, Br. 1 (2004)
[19] Dragićević, S.; Lambić, M.: Uticaj radnih i konstruktivnih parametara na energetsku efikasnost aktivnog solarnog zida, Energetske tehnologije br. 1 (2004), str. 3-7
[20] Radosavljević, J.; Lambić, M.; Đurđanović, M.; Mijailović, I. : Termodinamičko ponašanje solarne stambene zgrade sa staklenom verandom i termoakumulativnim zidom od betona, Energetske tehnologije br. 3 (2005), str. 1-3
[21] Lambić, M.; Vukadinović, B.: Uporedni pokazatelji eksperimentalnih karakteristika kod modela aktivnog i pasivnog masivnog solarnog zida, Energetske tehnologije br. 4 (2005), str. 25-28
[22] Radosavljević, J.; Petković, P.; Krstić, D.; Lambić, M.; Vlajković, S.: Termodinamičko ponašanje solarne stambene zgrade sa staklenom verandom i termoakumulativnim zidom od opeke, Energetske tehnologije br. 1-2 (2006), str. 49-52
[23] Radosavljević, J.; Lambić, M.; Pavlović, T.: Thermodynamic Designing of a Solar Block of Flats with a Tromb's Wall with Ventuce Holes, Facta Universitatis, Vol. 3, No 1 (2004), p. 19 - 26
[24] Lambic, M.; Lambic, D: Heat Characteristics of Massive Solar Walls, Energetic Technologies, Vol. 5, No 3 (2008), p. 3 - 7
[25] Lambic, M. et al.: Contribution to Analysis of Charasteristics of Flat-Plate Collectors, Sun Energy, 3 (1981) 1-2, p. 205-211

ANALYSIS OF ENERGY EFFICIENCY AND ECONOMIC SYSTEMS HEATING POWER PLANTS - HEATING REFRIGERATING MACHINES (ABSORPTION AND EJECTOR) AND CONDENSING POWER PLANTS - TURBOCOMPRESSOR COOLING STATIONS IN THE SYSTEM SUPLY CENTRALIZED HEAT AND COOLING ENERGY

Šefik M. Bajmak
University of Pristina, Faculty of Technical Sciences of Kosovska Mitrovica
bajmak@yahoo.com

Abstract: In many sectors of the economy is widely used heating and cooling energy to achieve the various technological processes. Based on the analysis constructive solution was found, that the centralized supply of cooling energy with water as the carrier cooling energy, funds invested per unit of production from the cooling energy can be reduce to 2 times the intended effect of cooling station (equipment) to 1.3 times the cost of electrical energy up to 1.5 times the number of workers who serve cooling system from 2.5 to 3.5 times. To this end, the paper analyzes the economic and energy indicators of the system of centralized supply of cooling energy in the following variants: Heating-power station (HPS) - an absorption cooling station (ABCS) Condensation power plants (KEC)-Turbo compressor cooling station (TCCS) for the conditions of our region. Based on the energy and economic analysis that was performed for three types of fuel (solid, liquid and hard waste) can be said that plant incarnation of waste has a greater economic effect compared to the HPS on the solid and liquid fuel. This efficiency is higher at higher temperatures, the carrier of energy to the ABCS.
Key words: energy efficiency, centralized system, an absorption machine, the turbo compressor machine.

DETERMINATION OF ECONOMIC EFFECTIVENESS OF THE SYSTEM SUPPLY NOG CENTRALIZED HEAT AND COOLING ENERGY

For determining the economic effectiveness of the system of centralized heat supply and cooling energy (SCHSCE) it is necessary to have available annual project costs T_{god} [1,2,3,4,5]. In the general case, the project costs for SCHSCE we present the equation:

$$T_{god} = r \cdot \left(T_{tre} + T_{mthv} + T_{ntre} + T_{lep} + T_{ttv} + T_{cse}\right) + T_{ek} + T_{am} + T_{ld} + T_{mat} \quad (1)$$

In this analysis, the funds invested in building air conditioning system will not take them into account, since it is constant for any type SCHSCE. Economic effectiveness SCHSCE best ocenuje using specific costs $\overline{T}_{god}$ per unit heat gains regions:

$$\overline{T}_{god} = T_{god} / Q_{td} = r \cdot \left(\overline{T}_{tre} + \overline{T}_{mthv} + \overline{T}_{ntre} + \overline{T}_{lep} + \overline{T}_{ttv} + \overline{T}_{cse}\right) + \overline{T}_{ek} + \overline{T}_{am} + \overline{T}_{ld} + \overline{T}_{mat} \quad (2)$$

Taking into account the loss of cooling and thermal energy in the hot water and water main cold water, heat gains and heat losses of energy can be represented in the following form:

$$Q_{tg} = Q_{oh} \cdot \eta_{gu,oh} \cdot \eta_{gu,skv} = 0{,}8835 \cdot Q_{oh}; \quad Q_{td} = Q_t \cdot \eta_{gu,t} \cdot \eta_{gu,skv} = 0{,}855 Q_t \quad (3)$$

Invested funds, for example, in an absorption cooling stations, per 1KW of heat gain is determined by the formula:

$$\overline{T}_{tre} = T_{abrs} / Q_{td} = T_{abrs} / 0{,}8835 \cdot Q_{oh} \quad (4)$$

Specific equity in the pipe network system is determined by the expression:

$$\overline{T}_{mthv} = Q_{td}^{-0,5} \left[S_1 \cdot Q_{td}^{0,5} + \frac{1{,}129 \cdot S_2}{c_w \Delta\tau_w \rho_w} \cdot \frac{L}{W^{0,5}} + \frac{1{,}275 \cdot S_3}{\left(c_w \Delta\tau_w \rho_w\right)^{0,5}} \cdot \frac{L}{W} Q_{td}^{0,5} \right] \quad (5)$$

If the carrier power and cold water, in which the characteristics of the water of cold water: $L = 1000(m)$; $\rho = 1000\left(kg/m^3\right); \Delta\tau = 6\left({}^0C\right)$; $W_{op} = 4{,}1(m/s)$; $S_1 = 50(Evra/m)$;

$S_2 = 2450\left(Evra/m^2\right)$; $S_3 = 3060\left(Evra/m^3\right)$; expression (5) can be represented as a function of the heat gains:

$$\overline{T}_{mthv} = Q_{td}^{-0,5}\left(50 \cdot Q_{td}^{-0,5} + 8,605 + 0,037Q_{td}^{0,5}\right) \quad (6)$$

Exploitation costs of energy (heat and power) can be determined without major mistakes in respect of costs for the fuel needed in the center for the production of energy (HPP,CPP, boiler) in the period of functioning SCHSCE. Specific annual fuel cost is determined by the expression:

$$\overline{T}_{gor} = 3600 \cdot Q_{kp} \cdot Z_{kp} \cdot C_{gor} / Q_{td} \cdot H_d \quad (7)$$

Relationship $q_{sctre} = Q_{kp}/Q_{td}$ represents the specific consumption of heat in the center for the production of heat and cooling energy (CPHCE) to cover the heat gains 1KW regions and takes into account all forms of energy and energy losses in all nodes and CPHCE and SCHSCE. To determine the fuel costs it is necessary to know the values for different combinations CPHCE and SCHSCE.

Costs of salaries SCHSCE depend on the size of heat or cooling capacity and power equipment unit [1,2,3,4,5,6]. They range depending on the type of refrigeration plants in the border out $9 \div 14\left(Evra/KW \cdot god\right)$. Other sizes, which are included in the terms are (1) and (2) depend on the respective type, and sets CPHCE CPTRE and SCHSCE.

ECONOMIC INDICATORS SYSTEM SUPPLY CENTRALIZED HEAT AND COOLING ENERGY (SCHSCE) IN COMBINATION HEATING POWER STATION – ABSORPTION COOLING STSTIONS OR EJECTORS COOLING STATIONS

When supply cooling energy based **SCHSCE** combination HPS-ABCS or HPS-EJCS, usually ABCS or EJCS is located in the region of the cooling consumption and connected to the water network of cold water and heat carrier from the plant to the ABCS or EJCS the heating system. Specific investment costs **SCHSCE** are determined by the expression [1,2,3]:

$$\overline{T}_{tec-trs}^{in} = \overline{T}_{trm} + \overline{T}_{mthv} + \overline{T}_{ttv} + \overline{T}_{tec} \quad (8)$$

Specific **SCHSCE** exploitation costs are determined by the expression:

$$\overline{T}_{tec-trs}^{ek} = \overline{T}_{gor} + \overline{T}_{am} + \overline{T}_{ld} + \overline{T}_{mat} \quad (9)$$

To determine the specific costs of fuel necessary to know the specific consumption of heat in the boiler TEC covering 1KW of heat loss, which for a given system can be determined by the formula:

$$q_{SCSTRE}^{TEC-TRS} = \frac{Q_{kp}}{Q_{ld}} = \frac{1}{\eta_{kv}\eta_{gu,h}\eta_{gu,t}\eta_{kp}\xi_{tm}\varphi} \quad (10)$$

Analysis of the ABCM or EJCM we have shown that the thermal coefficient depends on the temperatures heat carrier in the main pipeline. This dependence is given to the following terms:

$$\xi_{ABM} = 0,555\left(1 + 27,5/t_{nt}\right) \quad (11)$$

$$\xi_{EJM} = 0,36 + 0,00117t_{nt} \quad za\ t_0 = 7^0 C \quad (11)$$

$$\xi_{EJM} = 0,36 + 0,00122t_{nt} \quad za\ t_0 = 5^0 C \quad (11)$$

Coefficient of φ is determined on the basis of steam cycle toplifikacionog in $i - s$ different temperature diagram for subtraction of water vapor, which is determined by the expression on the $t_{odu} = t_{nt} + 10^0 C$. Cycles are shown in Figure 1a and 1b, and the temperature of heat carrier is on this basis, the coefficient φ can be determined by the expression:

$$\varphi = \frac{1 - \eta_{tec}^{t} \cdot \eta_{oi}}{1 + 0,43 \cdot \dfrac{i_4 - i_1}{i_4 - i_2}} = \frac{1 - \eta_{tec}^{t} \cdot \eta_{oi}}{1 + 0,43 \cdot \overline{I}} \quad (12)$$

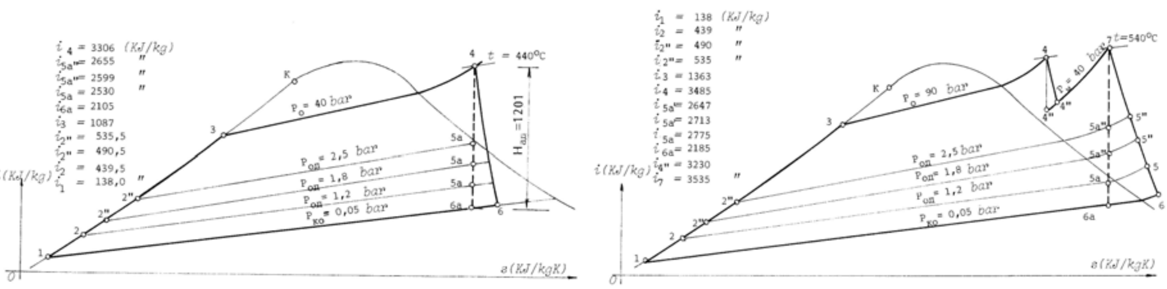


Figure 1. Heting cycle of the plant shown in the $i-s$ diagram

Relative efficiency values η_{oi} turbine engine that works on the basis of those cycles respectively is the $\eta_{oi}^{a}=0{,}81$, $\eta_{oi}^{b}=0{,}83$. Based on these cycles in Figure 1a and 1b and the corresponding formulas are calculated values for $\eta_{tec}^{t}, \bar{I}, \varphi$ different temperatures deprivation of water vapor. Based on given coefficients were calculated for $q_{SCSTRE}^{TEC-ABM}$ values and their values are shown in Figure 2.1. Analogous to formula (7) exploitation fuel costs can be expressed in the form of the expression:

$$T_{gor}=3600\cdot\eta_{SCSTRE}^{TEC-ABM}\,\frac{Z_{kp}\cdot C_{gor}}{H_d}Q_{td} \tag{13}$$

Knowing the details of the conditions of our region: $n_h=2201(h/god)$; $Q_{td}=2500(KW)$; have been determined for the cost of fuel at different temperatures of the heat carrier, fuel types and cycles. Annual costs in personal incomes are calculated by the expression: $T_{ld}=\overline{T}_{ld}\cdot Q_{ld}(Evra/god)$.

Specific funds invested into the cooling station, which is composed of the cooling tower, transformer and substation facilities, is: $\overline{T}_{ABRS}=570(Evra/KW)$ $\overline{T}_{EJRS}=950(Evra/KW)$.. Specific funds invested in the district heating network is: $\overline{T}_{mthv}=230(Evra/KW)$.Specific funds invested in transit from the heating system to HPS to ABCS is: $\overline{T}_{mthv}=250(Evra/KW)$. Specific funds invested in the production center of energy, that is, the HPS is: HPS claims to waste $\overline{T}_{TEC}^{TKO}=2500(Evra/KW)$;HPS solid fuel $\overline{T}_{TEC}^{CG}=1200(Evra/KW)$; HPS on liquid fuel $\overline{T}_{TEC}^{TG}=800(Evra/KW)$.Total funds invested in specific **SCHSCE** combination:

HPS-ABCS is : HPS the hard waste $\overline{T}_{TEC-ABRS}^{TKO}=3580(Evra/KW)$; HPS solid fuel $\overline{T}_{TEC-ABRS}^{CG}=2280(Evra/KW)$, HPS liquid fuel, $\overline{T}_{TEC-ABRS}^{TG}=1880(Evra/KW)$, or

HPS –EJCS is: HPS the hard waste $\overline{T}_{TEC-EJRS}^{TKO}=3950(Evra/KW)$; HPS solid fuel $\overline{T}_{TEC-EJRS}^{CG}=2650(Evra/KW)$; HPS on liquid fuel $\overline{T}_{TEC-ABRS}^{TG}=2250(Evra/KW)$;

Total funds invested in **SCHSCE** are discussed and arranged prikzana in Figure 3.1 and 3.2. To be deemed a realistic economic efficiency **SCHSCE** combination HPS – ABCS or HPS –EJCS is necessary to take into account energy P_{TEC}^{h}, obtained by heating regime and consumed for the production of cooling energy in ABCS or EJCS , which is given by:

$$P_{TEC}^{h}=\frac{Q_{td}\cdot\eta_{oi}\left(\eta_{TEC}^{to}+0{,}43\cdot\eta_{TEC}^{ko}\cdot\bar{I}\right)}{\eta_{gu,h}\cdot\eta_{gu,kv}\cdot\eta_{gu,t}\cdot\xi_{AB}\cdot\left(1-\eta_{TEC}^{to}\cdot\eta_{oi}\right)} \tag{14}$$

Part P_{TEC}^{h} energy, spend for our own purposes **SCHSCE** to run pumps, vacuum pumps and fans in ABCS which opremenjen **SCHSCE** E combination HPS-ABCS . Based on this, the useful energy produced by the turbine HPS heating cycle is determined by the expression:

$$P_{TEC}^{h,to}=P_{TEC}^{h}-P_{TT,PU}-P_{KU,TEC}-P_{AB,PU}-P_{KU,AB} \tag{15}$$

Or after rearrangement, the expression (15) we have that:

$$P_{TEC}^{h} = \frac{Q_{td}}{\eta_{gu,h} \cdot \eta_{gu,kv} \cdot \eta_{gu,t} \cdot \xi_{AB}} \left\{ \eta_{oi} \frac{\eta_{TEC}^{to} + 0,43 \cdot \eta_{TEC}^{ko} \cdot I}{1 - \eta_{TEC}^{to} \cdot \eta_{oi}} - \frac{10^{-3}}{\eta_{pu} \cdot c_w} \left[\frac{\Delta p_{tt,p}}{(t_{nt} - t_{kon}) \cdot \rho_w} + \frac{0,43 \cdot \Delta p_{ku,TEC} \cdot (1 - \eta_{TEC}^{ko} \cdot \eta_{oi})}{\rho_w \cdot \Delta t_w \cdot (1 - \eta_{TEC}^{to} \cdot \eta_{oi})} + \underline{10^3 \cdot \Omega_A \cdot \frac{\xi_{TM} \cdot \eta_{gu,t} \cdot \eta_{pu} \cdot c_w}{\eta_{gu,e}}} + \frac{(1 + \xi_{TM}) \cdot \eta_{gu,t}}{\eta_{gu,e}} \left(\frac{\Delta p_{ku,p}}{\rho_w \Delta t_w} + \frac{\Delta p_{ku,ve} \cdot \eta_{pu} \cdot c_{nt}}{c_v \cdot \rho_v (t_s - t_{vt}) \cdot \eta_{ku} \cdot \eta_{ve}} \right) \right] \right\} \quad (16)$$

In case of application by bars EJCS intermittent member of the equation (16) should. The results of calculations for determining the required energy for their own needs **SCHSCE** and produce useful energy for heating regime (regime with a subtracting heat) are given in Figure 2.3.

ECONOMIC INDICATORS SYSTEM SUPPLY CENTRALIZED HEAT AND COOLING ENERGY (SCHCE) FOR COMBINATIONS OF CONDENSING POWER PLANTS (CPP) – TURBO COMPRESSOR COOLING STATIONS.

When cooling energy supply based on combining CPS-TCCS , turbo compressor is needed electrical energy that is produced in the CPS [1,7,8,9]. Specific investment costs **SCHCE** is determined by the expression:

$$\overline{T}_{KEC-TK}^{in} = \overline{T}_{tk} + \overline{T}_{mthv} + \overline{T}_{cse} \quad (17)$$

Specific eksplotacioni **SCHCE** costs are determined by the expression:

$$\overline{T}_{KEC-TK}^{in} = \overline{T}_{gor} + \overline{T}_{am} + \overline{T}_{ld} + \overline{T}_{mat} \quad (18)$$

To determine the cost of fuel, it is necessary previously to define the specific consumption of heat in the boiler CPS, $\Sigma q_{SCSRE}^{KEC-TK}$ to cover 1KW heat gains. For this combination, the specific heat consumption for the production of cooling energy to cover the heat gains are calculated by the following equation:

$$q_{SCSRE}^{KEC-TK} = 1/(\eta_{gu,kv} \cdot \eta_{gu,h} \cdot \eta_{tk} \cdot \eta_{gu,e} \cdot \eta_{KEC} \cdot \eta_{oi} \cdot \eta_{kp} \cdot \varepsilon_{tk}) \quad (19)$$

The coefficient for the cooling cycle theory with regulating valve with temperature evaporation $t_o = +2^0 C$ (necessary for the preparation of carrier cooling energy - cold water systems 7/12C) and the temperature of the condensation of $t_{con} = +30^0 C$, nearly all cooling agents is somewhere between the $\varepsilon = 6 \div 8$ .Changing of values for these coefficients in the expression (19):

$$\eta_{gu,kv} = 0,95; \eta_{gu,h} = 0,93; \eta_{gu,t} = 0,90; \eta_{gu,e} = 0,95; \eta_{oi} = 0,82; \eta_{tk} = 0,70;$$

$$\eta_{KEC} = 0,425; \eta_{kp,cg} = 0,85; \eta_{kp,tg} = 0,90; \eta_{kp,tko} = 0,70; \varepsilon = 6,5;$$

Specific heat consumption in the boiler CPS , figure 2.3. Depending on the type of fuel is respectively: $q_{SCSRE,CG}^{KEC-TK} = 0,884;$ $q_{SCSRE,TG}^{KEC-TK} = 0,843;$ $q_{SCSRE,TKO}^{KEC-TK} = 1,002;$, which is considerably less than the HPS with ABCS , that is, for systems with a combination of CPS-TCCS takes less fuel. In order to compare the energy efficiency **SCHCE** combination HPS-ABCS or HPS-EJCS and CPS-TCCS is CPS necessary to produce electricity equal P_{TEC}^{h} . This requires additional heat consumption in the CPS values:

$$q_{SCSRE}^{een} = \frac{Q_{KEC}}{Q_{kp}} = \frac{P_{TEC}^{h} + P_{KEC,TK}^{sop}}{Q_{td} \cdot \eta_{KEC} \cdot \eta_{oi} \cdot \eta_{kp}} \quad (20)$$

Shifts in expression (20) data for P_{TEC}^{h} and $P_{KEC,TK}^{sop} = 0,12 \cdot Q_{td}$ define the overall speciifčnu heating system in a boiler CPS , which is given by:

$$\Sigma q_{SCSRE}^{KEC-TK} = q_{SCSRE}^{KEC-TK} + q_{SCSRE}^{een} \quad (21)$$

Comparing the size $q_{SCSRE}^{TEC-ABRM}$,$q_{SCSTRE}^{TEC-EJRS}$ and q_{SCSRE}^{KEC-TK} shows that cooling energy production based on the use of the system CPS-TCCS is about 10-20% effective in comparison with HPS-ABCS or HPS-EJCS . Analogous to formula (7) eksplotacioni fuel costs can be expressed by the expression:

$$T_{gor} = 3600 \cdot \Sigma q_{SCSRE}^{KEC-TK} \cdot Q_{td} \cdot Z_{kp} \cdot C_{gor} / H_d \tag{22}$$

For conditions of our region, [duration of periods of cooling $n_h = 2201(h/god)$, heat load for - heat dobci $Q_{td} = 2500KW$] were determined by fuel costs T_{gor} for different values of the temperature of heat carrier t_{nt}, the type of fuel cycle. Annual costs for personal incomes amounted $T_{ld} = \overline{T}_{ld} \cdot Q_{td}$. Specific funds invested in TCCS with its accessories is: $\overline{T}_{TKRS} = 510(evra/KW)$.

Specific assets invested in the center of energy supply (CPS) with an electrical transmission line to TCCS is respectively: $\overline{T}_{KEC-TK}^{TKO} / \overline{T}_{KEC-TK}^{CG} / T_{KEC-TK}^{TG} = 2740/1890/1590/(evra/KW)$. Total funds invested in speciifčna **SCHCE** combination CPS –TCCS shown in Figure 3.3

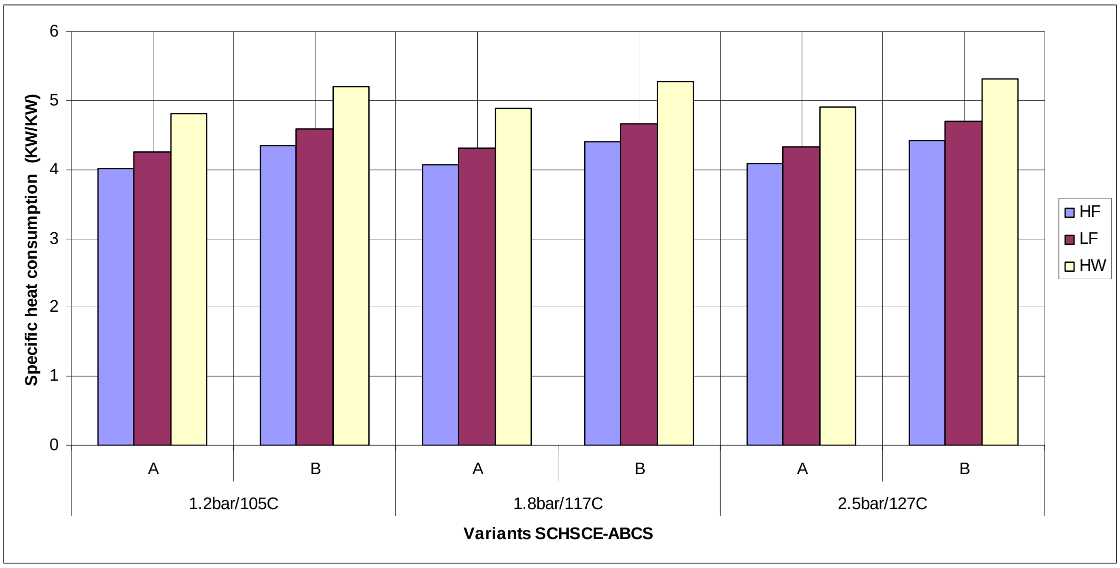


Figure 2.1. Specific heat consumption for $q_{SCSRE}^{TEC-ABRM}$ SCHSCE combination HPS-ABCS

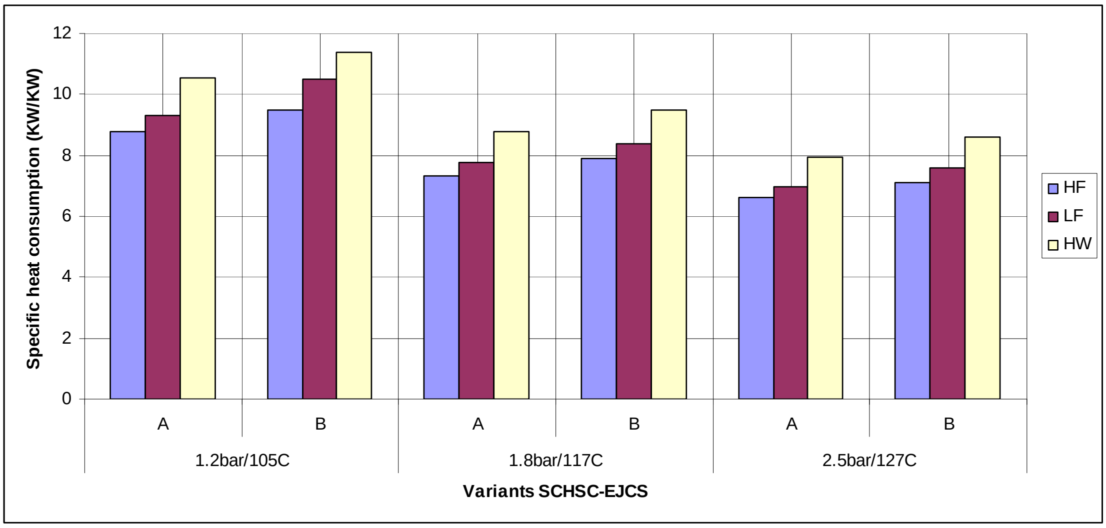


Figure 2.2. Specific heat consumption for $q_{SCSRE}^{TEC-EJCS}$ SCHSCE combination HPS-EJCS

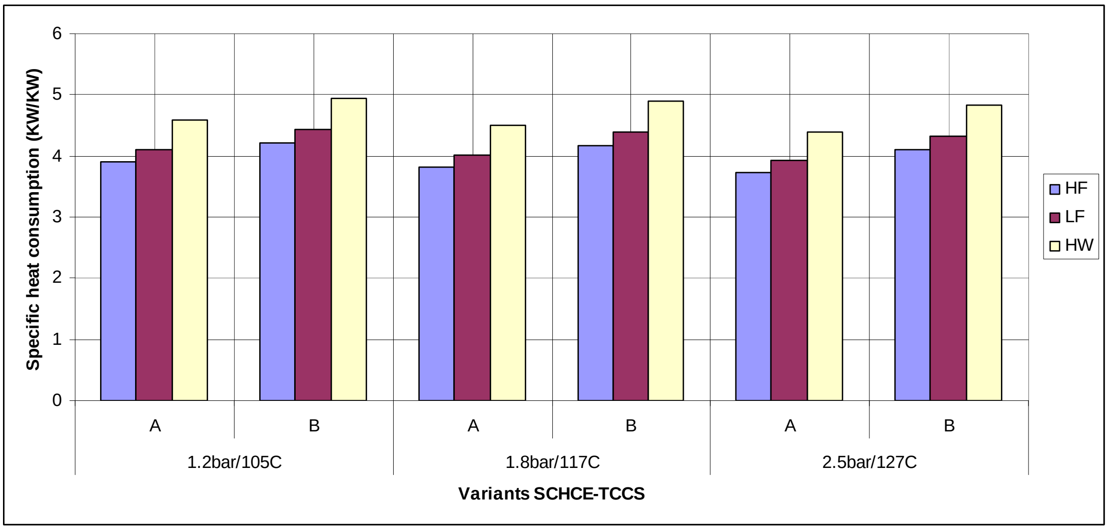


Figure 2.3. Specific heat consumption for $q_{SCSRE}^{KEC-TKRS}$ SCHSCE combination CPS-TCCS

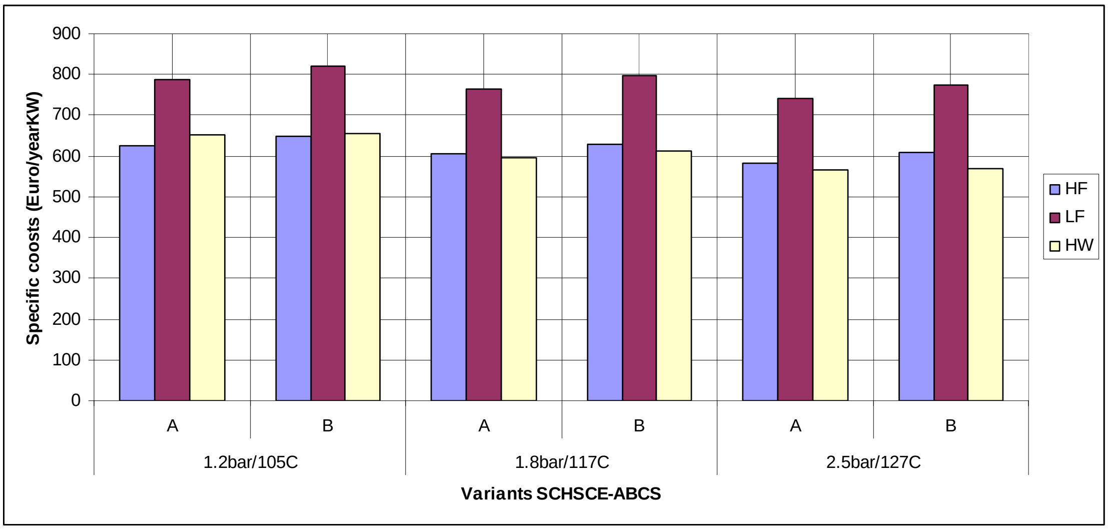


Figure 3.1. Economic indicators **SCHSCE** combination HPS-ABCS

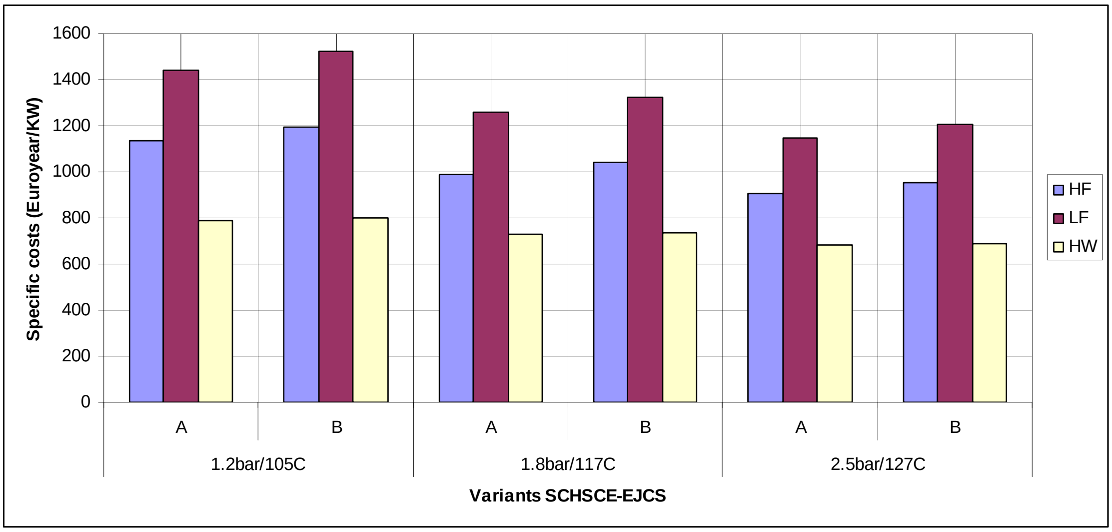


Figure 3.2. Economic indicators **SCHSCE** combination HPS-EJCS

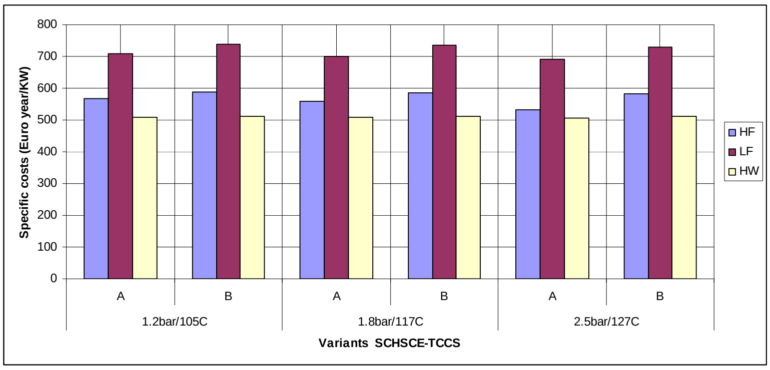


Figure 3.3. Economic indicators **SCHSCE** combination KPS-TCCS

CONCLUSION

This paper analyzes the economic and energy efficiency of the adopted energy structure. In order to view verodostojnijeg problem analysis was done for:

1. Heating-power station (HPS) and condensing power station (CPS) in solid and liquid fuel and for hard waste (refuse incineration);
2. temperature of the heat carrier is selected respectively, $105/117/127^0C$;
3. heting -cycles without overheating among (cycle "a") and among the overheating (the cycle of "b");

Based on the analysis can be defined:

- ✓ Specific heat consumptionv $q_{SCSRE}^{TEC-ABRS}$ depends on the type of fuel in the TEC and temperature heat carrier and heating cycle;
- ✓ with the temperature increase energy carrier specific heat consumption grows $q_{SCSRE}^{TEC-ABRS}$;
- ✓ analysis of energy and economic indicators, we can say that incineration waste has a greater economic effect compared to the HPS on solid and liquid fuel. This efficiency is higher at higher temperatures, the carrier energy to ABCS .
- ✓ production of cooling energy in **SCHCE**-CPS-TCCS is cheaper for 5-28%, depending on the type of fuel in the CPS and temperature heat carrier to ABCS compared to **SCHCE -** HPS – ABCS ;
- ✓ production of cooling energy (cold water systems 5/12C) in screening **SCHCE-CPS-TCCS** the municipal solid waste is cheaper for 9-40%;

REFERENCES

[1] Šefik, M.B., Analiza efektivnosti i optimizacija toplifikacionih i hladifikacionih sistema korišćenjem energije dobijene sagorevanjem tvrdog komunalnog otpada, doktorska disertacija, Priština, 1994
[2] Aršakjan, D.T., Optimizacija shema teplosnabženija gorodov i promišljenih rajonov , Teploenergetike, 1972., No.6,str.58-60
[3] Melikjan, Z.B., Centralizovannoe teplohladosnabženie graždenskih i promišljenih sooruženii , Strjoizdat, str.200.,MOSKVA 1985.
[4] Rozenfeld, L.M., Gešković, F., Analiza efektivtosti teplohladifikacionih sistem, Vodosnabženie i sanitarnaja tehnika, 1973., No. 4, str. 16-20
[5] Tihonov, B.S.,Centralizovannoe teplogazosnbženie i ventilacija, str.187,Moskva, 1968
[6] Reknagel-Špreneger-Herman: Grejanje i klimatizacija, IRO Građevinska knjiga, str. 652,Beograd, 1987
[7] Abramov,I.A., Izvekov,I.V.,Serihin,A.H.: Proeektirovanie turbogeneartov , Višaja škola, str.336, Moskva 1990
[8] Abramov V.I., Filipov,G.A., Frolov, V.V.: Teplovoj rasčet turbin, Mašinostroenie, str.182, Moskva, 1974
[9] Benjjamovskij, N.D.: Termičeskie metodi obezvreživanija tvrdih bitovih odhodov, Strojizdat, str. 192, Moskva, 1979.

IMPACT OF APPLYING ENERGY EFFICIENCY MEASURES IN MULTIFAMILY BUILDING ON GHG EMISSIONS REDUCTION

Bratislav Blagojević[1], Marko Ignjatović[1], Mladen Stojiljković[1], Branislav Stojanović[1], Mirko Stojiljković[1]
[1]University of Niš, Faculty of Mechanical Engineering in Niš, Niš
e-mail: marko.ignjatovic@masfak.ni.ac.rs

Abstract: Application of energy efficiency measures in buildings is a common practice in Serbia for new buildings and for refurbishment projects. "Local" benefit of applying these measures is mirrored in reduced energy costs and is understood very well by both the experts and the investors. But these measures have also the "global" benefit which is mirrored in GHG emissions reduction through lowering building energy consumption. In this paper, GHG emissions reductions rising from application of various energy efficiency measures were calculated with EnergyPlus simulation software for one multifamily building located in City of Niš, Serbia. It is shown that adding insulation to building envelope, replacing fenestration, boiler fuel switching to natural gas and adding boiler control can result in emission reduction up to 70.9% compared to the base-case scenario (inefficient building, coal fired boiler).
Key words: energy efficiency measures, EnergyPlus, GHG emissions reductions

INTRODUCTION

Energy use in buildings represents about 40% of the total EU final energy consumption. Similar situation is in Serbia. This is why in construction of new buildings and refurbishment of old ones, special attention must be given to applicable energy efficiency measures (EEM). Besides obvious economic effects, these measures have a more "global effect mirrored in GHG emissions reduction. Only recently (on September 30th 2012), first regulation concerning energy efficiency in buildings came into force in Serbia. By adopting this regulation, Serbia joined all EU member countries which have similar regulation starting from 2002 and the adoption of EU Directive 2002/91 [1]. What is more important, this regulation defines influential parameters on building energy consumption and GHG emissions, which can be treated as benchmark values in research and in common practice. Many authors investigated the influence of various EEM in refurbishment projects. Milne and Boardman [2] concluded that refurbishment improved energy efficiency and also increased thermal comfort. Roberts [3] examined reduction in building energy consumption by applying various EEM like adding insulation, replacing fenestration, replacing boilers and use of RES. There are domestic authors dealing with these topics as well. Bojić *et al.* [4] investigated the possibilities to decrease energy consumption of a thermally non-insulated old house in Belgrade, Serbia. By using EnergyPlus software, the space heating inside the old and refurbished houses is simulated for the single and combined refurbishment measures. These measures included insulation of external walls, insulation of the ceiling and lowering the ceiling. They calculated financial savings for each individual measure and for sets of measures.
This paper deals with possibilities to decrease GHG emission during heating season by applying various single or set of EEMs through refurbishment of an existing old house. EEMs include: insulation of thermal envelope (outside walls, roof, surfaces in contact with ground etc.), replacing fenestration surfaces (windows and outside doors), fuel switching, and adding boiler control. GHG reductions are calculated from reduced building energy consumption which is obtained by building energy simulation software EnergyPlus [5]. For this paper, the building with its HVAC and other systems was modeled in Google SketchUp [6] and simulated in EnergyPlus ver. 7.1.

BUILDING AND SYSTEMS DESCRIPTION

The building itself is shown in figure 1. It is a three-story residential multifamily building with total floor area of roughly 350m^2. It was built in the early 80s and is located on the city outskirts. It is not surrounded by other buildings. Each building story represents an apartment with living room, dining room, two bedrooms, bathroom, corridor which is heated and two additional unheated rooms. All the apartments have joint unheated staircase. Basement and roof are unheated as well. For the energy simulation purposes, all the rooms are presented as separate thermal zones, which enable defining occupancy, lighting, equipment usage, and heating setpoint schedules.

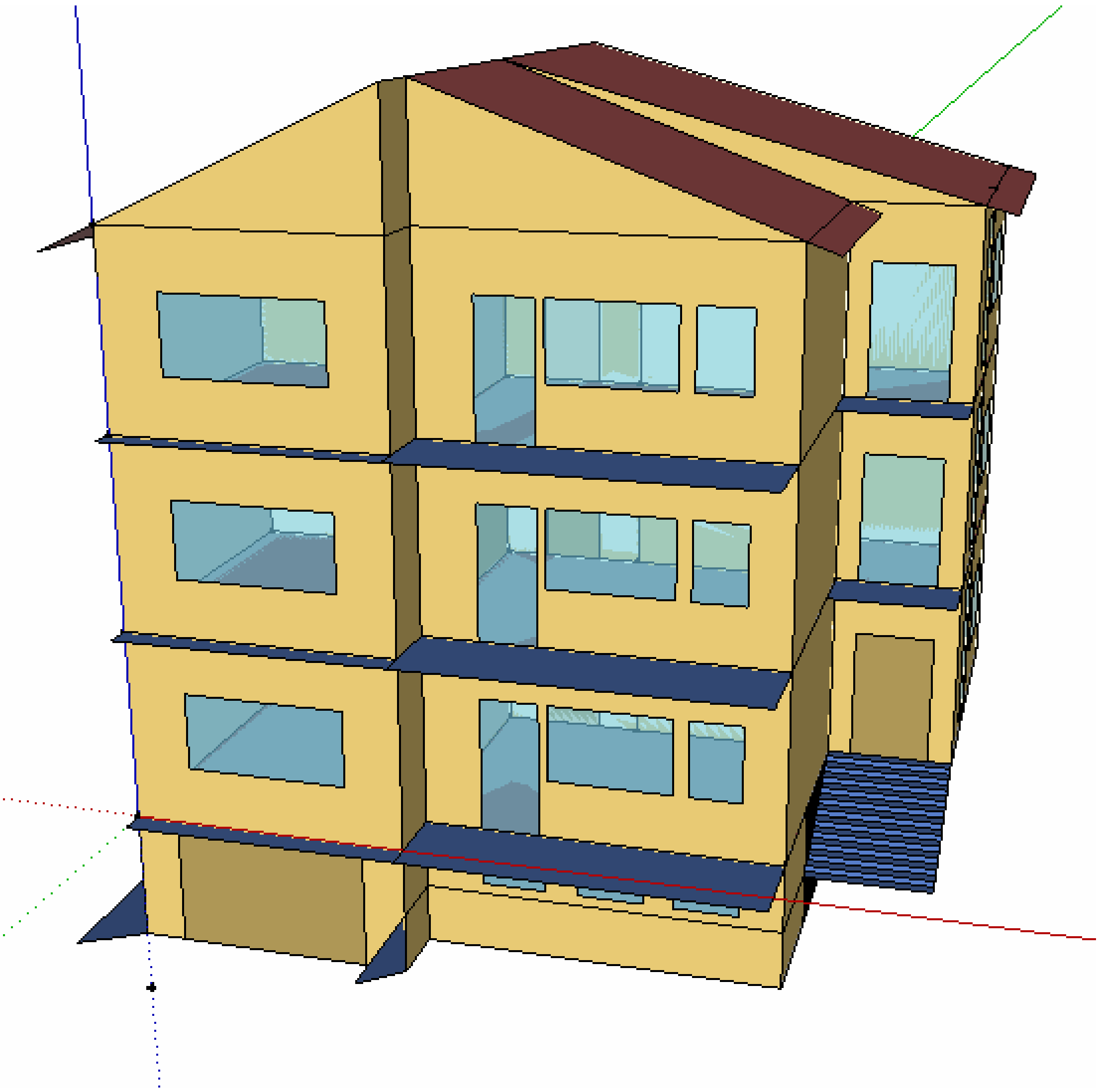


Figure 1. Model of the building in GoogleSketchUp (South-East view)

Building thermal properties

Since the building was built in the early 80s, thermal properties of the building do not satisfy the propositions of new *Ordinance on Energy Efficiency in Buildings* [7]. For better overview, all the constructions with corresponding U-values are shown in table 1. Building air-tightness which influences infiltration loads is selected from [7] for façade in bad condition and for exposed position of the building and is set to 1.2 ACH (air changes per hour).

Table 1. Composition and U-value of the building envelope elements

Construction	Material	Thickness [m]	U-value [W/m^{2}K]
External wall	Mortar	0.015	1.65
	Brick	0.25	
	Mortar	0.015	
Internal wall, Internal wall towards unheated space	Mortar	0.015	2.14
	Brick	0.12	
	Mortar	0.015	
Floor/Ceiling, Floor/Ceiling between different users	Wood floor tiles	0.02	1.1
	Insulation	0.01	
	Concrete plate	0.25	
	Mortar	0.015	
Roof	Roof tiles	0.02	6.98
Floor on ground	Ceramic floor tiles	0.015	0.74
	Insulation	0.04	
	Concrete	0.1	
Wall in ground	Mortar	0.015	3.81
	Concrete	0.25	
	Moratr	0.015	
Ceiling towards unheated roof area	Stone wool	0.04	0.77
	Concrete plate	0.25	
	Mortar	0.015	
Windows	Double glazed air filled	4-12-4mm	2.675

Building HVAC and lighting system, occupancy

The building has a hot water heating system with radiators. Internal room air temperature is controlled by thermostat and is set to constant value of 20°C. Heat is provided by coal (wood) fired boiler and circulated through the system with constant speed pump. In addition to this base case, fuel switching prior to refurbishment is analyzed as well. Building heating system operates in temperature regime 90/70°C and its schematic is shown in figure 2.

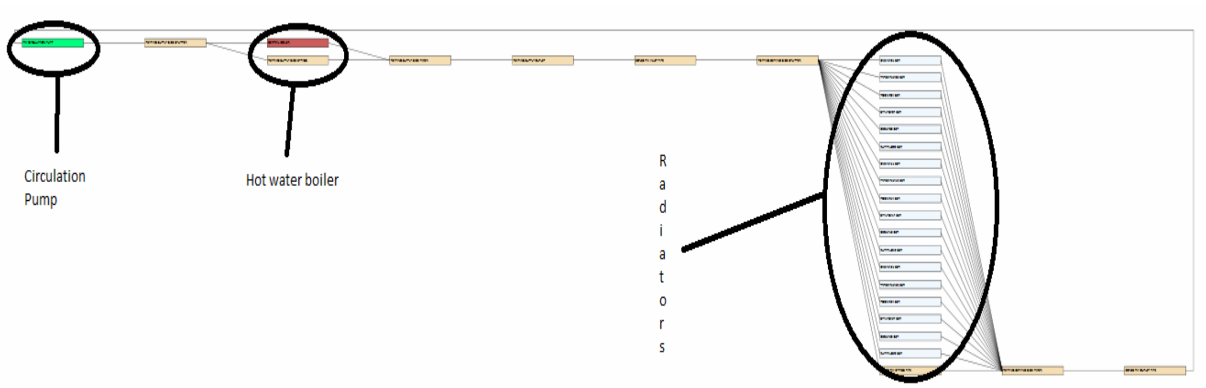


Figure 2. Heating system schematic

Building lighting system is defined as lump sum value of 5W/m^2 of floor area. Electric equipment is defined for sets of rooms with the following values: living and dining rooms 20W/m^2; bedrooms 5W/m^2; bathrooms 150W/m^2. Lighting system, equipment usage and room occupancy are defined with proper schedules of operation.

ENERGY EFFICIENCY MEASURES

Potential individual energy efficiency measures include: fuel switching before the refurbishment process, adding insulation to construction in order to meet the requirements of [7], replacing windows and external doors in order to meet the requirements of [7]. Also the set of all refurbishment measures with fuel switching is analyzed. Finally, just as an example, adding boiler control to natural gas fired boiler and variable sped pump in a refurbished building is shown.

EEM#1 - Fuel switching

This option is selected since it is requires the least investment. Four boiler types were selected:

1. Coal (wood) fired boiler, using coal with a heating value of 12000 kJ/kg,
2. Fuel oil boiler, using light fuel oil with a heating value of 42000kJ/kg,
3. Electric boiler, using electricity from the national grid,
4. Natural gas boiler, using natural gas with a heating value of 33333kJ/m^3_N.

Overall efficiency, consisting of the boiler, heating system and control system efficiencies is selected from [8]. These values are respectively: 0.65, 0.82, 0.95, and 0.9.

EEM#2 - Envelope insulation

This EEM is widely adopted in Serbia in refurbishment projects. For this paper, insulation is added on envelope constructions only to meet the minimum requirements of [7]. These requirements are, based on construction type:

- External walls 0.4 W/m^2K
- Walls and other construction between heated spaces of different users 0.9 W/m^2K
- Pitched roof above unheated space 0.4 W/m^2K
- Internal wall towards unheated space 0.55 W/m^2K
- Floor above unheated space 0.4 W/m^2K
- Floor on ground 0.4 W/m^2K
- Wall in contact with ground 0.5 W/m^2K

In table 2 only additional insulation and new U-values are given based on composition and U-values given in table 1.

Table 2. Additional insulation thickness and U-value of the refurbished building envelope elements

Construction	Added insulation thickness [m]	U-value [W/m^2K]
External wall	0.08	0.39
Internal wall towards unheated space	0.06	0.52
Floor/Ceiling, Floor/Ceiling between different users	0.01	0.82
Roof	0.1	0.38
Floor on ground	0.04	0.39
Wall in ground	0.08	0.45
Floor towards unheated basement	0.05	0.4
Ceiling towards unheated roof	0.06	0.36

EEM#3 - Replacing windows and improving air-tightness

This EEM reduces both transmission losses since new windows have lower U-value and infiltration losses because building is more air tight. Requirements for windows specified in [7] are that all windows and outside door must have U-value no more than 1.5W/m^{2}K and 1.6W/m^{2}K, respectively. Since the original building has classic double glazed windows filled with air (4-12-4mm), new state-of-the art windows which meet the above requirement were selected. New windows are double glazed with low emission outer glass filled with Xenon. Windows have a U-value of 1.342W/m^{2}K. Additionally, infiltration is reduced to 0.5 ACH.

EEM#4 - Boiler control and variable speed pump

Control of the heating systems is more advanced EEM since it requires a lot of knowledge to be implemented in the project. For this paper simple two-point boiler qualitative control is selected. Boiler supply temperature is linear function of outside temperature. Common practice in Serbia is to have the control curve in residential buildings as shown in figure 3.

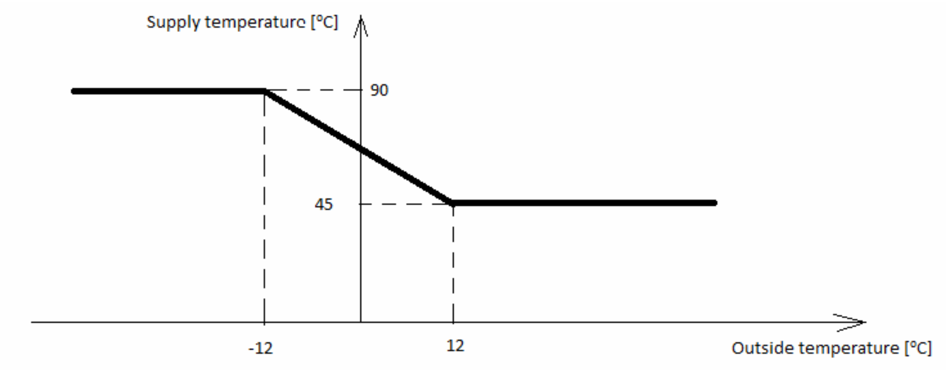


Figure 3. Two-point linear boiler control

RESULTS AND DISCUSSION

Simulations of basic case, implementation of single and set of EEM were performed for the building located on the outskirts of City of Niš, Serbia. For simulations .epw file for Niš was used [8]. In order to evaluate GHG emissions, virtual energy meters have been created in EnergyPlus. Values from these meters were multiplied by the appropriate conversion factors in order to obtain primary energy. GHG emissions for each case are then calculated by multiplying these values with appropriate emission factors specified in [7]. Due to better overview, for each simulated case heating energy consumption, electricity consumption, primary energy consumption for heating and electricity and finally GHG emissions are shown separately.
Primary energy conversion factors and GHG emission factors are given in table 3.

Table 3. Primary energy conversion factors and GHG emission factors

Fuel type	Primary energy conversion factor	GHG emission factor [kg/kWh]
Coal	1.3	0.32
Extra light fuel oil	1.2	0.265
Electricity	2.5	0.53
Natural gas	1.1	0.20

EEM#1

Results obtained from base case simulation and fuel switching before refurbishment is shown in table 4.

Table 4. Base case and fuel switching, energy consumption and GHG emissions

		Coal	Fuel oil	Electricity	Natural gas
Final energy [kWh]	Heating	68127	56495	46236	48764
	Electricity	7723	7723	7723	7723
Primary energy [kWh]	Heating	88565	67794	115815	53641
	Electricity	19309	19309	19309	19309
GHG emissions [t]	Heating	29.23	17.97	61.38	10.73
	Electricity	10.23	10.23	10.23	10.23
TOTAL GHG emissions [t]		39.46	28.2	71.62	20.96

From the table above it is clear that switching to electric boiler would lead to significant increase in GHG emissions (81.5%). The main reason for this is that Serbian electricity grid factor is very low due to small portion of RES supplying it. The best choice of fuel, from environmental protection, is natural gas, since the emission reduction is 46.88%.

EEM#2 and fuel switching

Adding insulation significantly reduces heating energy consumption as shown in table 5.

Table 5. Energy consumption and GHG emissions for envelope insulation

		Coal	Fuel oil	Electricity	Natural gas
Final energy [kWh]	Heating	30383	25196	20661	21748
	Electricity	7723	7723	7723	7723
Primary energy [kWh]	Heating	39499	30235	51652	23923
	Electricity	19309	19309	19309	19309
GHG emissions [t]	Heating	13.03	8.01	27.38	4.78
	Electricity	10.23	10.23	10.23	10.23
TOTAL GHG emissions [t]		23.27	18.25	37.62	15.02

Adding insulation on building envelope reduces GHG emissions for the base-case heating system by 41%. If fuel switch option is selected as well, this reduction ranges from 4.7% (electric boiler) to 61.9% (natural gas boiler).

EEM#3 and fuel switching

Replacing windows and improving building air-tightness reduces heating energy consumption as shown in table 6.

Table 6. Energy consumption and GHG emissions for window replacement

		Coal	Fuel oil	Electricity	Natural gas
Final energy [kWh]	Heating	43992	36480	29914	31488
	Electricity	7723	7723	7723	7723
Primary energy [kWh]	Heating	57190	43777	74786	34638
	Electricity	19309	19309	19309	19309
GHG emissions [t]	Heating	18.88	11.6	39.64	6.93
	Electricity	10.23	10.23	10.23	10.23
TOTAL GHG emissions [t]		29.11	21.83	49.87	17.16

Replacing windows reduces GHG emissions for the base-case heating system by 26.2%. If fuel switch option is selected as well, GHG emissions could increase by 26.4% (electric boiler) or decrease by as much as 56.5% (natural gas boiler).

EEM#2, EEM#3 and fuel switching

Combination of EEM#2 and EEM#3 coupled with fuel switching leads to even more emission reductions as presented in table 7. This is common practice in Serbia.

Table 7. Energy consumption and GHG emissions for insulation and window replacement coupled with fuel switching

		Coal	Fuel oil	Electricity	Natural gas
Final energy [kWh]	Heating	9114	7558	6198	6524
	Electricity	7723	7723	7723	7723
Primary energy [kWh]	Heating	11848	9070	15494	7176
	Electricity	19309	19309	19309	19309
GHG emissions [t]	Heating	3.91	2.40	8.21	1.44
	Electricity	10.23	10.23	10.23	10.23
TOTAL GHG emissions [t]		14.14	12.64	18.45	11.67

In this case GHG emissions could reduce from 53.2% (fuel switch to electric boiler) to 70.4% (fuel switch to natural gas). Interestingly, if one chooses to keep existing boiler GHG emission reduction of 64.2% is higher than to switch to electric boiler.

EEM#4 applied to natural gas fired boiler – best case scenario

Boiler control benefits can be clearly seen from the table 8.

Table 8. Adding natural gas boiler control and variable speed pump in refurbished building

		Natural gas
Final energy [kWh]	Heating	5715
	Electricity	7723
Primary energy [kWh]	Heating	6286
	Electricity	19309
GHG emissions [t]	Heating	1.26
	Electricity	10.23
TOTAL GHG emissions [t]		11.49

GHG emission reductions are 70.9% and represent the highest possible reductions in this particular case.

CONCLUSION

From the results shown above it is clear that application of some individual EEM could not lead to GHG emissions reduction. This is clear if the fuel switch option is selected inadequately (electric boiler). Applying two or more EEMs could lead to GHG emission reductions up to 70.9%. The biggest individual reductions occur when applying envelope insulation. The idea of the paper is to show that applying specified EEMs leads, not only to reduction of fuel usage (and thus lower fuel costs) but also to increasing environmental protection (reduction of GHG emissions).

ACKNOWLEDGEMENT

This paper was done within the framework of the project TR 33051-"The concept of sustainable energy supply of settlements with energy efficient buildings" (2011-2014), financed by the Republic of Serbia Ministry of Education and Science.

REFERENCES

[1] COM 2002/91/EC: Directive on the energy performance of buildings, EC, 2002.
[2] G. Milne, B. Boardman, Making cold homes warmer: the effect of energy efficiency improvements in low-income homes: a report to the Energy Action Grants Agency Charitable Trust, Energy Policy, Vol. 28, pp. 411–424, 2000
[3] S. Roberts, Altering existing buildings in the UK, Energy Policy, Vol. 36, pp. 4482–4486, 2002.
[4] M. Bojic, et al., Decreasing energy consumption in thermally non-insulated old house via refurbishment, Energy Buildings, 2012, http://dx.doi.org/10.1016/j.enbuild.2012.03.045
[5] DOE, EnergyPlus 7.0 Engineering Reference, U.S. Department of Energy, 2011, http://apps1.eere.energy.gov/buildings/energyplus
[6] http://www.sketchup.com/
[7] ***, Republic of Serbia Ministry of Environment, Mining and Spatial Planning, Ordinance on Energy Efficiency of Buildings, Official Journal of the Republic of Serbia (in Serbian), 61/2011
[8] ***, EnergyPlus Support Group, http://tech.groups.yahoo.com/group/EnergyPlus_Support/files/Meteonorm_Weather_Files/Europe/Serbia%20%28SRB%29

A MATHEMATICAL MODEL FOR DETERMINING ENERGY EFFICIENCY OF THE ELEMENTS OF THE PASSIVE SOLAR BUILDING DESIGN SYSTEMS

Radivoje Topić[1], Nenad Ćuprić[2], J. Topić[3], Goran Topić[4]
[1] University of Belgrade, Faculty of Mechanical Engineering,Belgrade, Serbia
[2] University of Belgrade, Faculty of Forestry, Belgrade, Serbia
[3]Certified designer, Energoprojekt, Belgrade, Serbia
[4]Certified designer, Srbijagas, Belgrade, Serbia
e-mail: rtopic@mas.bg.ac.rs

Abstract: Sustainable development, energy efficiency, usage of renewable energy and environment protection are the current interests on the beginning of this century. This paper presents the short review of the passive systems for room heating by using solar energy and a mathematical model for determining energy efficiency of the passive solar building design system elements.

Key words: Solar energy, Passive solar systems, Trombe wall, Optical parameters

INTRODUCTION

The passive building design systems have an important role in establishing a new approach to the living environment and the process of substitution of fossil fuels with renewable. Three main concepts of the solar energy usage exist: obtaining thermal energy, obtaining electrical energy and obtaining energy from biomass. Beside these three concepts, it is possible to obtain energy from wind, ebb and tide, sea and ocean waves as indirect forms of the solar energy. Also, solar energy is used for other different purposes. Different passive and active systems are in use for obtaining heat from solar energy. Passive solar systems do not use special solar receivers for collecting solar energy, instead the parts of the building are used for that purpose. The obtained heat is transferred through the building mainly by natural convection.

THE SYSTEMS OF SOLAR ENERGY WHICH USE HOT WATER OR AIR FOR ROOM HEATING

Room heating is one of more important ways of using solar energy. The room heating system can be active or passive. The active systems use solar energy receivers. Heat is accumulated in the thermal accumulators from where it is used in the form of heated water or heated air for room heating. Passive usage of solar energy means that the parts of the building are in the same time the solar energy receivers and accumulators and the working fluid naturally circulates without any pumps, fans or similar devices. Room heating by using solar energy can be obtained in many different ways. Heated air from a solar energy receiver can be used directly for the room heating or can be put through the thermal accumulator where the heat is stored for later use. In the systems which use water as the working fluid the heated water can be used for heating, or a heat exchanger "water – air" can be used for heating the air in the room. Room heating can be obtained by using solar heat receivers placed on the roof or facade of the building (patented as "SolarWall"). Some of active systems for room heating using solar energy which use heated air as working fluid and receivers placed on the facade are shown on the figure 1. a. b. and c.

THE PASSIVE SOLAR ENERGY SYSTEMS FOR HEATING

Passive systems use some parts of the building for heat absorption (without special receivers) and the heat is transferred mainly by natural convection, conduction or radiation. Sometimes passive systems use a ventilator for more efficient air circulation, but the ventilator's purpose is different compared to the active systems. Passive systems use windows, roofs, walls, swimming pools and the other building elements as solar energy receivers and heat accumulators. Sometimes special heat accumulators are used too. Solar houses with passive and active heating systems have to have minimal heat loss and good thermal insulation which provides better energy efficiency. The building has to be designed in the way to achieve maximal savings and ensure a better use of solar energy. In the designing of a building with the passive system the position of the object, orientation, window position and size, position and color of the walls and roof should be well determine. Well-designed passive system can be effectively the same as the corresponding active system.

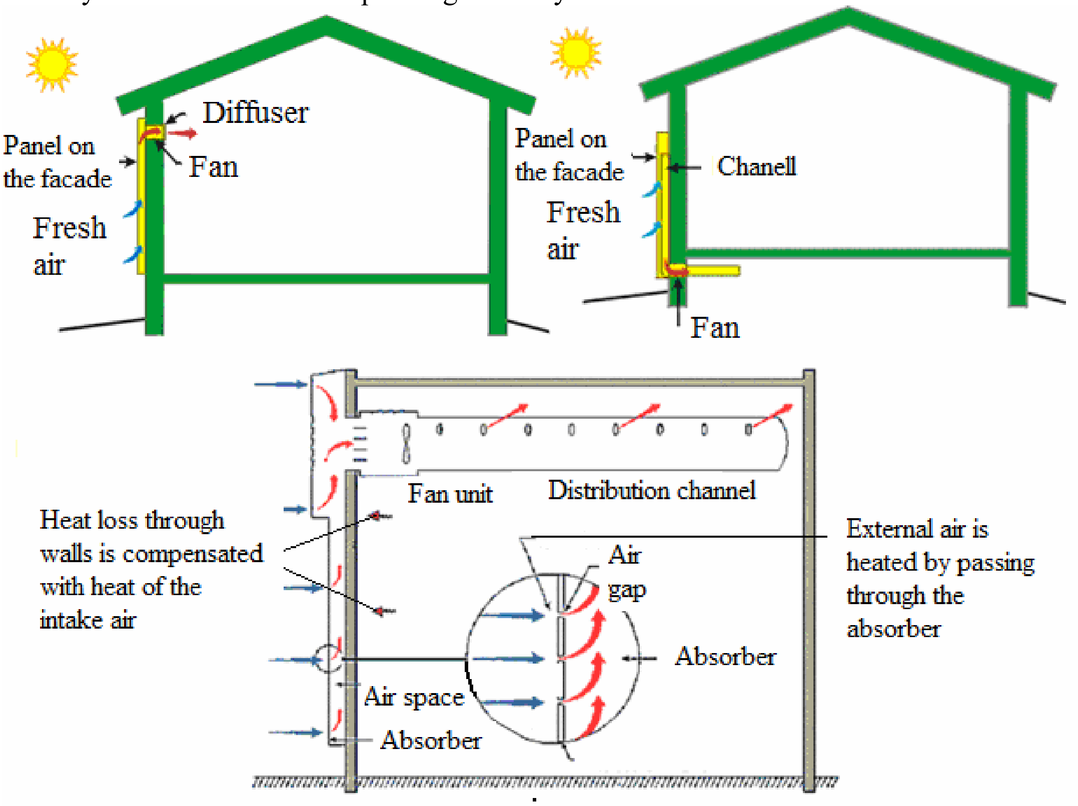


Figure 1. Some examples of the “SolarWall” heating system

The main advantages of the passive system are: the maintenance costs are minimal, uncomplicated system management, the operating cost is lower and it has longer service life. Also, the same passive system can very often be used for cooling during the summer. The main disadvantage is that in most cases it is not possible to implement passive systems in already built objects because its orientation, position and construction are not in accordance with the requirements of the passive system design. Several different ways of passive heating are in use. One of the simplest is presented on the figure 2 a and b.

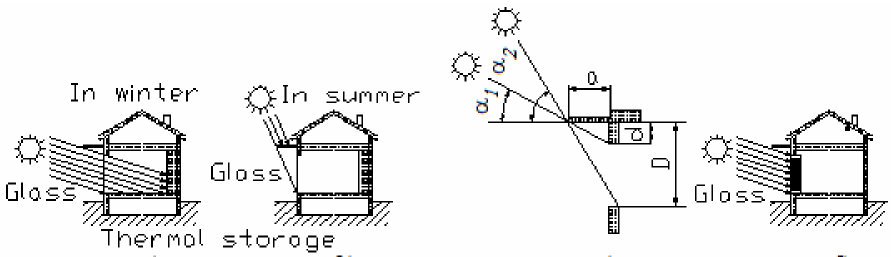
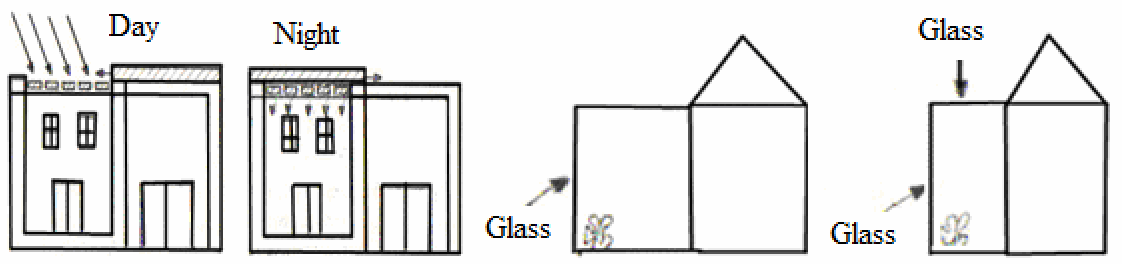


Figure 2. The usage of the solar energy for room heating – passive design

The main characteristic of the system is heat accumulation in the elements of the room or in special thermal accumulators and canopy which protects the room from solar radiation during the summer. Also, a glazed south wall of the building, “Trombe wall”, can be an efficient passive system which is the solar energy receiver and the heat accumulator at the same time. The facade of the vertical wall is

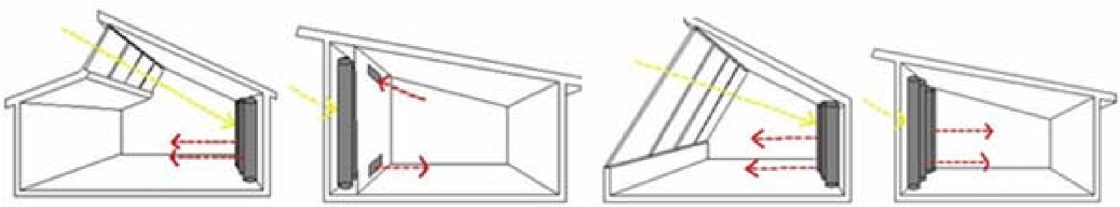
painted black and single or double glazed. The openings on the base and the top of the wall provide air circulation. In this way almost continual room heating is obtained.
The heat can be absorbed and accumulated in a specially constructed roof, Figure 3 a and b. It can be made of metal with plastic bags filled with water or in form of shallow pools. The large glazed and covered balconies on the south side and the glass veranda in front of the house with a glazed or plain roof are used too.



a b c d

Figure 3. The roof as an element of the solar energy receiver in the passive system

The passive concept of solar energy usage, such as "Climate House", uses available construction materials for heating, cooling and lighting. To achieve required results the traditional construction materials and elements are in use: insulation, glass, massive floors, ect. The starting investment is higher, but it is justified with lower energy costs during the time. Also, passive systems are more environmental friendly and give more energy independence. Passive systems represent the future in terms of energy savings. The basic concept includes outside and inside walls and floors, but it also includes the permanent house elements used as "thermal mass" which is simply a solid or liquid material that will absorb and store warmth and coolness until it is needed.
This concept gives ideal living space. It obtains beautiful connection with exterior and lot of natural light during the whole year. Several basic architectural models of these houses exist. These models are developed in several variants which enrich house design. Four essential elements of passive concept are: proper house position, lot of windows facing south (on the north hemisphere) to obtain better solar energy collection during autumn, winter and spring, enough internal thermal mass to annul external temperature changes, thermal accumulators and very good insulation. All those elements have to be coordinated and matched together. For less temperature changes the insulation can be placed on the outside surface of the walls. In the case when faster heating is required or when the thermal capacity of the internal elements are lower it is necessary to insulate internal wall surfaces too. Carefully balanced structure of thermal mass and insulation provides savings in energy consumption and also in construction material.
Solar architecture is a part of the passive concept of solar energy usage. The buildings are designed in the way that they are collectors, transmitters and accumulator of the thermal energy in the same time. Heating is obtained by direct sun radiation through the large windows and transparent surfaces or by receivers placed on the roof and facade ("SolarWall"). Some of the solutions are presented on Figure 4.



a b c d

Figure 4. Some examples of the "Solar architecture" concept

They differ in position of the transparent surfaces or windows, the passive system elements and dimensions. The solution on figure 4 a collects solar energy through large windows, which is absorbed in the pipes, filled with water. Canals are filled with colored water to increase heat absorption. The solution presented on the figure 4 b is specific because it has a dividing wall which separates the pipes of the thermal accumulator from the rest of the internal heating space. In that case it is easier to control constant thermal losses as well as variable ones. The pipes are used in case when the object has large transparent surfaces, with the high transmittance and in the region with good insulation. In the regions with poor insulation it is necessary to analyze additional costs and energy savings. The pipes are painted black and placed vertically. The air flows around the pipes vertically or horizontally. This construction obtains shadows during the summer and reduces losses during the winter. Sun architecture includes the usage of PV modules too.

THE ANALITICAL DETERMING OF THE CHARACTERISTICS OF THE PASSIVE SOLAR ENERGY SYSTEMS FOR HEATING

In the design of the heating system two characteristics are calculated: the amount of heat from solar radiation, which is absorbed by the surface of the building, and the efficiency of energy transmission of the solar radiation. For the specified geographical location following parameters are defined:

- Geographical latitude,
- Duration of the heating period, day and night, n_{pg},
- The average temperature during the heating period t_{pg},^{0}C ,
- The number of months of the heating period M, and
- The number of days and nights for the each month during the heating period, m.

For determination of those parameters for the specified location the months with the average month temperature of the outside air $t_o \leq 8^o C$ are counted. If the number of those months is $n_{\Sigma} > n_{pg}$ for calculation only the number of that months are used. Thereby the calculated number of the days and nights for the final two months are:

$$m = m_k - 0{,}5\left(n_{\Sigma} - n_{pg}\right), \tag{1}$$

where m_k is the number of the calendar days in the month.
If the $n_{\Sigma} < n_{pg}$ for the calculation two adjacent months with calculated number of days and nights are used:

$$m = 0{,}5\left(n_{\Sigma} - n_{pg}\right). \tag{2}$$

Determination of the heat quantity absorbed by the surface of the absorber

Trombe wall is used as an example. The sun radiation energy which comes into the room through the glass of the window and which is absorbed by the surface of the wall – receiver, in the period of every month and divided by the area of the wall is:

$$q_a = k_s \cdot k_z \cdot k_p \left[\, (\tau\alpha)_u \cdot P_d \cdot f_d \cdot k_i \cdot S_{mdz} + (\tau\alpha)_{dif} \cdot P_{dif} \cdot f_{dif} \cdot k_o \cdot D + r \cdot (\tau\alpha)_r \cdot P_r \cdot f \cdot (S_{mdz} + D) \, \right] \tag{3}$$

where S_{mdz} and D are the month sum of direct, diffusion and reflective radiation, respectively, which falls on the horizontal surface.
For the months in which is $m<m_k$ selected values are multiplied with the quotient m/m_k .
Conditional absorption for direct radiation is:

$$(\tau\alpha)_u (\tau\alpha)_1 \cdot (\tau/\tau_1)_{upp} \cdot (\alpha/\alpha_1)_{uap}, \tag{4}$$

The values for $(\tau / \tau_1)_{upp}$ and $(\alpha / \alpha_1)_{uap}$ are used from corresponding diagrams depending on the average value of the angle of sunlight falling on the transparent surface and absorption surface during the month.
Conditional absorption of the system in the case of perpendicular light falling on the surface is:

$$(\tau\alpha)_1 = \frac{\tau_1 \cdot \alpha_1}{\left[1-(1-\alpha_1)\right]\cdot \tau_{sp}} \quad . \tag{5}$$

The glass transmittance is:

$$\tau_1 = \frac{1-\rho}{1+(2n-1)\cdot\rho}\cdot \exp(-\kappa\cdot n\cdot \delta_s), \tag{6}$$

where ρ is reflectance (for the glass is ρ=0.043); n-is the number of the glass layers; δ- is the thickness of the each layer in cm; κ – is the attenuation coefficient of sun radiation in a layer, for window glass it is κ = 0.16 cm^{-1}.
The spectral reflectance of transparent covers is 0.16, 0.24 and 0.29, respectively, for the single layer, double layer and triple layer glass. Sunlight absorbance of the surface of the receiver in the case when it is black is α_1= 0.9. Conditional absorbance for the diffusion $(\tau\cdot\alpha/d)$ and reflective $(\tau\cdot\alpha)$ radiation is calculated by expression (4). In the expression (3) P_d , P_{dif} and P_r are coefficient of the position of the transparent surface, respectively, for direct, diffusion and reflective radiation.
The value of P_d is determined from the table 1.

Table 1. The average value of P_d during the month for the receivers south directed, in dependence on the different inclination angle β to the horizon.

β, [^{0}]	Months											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Geographic latitude 40^0												
25	1,76	1,49	1,30	1,13	1,04	1,00	1,01	1,08	1,22	1,40	1,66	1,85
40	2,24	1,22	1,36	1,11	0,97	0,90	0,93	1,03	1,24	1,55	2,03	2,45
55	2,46	1,79	1,33	1,03	0,86	0,73	0,81	0,94	1,17	1,56	2,18	2,72
90	2,30	1,48	0,91	0	0	0	0	0,75	0,75	1,17	1,96	2,61
Geographic latitude 45 ^{0}												
30	2,14	1,71	1,42	1,19	1,07	1,02	1,04	1,13	1,30	1,56	1,96	2,31
45	2,86	1,99	1,43	1,17	1,00	0,92	0,95	1,08	1,38	1,74	2,47	3,27
60	3,13	2,07	1,45	1,09	0,89	0,80	0,84	0,99	1,26	1,76	2,66	3,64
90	3,04	1,81	0,99	0,71	0	0	0	0	0,89	1,37	2,50	3,63
Geographic latitude 50 ^{0}												
35	2,77	2,01	1,57	1,27	1,11	1,05	1,03	1,19	1,42	1,79	2,44	3,12
50	4,06	2,38	1,65	1,24	1,04	0,95	0,98	1,33	1,44	2,00	3,22	5,27
65	4,46	2,47	1,61	1,16	0,93	0,82	0,87	1,04	1,37	2,02	3,47	5,90
90	4,46	2,26	1,30	0,64	0	0	0	0,72	1,06	1,77	3,36	6,04
Geographic latitude 55 ^{0}												
40	4,00	2,47	1,79	1,37	1,17	1,09	1,12	1,26	1,56	2,11	3,27	4,91
55	3,37	2,99	1,87	1,34	1,09	0,99	1,03	1,21	1,59	2,38	4,81	5,85
70	9,29	3,11	1,83	1,26	0,98	0,87	0,91	1,11	1,51	2,41	5,20	6,40
90	9,52	2,95	1,57	1,00	0,73	0	0	0,84	1,26	2,20	5,17	6,45
Geographic latitude 60 ^{0}												
45	7,53	3,23	2,08	1,49	1,26	1,15	1,19	1,36	1,76	2,59	5,03	14,42
60	8,85	4,11	2,18	1,46	1,16	1,04	1,09	1,30	1,80	2,96	13,71	17,29
75	9,57	4,28	2,13	1,38	1,06	1,92	0,97	1,12	1,70	3,01	15,00	18,99
90	9,64	4,16	1,92	1,16	0,85	0,74	0,77	1,01	1,52	2,85	15,26	19,39

The values of P_{dif} and P_r are calculated by following expressions:

$$P_{dif} = \cos^2\frac{\beta}{2}, \tag{7}$$

$$P_r = \sin^2 \frac{\beta}{2} \tag{8}$$

where β is the angle of the surface inclination.
Coefficients f_d, f_{dif} and f_r, in the expression (3) of the calculation of the Sun radiation which passes through the transparent surface for the energy receiving, Figure 2 d (Trombe wall), are equal to 1. In the expression (3), coefficient k_o takes into account the influence of the frame and it is equal to the ratio of the areas of the transparent surface and the surface of the whole window including the frame (k_o = 0.90 – 0.97). The bigger value is for the wooden frames and smaller for the frames made of the metal. The coefficient k_z takes into account the influence of the glass contamination. With the average glass contamination $k_z = 0.9^n$, where n is the number of the glass layers.The coefficient of radiation for the system with direct radiation k_{dz}, is in dependence on the applied shadowing methods. It has been assumed that protective canopy exists. The tangent of the angle is 0.25. The value of the k_{dz} is taken from the appropriate tables. The coefficient of the radiation for the system with diffuse radiation k_{difz} when protective shade exists is:

$$k_{difz} = 0{,}5(1 - R_h + \sqrt{1 + R_h^2}) \tag{9}$$

Reflectance on the Earth surface is r= 0.2 to 0.3.

Determination of the efficiency of the heat transfer

This efficiency shows which part of the solar energy absorbed by the passive element is used for the heating. For the system with Trombe wall the efficiency is:

$$\eta = \eta_{op} + \Delta\eta , \tag{10}$$

Where η_{op} is the efficiency of heat transfer in the absence of a natural circulation of air through the open space behind the glass (the space between glass and absorbing surface) and the room, $\Delta\eta$- increasing the efficiency of heat transfer of solar radiation in the presence of natural circulation, it is possible to use $\Delta\eta$=0.
For the Trombe wall is:

$$\eta_{op} = (R_{pro} + R_{pres}) / (R_{pro} + R_p), \tag{11}$$

where R_{pro} – is the resistance to the heat transfer of the air behind transparent surface and outside air, without influence of the air infiltration:

$$R_o = R_{op} - 0{,}115 + R_{vs} , \tag{12}$$

where R_{op} – is the resistance to the heat transfer of the transparent surface; R_{vs} – is the resistance to the heat transfer of the indoor air layer.
The values of R_{op} and R_{vs} are determine based on the standard (for the window glass R_{op}= 0.37 $m^2 \cdot K/W$, for the indoor air layer R_{vs}= 0.19 $m^2 \cdot K/W$).
The resistance to the heat transfer of the receiver wall is:

$$R_o^p = R_{pres} + R_z^p + 0{,}115 \tag{13}$$

where R_{pres} – is the resistance of the heat transfer from the external side of Trombe wall, R_{pres}=0.5 R_{vs}.
The thermal resistance of the receiver wall is:

$$R_z^p = \sum_i \frac{\delta_i}{\lambda_i} \tag{14}$$

where δ_i – is the thickness of the i- layer, m; λ_i – is thermal conductivity of the material in the i - layer of the wall.
If the $A_{o=1} / \sqrt{H} \rangle 0{,}1 f_o$, the value of the $\Delta\eta$ is:

$$\Delta\eta = f_o \cdot \lfloor 1 - g_{\exp}(-dR) \rfloor , \tag{15}$$

where f_o – depends on the ratio of $A_o / \sqrt{H}$; A_o – is the area of the opening for the air circulation per the unit of width of the wall receiver; H- is the vertical distance between the axes of the inlet and outlet openings.

If the $A_{o=1}/\sqrt{H}\angle 0{,}1 f_o$ the value of the $\Delta\eta$ is determined from the appropriate diagrams.
The values for coefficients *c, d* and *g*, for the different materials of the wall, are determined from the appropriate tables.

The determination of the coefficient of thermal energy saving

The flux of solar radiation that reaches the room is:

$$Q_{pro} = A_{ss} \cdot q_a \cdot \eta \tag{16}$$

where A_{ss} – is the area of the passive heating system in the room, m^2.
The quantity Q_{pro} is determined for the each month of the period of heating.
The total heat loss of the room during sun radiation absence, *MJ*, is:

$$Q_{tg} = 86{,}4 \cdot 10^{-3} \cdot m \cdot \left(\sum_i \frac{A_i}{R_{oi}} + M_{\inf} \right) \cdot \left(t_p - t_o \right), \tag{17}$$

where A_i – is the area of the walls m^2; R_{oi} the heat resistance of the surfaces, $m^2 \cdot K/W$; M_{inf} – is the quantity of the infiltrated air in the room, and it is determined based on the standard; t_p- the calculated temperature in the room ^oC.
for Trombe wall:

$$R_o = R_p + R_o^v. \tag{18}$$

Based on the values of Q_{pro} and Q_{ig} the coefficient of the heating is:

$$k = \frac{Q_{pro}}{Q_{tg}}. \tag{19}$$

The coefficient of heat substitution is determined from the appropriate diagrams for the heat which is used for the heating with the solar radiation:

$$f_z^g = \frac{\sum_{k=1}^{m} f_{zk} \cdot Q_{tgk}}{Q_{tg}^g}, \tag{20}$$

where *k* – is the index for the *k*- month in the period of heating.

$$Q_{tg}^g = \sum_{k=1}^{m} Q_{tgk}. \tag{21}$$

In the selection of materials recommendations should be kept. The dimensions of the wall should be determined in accordance with construction recommendations. The thickness of the wall should be between 0.16 and 0.24 *m.* The thickness of the air layer between glazed and absorption surface should be similar to the thickness of the wall. The openings for air circulation should be placed at the base and at the top of the wall. The area of the opening per 1 *m* of the wall width should be between 0.05 and 1.2 m^2.

CONCLUSION

The development of civilization caused and was conditioned by the very rapid development of the use of energy, especially during the last two centuries. The Industrial Revolution in the late 19th and in the 20th century led to a rapid development of technology, and a sudden increase in energy use. The main goal was reduced to the profit and consumption, which affected the way of life and thinking, which means planning and design.
Large energy savings can be achieved by rational use. Cheap energy oriented manufacturers in the industry to processes based on criteria that are rarely implied rational consumption and energy savings. The utilization level of natural resources, as conventional sources of energy, is entering the phase when it is necessary to be thought about expansion and diversity of energy sources in order to adequately reply to the growing demands for the energy. New renewable energy sources, which are in most various forms of solar energy, through various technologies, offer directions for resolving the

existing dilemma. Solar energy reaches the Earth mostly in the form of electromagnetic radiation, which through various biochemicals, physicochemical and physicals processes provides and supports life on Earth. Solar energy has a daily/seasonal and geographical variability (diffuse character), but the lack has local character. At the global level, the distribution of day/night, summer/winter, and south/north is naturally harmonized and allows solar energy to be at any time insufficient to meet energy needs. The variety of technologies which are available today enables efficient use of solar energy in its various forms. The whole world and each individual nation are faced today with many dilemmas of planning their own future and the possibilities to realize these plans. That clearly pertains to the population growth, the need for food and water, and the progress of civilization in general. From any point of view to analyze the solution of these problems, energy is an important factor. Because of the activities related to energy derives a major threat to environmental protection, resolving the energy problem has become significant from the environmental aspects. From that reason renewable and "clean" energy sources have come to the fore. Expanding practical use of solar energy has contributed to the very fast development of knowledge and technology, together with the prior understanding of physical laws, as well as the steady increase in energy needs, and also the fact that energy resources are finite.

REFERENCE

[1] Topic R. J., Tehnologies and systems for using solar energy, M.Sc., Mechanical Engineering, Belgrade, 2005. (In Srebian)
[2] Labudović B.: The renewable energy sources, Energetika marketing, Zagreb, 2002. (In Croatian).
[3] Topic M. R., Petrović Lj. A., Božović R. M., Ćuprić Lj. N.: The renewable energy sources, drying and sustainable development, Proc. of the Conff., Perspektive agrobiznisa Srbije i evropske integracije, Valjevo, Srebia, May 26, Vol.2., pp. 785 – 798. (In Serbian)
[4] Vladimir Knapp, Petar Kulišić, The new energy sources, Školska kniga, Zagreb, 1985. (In Croatian).
[5] Draganov X.B., Kovaljev A.S., Lazorenko, A.B., Cubanov, A.A., Korotinjenskij A.B., Kursovoe projektirovanjije po teplotehnike i primenjenii teploti v seljskom hozjajstve, „Agropromizdat“, Moskva, 1991.
[6] *** www.solarsam.com
[7] *** www.mysolar.co

SESSION 11: Students papers

GRAPHIC MODELING ASSEMBLY OF INTERNAL COMBUSTION ENGINE PISTON IN 3D WORKING ENVIRONMENT USING AUTOCAD MECHANICAL SOFTWARE

Željko Stojanović[1], Miroslav Đurđev[1], Darjan Jonaš[1]
[1]Technical faculty »Mihajlo Pupin«, Zrenjanin, Serbia
e-mail: zeljkoelemir@gmail.com

Abstract: This paper presents the design apropos graphic modeling of 3D solid model piston of classic internal combustion engine, as the subassembly of one motor car assembly using *AutoCAD Mechanical* software package. Explained the method and a way of modeling the piston head, connecting rod, thread and threaded pair with a given visual view of methodological steps. In this paper author did not presented separately the procedure for entering comands used in composing of components and subassemblies of model which would be utterly trivial and which would require much greater workspace, but are focused on the short, clear and directional manner to explain procedure of modeling presented parts and shows the most important steps of creating model of the piston assembly. According, the paper presents the positioning of objects in space as well as forming profiles at creating individual 3D solid models.
Key words: modeling, AutoCAD, piston head, connection rod, threaded pair

INTRODUCTION

With the development of computer technology have been created many new approaches and solutions for accelerating and automating of design process. [1] Modern design and construction in mechanical engineering, civil engineering, architecture, transportation, electrical engineering and so on, is actually a complex task which is today, largely, supported by methods of computer oriented technologies. [2] Nowadays design and construction is performed exclusively using computer.
Many believe that is the design of mechanism one of the most fascinating topics in the overall mechanical engineering. Appearance of computers and its accessibility to a wide range of users has led to the development of appropriate software which give great opportunities not only in design, but also in the use of machines and mechanisms and possibilities of their adapting to working conditions in order to more efficient and more rational use. Resources and tools of CAD technology has the widest application in the automatization of the design process and emerge as the mechanisms support in process of modeling objects, engineering analysis and documentation.
Under the term of modeling of the assembly means all necessary actions for the creation of its model. [3] Firstly should be modeled all components (parts) assembly and subassembly. After generating the parts are modeled subassemblies apropos are assembled the components in subassembly, and then coming to the conclusion of all subassemblies and other components in assembly. Each assembly can be subassemblies of assembly higher level and so on to the final assembly of the highest level in the tree model. In this paper are assembling the assembly of "internal combustion engine piston". This assemby of internal combustion engine piston is composed of nine components, of which one are repeated (bolted conection). Construction of the piston 3D solid model as well as analysis of design solutions can be effectively modeled using *AutoCAD* software package. Modeling of the piston in *AutoCAD* software package the authors have chosen because of its prevalence in the implementation of engineering projects.
The future of 3D modeling in the field of techniques is in production. Because the aim of this paper is, besides showing the simplicity and speed in working with *AutoCAD Mechanical* software package, and pointing on possibility of increasing product quality and marketing improvement, which is of great importance for the market because in developed countries attaches great importance to a visual perception of the product.

MODELING OF THE PISTON ASSEMBLY

To be modeled any assembly it is necessary to becam familiar with basic principles of the assembling of its constituent components. This includes the application certain steps which are positioned component in assembly. The final status of each components must be completely determined, ie. concluded. [3]

Modeling of the piston head subassembly

Modeling of internal combustion engine piston starts presenting of the piston head height and its radius by profile in the plane (Figure 1) to be later this profile rotated (reversed) by Revolve command around the y-axis. Before applying Revolve command should be applied the Region command from Draw toolbar which of profile with picture 1 obtained a surface in the plane defined by the closed contur, apropos the territory closed in whole. The next step is to application of the Revolve command from Modeling toolbar by which we get the basic model of piston, according to the same Figure. Revolve command was used to construct the unique 3D solid generated by rotating a closed 2D object of piston around the selected rotation axis. After selecting the profile, in order to create a solid, choose two specific points which define the axis of rotation in space. By rotating of piston profile, the volume is pulled under the angle of 360 degress.

Now we approach the formation of cut-out which shapes the bottom part of the piston. By Line command from Draw pallete we given the shape as at Figure 2. After that apply the extrusion command-Extrude from Modeling toolbar which we use on the profile from Figure 2 so that we obtain the third dimension of the object. By Move command from Modify toolbar (with included support Object Snap and Ortho mode) combine the object with a piston as shown on Figure 2. Than it applies Subtract command from Solid Editing toolbar which subtract by object part of the piston. By Subtract command is created a complex body by removing the volume which is common to one or several solids, compared to other solids. [4] First we selecting the bodies from which we want to subtract other solids, and then are selected solids which will be subtracted from the first set of selected solids. Concretely, the first set contains only one object, ie. piston head. The second set is also unique because this is that object who will give shape to the bottom part of the piston. At the end will occur resulting volume of new solid, as a logical volume diference between two solids, as shows bottom Figure 3.

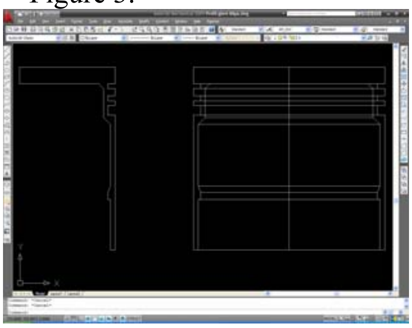


Figure 1. Profile of piston head and look at the created 3D solid model of piston head on the basis of rotation profile

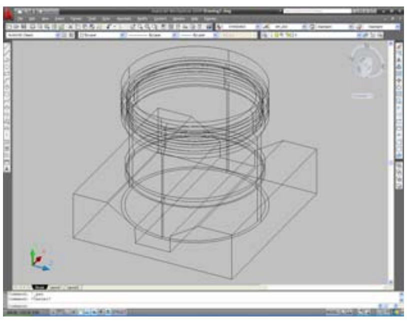


Figure 2. Centering support object and model of piston head

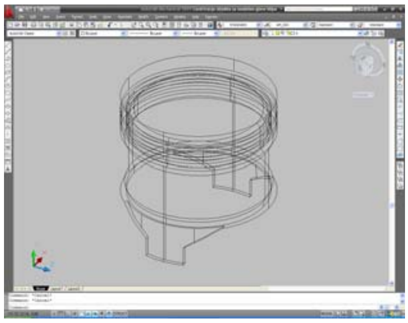


Figure 3. Obtaining a new object of piston head by differences of the two previous object

Over certain edges of piston head is necessary to create a rounded angle by Fillet command from Modify toolbar. By Cylinder command are formed two cylinders, one which has the dimensions as well as piston, and second, dimensions which will correspond to obtained object after the application Intersect command, as shows at Figure 4. The Intersect command from Solid Editing toolbar is the third Boolean command which enable to forming a new complex body which is composed of a common volume of two or more 3D solids who cut. The next step is the positioning and connecting the piston head and object. By Box command (or Line command) is necessary make the object and center it according to piston which will be take a part of the cylinder which was previously connected with piston, using Subtract command. The newly obtained shape of the piston head is shown at Figure 6.

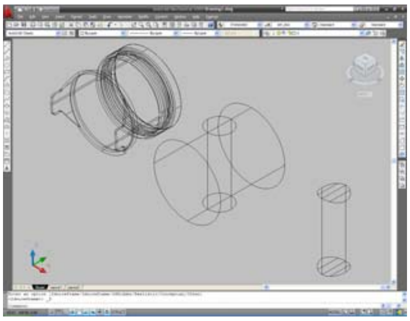


Figure 4. The intersection of two cylinders and obtaining a new core object

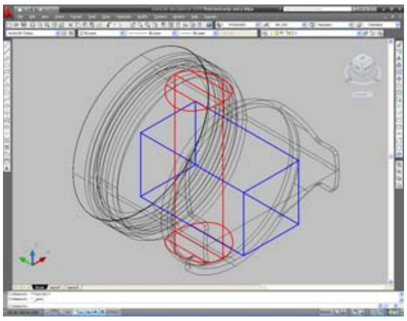


Figure 5. Positioning and connecting the future lugs with piston head

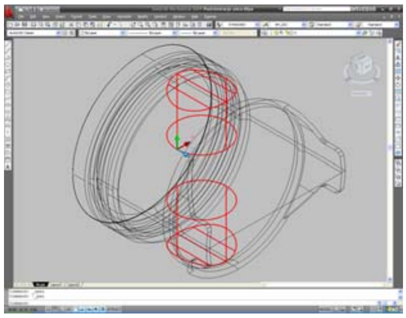


Figure 6. Obtaining new object of piston head by difference of the two previous object

Over certain edges of the piston head will be carried out overthrow the same by Fillet command. Then needed to make a cylinder by Cylinder command and center it according to piston, which will be take away part of the cylinder which was earlier connected with the main object (piston head), using Subtract command in order to obtain opening through which will pass the piston pin (see Figure 7). Before the application of Subtract command should be applied the Union command, as shown at Figure 7. Union is one of the main Boolean commands from Solid Editing toolbar. It creates a new body by logical adding two or more 3D solids. [4] The newly obtained model of the piston head with the created holes for pin is shown at Figure 8.

The next step is moving the User Coordinate System on the top center of piston head with UCS Origin command, and creating two circles of different radius with the Circle command from Draw toolbar, which need connect by Loft command from Modeling toolbar, as shown at Figure 9. The Loft command interpolates surface or 3D solid through a combination of several curves. If the curves are opened AutoCAD creates a surface. If they are closed, creates a 3D solid. After this starts command for rotation objects in 3D space, 3D Rotate from the Modeling toolbar whereby the selected object is rotated for the appropriate angle, as shown at the same pictures. UCS is the most widely used orientation system because it represents current coordinate system whose location changes as needed. UCS defines how the objects in the plane, apropos, the space set.

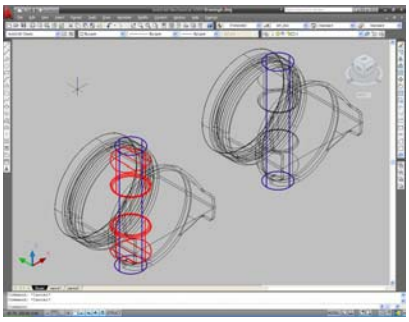


Figure 7. Setup support object and formation of holes on piston head

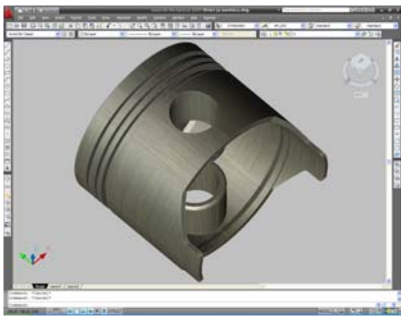


Figure 8. Subassembly of piston head with the created holes for pin and assigned material-brushed aluminium

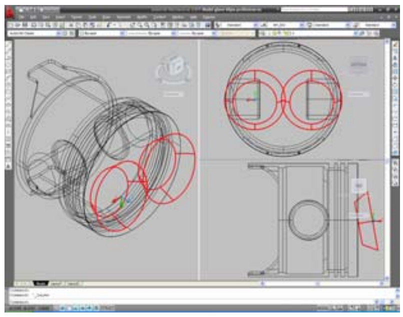


Figure 9. The principle of modeling the piston forehead

Using the previous commands listed earlier in this paper, we obtain the final look of the piston head displayed at Figure 10.

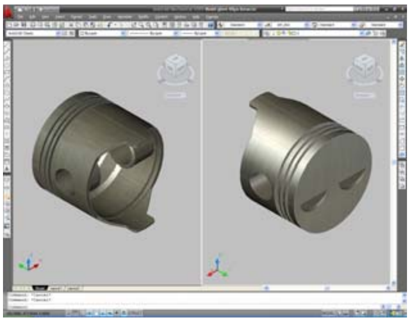


Figure 10. The appearance of the piston head subassembly

Modeling piston rod subassembly

Modeling of piston rod begins the construction of halves which correspond to bearing rod. On these parts is located extensions through which pass bolts for connection halves. Figure 11 shows the profile from which to make model by extrusion. Making this part is based on the Line, Chamfer and Fillet command. Furthermore, it is should be formed region and then extrude the previous profile, as shown at Figure 12. Now create a model of screw holder which is connect with the bottom halve of piston rod. This model (see Figure 13) is needed modified for connecting with the bottom halve, on that way which is one side of the model rotate by using Rotate faces command from Solid Editing toolbar. With this command received the model from Figure 13 which is needed, in the next step, join to the basic model, ie. bottom halve of the big fist of piston rod.

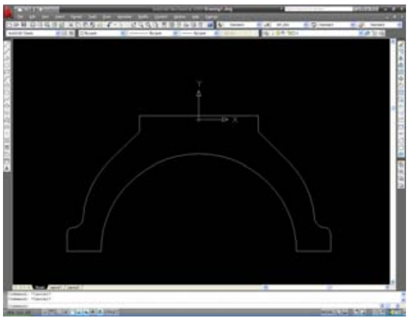


Figure 11. Profile of the bottom halve of the connection rod large fist

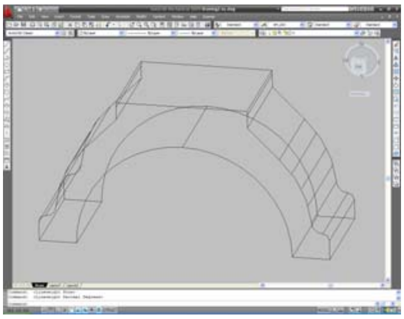


Figure 12. Model of the bottom halve of connection rod large fist obtained by extrusion

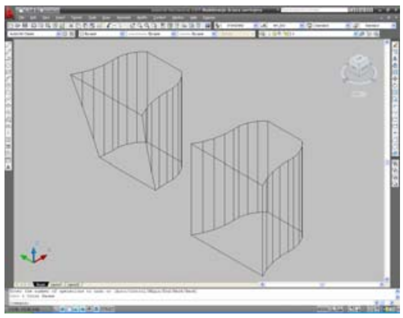


Figure 13. Screw holder

After centering both model as well as copying of bolt carrier by Mirror3d command, access to connecting model by Union command, after which is obtained unique model shown in Figure 14. Now we need to make two holes through which pass bolts. By Cylinder command makes of roller which is centered as shown in Figure 14, and copied with Mirror3d command. At the end is needed to apply the Chamfer command from Modify toolbar which will overthrow edges, after which is obtained the final shape of the model shown at the same Figure. After this follows the modeling upper part of the piston rod halve (cover), which is similar to the bottom part, the defference is that the upper part will be connect with the neck (stem) of piston rod. The bottom part of the piston rod halve will be used for modeling the cover so that the Box command (or Line command) form the objects by which will be subtracted model of the bottom part of piston rod halve (see Figure 15). By this procedures was obtained the final look of the piston rod cover model, which is shown at Figure 16.

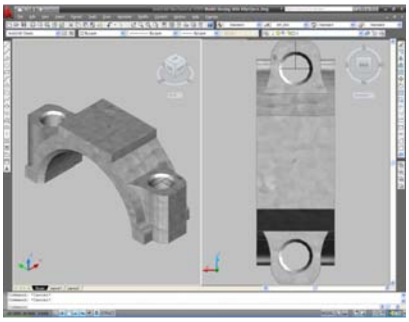


Figure 14. A complete appearance of the bottom halve of connection rod large fist component with assigned material-constructional steel

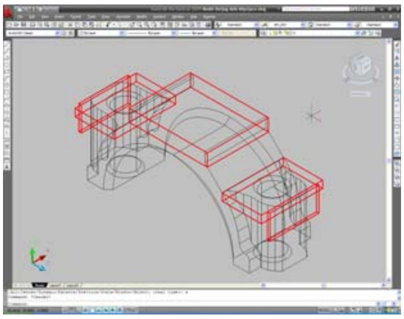


Figure 15. The method of modeling a cover of connection rod large fist

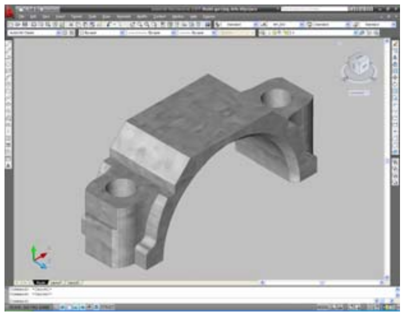


Figure 16. A complete appearance of the above halve (cover) of connection rod large fist component

The next step is creating a neck (stem) of connecting rod by using Region and Extrude commands. By Cylinder command is necessary to form a cylinder by which is cut the upper opening on the connection rod neck as shown at Figure 17. Figure 18 shows the profiles which were used while drawing for the subtraction the main model of connection rod neck as well as for the formation of groove in the connection rod neck. At the end, it is necessary to apply the Chamfer command with the aim overthrow of opening edges small fist of connection rod after which is obtained the final look of the connection rof, show at Figure 19.

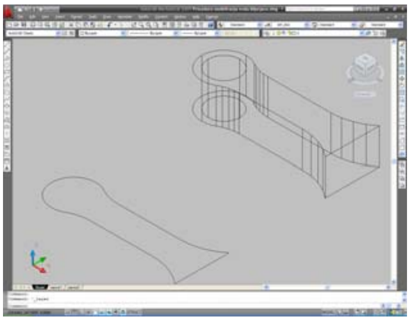


Figure 17. The method of modeling the initial profile and model of connection rod neck

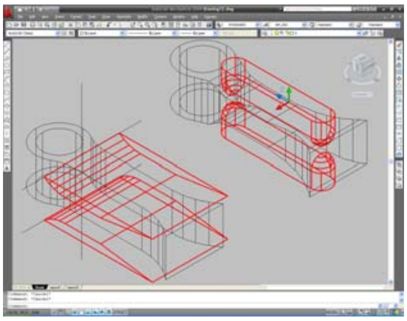


Figure 18. The positioning support models in relation to the connection rod neck

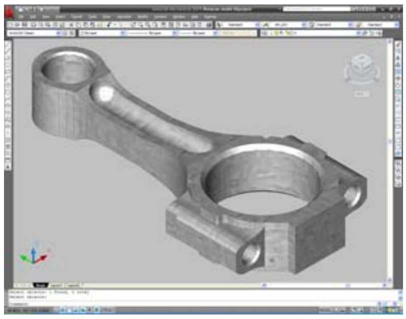


Figure 19. The final appearance of connection rod subassembly

Modeling bolt and nut component

Modeling of hexagonal nut M8 is performed according to standard dimensions (in accordance with ISO standard), by Line command, to construct a profile of nut, or Polygon command. In the first case, the initial profile are two equilateral triangles, of which we get the profile of nut by Trim command. In the second case (Figure 20), the profile of nut is made immediately, without use of additional commands. Profile nut, which is given in the shape of hexagons, is now necessary to extrude after which access to rounding of individual vertex of nut by model which is made from profile at the Figure 20. The same Figure shows the positioning of the model obtained by use Mirror3d command in relation to the basic model of nut, before applying the Subtract command.
On the basic model of nut is necessary to make a hole by Cylinder command, as shown at Figure 21. Spiral can be created by setting the following parameters: the radius of its base and peek, number of coils, their height and direction (in direction or opposite of direction of movement clockwise). The newly created object is a helix (Figure 21). Spiral parameters is possible changed by using grips or through Properties pallete. Explode command from the Modify toolbar converts the helix into Spline curve. [6] Spirale can be used as a path for extrusion profile by Sweep command in AutoCAD, as shown at Figure 22. The resulting model of nut is necessary overthrow the opening edges by Chamfer command.

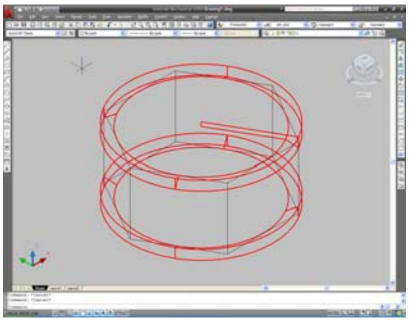


Figure 20. The basic profile and the basic model of nut obtained by extrusion

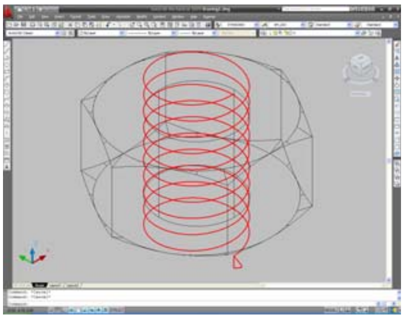


Figure 21. Creating a spiral and profile of metric thread with coarse step

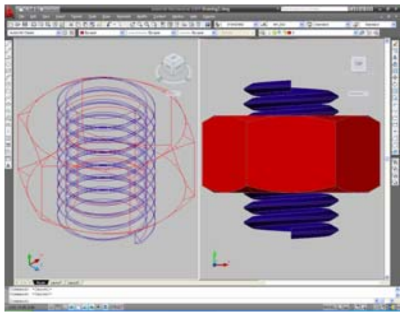


Figure 22. Extrusion of the metric thread profile with coarse step by Sweep command

By applying the above mentioned commands, we get the final look of nut shown at Figure 23, which was, as material assigned stainless steel. The screw standard dimensions (Figure 24) can be formed by using the tools: Extrude, Revolve, Cylinder, Chamfer, Helix and Sweep, or in a way in accordance with the routine of artists (the designer). It is important to pay attention on the position of these components in space when selecting the reference (constructional) plane, because that will facilitate the work when setup the components in the assembly. Pin can be modeled by using the tools Cylinder, Subtract, and overthrow edges by Chamfer command, as shown at Figure 25. Is necessary to create two cylinders, in order to produce a hole in the pin.

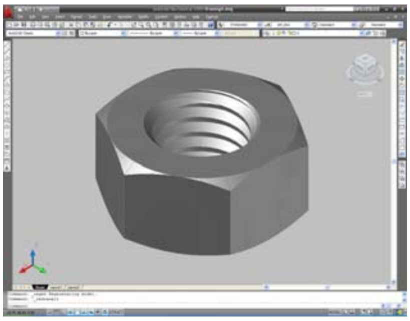


Figure 23. The final appearance of the nut M8 component with assigned material-stainless steel

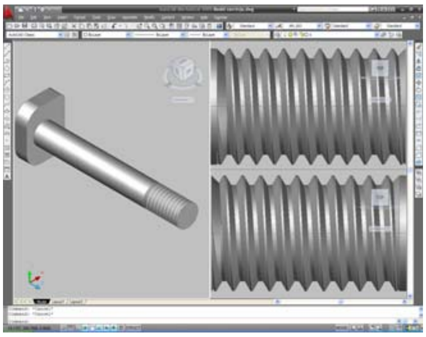


Figure 24. The final appearance of the screw M8 component

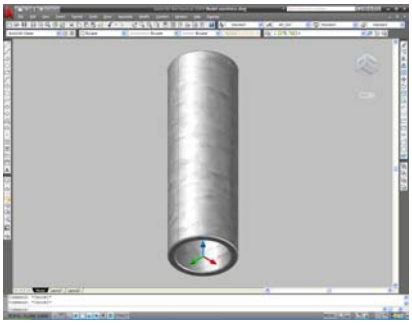


Figure 25. Look on the final appearance of piston pin component

The main task in creating assembly is the perfect assembling of its components. That means that the components in assembly have such relationship which does not lead to mutual deviations, apropos, deviations of their entity (subassemblies and components), for example, alignment of shaft and sleeves, holes, gaps, coincidence of surfaces, planes, edges etc [3]. Figure 26 shows switching model of internal combustion engine piston.

In AutoCAD exist several parameters which determine display of component or assembly in shaded mode, as well as while creating of rendered images. Color is the most important parameter of their view. Beside color, defines the structure, transparency, reflections, shadows etc. The display can be defined for the whole object or just for certain areas. Rendering in AutoCAD allows to create a visual effects, use characteristics such as fog, scene, photorealism, setting the light rays, beckground color, setting shadows, reflectivity and transparency of the material. The following Figure 27 is presented the rendered model of the piston assembly with the effect of shadows on the basis placed parameters and with set the scene. As basis of the scene was set the stone Onyx.

The following Figure 28 is presented the rendered piston assembly with mirror effect on the surface which improves the overall impresion which image leaves. Was used a six light source of Point light type. Shadows option is turned off on the window for rendering. The reflection (mirror color effect) is turned on at the dialog box for manipulatting of materials. These two pictures are just examples because there are many possibilities, by changing colors, materials, lights, imaging angles, by changing the background and effects.

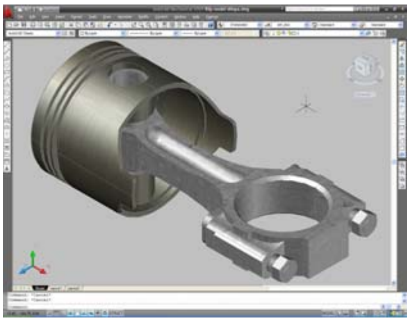


Figure 26. The final model of internal combustion engine piston assembly

Figure 27. The final model of piston assembly with set the scene and the shadow effect

Figure 28. The final model of piston assembly with set the scene and the mirror effect

CONCLUSIONS

One of the aims of this paper was to demonstrate the simplicity and speed in working with *AutoCAD Mechanical* software package. On the basis of above mentioned, the authors have succeeded to show that the modeling of high quality piston model, which is shown in this paper, can be successfully performed in *AutoCAD Mechanical* program, using relatively small number of comands. In developed countries, east and west, great importance is attached to the visual perception of future product. Designers are trying and tend to their work appear more realistic, and drawings on paper exchange with multimedia presentations of their product. In this paper are explained rendering of 3D model and photorealistic images are shown. Rendering has enabled to present an imaginary product, before it is physically produced, whereby significantly influence on marketing of product.

REFERENCES

[1] Gligorić, R., Desnica, E., Letić, D., CA technology and machine mechanism design-some aspects of education, Chronicle of scientific papers, 1, p. 40-48, 2004.
[2] Letić, D., Desnica, E., Some aspects of computer oriented education of constructor engineers, Tractors and power machines, p. 120-125, 2004.
[3] Nestorović, G., Adamović, Ž., Modeling assembly in Pro/ENGINEER Wildfire 5.0 (Creo Elements/Pro 5.0), Technical school with students house „Nikola Tesla“ in Kostolac, Kostolac, 2011.
[4] Letić, D., Anđić, Ž., Srdanov, Đ., Graphical comunications in engineering design, University in Novi Sad, Technical faculty „M. Pupin“ in Zrenjanin, Zrenjanin, 2002.
[5] http://www.scribd.com/doc/52872278/AutoCAD-2007 (downloaded april 2012)
[6] http://www.teamcad.rs/index.php?option=com_content&view=article&id=276:helix-kreiranje-spiralnih-objekata-u-autocad-u-2007-&catid=15:autocad-3d&Itemid=89 (downloaded mart 2012)

THE IMPORTANCE OF BRANDS IN THE INDUSTRY

Suzana Gardinovački
[1]University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
e-mail: suzy14788@gmail.com

Abstract: This work represents a review of Coca-Cola brand. Coca-Cola's marketing strategies are very effective and are going to continue to increase its market share. Coca-Cola is one of the world's most popular and best-known brends. Thus, Coca-Cola management strategy is directed towards the continued success of its product. Its strategy is focused on creating new brands and finding ways to deliver those brands to people all over the world.
Key words: Coca-Cola, management, advertising, competition

INTRODUCTION

Coca-Cola is the most popular and biggest-selling soft drink, as well as the best-known product in the world. It was created in Atlanta, Georgia by Dr. John S. Pemberton who mixed Coca-Cola syrup with carbonated water, Coca-Cola was introduced in 1886, patented in 1887, registered as a trademark in 1893 since when it began to be sold in every state in the United States as delicious and refreshing - a theme that continuous to echo today wherever Coca-Cola is enjoyed. Thinking that the two Cs would look well in advertising Dr. Pemberton's partner and bookkeeper, Frank M. Robinson, suggested the name and penned the now famous trademark Coca-Cola in his unique script. In 1899, The Coca-Cola Company began franchised bottling operations in the United States (fig. 1).

Figure 1. Logo of the Coca-Cola company

Coca-Cola was sold in bottles for the first time on March 12, 1894. Cans of Coke first appeared in 1955. The equally famous Coca-Cola bottle, called the contour bottle within the company, but know to some as the hobble skirt bottle, was created in 1915 by bottle designer, Earl R Dean. In 1915, the Coca-Cola Company launched a competition among its bottle suppliers to create a new bottle for the beverage that would distinguish it from other beverage bottles ... a bottle which a person could recognize even if they felt it in the dark and so shaped that, even if broken, a person could tell at a glance what it was. Chapman Root approved the prototype bottle and a design patent was issued on the bottle in November, 1915. The bottle was chosen over other entries at the bottler's convention in 1916 and was on the market the same year. By 1920, Dean's contoured bottle became the standard for the Coca-Cola Company. Today, the contour Coca-Cola bottle is one of the most recognized packages on the planet.

Coca-Cola might owe its origins to the United States, but its popularity has made it truly universal. Thus, you can find Coca-Cola in virtually every part of the world. Today, the Coca-Cola Company is the world's leading manufacturer, marketer, and distributor of nonalcoholic beverage concentrates and syrups. Its world headquarters is based in Atlanta, Georgia. The company and its subsidiaries employ nearly 31,000 people around the world. The Coca-Cola Company manufactures syrups, concentrates and beverage bases for Coca-Cola, the company's flagship brand, and also produces over 230 other soft-drink brands sold by and its subsidiaries in nearly 200 countries around the world (fig. 2).

Figure 2. Coca – Cola products

MANAGEMENT IN COCA COLA

Coca-Cola is one of the world's most popular and best-known brends. Thus, Coca-Cola management strategy is directed towards the continued success of its product. Its strategy is focused on creating new brands and finding ways to deliver those brands to people all over the world. Today, Coca-Cola operates in more than 200 countries around the world in order to fulfill one of its main goals - to make its products available to all people in all countries. The company has grown due to its ability to build and develop relationships with consumers but also with suppliers, government agencies, communities, employees and share owners. Among other things, this enables the company to ensure a healthy and permanent marketplace.

Generally, Coca-Cola management is guided by six strategic principles:

- accelerate carbonated soft-drink growth, led by Coca-Cola
- selectively broaden the family of beverage brands to drive profitable growth
- grow system profitability and capability together with our bottling partners
- serve customers with creativity and consistency to generate growth across all channels
- direct investment to highest-potential areas across markets
- drive efficiency and cost-effectiveness everywhere.

Ethical management is an important strategic priority of Cola-Cola as well as the development of thought diversity. This mainly refers to the presence of Coca-Cola in the countries all over the world reflecting the countries and cultures in which it does its business. The company's tendency is to be present in as many countries as possible and to respect the diversity in the company. The belief of the company is: the more diverse our thinking, the more opportunity for innovation. Thus, Coca-Cola is organized into five geographic operating segments which are also called strategic business units: North America, Africa, Asia, Europe, Eurasia and Middle East and Latin America. The company tries to develop the knowledge of all the cultures where it is present and to use it for the marketing purposes and other activities.

The strength of the company does not lie only in the diversity concerning its employees and marketplace but also in the diversity of its products. Globally, Coca-Cola owns or licenses nearly 400 brands in the nonalcoholic beverage business including carbonated soft drinks, juices, sports drinks, water products, teas and coffee. Actually, Coca-Cola always focuses on the changing needs of its consumers according to which the company creates new products. Thus, in the 21st century when the tendency toward healthy life style has become more prominent, Coca-Cola launched a Diet Coke and another diet product, Coca-Cola Zero. Recently, Coca-Cola has begun to sell a new "healthy soda" Diet Coke with vitamins B6, B 12 and Magnesium, Niacin, and Zinc, marketed as "Diet Coke Plus".

At the Coca-Cola company, long-lasting success means operating responsibly and creating enduring economic value that is important to the company's business and its share holders, too. The management of the company tends to use the financial resources wisely, with focus and care responding to the stakeholders concerns. In order to operate as effectively as it is possible, besides the division into geographical units, the company is also divided into several segments according to their functions. Actually, there are nine different functions and segments: Corporate External Affairs, Customer Management, Finance, Human Resources, Innovation/Research and Development, Legal, Marketing, Quality and Worldwide Public Affairs and Communications. There is also the Executive Committee which is responsible for setting policy and strategic direction for the company. The Executive Committee consists of twelve company officers.

Investment into the development of human resources is what ensures a long lasting success. Thus, last year the company spent more than 90,000 hours organizing a variety of training programs for all employees. The company organizes systemic, technical and leadership trainings. The latest company's project is an academy for business developers which is present in our country, too. Every student of the academy receives forty-hour-training in classrooms and eight-hour-training in the field. Thus, this academy offers one f the most intensive training programs for employees.

Since the Coca-Cola company has its subsidiaries all over the world, there has to be good communication among the employees in different countries. This is achieved though the use of computer technology. Namely, every employee can contact any of their colleagues all over the world by typing his or her name into the program. Thus, if an employee has a problem, he/she can get a piece of advice from colleagues all over the world. In that way the international knowledge of the company is shared among the employees. Through this kind of experience exchange, the employees constantly work on their professional development.

In the countries which do not belong to the English-speaking ones, the employees attend Business English courses. When they complete the course, the employees take a final exam in order to get Business English Certificate Cambridge. At the same time, the employees develop their managing, organizing and negotiating skills as well as their knowledge of the work in other sectors so that they have an overall picture of functioning of the entire system.

The system of functioning in the Coca-Cola company is rather complex so that the employees have to understand its main idea but also to develop their knowledge. Every employee has an opportunity to acquire the knowledge of the function of all the departments regardless of their ultimate roles in the system. This also ensures better cooperation among the employees which is the key factor in achieving a long-lasting success.

ADVERTISING IN COCA-COLA

One of the first Coca-Cola advertisements appeared in 1890s. Since then, Coca-Cola's advertising has had a significant impact on American culture. Coca-Cola's advertisements are famous for their presentation of a modem image of Santa Claus as an old man in red and white clothes. This image was first promoted in 1930s in winter advertising campaigns. Since its first advertisement, Coca-Coal has used different images and spokespersons in its advertising. For example, in 1895, an advertisement with a young actress Hilda Clark appeared. Then, in the 1970s, a song from a Coca-Cola commercial called "I'd Like to Teach the World to Sing", produced by Billy Davis, became a popular hit single. Many of these early television commercials for Coca-Cola featured movie stars, sports heroes, and popular singers of the day. Selena, a famous singer, was a spokesperson for Coca-Cola from 1989 till the time of her death. She filmed three commercials for the company. In 1994 to commemorate her 5 years with the company, Coca-Cola issued special Selena coke bottles.

Coca-Cola has gone through a number of different advertising slogans in its long history, including "The pause that refreshes", "I'd like to buy the world a Coke", and "Coke is it".

The company has been using different means of advertising and not only the usual ones such as the advertisements on the billboards and TV commercials. Thus, in 2006, Coca-Cola started a campaign called My Coke Rewards in which customers get virtual points by entering codes from special marked packages of Coca-Cola products into a website. Depending on the number of points, they can be potentia1 winners of different prizes. Thus, Coke drinkers are able to receive a prepaid mobile phone displaying the Coke logo, a hand's free set, a battery charger, and a 10 call voucher, etc. The company tries hard in order to increase the numbers of consumers making its products suitable to their needs. For example, the 20~ounce cups will be available in clear or green plastic with a spill resistant lid. Coca-Cola holds 65% of the fountain soda market and is coming up with innovative ways to capture a larger share, such as, a fountain machine that plays music as it pours.

Also, Coca-Cola presents its products through sponsorship of sporting events. Coca-Cola was the first sponsor of the Olympic games in 1928 in Amsterdam and has been an Olympics sponsor ever since. Since 1978 Coca-Cola has sponsored each FIFA World Cup and other competitions organized by FIFA. Among other ways of advertising, Coca-Cola has used mass media, too. Coca-Cola has been featured in many films and television programs. It was a major plot element in films such as One, Two, Three, The Coca-Cola Kid, and The Gods Must Be Crazy.

The importance of advertising is best shown by the 'advertising war' between Pepsi and Coca-Cola. In 1980's, Pepsi-Cola ran a series of television advertisements showing people participating in taste tests which showed that: "Fifty percent of the participants who said they preferred Coke actually chose the Pepsi". Statisticians pointed out the problematic nature of a 50/50 result because it meant that in blind tests, most people simply cannot tell the difference between Pepsi and Coke. Coca-Cola ran ads to fight Pepsi's ads. One of Coke's ads compared the so-called Pepsi challenge to two chimpanzees deciding which tennis ball was furrier. This advertisement helped Coca-Cola to regain its leadership in the market.

Advertising seems to be the key factor in increasing the sales of Coca-Cola's products. This is proved by the large amounts of money that Coca-Cola spends on its advertising campaigns. For example, in 2006, the estimated amount of money that Coca-Cola spent during that year on its advertising campaigns is $1.9bn which marked Coca-Cola as the 12th advertiser in the world.

Coca-Cola has a policy of avoiding using children younger than the age of 12 in its advertising. This decision was made since it was claimed that Coke's caffeine is dangerous for children. However, the company's target audience are children and young people.

Due to its successful advertising campaigns, Coca-Cola is the second most frequently used word in the world (OK is the first on the list of most frequently used words). Coca-Cola's carefully chosen marketing team gives its best to maintain Coca-Cola's position of the market leader. The team works hard to create original campaigns. Creativity and surprise is what customers expect from Coca-Cola.

COMPETITION AND MARKET STRUCTURE IN COCA-COLA

The Coca-Cola Company is the world's leading producer and distributor of nonalcoholic drinks. Its main brand is Coca-Cola but there are over 230 other soft-drink brands sold around the world. Coca-Cola's main competitor is Pepsi-Cola which is the world's second most famous multi-billion dollar brand. The war between Pepsi and its rival Coke lasts for years. In 1950 Coke outsold Pepsi by 500 percent worldwide. But Pepsi’s aggressive advertising campaigns aimed at young consumers and major bottling and marketing deals made Pepsi a close rival to Coke by the 1980s. PepsiCo has also enjoyed great success with its canned and bottled Lipton brand iced teas, earning higher sales than the Coca-Cola Company's Nestea products. Also, in the United States, Pepsi had virtually an even market share with Coke in the mid-l 980s, when the Coca-Cola Company changed the formula for Coke. In an attempt to regain market dominance, the company attempted the first revision of the original Coke recipe. The American public rejected New Coke, and so the company quickly returned to also producing the old recipe under the name Coca-Cola Classic. However, as Coke regained popularity worldwide in the late 1980s and into the 1990s, it again became the globa1 soft-drink leader. In 1996 Pepsi-Cola International, PepsiCo's international beverage production and marketing division, suffered difficulties in Latin America, one of its most important markets. The company was particularly hurt by the loss of a bottling plant to the Coca-Cola Company in Venezuela.

This rivalry has been extended into other product areas as well. Parent PepsiCo is currently the leader outside the cola market, with a range of soft drinks that generally outsells its rivals from The Coca-Cola Company. However, Pepsi-Cola stays in the second place, but only to the rival cola. In all other respects this is still a global giant, with worldwide sales of around $15bn.

Around the world, there are other local brand that compete with Coke. In South and Central America, Kola Real , on the French island of Corsica, Corsica Cola, in Peru, Inca Kola outsells Coca-Cola, and many others.

Taking into account the existence of a large number of companies producing soft-drinks, especially different drinks similar to Coca-Cola, it can be concluded that the structure of the market of soft-drinks involves perfect competition since there are many firms producing a homogeneous product. However, monopolistic competition is also present because all the competitors have only a small proportion of the market share in comparison to the market leaders Coca-Cola and Pepsi-Cola.

BUSINESS ETHICS IN COCA-COLA

The Coca-Cola Company has been criticized for its business practices mainly related to the bad health effects of its products whose formulas contain stimulants in small amounts - cocaine and caffeine. However, to this day the company has change the formulas for its products so that it uses as an in cocaine-free coca leaf extract prepared at a Stepan Company plant in Maywood, New Jersey respecting the ethics of production. Several lawsuits have been filed against Coca-Cola based on the harmful effects that its product have but all of them have been dismissed by American courts because researchers have found these criticisms baseless.
The Coca-Cola Company continues to broaden the range of low- and no-calorie alternatives that it provides to help people manage their caloric intake. And it offers an increasing variety of package sizes to allow consumers to manage their consumption. Also, there are drinks with added vitamins, such as vitamin D because the company's scientific team conducted research confirming low vitamin D intakes among several U.S. population groups.
The core of the ethics program at the Coca-Cola Company is its Code of Business Conduct. The Code guides our business conduct, requiring honesty and integrity in all matters. All of our associates and directors are required to read and understand the Code and follow it in the workplace. The Code is administered by our Ethics & Compliance Committee. It supervises all ethics and compliance programs and determines Code violations and discipline. They regularly monitor the company's business activities to ensure compliance with the Code and the law. In 2008, the company revised the Code to improve its effectiveness. The employees worldwide receive a variety of ethics and compliance training courses organized by the Ethics & Compliance Office. The employees were trained on the Code of Business Conduct, European Union competition law, Latin American competition law, financial integrity, and, drug-free workplace and preventing workplace violence. Our employees, bottling partners, suppliers, customers and consumers can ask questions about our Code and other ethics and compliance issues, or report potential violations, through Ethics Line, a global Web and telephone information and reporting service available 24 hours a day, seven days a week.
The Coca-Cola Company is focused on ethics of production which also includes ethical relations between companies and the environment. Thus, e company as ma e an investment of more than $60 million to build the world's largest plastic bottle-to-bottle recycling plant and to support recycling in the U.S. It runs recycling projects that recover packaging and integrate it back into the production system. The Coca-Cola Company designs packages that can be used after the beverages they contain are consumed. To ensure that this value is realized in the marketplace, the Coca-Cola system provides financial assistance and other support for recovery and collection systems around the world. Also, for the company's cold drink equipment, an innovative energy management system that delivers energy savings of up to 35% has been developed.
Coca-Cola aims at returning to communities and nature an amount of water that it uses in its beverages and their production. This means reducing the amount of water used to produce the drinks, recycling water used for production processes so it can be returned safely to the environment, and providing new water supplies in communities and nature through locally relevant projects.
The ethics of the human resource management is fully respected by The Coca-Cola Company . One of the main company's projects in this field is the elimination of child labor. Each year, the company buys tens of thousands of hand stitched promotional soccer balls. The risk of child labor in soccer ball production is high. Children working at home are often employed to hand stitch soccer ball panels together, creating an invisible workforce that is sometimes not paid for its work. In order to solve this problem, the company created a Soccer Ball Pre-Certification System which includes checking and pre-certifying compliant suppliers. This system directs the company's teams to only buy soccer balls from pre-certified suppliers.
In conclusion, it can be said that The Coca-Cola Company aims to lead by example and to learn from experience. It sets high standards for its people at all levels and tries to consistently meet them. The company is guided by its established standards of corporate governance and ethics. Corporate responsibility is managed through the Public Policy and Corporate Reputation Council, a cross-functional group of senior managers from the company and bottling partners. The Council identifies risks and opportunities faced by our business and communities and recommends strategies to address these challenges.

CONCLUSION

In conclusion, The Coca-Cola Company has its own vision and mission that is clearly stated ensuring that all the company's subsidiaries are working towards the same goals. Its mission is to make the consumer feel optimistic, to refresh their mind and spirit through its products and actions and to make a difference wherever its drinks are consumed. However, the company's main task is to provide high quality brands that satisfy the consumers' wishes and needs. The second most important task is to create a winning network of suppliers and consumers.

Employees play an important role in ensuring a long-term success of the company. That is why the company gives its best to be a great place to work so that the people are inspired to be the best they can be. The work place should be a place of exploration, creativity, professional growth and interpersonal relationships.

"Innovation is at the heart of everything we do!" This is one of the company's slogans which prove that introducing innovations in every aspect of its activities is the only way to meet the consumers' changing needs. Firstly, the company has introduced innovations in its products. Recently, the consumers have been able to buy a new drink Jianchi, inspired by the ancient principles of traditional Chinese wisdom. Secondly, The Coca-Cola Company has invested a large amount of money to build the largest plastic-bottle-to-bottle recycling plant. In the marketing field, the company has launched Bum Alter Ego application which enables users of facebook to create virtual identities, contact old friends and make new virtual friendships. Bum is Coca-Cola's energy drink brand.

However, innovation also brings certain risks. It might not work well. Fortunately, many of the company's innovations have brought business success. There were also some that have not been successful but the employees have learnt from these and used that knowledge to do things better next time. Those experiences and the lessons learnt have helped the company to move toward soft-drink leadership in the world's market. There are many innovations that remain to be seen in the future.

REFERENCES

[1] www.oppapers.com/topics/coca-cola-competition.html
[2] www.thecocacolacompany.com/investors/annualandotherreports/2005/management.html
[3] www.independent.ie/breaking-news/national-news/cocacola-management-to-meet-staff-at-drogheda-plant-1068361.html
[4] www.oppapers.com/topics/market-structure-pricing-coca-cola.pdf
[5] www.coca-cola.co.nz/default,712,competition_terms_conditions.sm
[6] www.coca-cola.com/management.pdf
[7] www.thecoca-colacompany.com/presscenter/av_advertising.html
[8] www.thecoca-colacompany.com/management.html
[9] www.wordpress.com/tag/coca-cola-advertising-historyasp
[10] www.thecoca-colacompany.com/citizenship/governance_ethics.html
[11] Desnica, E., Nikolić, M,Industrijski dizajn, Tehnički fakultet „Mihajlo Pupin", Zrenjanin 2012.
[12] Đorđević, D., Ćoćkalo, D., Osnove marketinga, Univerzitet u Novom Sadu, Tehnički fakultet "Mihajlo Pupin" Zrenjanin, 2010.

DEVELOPMENT, DESIGN AND WORK PRINCIPLE OF PACKAGING MACHINE

Neda Smiljčić, Vladimir Fajka
[1]University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
e-mail: smiljcic@gmail.com, vladimirfajka@hotmail.com

Abstract: This paper describes how, throughout history developed machine for the manufacture of corrugated paper and how it looks today. Design and development of the industry machine for corrugated paper gets a new look and packaging corrugated paper are used increasingly in almost all branches of industry.
Key words: design, corrugated paper, packaging machine

INTRODUCTION

World industrial revolution began in second half of 18th century, when hand production started to be replaced with steam machines. Then in the late 19th century came Tesla's historic discovery of alternate electric current that led to replaced steam machines with machines propelled with electric current.

When first factory started with production of carton paper, more products were in market offer that require for adequate packaging. We can hear often that packaging sells the products it means that product who easier "catches the eye" will easier find its way to buyer.

HISTORY OF THE MACHINES

History of corrugated board, most famous packaging today, started in mid 19th century when two Englishmen Edward G. Healyho and Edward E. Allen made first hand powered corrugating machine, that was build from two interconnected, toothed rolls, so when they released flat paper board trought rolls they got perfect corrugated paper board.

Figure 1. Hand propeled packaging machine

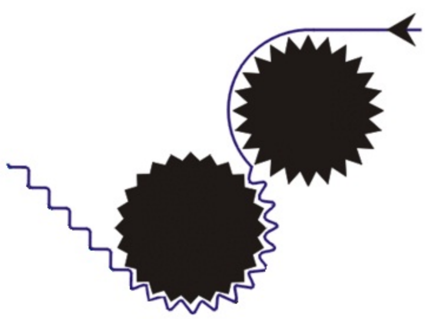


Figure 1a. Toothed rollers

Very quickly demand and production of this exceptional invention started to raise, for result had big development of this “for the eye” simple machine, from Hand-powered machine to production lines with length up to 250m.
In 1882. American company “Thompson and Norris Company” has constructed and built the first mechanically driven production line for making single-facer one-line paper.

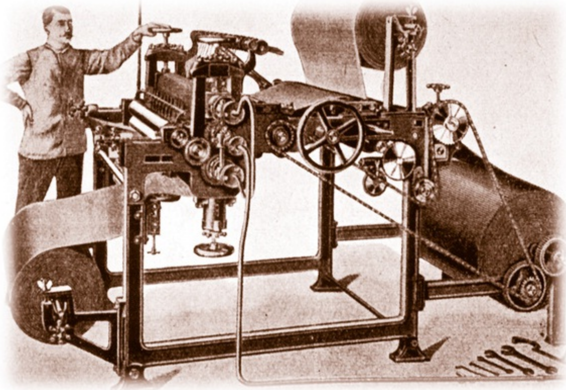


Figure 2. Machine for macking single-facer one-line paper

Next important step in cardboard production was in 1916. in “Sefton Kokoma” (Indiana) company. They added on one-line cardboard on double-faced cardboard, which for the result had two layers of corrugated paper and three layers of flat paper.

MACHINE DEVELOPMENT

Through 20th century cardboard production packiging was used in almost every part of industry, machines were developed more and more so that they could follow the great demand and machines grew to the productions lines in length up to 250m, depending of the thicknes cardboard which production line can produce.

Figure 3. Production line

System that is responsible for unwinding of paper roll contains two carrier rolls. The purpose of the secondary carrier is for wait with a full roll of paper to supply primary roll.
To keep production continously, with as few interruptions and delays, above carrier roll is a system for connecting consumed with the new paper roll. System is known as the "Splicer".

Figure 4. Splicer

After the carrier combiner and roll paper, the module comes a machine that play a major part in the production of corrugated cardboard works. This segment of the machine is known as the "Single-Facer".

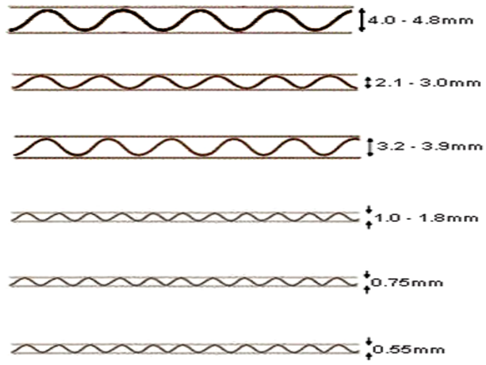
Figure 5. Single-Facer

Single-Facer basically compiles the already mentioned "one-line" or single line card, ie. in a corrugated layer glued to a flat layer of paper. The entire length of the production line of Single Facer-module determines how many ply cardboard is a machine able to produce. Today we meet with cartons up to 7 layers of paper, of which there are three layers of corrugated paper and four layers are flat paper.
Also very important and indispensable factor "Single-Facer" module is the ability to select multiple models toothed rollers, which determines the size of the waves, and thus the very strength of cardboard that dictates the market demand.
Wrapper has a very wide application today, so it can be found almost everywhere:
- Cardboard boxes for cakes
- Cardboard boxes for packing clothes
- Cardboard boxes for packing bottles, house, dishes
- A dedicated boxes for food
- Pack heavier items, machinery parts in industries

So we can conclude from the enclosed card determines the strength of the final product and its weight and volume as the most important factors.

In the production of cardboard used many types toothed rollers today, but few of them considered to be the standard, as follows

- A - wave height 4.0 - 4.8 mm
- B - wave height 2.1 - 3.0 mm
- C - wave height 3.2 - 3.9 mm
- E - wave height 1.0 - 1.8 mm
- F - wave height 0.75 mm
- G - 0.5 mm wave height



In "Single-Facer" merge module papers with two different rolls, with the condition that one of the paper passes through rollers that are toothed steam heated to 180 ° C. Immediately after the onset of corrugated paper layer in such a starch-based adhesive is applied and then connects with a flat layer of paper which is slightly suppressed with the help of the thrust belt.
The obtained single line card is stored in a so-called accumulator bridge waiting for further conversion, or can be directly used if there is no need for additional padding.

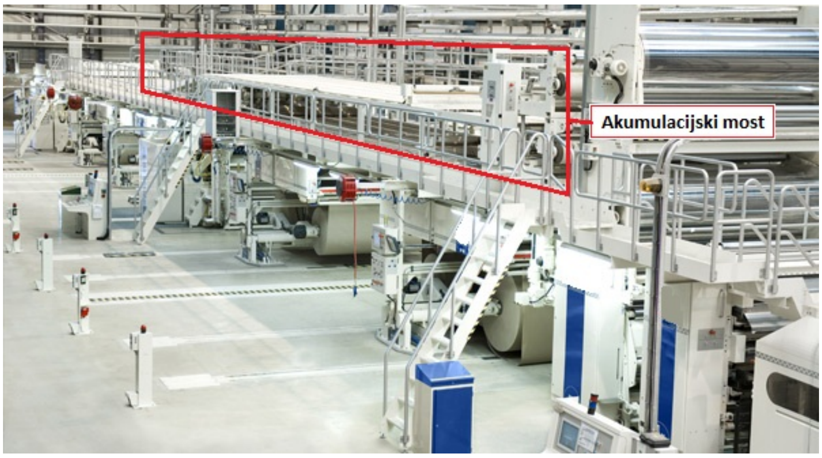


Figure 6. Store bridge

Accumulation bridge can be up to three floors, each floor is accumulated single line card, transported under so preheater, and then as needed in the dry section connects the whole of three, five or seven layers.
The purpose of the system is preheating optimum temperature process heat in this system of rollers around which passes single line card is made with steam. The result is a perfectly fitting of cardboard and therefore the optimal plane of the end product, without the possible occurrence of so-called "air balloon".
When all the layers are adequately prepared to enter the module for applying the adhesive, as last important module before the creation of the end product cartons.

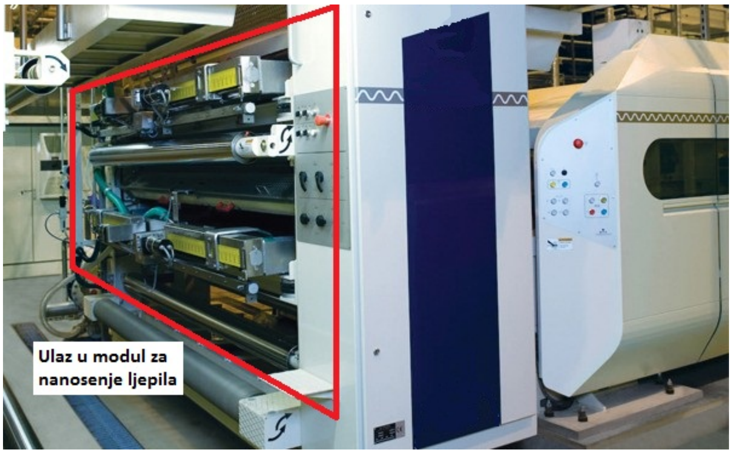


Figure 7. Modul for spreading glue

Thus prepared layers mono line card is entering the final phase of development, that dry section.

Figure 8. Dry sections

Dry sections successfully, with the help of steam as the heat source, and connects the starchy adhesive dries of obtaining the finished product, or file for further processing.
Modules following a arid sections are intended first longitudinal, transverse and then cutting out cardboard produced.
Figure 9 shows us the module in charge of the machine longitudinal Shear paper, and for making so-called. Depressions in the carton, which are essential for later development of packaging.

Figure 9. Modul longitudinal cutting machine for paper

Module for longitudinal cutting so we Leaves infinitely long board, which is then cut transverse blade thus obtaining the finished plate of small dimensions and transport ready for further processing.

Figure 10. Transverse knife for cutting cardboard

Finished board is transported via conveyor belt and supplied to the palletizer and then transported to storage or directly to sales.

Figure 11. Conveyors

CONCLUSION

Such modern line is able to produce cardboard up to 400 meters per minute, thanks to advanced technology and sophisticated equipment available to us in the market.
The whole production process is controlled via the control panel equipped with touch screens, cameras to monitor the process, with the support of modern programming done exclusively for this product line, which enables rapid and uninterrupted production and continuous monitoring of all modules in the machine any production periods.

REFERENCE

[1] http://www.wellpappe.at
[2] http://www.bhs-world.com
[3] http://young-package.com
[4] http://www.wellpappe-wissen.de
[5] http://www.fefco.org/corrugated-packaging
[6] http://young-package.com/about-the-material/corrugated-board/a153
[7] http://behkarbord.com/history.htm
[8] The History of Corrugated Fiberboard Shipping Containers, Diana Twede, Michigan State University, East Lansing MI, USA
[9] Desnica, E., Nikolić, M,Industrijski dizajn, Tehnički fakultet „Mihajlo Pupin", Zrenjanin 2012.

EFFICIENCY ANALYSIS OF FURNACES AND DRYER IN THE INDUSTRY OF BRICK PRODUCTS

Mladjana Asimi
University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
e-mail: masimi25@gmail.com

Abstract: The paper gives the analysis of efficiency furnace and dryer in the industry of brick products. In order to increase energy efficiency, an analysis of efficiency furnaces and dryers in the IGM "NEIMAR" in Zrenjanin. Using modern scientific achievements can achieve a higher level of efficiency, and therefore greater energy efficiency as the goal of sustainable development in the future industries.
Key words: Tunnel oven, drying chamber, combustion efficiency, energy efficiency…

INTRODUCTION

The tunnel oven and dryer are the largest consumer of energy, in the clay products industry. Dryer can be a tunnel or chamber. The flow of materials is from dryer to the furnace, and the flow of energy is from furnace to dryer, as shown in Fig. 1. The raw clay products first go to dry, and then to bake, while warm air is first pre-roasted dried products, and as a waste air flows into the dryer where it is re-used for drying the following products ...

MATERIAL AND METODS

Analysis of the tunnel kiln

General characteristics

Dry products are transported from the dryer to the unloading automation, by transportation companies, where they are being unloaded from the wagon to the conveyor. Stacking of dry materials to bake car robot performs. Baking products is performed in the tunnel oven.

Baking is a process in which undergoes a series of physical - chemical reactions at high temperatures, but the product gets the final characteristics. The temperature is 930°C. Baked products are removed from carriages furnace by the robot while sorting by quality, they stacked on pallets and wrap an elastic wrap, deposited at the warehouse, and so the production process is completed [4].

Technical Data

Movements in hot air oven – dryer

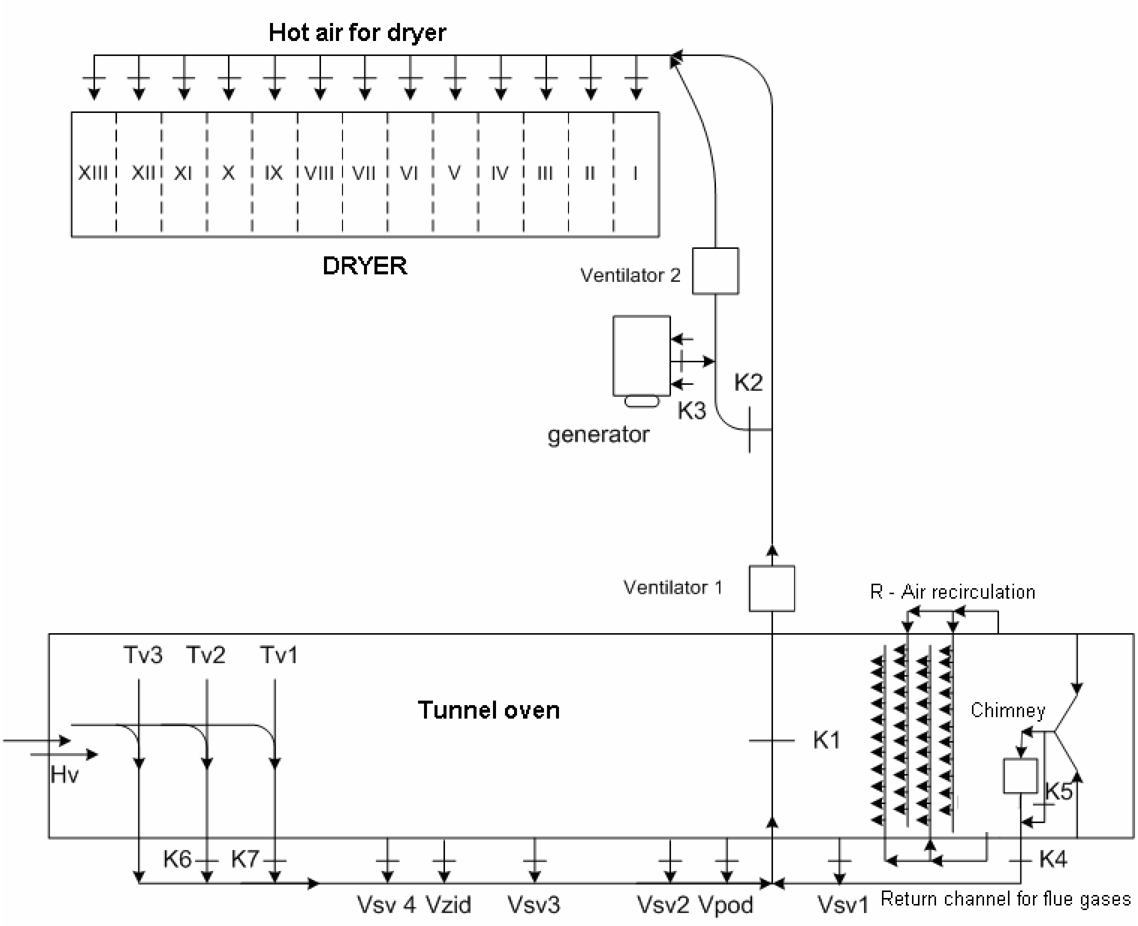


Figure 1. Schematic view of the movement of air furnace - dryer[4]

Hv - The cold air that inserts the final cooling fan
Tv1 – hot air for dryer from the first exhaust (about 350°C)
Tv2 – hot air for dryer from the second exhaust (about 250°C)
Tv3 – Warm air for dryer from the third exhaust (about 120°C)
Vsv,1.2.3.4. – air cooling of the kiln furnace vault
Vzid – air for the dryer from the furnace walls
Vpod - air for the dryer from the basement of furnace
K1 – main valve in the pipework of hot air
K2 – slider on the second pipeline of hot air
K3 – valve on the pipeline from the generator to the auxiliary pipeline of hot air
K4 – slider on the pipeline for the return of the flue gases
K5 – slider on the connecting pipeline of flue pipe and duct to return flue gases
K6 i K7 – damper on the first and second exhaust
„R“ – flue gas recirculation.

Efficiency analysis of tunnel oven [3]

$$\eta_t = \frac{t_{ul} - t_{izl}}{t_{ul}} \tag{1}$$

Efficiency of the first furnace exhaust

$$\eta_{t1} = \frac{t_{ul} - t_{izl}}{t_{ul}} = \frac{930 - 350}{930} = 0{,}6236 = 62{,}36\%$$

Efficiency of the second furnace exhaust

$$\eta_{t2} = \frac{t_{ul} - t_{izl}}{t_{ul}} = \frac{930 - 250}{930} = 0{,}7312 = 73{,}12\%$$

Efficiency of the third furnace exhaust

$$\eta_{t3} = \frac{t_{ul} - t_{izl}}{t_{ul}} = \frac{930 - 120}{930} = 0{,}8710 = 87{,}10\%$$

The results based on the analysis thermal efficiency are given in Table 1

Table 1. Thermal efficiency level tunnel oven

t_{izl} (°C)	350	250	120
η_t	0,6236	0,7312	0,871

Diagram of efficiency tunnel kiln

The following figure shows the diagram of the level of utilization of the tunnel oven exhaust all three.

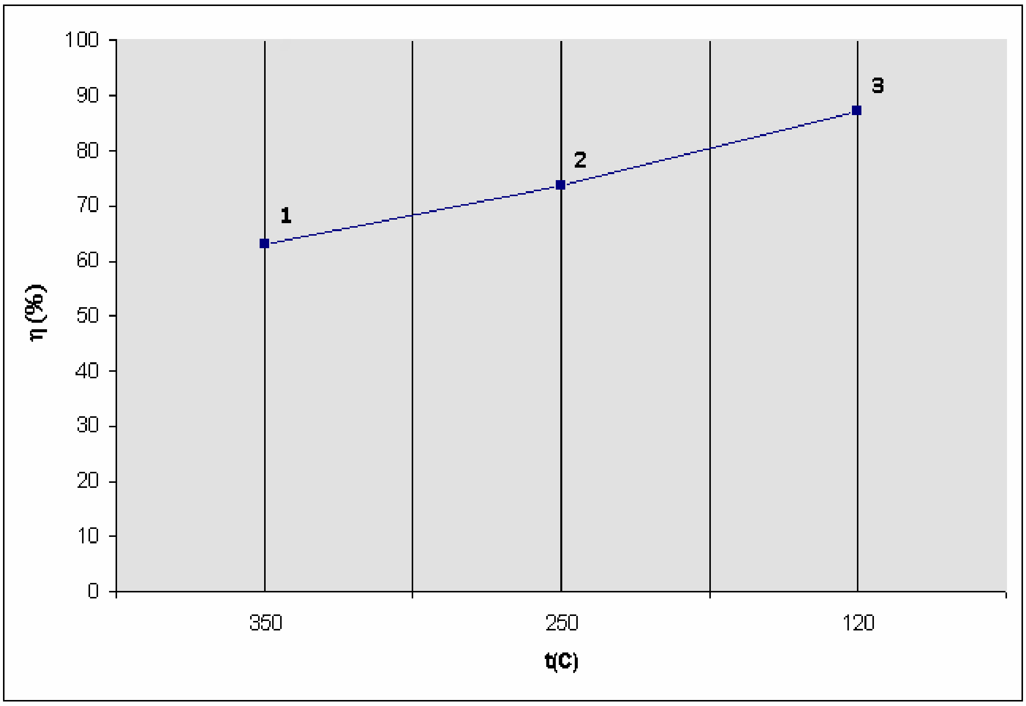


Figure 2. Diagram of efficiency furnace exhaust in all three

Analysis of drying chamber

Drying of the product is the physical process of removing moisture from the product. Moisture in the clay formation is about 19%. Products cut to the appropriate size are stacked on wagons, by the loading elevator and then transported to the dryer. Drying takes place in the dryer, which in this case is the type of chamber. This means that the dryer consists of multiple independent chambers, each with a separate drying regime. Drying is done with hot air temperature of about 70^o C, which is obtained from two sources: the furnace waste heat and as a heat generator. Moisture content in the product after drying is 1 - 2%, while the temperature of moist air that comes out of the dryer is 30^o - 40^o C [4].

Efficiency dryer:

$$\eta_t = \frac{t_{ul} - t_{izl}}{t_{ul}} = \frac{70 - 35}{70} = 0{,}5 = 50{,}00\%$$

DISCUSSION

Analysis of thermal efficiency of dryer chamber shows a relatively low efficiency, which leads to a more detailed analysis needs and necessary improvements in the functioning of the kilns, primarily because the dryer is not automated. It is necessary to develop a plan for its reconstruction, as it is currently drying process depends on the human factor. Opening and closing the valves at the openings for the insertion and ejection of moist air from the chamber is carried out manually. This could be automated, which would facilitate and enhance the process of drying and reduce human error factor.

Regarding the thermal efficiency of the tunnel oven it is satisfactory, primarily because of the structure or tunnel kiln, which allows maximum use of heated air.

CONCLUSION

Analysis of thermal efficiency of tunnel oven and dryer chamber can be said that the greater efficiency of tunnel oven, which leads us to the conclusion that the tunnel dryer was more effective than the chamber. However, the drying chamber provides an assortment of single mode for each drying chamber, while the tunnel dryer not given such an opportunity. The modern way of doing business requires versatility and ability to quickly adapt the market so that those reasons have an advantage drying chamber.

Detailed analysis of the data, with a techno - economic aspects, will be made in the development plan automation of dryer, which is going to be made for the future.

REFERENCES

[1] Tolmač, D., Design of technological systems - production systems -, Technical Faculty, "Mihajlo Pupin", Zrenjanin, 2008.
[2] Tolmač, D., Prvulovic, S., Radovanovic, Lj., Blagojevic, Z.,: Designing systems theory - design, investment, re-engineering -, Technical Faculty, "Mihajlo Pupin", Zrenjanin, 2007.
[3] Tolmač, D., Introduction to the Theory of drying from practice - Processing Plant, Technical Faculty, "Mihajlo Pupin", Zrenjanin, 2008.
[4] www.neimarzr.co.rs

ELEMENTS OF AN EFFECTIVE MAINTENANCE PROCESS

Martina Popov
University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin
e-mail: martinapopov@hotmail.com

Abstract: This work describes an approach to select the appropriate maintenance program development methodology for individual assets. When applied across an enterprise this rational normally requires the adoption of several approaches simultaneously.
Key words: maintenace, asset, technology

INTRODUCTION

Maintenance work is defined as the collection of work done on the equipment with the intent of predicting, preventing or correcting equipment failure. It excludes all work done to modify the initial capability of the asset and improve its performance. The second type of maintenance work is defined as 'Non-Value Added Work'. Included in this category are any activities done in the name of preventing or predicting failure that are not necessary to achieve the targeted performance requirements. This includes unnecessary inspections and scheduled overhauls. It also includes the execution of any predictive or preventive task more frequently than required. In other words, this work can be described as 'Too Much / Too Soon'. The third type of maintenance work is 'Deviation Work'. This work results from equipment failure. The absence of base work and the presence of non-value added work, disrupting otherwise stable systems contributes to the number of failures that occur and increases the volume of 'deviation work'. Failures that are non-maintenance preventable and failures that are not worth preventing are also included.

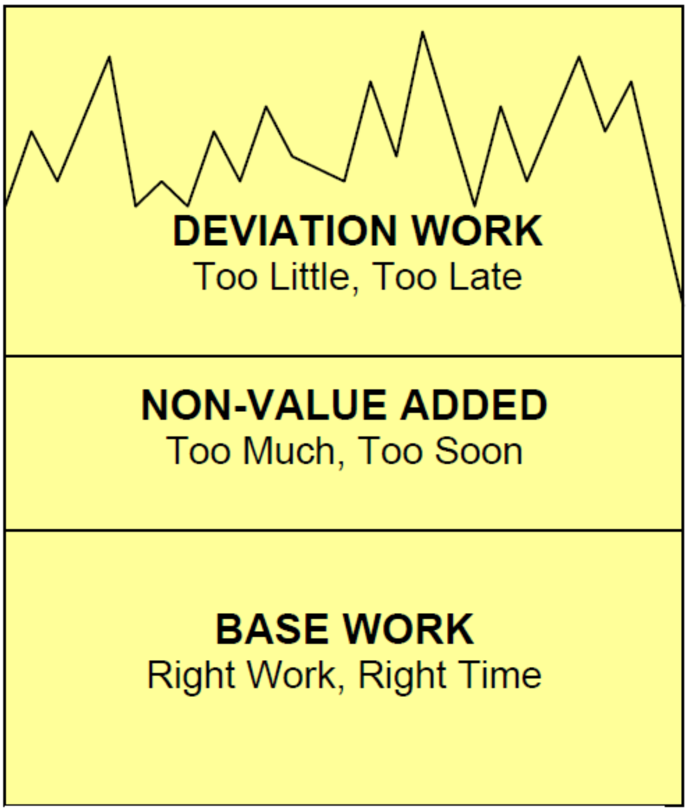


Figure 1. Classifying Maintenance Work

Physical Asset Management

Equipment performance parameters can be associated with quality, availability, cost/unit, safety and environmental integrity. To achieve this performance there are three inputs to be managed.

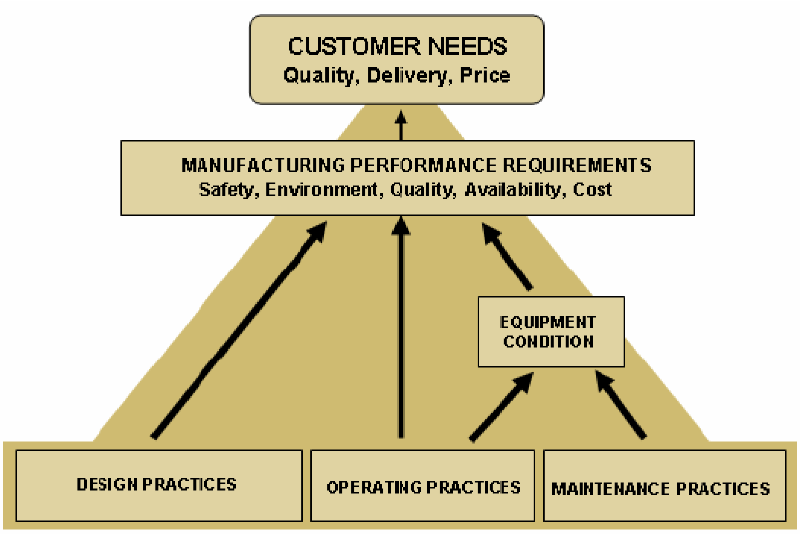


Figure 2. Managing physical asset performance to meet customer needs

The first requirement is ***Process Technology***. Process Technology provides capable equipment "by design" (inherent capability), to meet the equipment performance requirements.
The second requirement is ***Operating Practices*** that make use of the inherent capability of process equipment. The documentation of standard operating practices assures the consistent and correct operation of equipment to maximize performance.
The third requirement is ***Maintenance Practices*** that maintain the inherent capability of the equipment. Deterioration begins to take place as soon as equipment is commissioned. In addition to normal wear and deterioration, other failures may also occur. This happens when equipment is pushed beyond the limitations of its design or operational errors occur. Degradation in equipment condition results in reduced equipment capability. Equipment downtime, quality problems or the potential for accidents and/or environmental excursions are the visible outcome. All of these can negatively impact operating cost.

The Asset Reliability Process

The Asset Reliability Process focuses the maintenance of physical asset reliability on the business goals of the company. The potential contribution of the equipment asset base to these goals is evaluated. The largest contributors are recognized as critical assets and specific performance targets identified. The Maintenance Process, represented by the series of six (6) elements on the right of the model aims to deliver the performance required by the enterprise to meet all of its corporate objectives. Each element within the Maintenance process is in itself a subprocess.

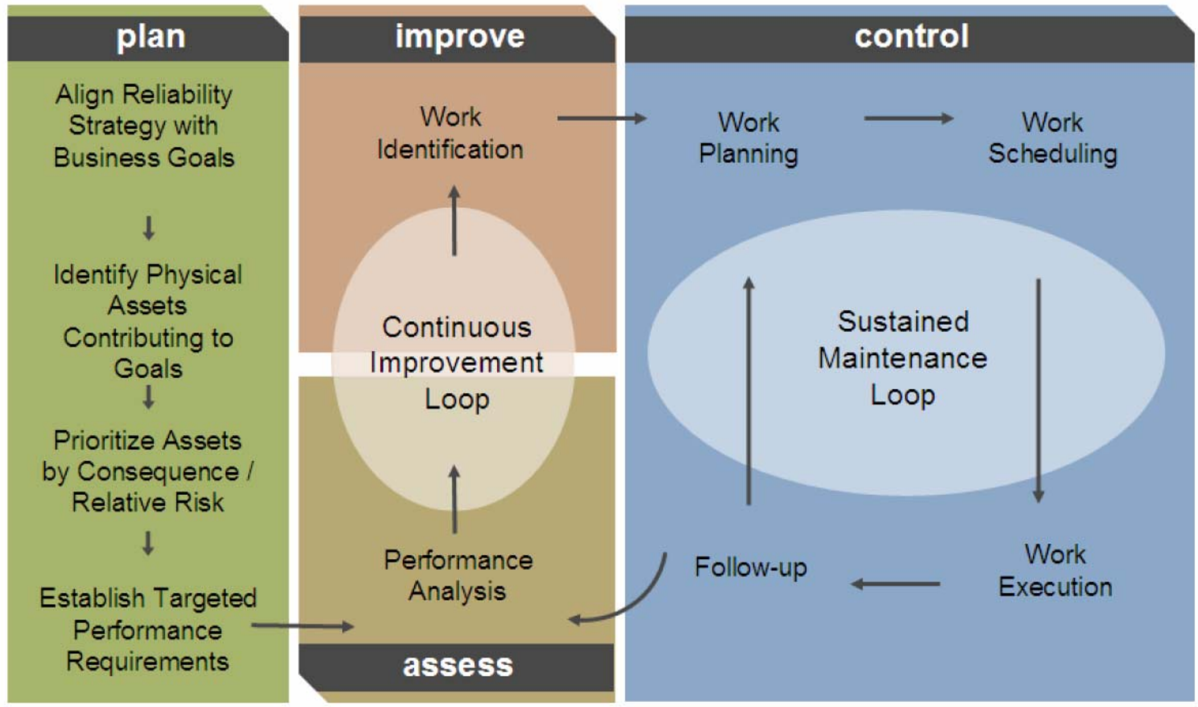


Figure 3. Asset Reliability Business Process Model

A brief description of each element follows:

Work Identification, as a process, produces technically based Asset Reliability Programs. Program activities identify and control failure modes impacting on the equipment's ability to perform the intended function at the required performance level. Activities are evaluated to judge if they are worth doing based on the consequences of failure.
Planning develops procedures and work orders for these work activities. The procedures identify resource requirements, safety precautions and special work instructions required to execute the work.
Scheduling evaluates the availability of all resources required for work "due" in a specified time frame. Often this work requires the equipment to be shut down. A review of production schedules is required. Resources are attached to a specific work schedule. The use of resources is balanced out. In the
Execution process, trained, competent personnel carry out the required work.
The ***Follow-up*** process responds to information collected in the execution process. Work order completion comments outline what was done and what was found. Actual time and manpower, to complete the job, is documented. Job status is updated as complete or incomplete. Corrective work requests, resulting from the analysis of inspection data, are created. Requests are made for changes to drawings and procedures. The process of
Performance Analysis evaluates maintenance program effectiveness. Gaps between actual process performance and the required performance are identified. Historical maintenance data is compared to the current process performance. Maintenance activity costs are reviewed. Significant performance gaps are addressed by revisiting the Work Identification function.

Each element is important to provide an effective maintenance strategy. Omitting any element will result in poor equipment performance, increased maintenance costs or both.

Maintenance Task Analysis

A common way to develop an asset reliability program is to ‘implement the obvious’ proactive tasks recommended by various sources of knowledge about the equipment. These knowledge sources include manufacturer recommendations, tasks done on similar equipment and the input of skilled trade personnel and specialists. Over time, templates summarizing failure modes and maintenance action plans by type of equipment are developed to speed up the review process. In all cases, these templates need to be carefully reviewed to ensure that the recommended tasks are applicable and effective in the context of the equipment being reviewed. Maintenance Task Analyses are intended to define 'base work'. In the absence of a proactive asset reliability program, this approach can be effective in reducing maintenance preventable failures. However, they are not conducted following a rigorous process. The potential exists to miss required tasks, specify tasks that are not required and incorrectly specify task intervals. This can result in the creation of 'non-value added' work or 'deviation' work resulting when unnecessary intrusive maintenance interferes with an otherwise stable system.

Failure Analysis

Different approaches are available to investigate the cause of failures and identify what should be done to prevent them from re-occurring. Like Reliability-centred Maintenance, failure analysis methodologies seek to identify the failure modes responsible for equipment failure. Failure analysis is conducted in reaction to a specific failure. It seeks to identify the cause of that failure and what should be done to prevent the specific failure cause in the future. Often the focus of failure analysis is on the component (s) that have failed.

CONCLUSION

Opportunity exists to use Best Practice Reviews and Predictive Maintenance Needs Assessments to establish the maintenance program. Changing the emphasis to proactive maintenance will help to stabilize the situation. Resource intensity in developing the program should be low and emphasis placed on speed to implement.

REFERENCES

[1] Thomas R., Elements of an effective maintenance process - Understanding the Requirements of a World Class Maintenance Organization, IVARA CORPORATION 935 Sheldon Court, Burlington Ontario. Canada. L7L 5K6, 2006.
[2] Adamovic, Z., Maintenance Technology, Technical Faculty "Mihajlo Pupin", Zrenjanin, 2009.
[3] Adamović, Ž., Machine reliability, Technical Faculty "Mihajlo Pupin", Zrenjanin, 2008.

NANOTECHNOLOGY

Kristina Terkelj
University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
e-mail: terkelj@open.telekom.rs

Abstract: From mascara to tennis balls to baby wipes, tiny nanomaterials are hidden in many of the products we use every day. Although there is much more we'd like to know about how exposure to nanomaterials affects human health and the environment, preliminary studies demonstrate that some nanomaterials are likely to be harmful. The current approach to chemical regulation cannot be relied upon to prevent harm from nanomaterials; it is slow, costly, and fails to prevent exposures to known hazardous chemical pollutants. It is crucial that government regulation and public debate catch up with this rapidly advancing technology.
Key words: nanomaterials, nanotechnology

INTRODUCTION

Nanotechnology is engineering at the molecular (groups of atoms) level. It is the collective term for a range of technologies, techniques and processes that involve the manipulation of matter at the smallest scale (from 1 to 100 nm2).
The classical laws of physics and chemistry do not readily apply at this very small scale for two reasons. Firstly, the electronic properties of very small particles can be very different from their larger cousins. Secondly, the ratio of surface area to volume becomes much higher, and since the surface atoms are generally most reactive, the properties of a material change in unexpected ways. For example, when silver is turned into very small particles, it takes on anti-microbial properties while gold particles become any colour you choose. Nature provides plenty of examples of materials with properties at the nanoscale – such as the iridescence of butterfly wings, the sleekness of dolphin skin or the 'nanofur' that allows geckos to walk up vertical surfaces. This latter example is illustrated in Figure 1. The Gecko foot pad is covered with aggregates of hair formed from nanofibres which impart strong adhesive properties.

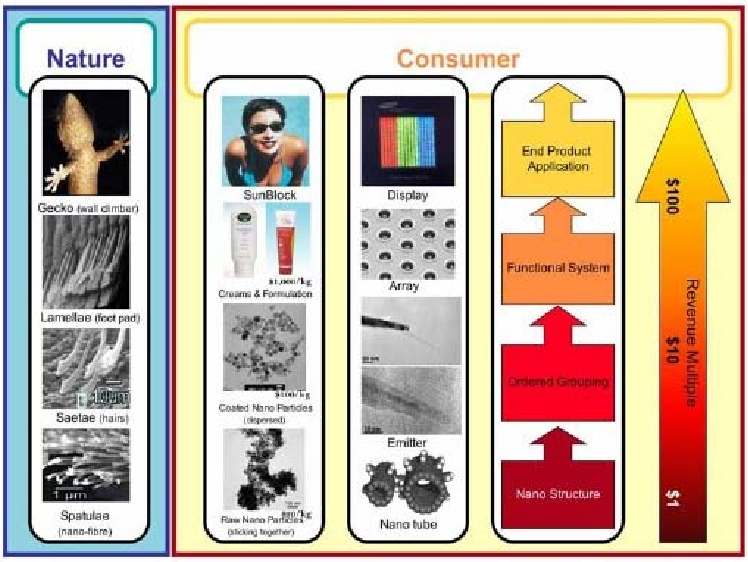


Figure 1. Examples of nanostructures in nature and nanotechnology

Nanotechnologists use similar principles to deliberately engineer at the nanoscale to create products that make use of these unusual properties. Starting with nanostructures, scientists rearrange them and then assemble functional systems that can be incorporated into products with unique properties. Figure 1 shows two examples. Firstly, the propensity for carbon to form tubes at the nanoscale can be used to generate arrays over micron sized conductors that illuminate flat panel displays for mobile phones, and

secondly nanoparticles can be manipulated to create effective, fully transparent sun block creams. These are but two of many examples of stronger, stickier, smoother and lighter products being developed.
The term nanotechnology was first used in 1974 by the late Norio Taniguchi1 (University of Tokyo) to refer to the ability to engineer materials precisely at the scale of nanometres.2 This is in fact its current meaning; 'engineer materials' is usually taken to comprise the design, characterization, production and application of materials, and the scope has nowadays been widened to include devices and systems rather than just materials. Nanotechnology is thus defined as the design and fabrication of materials, devices and systems with control at nanometre dimensions. The essence of nanotechnology is therefore size and control. Because of the diversity of applications, the plural term 'nanotechnologies' is preferred by some; nevertheless, they all share the common feature of control at the nanometre scale.

THE RELATION OF NANOTECHNOLOGY TO CHEMISTRY, BIOLOGY AND QUANTUM MECHANICS

Nanotechnology is (rightly) considered to be rather new, but it is by no means the only field concerned with atoms and molecules. In different ways, the disciplines of physics, chemistry and biology have long dealt with atoms and molecules, their behavior and their manipulation; and quantum mechanics is already firmly established as the science of the absolutely small. What is then really new in nanotechnology?

Chemistry

Chemistry is a powerful contender for the nanotechnology label. While chemistry also deals with the manipulation of molecules, and hence is no stranger to nanometre dimensions, the chemist does not control systems in the way that the engineer does. That is not to say that chemistry is not tremendously important to nanotechnology, but until now that importance has been rather negative, in the sense that chemical reality often thwarts the nanotechnologist's desire.

Biology

Biology is considered to provide living proof of principle of nanotechnology. Biological structures at macromolecular and supramolecular scales are apparently assembled using the principles of self assembly so eagerly sought by the nanotechnologist, and these structures, mostly protein-based, often combine extraordinary lightness with extraordinary strength, and may be miniature mechanisms of marvelous complexity.

Quantum mechanics

Size is mostly a relative term, but quantum mechanics offers a definition of absolute smallness: a system is absolutely small if it is perturbed by the act of observing it. Thus a photon is usually destroyed by the act of observation, or its state is irretrievably altered. Quantum effects are needed to understand certain nano-objects, for example the small clusters of atoms called quantum dots, nanodots or nanoparticles. These objects are tiny spheres of a solid, typically a semiconductor.

What can nanotechnology do for us?

Here we approach the question of why nanotechnology is often stated to be revolutionary. Let us consider three distinct aspects: indirect, direct and conceptual. By indirect is meant the progressive miniaturization of existing technologies, which opens up new areas of application for those technologies. Direct refers to the application of novel, nanoengineered artifacts, either to enhance the performance of existing processes and materials, or for wholly novel purposes. Finally, there is the conceptual aspect of nanotechnology, in which all materials and processes are considered from a molecular or even atomic viewpoint, as in living systems, in which complicated molecules (like proteins) are broken down into their constituent amino acids, which are then used for the templated synthesis of new proteins. The artificial counterpart of this process is largely untouched territory. Entirely novel integrated manufacturing life cycles await development, in which extreme energy economy and the absence of unpleasant waste products will be prominent. Furthermore, the conceptual nano-viewpoint offers the possibility of a new understanding of the world, its structures and its processes. Indirect nanotechnology is enabling technology.

Miniaturization can quantitatively enhance performance, and when a quantitative change is big enough, it becomes qualitative. A good example is provided by the history of the cellular telephone. Based on thermion valves (vacuum tubes), the circuitry for a cellular telephone would take up the volume of a large multistory building. The cell phone concept—which dates from the 1950s—only became useful once the circuits and their components became small enough to fit into a handset. The minute size of integrated circuit components enables circuits of far greater power and complexity to be realized than would otherwise be practically possible. All the applications of powerful computing, including the World Wide Web, are thus epiphenomena of nanotechnology. Novel forms of matter, such as nanoparticles, or the still-to-be-realized nanosized robots (nanobots), represent direct nanotechnology. There are many advances in this realm whose field of application is such that the nanocomponent is hidden. A good example is nanofoils made from thousands of alternating nanometre-thick layers of two different metals. A brief electrical pulse applied across the foil initiates mixing of the two metals and the release of a large amount of heat, sufficient for highly localized interfacial bonding of the materials between which the nanofoil is placed. Therefore any assemblage whose components are bonded together using this technique is a manifestation of nanotechnology. The assemblage could be very large, such as an airplane. Finally, by conceptual nanotechnology we mean that nanotechnology represents a novel viewpoint from which to survey the world: one in which structures are scrutinized at the nanometre scale, and processes are analysed by considering the movements of each individual atom. This should lead to wholly new ways to understand the world—with the hope that the underlying mechanisms of many hitherto puzzling phenomena will be thereby revealed.

But is this really so new? The answer is that although man often stumbled upon nanomaterials with unique properties—mediaeval stained glass is an example—this was apparently done without being aware of the nanostructuring. By way of illustration, consider that although the properties of steel are now known to be due to structures existing down to the nanometre level, steel was discovered and manufactured largely in ignorance of these structures, and it makes little sense to call steel pioneers such as Bessemer nanotechnologists, any more than it makes sense to call Neanderthal man an early nanotechnologist just because he doubtless produced carbon nanotubes in abundance in his primitive cave fires. Using nanometrology, these nanotubes are now characterized at unprecedented levels of detail, accompanied by insights from computations. Indeed, the whole realm of computational chemistry and materials science has acquired a mantle of vastly greater significance through nanotechnology than it had previously. Before the nano era, the difficulties faced by the computational scientists were well caricatured by the worker who spent six months computing the density of water from first principles, finally producing the result of 1 g/cm3, with an uncertainty of, say, ± 0.5 g/cm3, whereas a result with four or more orders more of precision could have been obtained within a couple of minutes in a modern analytical laboratory by simple weighing. The cardinal rule of computational science, that calculations should only be undertaken if the desired result would thereby be obtained more quickly than by experiment, has been broken so often that the discipline became marginalized, producing results that were at best confirmatory. Thanks however to the small size of nano- objects, and to the vastly increased computational power enabled by circuit miniaturization, their properties can now often be explicitly and usefully calculated from first principles, more rapidly than they can be elucidated from experiment.

RESULTS AND DISCUSSION

The research results are very encouraging. The term nanotechnology is being used in Serbia. Using methods and development of nanotechnology and bimolecular computing genetic and biological nanorobots will be applied to improve medicine. Recent development shows the feasibility of bimolecular computing biocomputer, which in turn is a first step towards the realization kind of nanoprocess. Certainly, the most obvious of the inherent characteristics of nanotechnology is to
may be so small that they are practically invisible to the human eye, as well as for our other senses. In other words, nanomachines can work around us and even within us, without us even realizing it. Incidentally, this is one of the most anticipated benefits of this technology.

CONCLUSION

Through this work, we realized how big the potential of hiding the concept of nanotechnology. Although at first glance a very mystical area, given parsing the basic principles of thinking and see how the development in this area is quite logical. There is an infiltration of nanotechnology in all aspects of science and technology and everyday life already. Nanotechnology as the next industrial revolution, the new mine topics for research and application of new principles and materials science.
This is surely just the beginning, come new principles yet to be discovered and described, and that can be developed or integrated into existing knowledge and principles and are thus improved. It remains to scientists who will lead the way from theoretical considerations and experiments to engineers that will enable both live and nano-devices closer to each man.

REFERENCES

[1] Lidija Matija, Dušan Kojić, Aleksandra Vasić, Božica Bojović, Tamara Jovanović, Đuro Koruga, Uvod u nanotehnologije, Nauka-DonVas, Beograd, 2011.
[2] www.wikipedia.org
[3] Jeremy J. Ramsden, What is nanotechnology?, Department of Advanced Materials, Cranfield University, Bedfordshire, UK
[4] http://ilicv.on.neobee.net/NanoTech.htm

Industrial Engineering
and
Environmental Protection

IIZS

conference
2012