UNIVERSITY OF NOVI SAD
Technical faculty "Mihajlo Pupin"
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Industrial Engineering and Environmental Protection
IIZS
conference

PROCEEDINGS

IV International Conference – Industrial Engineering And Environmental Protection (IIZS 2014)

Zrenjanin, 15th October 2014.

University of Novi Sad
Technical faculty “Mihajlo Pupin”
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Proceedings

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INTRODUCTION

Departments of Mechanical engineering and General Technical Sciences, at Technical Faculty "Mihajlo Pupin", Zrenjanin, organized three international conferences:
1. »PTEP 2011 - Process Technology and Environmental Protection»,
2. «IIZS 2012 - Industrial Engineering and Environmental Protection»,
3. «IIZS 2013 - Industrial Engineering and Environmental Protection»,
4. «IIZS 2014 - 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.

The theme of scientific conference «IIZS 2014», 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, Oil and gas industry, 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; presentation of scientific knowledge and exchange of experiences in the field of industrial engineering.
We express gratitude to:

- The partners of the conference – University of agriculture, Faculty of agricultural engineering, Krakow, Poland; Technical university-Sofia, Plovdiv branch**,** Faculty of mechanical engineering, Plovdiv, Bulgaria; „Aurel Vlaicu" University of Arad, Faculty of engineering, Arad, Romania; University Politehnica Timisoara, Faculty of engineering, Hunedoara, Romania; University of Niš, Faculty of mechanical engineering, Niš, Serbia; University of East Sarajevo, Faculty of mechanical engineering East Sarajevo, B&H, Republic of Srpska; University «St. Kliment Ohridski«, Technical faculty, Bitola, Macedonia,
- Zrenjanin Town Hall,
- Regional Chamber of Commerce,
- The management of Technical Faculty «Mihajlo Pupin», University of Novi Sad,for supporting the organization of the conference «IIZS 2014». We are also grateful to all the authors who have contributed with their works to the organization of the scientific meeting «IIZS 2014».

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, become better in organizational and program sense.

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

Zrenjanin, 15th October 2014.

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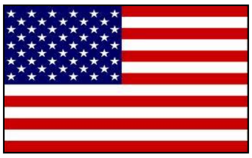

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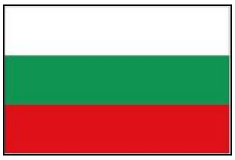

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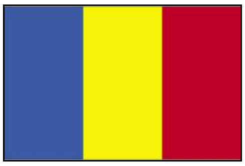

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Session 4. Maintenance

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Session 10. Reengineering and project management

Session 11. Process management

Session 12. Student papers

Session 1.

Process technology and Energy efficiency

ANALYSIS OF HEAT EXCHANGERS WITH DIFFERENT SHAPED RIBS USED IN THE GRAPHIC INDUSTRY

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Abstract. Extended surface heat exchangers are presented in this article. They are used for water and air as operating mediums, and can be differentiated by the shape of the ribs. The one has sinuous type of ribs, while the other one has flat lamella ribs. Better heat transfer can give the exchanger with higher values of coefficient α_r and factor j_a. A comparison between both types of heat exchangers is made with reference to air velocity in the minimum flow cross - section and Reynolds' number.
Key words: heat transfer, heat exchanger.

MATHEMATICAL MODEL

Temperature condition for the calculation of heat transfer through ribbed surface of tubes at lamella type heat exchangers, for working mediums water-air and where cooling of the air occurs is visible on Fig. 1. Here, we can see that heat from the fluid surrounding the pipe outside (air) is transferred on the fluid inside the pipe (water).
Heat transfer from the air onto the water is constant since there is neither heat source nor heat sink between both medias.
Total transferred heat is a sum of heat transferred through the outer surface of the pipe (without ribs) A_{cn}, and the heat transferred through ribs area, A_r.

$$Q = \alpha_r \cdot A_r \cdot (t_a - t_{rm}) + \alpha_{cn} \cdot A_{cn} \cdot (t_a - t_{cn}), \text{ W} \tag{1}$$

α_r and α_{cn} are almost equal,

$$Q = \alpha_r \cdot [A_r \cdot (t_a - t_{rm}) + A_{cn} \cdot (t_a - t_{cn})] \quad \text{, W} \tag{2}$$

Coefficient of convective heat transfer from the outer side is,

$$\alpha_{an} = \alpha_r \cdot \left(\frac{A_r}{A_n} \cdot \eta_r + \frac{A_{cn}}{A_n} \right) \tag{3}$$

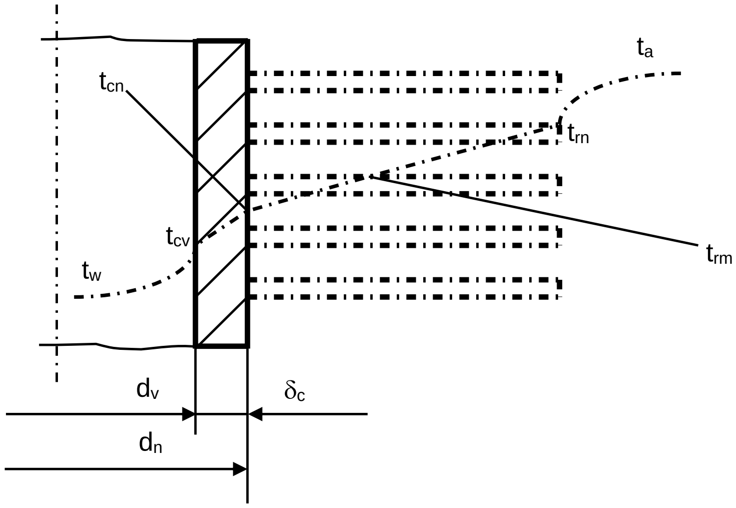

Figure 1. Temperature variations on ribbed pipe

Where,

$$\eta_r = \frac{t_a - t_{rm}}{t_a - t_{cn}} \tag{4}$$

Expressions for η_p and α_r form system of two equations with two unknowns that is solved through iteration method. Approximately, for the first iteration η_p=0,8.
Air flows by the length of the rib and upright on the pipe. Cross-section of the fluid between ribs is changed through the current flow. Because of that and sinuous form of lamellas, local coordinates depend on the direction and value of speed.
Most of authors, [1] and [2], in their calculations, use maximum velocity of the air in the minimum cross-section,

$$w_{amax} = \frac{m_{sa}}{A_{min}} \tag{7}$$

Hydraulic diameter is taken as a characteristic value when Reynolds' number is calculated [1],

$$d_h = \frac{4 \cdot A_{min}}{A_{cn}} \tag{8}$$

where Reynolds' number,

$$Re_a = \frac{w_{amax} \cdot d_h}{\nu_a} \tag{9}$$

Heat transfer factor, j_a, is usually in non-dimensional form [3],

$$j_a = St \cdot Pr_a^n \tag{10}$$

Stanton's-number,

$$St = \frac{Nu}{Re_a \cdot Pr_a} \tag{11}$$

Solution of the previous two terms is,

$$j_a = \frac{\alpha_a \cdot A_{min}}{m_{sa} \cdot c_{pa}} \cdot Pr_a^n \tag{12}$$

A number of authors, in the calculation of convective heat transfer, take the value of exponent of Prantdl's number to be n =0,667. Kotke and Blenke examined the influence of flow on this exponent. They suggest the following function in the expression of convective heat transfer, [4],

$$Pr_a^n = f(\mathrm{Pr}_a) = 1{,}8 \cdot Pr_a^{0{,}3} - 0{,}8 \tag{13}$$

Now,

$$j_a = \frac{\alpha_r \cdot A_n}{m_{sa} \cdot c_{pa}} \cdot 1{,}8 \cdot Pr^{0{,}3} - 0{,}8 \tag{14}$$

Factor j_a can be found as a function of Reynolds' number,

$$j_a = a \cdot Re_a^b \tag{15}$$

Constants *a* and *b* are coefficients of correlation of the values for j_a and Reynolds' number.

RESULTS AND DISCUSSION

Measurements are taken on two heat exchangers, and their dimensions are visible on Table 1. Heat exchanger number 1 has sinuous lamellas, while heat exchanger number 2 has flat lamellas, [5].

Table 1. Measured dimensions of heat exchangers

Dimensions	No. 1	No. 2
H_t (mm)	468	468
B_t (mm)	500	500
H_r (mm)	465	465
δ_r (mm)	0,15	0,15
B_r (mm)	172,8	172,8
R_r (mm)	2,6	2,6
n_r	192	192
C_h (mm)	33,3	33,3
C_b (mm)	28,8	28,8
d_v (mm)	11	11
d_n (mm)	12,3	12,3
n_{red}	6	6
n_{red1}	14	14
n_{pc}	16	16
n_c	84	84

Calculated surface areas of the heat exchangers are presented on Table 2. Calculations are made according to [6], while surface area is given in m^2.

Table 2. Calculated dimensions of heat exchanger

Dimensions	No. 1	No. 2
Frontal surface area of heat exchanger: $A_f = H_t \cdot B_t$	0,234	0,234
Minimum flow cross-section: $A_{min} = (H_r - n_{cr} \cdot d_n) \cdot n_r \cdot R_r$	0,146	0,146
Ratio: $\sigma = \frac{A_{min}}{A_f}$	0,625	0,625
Surface area of non-ribbed pipes: $A_{cn} = d_n \cdot \pi \cdot n_r \cdot R_r \cdot n_c$	1,620	1,620
Surface area of ribs: $A_r = \frac{(d_r^2 - d_n^2) \cdot \pi}{2} \cdot n_r \cdot n_c$	29,812	27,102
Pipe surface area between ribs: $A_g = (R_r - \delta_r) \cdot d_n \cdot \pi \cdot n_r \cdot n_c$	1,527	1,527
Total area of heat transfer: $A_n = A_r + A_g$	31,339	28,629
Internal pipe area: $A_v = d_v \cdot \pi \cdot n_r \cdot n_c \cdot R_r$	1,449	1,449

Table 3. Measured and calculated values for heat exchanger number 1

m_{sa} kg/s	m_{sw} kg/s	t_{av} °C	t_{ai} °C	t_{wv} °C	t_{wi} °C	Q_a W	Q_w W	Q_s W	k W/m^{2}K	α_w W/m^{2}K	w_a m/s	α_r W/m^{2}K	Re_a	j_a	η_r	η_p
0,233	0,231	20,88	12,83	5,32	10,18	5029	4715	1965	17,20	513,19	1,309	27,86	2566	0,0143	0,89	0,88
0,315	0,231	19,90	13,40	5,32	10,27	5059	4802	2138	17,68	513,16	1,768	34,38	3473	0,0130	0,86	0,86
0,413	0,231	19,69	13,66	5,21	10,23	5126	4870	2586	17,81	512,80	2,318	43,97	4553	0,0127	0,83	0,83
0,491	0,231	19,94	13,86	5,22	10,31	5235	4938	3087	17,96	512,83	2,758	55,51	5407	0,0135	0,80	0,79
0,563	0,231	20,57	14,28	5,31	10,57	5341	5103	3652	17,65	513,12	3,168	61,04	6185	0,0129	0,79	0,78
0,665	0,231	18,77	13,42	5,49	10,12	4716	4492	3652	17,94	513,65	3,725	78,11	7349	0,0140	0,74	0,73
0,754	0,231	18,06	13,35	5,91	10,25	4335	4211	3638	17,88	514,95	4,218	84,45	8346	0,0134	0,73	0,72
0,833	0,231	19,66	14,46	5,82	10,78	5040	4812	4436	18,18	514,69	4,682	99,82	9167	0,0143	0,70	0,68
0,925	0,231	22,34	16,46	6,03	12,06	6100	5850	5568	18,61	515,39	5,241	121,37	10071	0,0156	0,66	0,64
1,009	0,231	22,77	17,13	6,04	12,40	6302	6170	5823	18,23	515,44	5,728	108,04	10958	0,0128	0,68	0,67
1,084	0,230	23,25	17,75	5,97	12,70	6395	6501	6097	18,64	514,11	6,165	133,03	11742	0,0146	0,64	0,62
1,138	0,231	25,81	19,16	5,28	13,42	8376	7897	7750	18,91	513,10	6,516	143,12	12214	0,0150	0,63	0,61

Table 4. Measured and calculated values for heat exchanger number 2

m_{sa} kg/s	m_{sw} kg/s	t_{av} °C	t_{ai} °C	t_{wv} °C	t_{wi} °C	Q_a W	Q_w W	Q_s W	k W/m^{2}K	α_w W/m^{2}K	w_a m/s	α_r W/m^{2}K	Re_a	j_a	η_r	η_p
0,235	0,225	24,45	15,42	6,16	12,64	6310	6124	2251	19,82	550,59	1,334	27,96	2552	0,0142	0,89	0,88
0,324	0,225	22,90	15,85	5,91	12,31	6142	6048	2408	19,77	549,71	1,836	30,98	3528	0,0114	0,88	0,87
0,415	0,225	22,25	15,97	5,95	12,11	5850	5821	2727	19,30	549,82	2,349	34,41	4525	0,0099	0,86	0,86
0,477	0,226	21,80	15,67	5,87	11,72	5593	5553	3041	18,87	550,75	2,697	37,77	5209	0,0094	0,85	0,85
0,542	0,226	21,54	15,45	5,74	11,41	5436	5382	3417	18,51	550,30	3,062	41,89	5926	0,0092	0,84	0,83
0,595	0,228	21,61	15,40	5,72	11,31	5359	5353	3812	18,16	552,65	3,361	45,00	6505	0,0090	0,83	0,82
0,717	0,217	20,67	14,88	5,59	11,04	5087	4967	4262	18,43	538,69	4,040	62,00	7865	0,0103	0,78	0,77
0,827	0,218	21,52	15,52	5,04	11,20	5624	5640	5087	18,42	538,13	4,672	68,59	9041	0,0099	0,77	0,75
0,923	0,219	22,83	16,28	3,84	11,07	6679	6650	6194	19,16	535,42	5,233	85,59	10042	0,0111	0,73	0,71
1,025	0,223	18,30	14,27	5,91	10,69	4578	4477	4219	19,45	547,11	5,746	84,78	11318	0,0099	0,73	0,71
1,104	0,226	18,39	14,51	5,84	10,74	4677	4651	4374	19,87	550,54	6,192	93,60	12182	0,0101	0,71	0,70
1,177	0,227	18,88	14,93	5,46	10,76	5071	5053	4747	20,04	550,49	6,612	98,11	12961	0,0099	0,70	0,69
1,200	0,227	20,80	16,37	5,57	11,63	5549	5778	5429	20,39	550,89	6,780	114,14	13115	0,0113	0,67	0,65

Measured values are taken according to [7].

Measured and calculated values for both heat exchangers are presented on Tables 3 and 4, respectively. Calculations are made for constant mass flow of water, with the aim of calculating heat transfer from the outer side of heat exchanger. Values for convective heat transfer of the ribs, α_r, and heat transfer factor, j_a, are also shown.

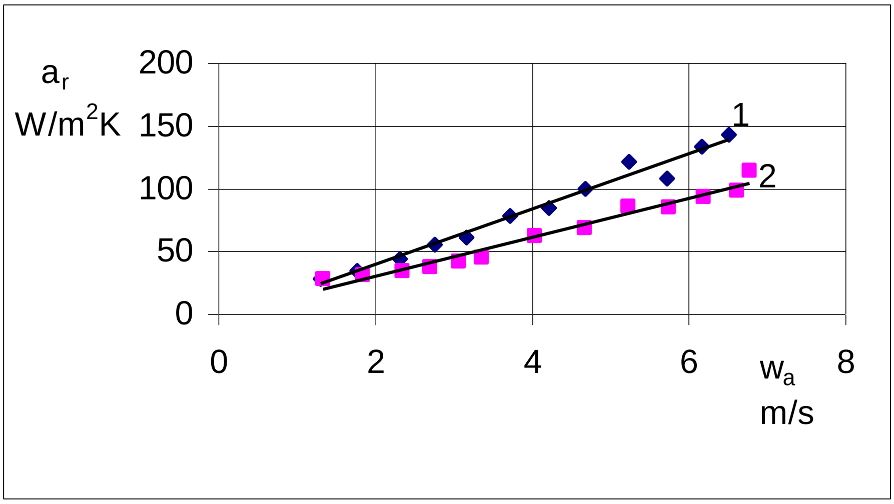

Figure 2. Dependence of coefficient of convective heat transfer from the air onto pipe with ribs α_r, from air velocity in the minimum flow cross-section w_a

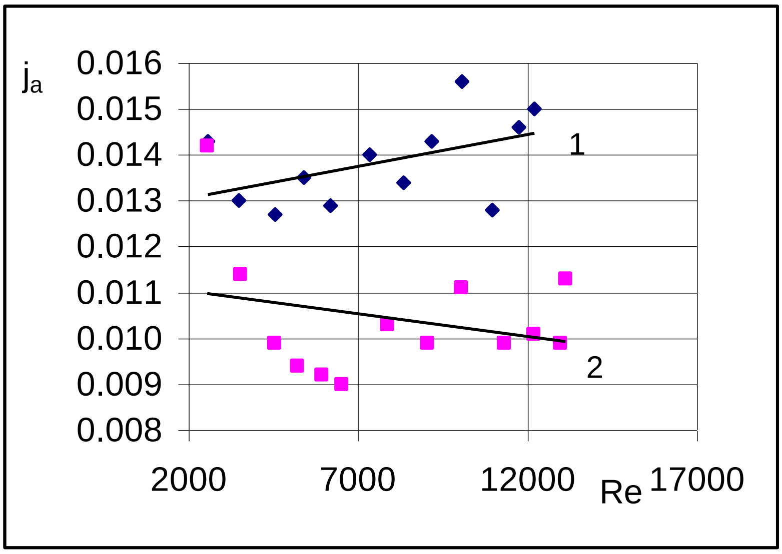

Figure 3. Dependence of heat transfer coefficient, j_a, from Reynolds' number

The dependence of both factors (α_r and j_a) relative to w_a and *Re* is shown on Fig. 2, and Fig. 3., respectively, while analytical dependence is given with the following expressions,

-Heat exchanger number. 1,

$$\alpha_r = 22{,}104 \cdot w_a - 5{,}1119 \qquad j_a = 0{,}0086 \cdot \mathrm{Re}_a^{0{,}0531}$$

- Heat exchanger number 2,

$$\alpha_r = 15{,}476 \cdot w_a - 0{,}7355 \qquad j_a = 0{,}00233 \cdot \mathrm{Re}_a^{-0{,}0912}$$

Heat exchangers with higher values of coefficient α_r and factor j_a have better heat transfer. According to this, heat exchanger number 1, with sinuous shaped lamellas has better heat transfer. This is expressed in larger values for w_a, or when $w_a > 4$ m/s and with greater Reynolds' number values, $Re > 9000$.

NOMENCLATURE

B_r - lamella's width (mm)
B_t - heat exchanger's width (mm)
C_b - distance between pipes onto heat exchangers' width (mm)
C_h - distance between pipes onto heat exchangers' height (mm)
d_n - external pipe diameter (mm)
d_v - internal pipe diameter (mm)
f_a - friction coefficient (dimensionless)
H_r - lamella's height (mm)
H_t - heat exchanger's height (mm)
j_a - heat transfer factor (dimensionless)
n_c - number of pipes (dimensionless)
n_r - number of lamellas (dimensionless)
Q - heat energy (W)
R_r - spacing between lamellas (mm)
t_a - temperature of the air (°C)
t_{cn} - temperature on the pipe's external surface (°C)
t_{cv} - temperature on pipe's internal surface (°C)
t_m - mean temperature (°C)
t_{rm} - mean temperature on the rib (°C)
t_w - water temperature (°C)
α_{cn} - coefficient of convective heat transfer from the air onto pipe without ribs (W/m^2K)
α_r - coefficient of convective heat transfer from the air onto ribbed pipe (W/m^2K)
α_w - coefficient of convective heat transfer on the side of the water (W/m^2K)
δ_r - lamella's thickness (mm)

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EXPERIMENTAL KINETICS IN PILOT SCALE HEAT PUMP DRYING OF GREEN PEAS

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Abstract: Drying is one of the most necessary process and technology in today's world and it is used, among other things, for food processing. The basic goal is to process the food for consumption by increasing its shelf life, and in order to achieve this moisture must be removed from raw material as moisture, which is the main promoter of biological activity and spoilage of the fresh products. Conventional drying is known for its high energy consumption and therefore it is costly. The conventional drying has also a negative impact on the environment and climate, providing the basis for heat pump drying development to ensure sustainable practice within the food industry. Heat pump drying is a relatively new technology developed at NTNU. It unifies the drying and heat pump cycles in which the heat pump is used to recycle energy, for reheat the air during drying the raw material. By recycling the heat from the dryer exhaust, energy is saved and the total energy input to the system is drastically reduced. In this master thesis a laboratory heat pump dryer is applied for drying green peas. The drying air was set on temperature regimes of 45°C, 35°C and 15°C with three levels of relative humidity: 60%, 40% and 20%, from which temperature regime of 45°C was set on 40% and 20%. Therefore, eight drying tests were performed and each test was done in period of three hours. The drying of green peas was conducted in fluidized bed mode. The results have shown that higher temperatures increase the rate of moisture removal from the green peas. Difference in relative humidity of the drying air also plays an important role in the process although the effect is much less compared to the temperature.
Key words:

INTRODUCTION

Today's world is facing an increase in human population and consequently need to produce more fresh and dried products for this expanding population. The consequence is a worldwide market rapid expansion, demanding more products and goods to be placed on trade as well as for the larger diverse range of products. Major factors in fulfilling these requirements are process development, economical profitability and sustainability of the environment and society. At the same time these new technologies should fulfill the objective of economical profitability, which is mostly dependable on energy efficiency due to the trend of increasing energy cost and cost of resources used to produce that energy, mostly carbon based fuels. Currently, as a process drying consumes up to 50% of the total amount of energy used in industrial purposes. One of the relatively new technologies that fulfill all these requirements is heat pump drying (HPD). The conventional dryers consume large amounts of energy and have an equivalent contribution to the emission of greenhouse gas (GHG) to the atmosphere. Another significant contributor to GHG emission is the artificially produced chemical refrigerants and foam-blowing agents.

This master thesis covers the experiments and modeling green peas drying on a pilot scale heat pump dryer. Focus will be given on the effect of heat pump operating conditions, drying temperature and relative humidity on kinetics and on the dried product's characteristics. Heat pump dryers have been known to be energy efficient when used in conjunction with drying operations. The principal advantage of heat pump dryers emerge from the ability of the heat pumps to recover energy from the exhaust gas as well as their ability to control the drying gas temperature and humidity. Many researchers have demonstrated the importance of producing a range of precise drying conditions to dry a wide range of products and improve their quality. The main components of the single stage heat pump system are the expansion valve, evaporator, internal and external condenser and compressor as illustrated in figure 1. After flowing through the evaporator and condenser of the heat pump the dry and warm air is ready to flow into the drying chamber in which the material, which is to be processed, is being placed. The simplified heat pump dryer has two separated loops with common heat exchangers. The drying air loop (abcd) contains the air cooler (EVA), heater (CON), blower and drying chamber. The refrigerant loop (12341) main components are the expansion valve (THR), evaporator (EVA), condenser (CON) and a compressor (COM). The fluid of the heat pump and drying air loops are coupled through the common evaporator and condenser to recover the exhaust energy.

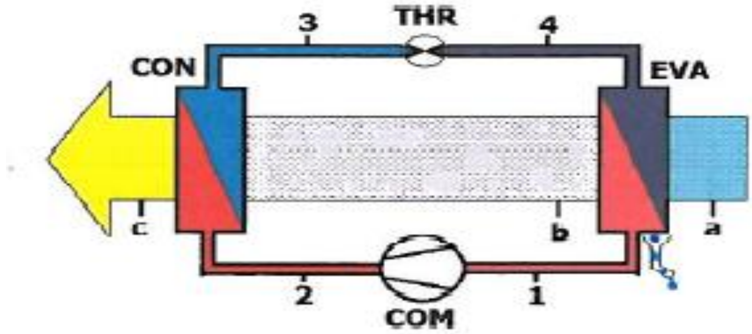

Figure 1. Principle of operation in a simplified heat pump dryer

PRINCIPLE OF HEAT PUMP DRYING

Figure 2 illustrates the isentropic and non-isentropic saturated vapor compression heat pumps with dry expansion evaporator and drying channels. Figure 4a shows the main components: A – compressor, B – three way valve, C – external condenser, D – drying channel with air heater, E – liquid receiver, F – expansion valve, G – drying channel with air cooler. Also, Figures 4a and 4b show the layout and the state points in the cycles in a log pressure versus enthalpy diagram, respectively. From state point 1 the saturated vapor is isentropic and non-isentropic compressed to super-heated vapor to points 2i and 2, respectively. Then, the vapor flows through the condensers changes phase to saturated liquid and is collected in the receiver. The saturated liquid leaves the receiver at point 3 and it is throttled to a liquid and vapor mixture at point 4. Then, the mixture flows through the evaporator and becomes saturated vapor at point 1 to be compressed again.

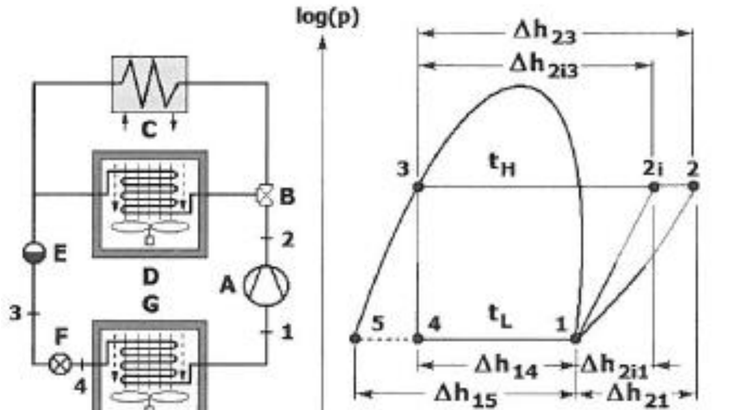

Figure 2. The isentropic and non-isentropic saturated vapor compression heat pumps indicating the corresponding specific enthalpy differences in each process

Advantages:

- Heat pump drying (HPD) offers one of the highest specific moisture extraction ratio (SMER), often in range of 1.0 to 4.0, since heat can be recovered from moisture-laden air.
- Heat pump dryers can significantly improve product quality by drying on low temperatures. At low temperatures, the drying potential of the air can be maintained by further reduction of the air humidity.

- A wide range of drying conditions typically -20°C to 100°C (with auxiliary heating) and relative humidity 15 to 80% (with humidification system) can be generated.
- Excellent control of the environment for high value products and reduced electrical energy consumption for low-value products.

However, heat pump dryers must be correctly designed to operate in the desired set points.

FLUIDIZED BED AND PRODUCT QUALITY

Fluidized bed dryers (FBD) are used extensively for the drying of wet particulate and granular materials that can be fluidized, and even slurries, pastes, and suspensions that can be fluidized in beds of inert solids. They are commonly used in processing many products such as chemicals, carbohydrates, foodstuff, biomaterials, beverage products, ceramics, pharmaceuticals in powder or agglomerated form, healthcare products, pesticides and agrochemicals, dyestuffs and pigments, detergents and surface-active agents, fertilizers, polymer and resins, tannins, products for calcinations, combustion, incineration, waste management processes, and environmental protection processes. Fluidized bed operation gives important advantages such as good solid mixing, high rates of heat and mass transfer, and easy material transport.
Some advantages of fluidized bed drying are the high rate of moisture removal, high thermal efficiency, ease of control and low maintenance cost. The high rate of moisture removal is due to the large interfacial surface area which is in order of 3000 to 45000 m^2/m^3 in the fluidized bed. This is also the reason for very high rates of heat transfer achieved in fluidized beds.
Some of the limitations in drying application of the fluidization are high pressure drop and high electrical power consumption for the blower. Also the drying product may be damaged in intensive fluidization or particle to particle and particle to wall collisions.

Water activity

Water activity is defined as the ratio of the vapor pressure of water in a food to the saturated vapor pressure of water at the same temperature, as it is shown in the next equation:

$$a_w = \frac{P}{P_0}$$

where P is the vapor pressure at the green peas surface and P_0 is the vapor pressure of pure water at the same temperature.

Color

Many naturally occurring pigments are destroyed by heat processing, chemically altered by change in pH or oxidized during storage. As a result the processed food may lose its characteristic color and hence its value.

Density

For particulate solids and powders there are two forms of density: the density of individual pieces and the density of the bulk of material, which also includes the air spaces between the pieces. The latter measure is termed the *bulk density* and is the mass of solids divided by the bulk volume. The bulk density of a material depends on the solids density and the geometry, size and surface properties of the individual particles

EXPERIMENTAL DESIGN

The experiments were conducted in a heat pump drying system with a fluidized bed. Each batch of raw material placed inside the drying chamber had a mass of 1000 grams. The green peas samples were dried at three values of drying air temperature and three values for the relative humidity. The temperatures were 45°C, 35°C and 15°Cand each temperature was fixed tested at relative humidity of 60%, 40% and 20% with exception of 45°C as previously mentioned. This resulted in a design of eight drying tests. The details of experimental conditions and setup for all eight tests are presented in Table 5.1.
The frozen green peas were mixed and homogenized to form a large batch that was partitioned into eight uniform batches of green peas to be dried according to the mentioned design. One drying test

took 3 hours to complete. During the drying of all tests the drying chamber was taken out every 20 minutes period to measure the change in mass. Relatively small masses of dried product samples were also extracted at every 60 minute interval, which makes 3 extractions every test. The extracted material was put in small vessels whose mass was determined previously, and then the total mass of vessel with extracted sample was measured, after which they were put into preheated oven for 24 hour drying period. The drying oven was set at a temperature of 105°C and for 24 hours. The already known mass of the empty vessel and total mass of vessel with the product allows us to calculate the mass of extracted product. The product was dried in the fluidized bed with the air velocity kept at approximately 1 m/s.

Table 1. Experimental conditions and setup for all six heat pump drying tests

Test Number	Temperature [°C]	Relative humidity [%]
1.	45	40
2.	45	20
3.	35	60
4.	35	40
5.	35	20
6.	15	60
7.	15	40
8.	15	20

The drying chamber and supporting cabinet

The drying chamber is placed inside the isolated wooden cabinet made of plywood with styro foam insulation. The cabinet's dimensions are 0.8x0.8m in cross section with height of 1.5m.The drying chamber is made of plexiglas and it is easily locked and unlocked in central base positioned within the cabinet using a three pin lock-rotation mechanisms. The chamber is inserted in the drying loop but separated from outdoors by a sampling access door located in the front of the cabinet. The door is opened and closed using two external locks. There are two inlet and outlet tubes connecting the cabinet and chamber to the drying loop. The inlet tube is connected to the central base of the cabinet and to the cylindrical chamber containing the green peas. The chamber exhaust flows through the outlet tube that is positioned at the upper part of the cabinet. During the process of moisture removal the green peas contained in the cylindrical chamber is in a fluidized by controlled air flow. A Mettler Toledo scale (XP 600 2M DeltaRange with an accuracy of 0.1 g) was used for measuring the mass of each batch of green peas the whole drying chamber containing the raw material. The density was measured based on standard determination of both mass and volume. Moisture content was measured with the use of a Mettler Toledo HB43-S moisture analyzer and the water activity was determined using the Aqua Lab CX-2 device.
A color meter, model X-RITE 948 Spectrodensitometer was used for measuring the color components such as brightness, red-green and yellow-blue.

ANALYSIS OF DATA AND MEASUREMENTS

Water content

The water content of the green peas sample is defined either on a wet or on dry basis.
The moisture content in wet basis is calculated using the equation:

$$w_{wb} = \frac{m_w}{m_t} = \frac{m_t - m_d}{m_t}$$

The moisture content on dry basis w_{db} is calculated by dividing the mass of water m_w in green peas sample with mass of dry-matter *md* as shown in equation:

$$w_{db} = \frac{m_w}{m_d}$$

Water activity
The water activity measurements of the green peas were made using an “Aqua Lab CX-2” meter made by Decagon Devices, Inc., Washington.

Color measurement
The color measurements of green peas were madethe “X-Rite 948 Spectrocolorimeter”. The measurements were made during every stage of testing and it was conducted on whole green peas.

The bulk density
We have used both the density of individual particles and the density of the bulk material, which also includes the air spaces between the particles. The latter measure is termed the *bulk density* and it is the mass of solids divided by the bulk volume as expressed through the equation:

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

The particle density
To obtain the particle density from each test samples of ten individual green peas were taken and the diameters were measured using a caliper with accuracy to 1/20mm.
Similarly the particle density is obtained using ratio of the average mass of ten particles and average volume of same particles and it is expressed by equation:

$$\rho_p = \frac{\overline{m}}{\overline{V}}$$

RESULTS AND DISCUSSION

Drying Kinetics
Table 2 shows the values of moisture content on dry basis calculated for tests 1 and 2 done with temperature of 45°C and relative humidity of 40% and 20%. The development of moisture content on dry basis follows the kinetic measurements at time intervals of 20 minutes over a period of three hours. It is obvious that test 2 with the lowest relative humidity is the one with the lowest moisture content after this drying time. The experimental data for these tests are plotted in Figure 3.

Table 2. Development of the moisture content on dry basis for tests 1and 2

Moisture content on dry basis [%]		
Elapsed time [min]	Test 1	Test 2
0	323.19	323.19
20	180.58	170.84
40	119.64	114.6
60	84.34	81.76
80	63.06	61.57
100	49.77	48.88
120	40.88	40.12
140	34.66	33.6
160	30.17	29.5
180	26.66	24.8

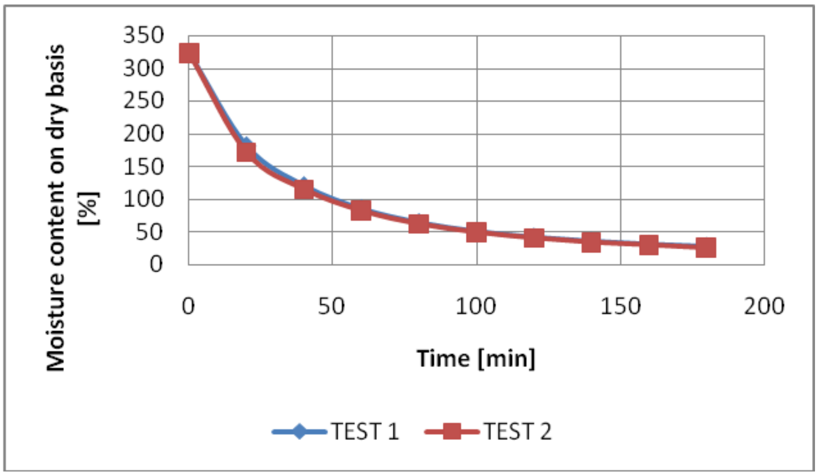

Figure 3. Development of water content on a dry basis for test 1 and 2

Table 3 shows the development of moisture content on dry basis for tests 6, 7 and 8 done with temperature of 15°C and relative humidity of 60%, 40% and 20%. Test number 8 is the one with lowest moisture content and it is the same test in which the drying air had the lowest relative humidity. The experimental data for these tests are plotted and presented in Figure 4.

Table 3. Development of moisture content on dry basis for tests 6, 7 and 8

Moisture content on dry basis [%]			
Elapsed time [min]	Test 6	Test 7	Test 8
0	323.19	323.19	323.19
20	295.13	252.98	229.07
40	252.43	195.68	183.16
60	210.71	160.85	153.15
80	180.45	131.19	126.62
100	154.08	111.38	106.01
120	132.84	95.68	92.64
140	110.92	79.73	78.42
160	97.93	70.46	69.83
180	86.67	62.21	61.96

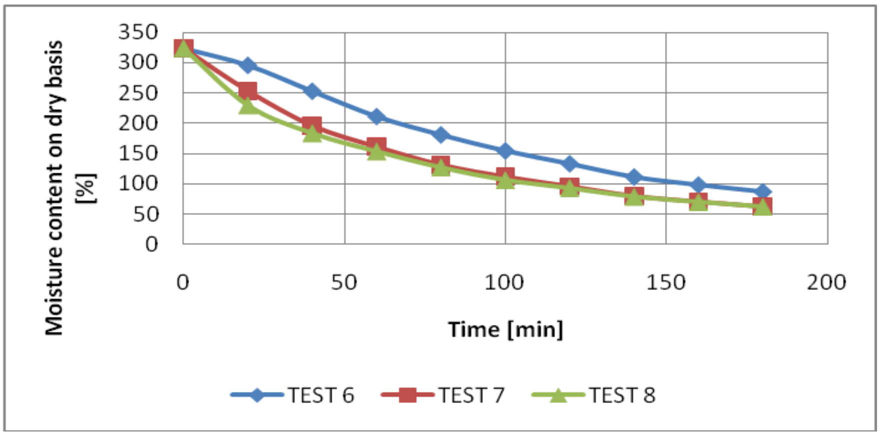

Figure 4. Development of moisture content on dry basis for tests 6, 7 and 8

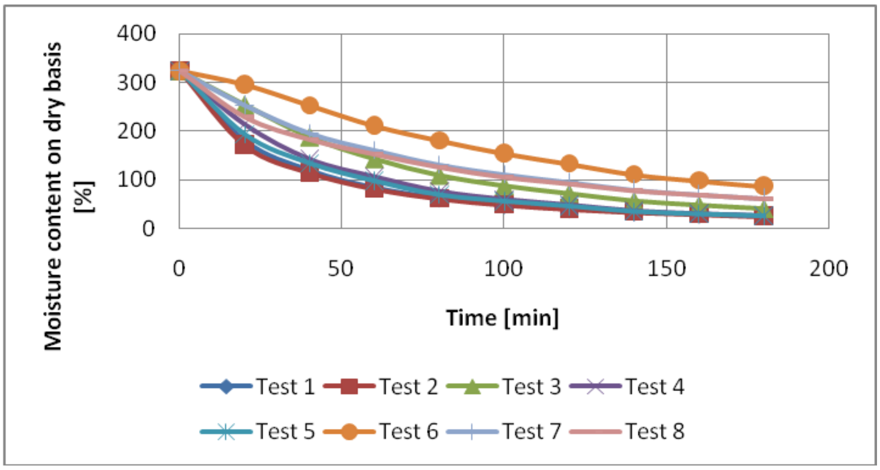

Figure 5. Development of moisture content on dry basis for all tests

CONCLUSION

This project work focus on heat pump drying of green peas at varying conditions. The tests and measurements were done using three sets of temperatures combined with two and three relative humidity modes, respectively. The results have shown that the temperature of the drying air has the highest influence on products moisture content.

There is also a significant influence of the relative humidity of the drying air on the final product's moisture content. We can see that the tests with 45°C inlet air have faster moisture removal but also that Test 4 and Test 5 with 35°C inlet air 40% and 20% of relative humidity is approaching the value of the test 1. On the other hand the set of tests with 15°C have high values of moisture content and it is obvious that for that low temperature not even changes in relative humidity can increase moisture removal rate.

Overall, test 2 produced the dried green peas with lowest moisture content. In terms of color a higher temperature regime influenced the most drastic change in the color properties of the final product but still the values remained relatively close between tests. The biggest difference that can be noticed is the similarity of values for Test 1 to Test 4, and also the similarity in results of color for Test 5 to Test 8.

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RESULTS FROM THE ENERGY AUDIT OF THE HIGH SCHOOL DORM "MIRKA GINOVA"- BITOLA

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Abstract: Measures for increasing of energy efficiency in buildings are closely related to Energy Audit. Faculty of technical sciences – Bitola (FTSB) is one out of five companies that were chosen as educating facilities for training of energy auditors. High School dorm "Mirka Ginova" in Bitola is the only state-owned dorm in the city. Preliminary energy audit for the nearby building of the dorm was performed as a part of the training for energy auditors. The calculations were performed by using of ENSI© EAB software.
Key words: energy audit, dorm, energy class, ENSI software.

INTRODUCTION

Following recent adoption of EU regulative in the area of energy auditing in the country, [1,2], the first step was to train energy auditors with a purpose of obtaining licenses for energy auditing. One of the institutions licensed for training of Energy Auditors is the Faculty of Technical Sciences in Bitola. In the course of this training, the building of the nearby High School dorm "Mirka Ginova", was used as an example for energy auditing with determination of its energy class using ENSI© EAB software.
The building of the dorm is located in the south-eastern part of the city of Bitola. The object does not have attached building to it, located in averagely urbanized part of the city, next to the city park, bus station and railway station. It was built in 1960 and significant reconstruction and extension took place in 1994. Main entrance of the building is on the south-western side (Fig. 1).

Figure 1. Location of the high school dorm "Mirka Ginova" in Bitola

DESCRIPTION OF THE BUILDING AND OTHER DATA REQUIRED FOR ENERGY AUDIT

Dormitory "Mirka Ginova" in Bitola is educational institution within the Ministry of Education and Science of the Republic of Macedonia, student standard department. The building is mainly divided in 2 parts: north and south part. South part consists mainly of bedrooms, while in the north part, the kitchen, dining room and administration offices are located. South part consists of basement, three floors with wooden roof construction covered with metal sheet roof, while the northern building has basement and two floors also covered with metal sheet roof. The capacity of the dorm is 270 high school students and 26 employees. In the summer months, the dorm is open to accommodate guests of different events in the city. In this period of the year, an average of 100-150 guests are staying at the dorm.

Total net area of the building is 3364 m^2, while total net volume is approx. 9420 m^3.
Last reconstruction of the building consisted of partial replacement of external windows and carpentry and took place in the year 2010.

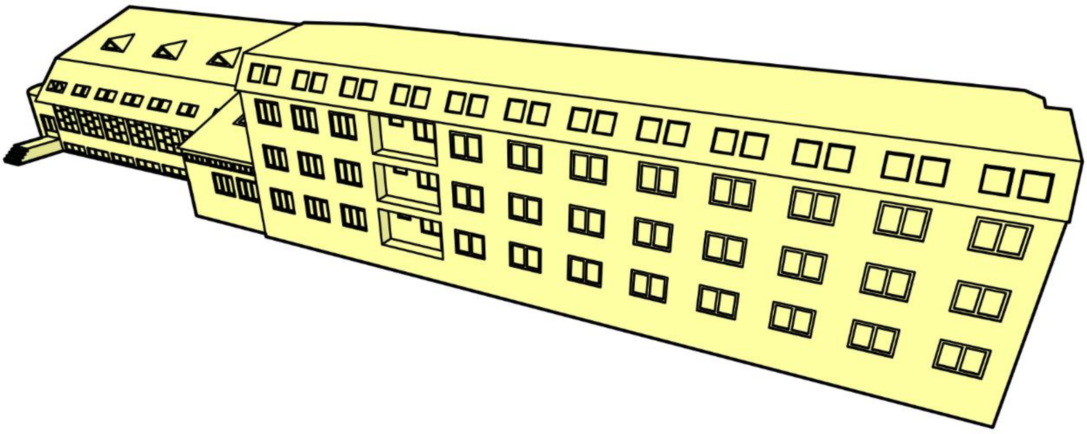


Figure 2. Appearance of the building from the south-west

Part of the other relevant data for the energy audit, required by the legislative, are given in the following table:

Table 1. Part of the data relevant for Energy Audit of dormitory's building

Characteristics of the building construction	Material (concrete, brick, hollow brick)	Total thickness [cm]	Thickness of the thermal insulation layer [cm]	Area of the construction [m^2]	Heat transfer coefficient U [W/m^{2}K]	Note
External wall NORTH	Concrete	36	5	31,14	0,914	
	Brick	43		297,61	1,16	
External wall SOUTH	Brick	43		252,40	1,16	
	Hollow brick	27		30,22	1,6	

	Execution of glazing for the windows, for example: triple insulated glass with inert gas and low emission coating	Carpentry – frame for the glazing, for example: wooden, aluminium, plastic etc.	Heat protection	Heat transfer coefficient through the window U [W/m^{2}K]
North façade [m^2]				
2,76	Double glazing	Wooden		2,9
21,66	Double thermopan glass with inert gas filling	Plastic (PVC)		1,3
15,00	Thermopan glass	Aluminum		3,25
2,54	Single glass	Steel		5,8
South façade [m^2]				
47,5	Double thermopan glass with inert gas filling	Plastic (PVC)		1,3
3,25	Thermopan glass	Aluminum		3,25
6,33	Single glass	Steel		5,8

Prior to entering of data in ENSI© EAB software, a detailed calculation of areas of all surfaces (external building envelope) as well as heat transfer coefficient for all materials was performed. In the following figures, example of calculated areas for building's south façade and cross-section of one type of external wall and roof are shown.

Figure 3. Dormitory's western façade – Total area without windows 517,1 m^2; red colored windows are with double glazing and wooden carpentry; yellow colored are with PVC carpentry and double thermopan glazing with inert gas filling, while blue colored windows are with aluminum carpentry and thermopan glazing.

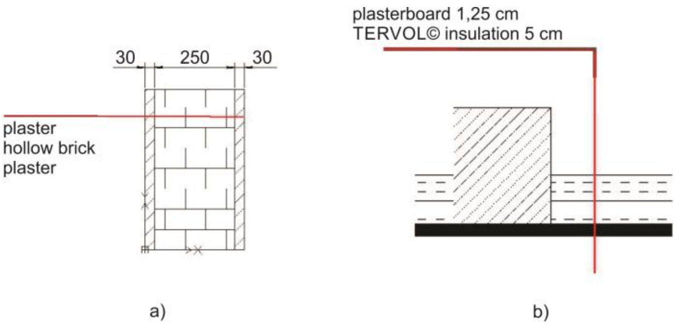
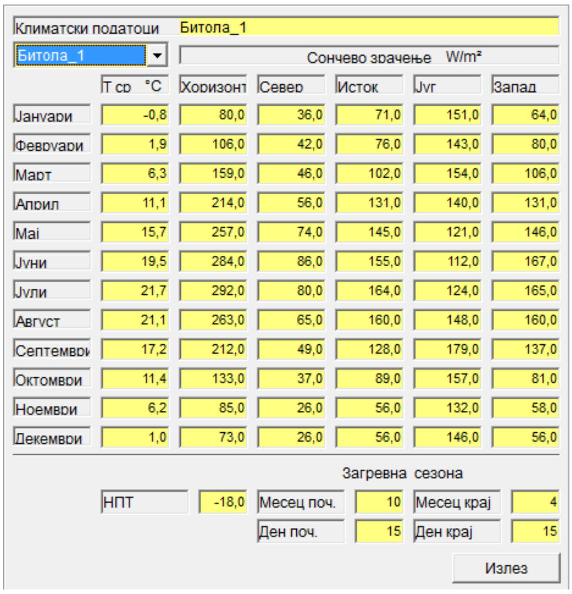


Figure 4. Cross section of construction - a) external wall with hollow brick; b) roof with plasterboard

At the end, we grouped external walls and windows in three groups according to building construction and heat transfer coefficients.
For the heating of building, hot water radiator heating system with forced circulation (with pump) is used. Heating installation is of a two-pipe system with lower horizontal branching. Two pumps are used for circulation of heating media (water). Boiler house consists of three hot water boiler connected in parallel, with a total of approx. 1100 kW installed heat power. Light oil is used as fuel. As part of the energy audit, a measurement of flue gases emission from one of the boilers was also taken.
Electrical equipment in use consists of more than 10 electric heaters (with total installed electric power of 54 kW) that are used prior to/after heating season (before 15.10 or after 15.04), electric appliances in the kitchen (total installed electric power of 116 kW), electric appliances in the laundry (around 53 kW), electric boilers with installed electric power of 102 kW, 15 personal computers copier machines, 11 air conditioning units (split system) etc. There are also around 180 fluorescent lightning tubes with electronic ballast installed for lamination and 52 light bulbs with total electric power of 5,2 kW.
For the purpose of energy audit preparation, detailed invoices – bills for electric energy and water consumption were collected from the accounting department.

INSERTING OF DATA IN ENSI© EAB SOFTWARE AND OBTAINING OF RESULTS

The ENSI© EAB Software, [3, 4], is tailored for quick energy calculations of the energy performance of existing and new buildings. The calculations can either be based on the standard climatic data, standard values and holiday tables that are included in the software, or by creating user defined standard values and holiday tables. In our case, we used the standard climatic values for the city of Bitola with user defined holiday tables, (Fig. 5).



Климатски податоци: Битола_1

Битола_1 — Сончево зрачење W/m²

	T ср °C	Хоризонт	Север	Исток	Југ	Запад
Јануари	-0,8	80,0	36,0	71,0	151,0	64,0
Февруари	1,9	106,0	42,0	76,0	143,0	80,0
Март	6,3	159,0	46,0	102,0	154,0	106,0
Април	11,1	214,0	56,0	131,0	140,0	131,0
Мај	15,7	257,0	74,0	145,0	121,0	146,0
Јуни	19,5	284,0	86,0	155,0	112,0	167,0
Јули	21,7	292,0	80,0	164,0	124,0	165,0
Август	21,1	263,0	65,0	160,0	148,0	160,0
Септември	17,2	212,0	49,0	128,0	179,0	137,0
Октомври	11,4	133,0	37,0	89,0	157,0	81,0
Ноември	6,2	85,0	26,0	56,0	132,0	58,0
Декември	1,0	73,0	26,0	56,0	146,0	56,0

Загревна сезона

НПТ	-18,0	Месец поч.	10	Месец крај	4
		Ден поч.	15	Ден крај	15

Излез

Figure 5. Climatic data for Bitola

After naming the project in the software, the first step is to enter the actual condition of building envelope (areas and U-values). The software allows to enter walls and windows in eight directions (N, NE, E, SE, S, SW, W, NW). "Walls" allow input of non-transparent constructions and "Windows" for transparent parts, (Fig. 6).

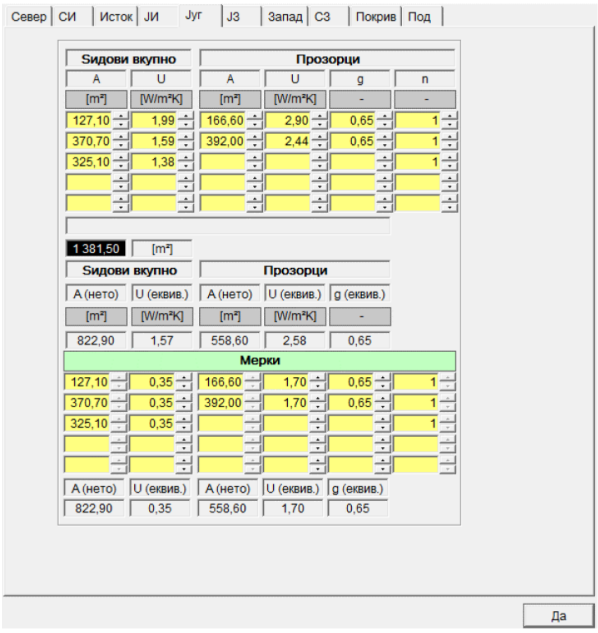
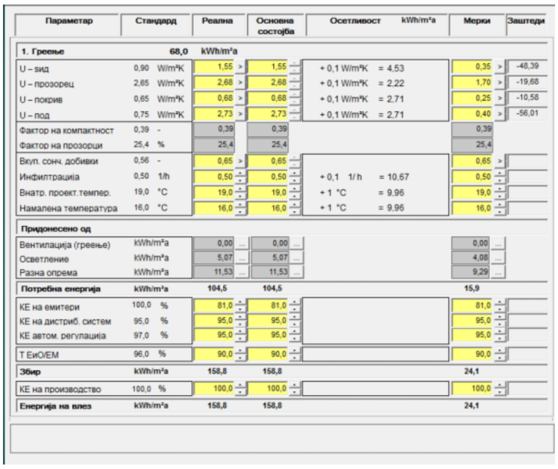


Figure 6. "Actual" and "After measures" condition of walls and windows on building's south façade

After entering of actual U-values, we also enter the U-values for the "Measures" – that is maximum permitted U-values for non-transparent surfaces according to the Rulebook for energy characteristics of buildings, [2]. When the entering of values for building envelope (walls, windows, floor and roof) is finished we proceed to enter the total conditioned (heated) area of the building and heat gains from occupants.

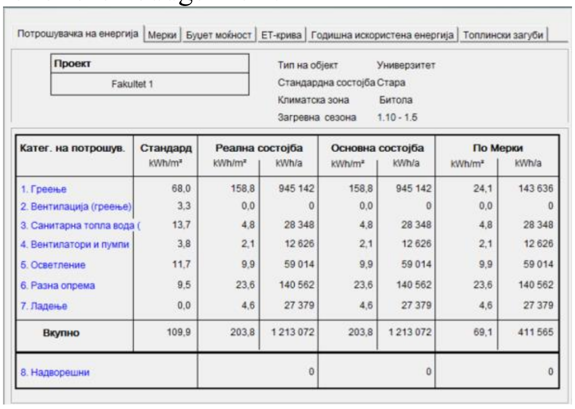
Next step is to enter/modify actual parameters for "Heating". This is done by changing of different efficiency coefficient referring to emission of heating objects, distribution efficiency, automatic control and production efficiency. It is also possible to enter parameters for "Measures" referring to condition after, for example, replacement of hot water boiler running on light oil fuel with corresponding boiler that uses wood pellets as fuel.



Параметар	Стандард		Реална	Основна состојба	Осетливост kWh/m²a	Мерки	Заштеди
1. Греење	**68,0**	**kWh/m²a**					
U – sид	0,90	W/m²K	1,55	1,55	+ 0,1 W/m²K = 4.53	0,35	-48,39
U – прозорец	2,65	W/m²K	2,68	2,68	+ 0,1 W/m²K = 2.22	1,70	-19,68
U – покрив	0,65	W/m²K	0,68	0,68	+ 0,1 W/m²K = 2.71	0,25	-10,58
U – под	0,75	W/m²K	2,73	2,73	+ 0,1 W/m²K = 2.71	0,40	-56,01
Фактор на компактност	0,39	-	0,39	0,39		0,39	
Фактор на прозорци	25,4	%	25,4	25,4		25,4	
Вкуп. сонч. добивки	0,56	-	0,65	0,65		0,65	
Инфилтрација	0,50	1/h	0,50	0,50	+ 0,1 1/ h = 10.67	0,50	
Внатр. проект.темпер.	19,0	°C	19,0	19,0	+ 1 °C = 9.96	19,0	
Намалена температура	16,0	°C	16,0	16,0	+ 1 °C = 9.96	16,0	
Придонесено од							
Вентилација (греење)		kWh/m²a	0,00	0,00		0,00	
Осветление		kWh/m²a	5,07	5,07		4,08	
Разна опрема		kWh/m²a	11,53	11,53		9,29	
Потребна енергија		**kWh/m²a**	**104,5**	**104,5**		**15,9**	
КЕ на емитери	100,0	%	81,0	81,0		81,0	
КЕ на дистриб. систем	95,0	%	95,0	95,0		95,0	
КЕ автом. регулација	97,0	%	95,0	95,0		95,0	
Т ЕиО/ЕМ	96,0	%	90,0	90,0		90,0	
Збир		**kWh/m²a**	**158,8**	**158,8**		**24,1**	
КЕ на производство	100,0	%	100,0	100,0		100,0	
Енергија на влез		**kWh/m²a**	**158,8**	**158,8**		**24,1**	

Figure 7. ENSI© EAB “Heating” screen

The next few steps include entering of values for “Ventilation” (in our case there is no mechanical ventilation of the building), followed by “Domestic Hot Water”, “Fans, Pumps and Lighting”, “Various exploitable and unexploitable” and “Cooling and Outdoor”.
When all the data are filled in, the software gives the results of calculations on five screens. The “Energy Budget” includes the energy use for the standard building and calculated energy use for “Actual”, “Baseline” and “After Measures”. The “After Measures” values summarize all the savings from the “Measure” columns for each budget item.



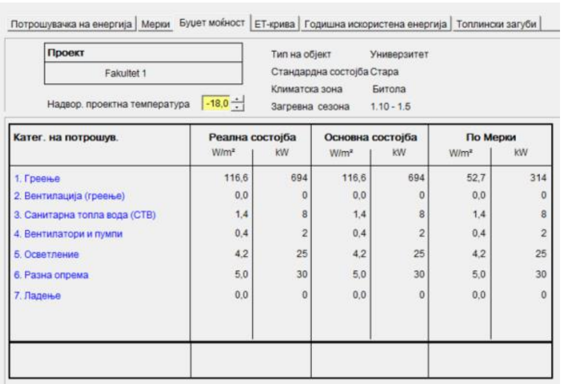
Потрошувачка на енергија | Мерки | Буџет моќност | ЕТ-крива | Годишна искористена енергија | Топлински загуби

Проект: Fakultet 1
Тип на објект: Универзитет
Стандардна состојба: Стара
Климатска зона: Битола
Загревна сезона: 1.10 - 1.5

Катег. на потрошув.	Стандард	Реална состојба		Основна состојба		По Мерки	
	kWh/m²	kWh/m²	kWh/a	kWh/m²	kWh/a	kWh/m²	kWh/a
1. Греење	68,0	158,8	945 142	158,8	945 142	24,1	143 636
2. Вентилација (греење)	3,3	0,0	0	0,0	0	0,0	0
3. Санитарна топла вода (	13,7	4,8	28 348	4,8	28 348	4,8	28 348
4. Вентилатори и пумпи	3,8	2,1	12 626	2,1	12 626	2,1	12 626
5. Осветление	11,7	9,9	59 014	9,9	59 014	9,9	59 014
6. Разна опрема	9,5	23,6	140 562	23,6	140 562	23,6	140 562
7. Ладење	0,0	4,6	27 379	4,6	27 379	4,6	27 379
Вкупно	109,9	203,8	1 213 072	203,8	1 213 072	69,1	411 565
8. Надворешни			0		0		0

Figure 8. “Energy budget” results screen

By clicking “Power budget”, the corresponding budget for maximum simultaneous power demand for each budget item will appear.



Потрошувачка на енергија | Мерки | Буџет моќност | ЕТ-крива | Годишна искористена енергија | Топлински загуби

Проект: Fakultet 1
Надвор. проектна температура: -18,0
Тип на објект: Универзитет
Стандардна состојба: Стара
Климатска зона: Битола
Загревна сезона: 1.10 - 1.5

Катег. на потрошув.	Реална состојба		Основна состојба		По Мерки	
	W/m²	kW	W/m²	kW	W/m²	kW
1. Греење	116,6	694	116,6	694	52,7	314
2. Вентилација (греење)	0,0	0	0,0	0	0,0	0
3. Санитарна топла вода (СТВ)	1,4	8	1,4	8	1,4	8
4. Вентилатори и пумпи	0,4	2	0,4	2	0,4	2
5. Осветление	4,2	25	4,2	25	4,2	25
6. Разна опрема	5,0	30	5,0	30	5,0	30
7. Ладење	0,0	0	0,0	0	0,0	0

Figure 9. “Power budget” results screen

Both specific and total power demands are presented in the columns “Actual”, “Baseline” and “After Measures”. The kW’s is the specific value multiplied by the conditioned area of the building, defined in the “Building envelope” window.

CONCLUSION

Following recent adoption of EU regulative in the field of Energy Auditing of buildings, the Faculty of Technical Sciences in Bitola is one of country's five licensed training centers for energy auditors, [5]. In the scope of training, practical part, the building of dormitory "Mirka Ginova" was taken as an example and general energy audit was performed on it. Calculations were performed using ENSI© EAB software for quick energy performance calculations.
The results from the calculations categorized the building of the High school dorm "Mirka Ginova" – Bitola as class "E" building. Calculated value of energy consumption is 158,4 kWh/(m^{2}a).

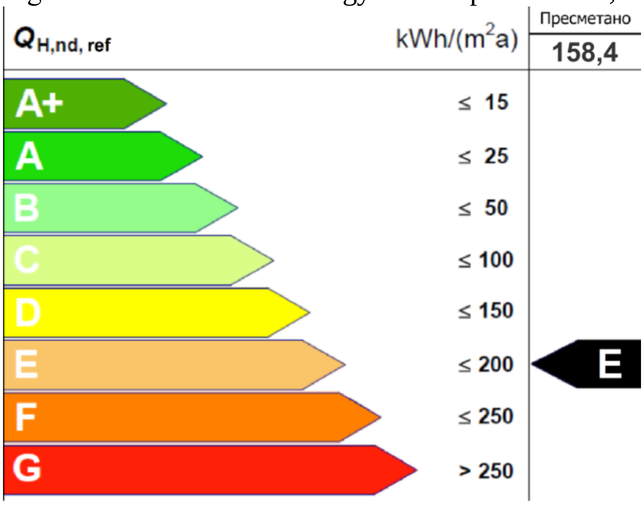


Figure 10. Energy class of the building

According to local legislative, [2], all buildings undergoing 'substantial reconstruction' must reach at least "D" energy class.
In the example of preliminary energy audit of the dormitory "Mirka Ginova" – Bitola building, the proposed measured would include:

- Thermal insulation of all external walls in order to reach maximum allowed U-value of 0,35 W/m^{2}K;
- Partial replacement of windows and carpentry in order to reach maximum allowed U-value of 1,7 W/m^{2}K;
- Installation of additional thermal insulation for the roof in order to reach maximum allowed U-value of 0,25 W/m^{2}K;
- Replacement of one of the hot water boiler running on light oil fuel with high efficiency hot water boiler running on wood pellets.
- Replacement of light bulbs and fluorescent lighting tubes with LED lights;

Implementation of these measures would 'raise' building's energy class to "C".
Return on Investment (ROI) period for implementation of these measures was also calculated and it ranges from 2 years (lights replacement) up to 5,5 years (replacement of windows and corresponding carpentry).

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SMEs IN THE FUNCTION SUSTAINABLE DEVELOPMENT WITH ASPECT OF THE USE OF RENEWABLE ENERGY

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Abstract: Production, distribution and consumption energy are activities that directly or indirectly affect all areas of human activity, but also on commercial and economic development of each country. At the end of the last century, the world has adopted the concept of sustainable development of communities, which in the area of energy, in addition to energy efficiency, raises the demand for increasing the use of renewable energy sources (RES) in order to meet the increasing total energy needs. In the world today there is a broad consensus that the concept of sustainable development brings hope for the rebirth of our planet, but also that the coming decade is critical for the implementation of this concept. The current crisis has caused a new sense of the need to respond promptly to a number of unsustainable trends in production, consumption, social relations, and habits of the people, and therefore should strive and provide conditions for the establishment of small businesses in this direction.
Key words: SMEs, sustainable development, renewable energy sources

INTRODUCTION

In an effort to increase part of total energy consumption, which comes from renewable energy sources, extensively around the world are taking many actions in the policy and legislative activities to promote and regulate the use of these energy sources. Within the framework of international and local financial institutions and organizations are established stable system of financing the construction and use of renewable energy, as well as research and education.
Developed countries as well as countries in transition and developing countries, defining short-term and long-term development strategy for the area, and the United Nations (UN), European Parliament and other relevant international organizations and institutions by their acts and directives define a very clear and precise directions and frameworks for these activity. The most striking political will to implement rapid introduction of renewable sources indicate countries of the European Union. The problem of climate change must solve urgent, reduce high energy consumption, especially in the transport sector, as well as to stop the disappearance of biodiversity and natural resources. The transition to a secure and sustainable economy with fewer negative effects on the environment will require in the near future, new economic policies at the global and local levels, as well as better strategic overview and management.
The European Union, our strategic objective of this decade, is deeply committed to the goals of sustainable development, which was confirmed by the European Strategy to 2020. The European Union will base its development on smart, sustainable and inclusive growth, knowledge-based, innovations economy that makes efficient use of resources, "green jobs" and the territorial and social cohesion. In this kind of Europe will not be a place for the state to ignore the principles of economic and social sustainability and environmental sustainability. The EU is generally attributed to buildings occupying 40% of the energy consumption and one-third of greenhouse gas emissions [4].
In line with B&H's efforts to join the EU, B&H legislation will must in a very short time to align with European legislation. To make this possible, it is necessary to establish an organized system of measures that will enable rapid implementation of EU directives in B&H legislation and achieving goals.
Local communities (municipalities/cities) are units in which they directly exercise rights and responsibilities of citizens and the framework in which implemented these requirements, in practically daily and direct contact local governments with citizens [5].
In a word, the immediate implementation of all policies, regardless of whether the policies adopted at the level of B&H or the Entities and Cantons are executed immediately at the local level. Legal status, competences, duties and responsibilities of local communities are regulated entity regulations. Laws on local government in both entities have been prepared in accordance with the

European Charter of Local Government, so as to contain a lot of similar solutions on specific issues relevant to the position of local communities. A both laws contain provisions about what is the local government. In both laws, the definition of local government is enshrined in Article 2 of the law as follows: "Local government includes the right and capacity of local governments, within limits of the law, to regulate and manage certain public affairs under their own responsibility and in the interest of the local population". Activities performed by the local government are also defined Laws. In the Republic of Srpska has adopted the Law on Local Government (Official Gazette No. 101/04 42/05, 118/05), which regulates the legal status of local communities. The scope of activities of local government regulates in Articles 12 and 22, and about competences and responsibilities of municipalities to provide better living conditions of citizens.

POTENTIAL OF RENEWABLE ENERGY SOURCES IN THE REPUBLIC OF SRPSKA

The potential of renewable energy sources in the Republic of Srpska are hydro energy, biomass, wind energy, the potential of the sun and geothermal energy. Due to its natural characteristics, developed landscapes, quite developed hydrographic network, the Republic of Srpska ranks in regions the rich hydro energy potential. Catchment areas in the Republic of Srpska are: the Drina, Vrbas, Bosna, Sana, Neretva and Trebišnjica. The total technically exploitable potential watercourse in the Republic of Srpska, including border rivers is 13.505,0 GWh/year. Technically exploitable potential, which belongs to Republic of Srpska amounts to 10.027,5 GWh/year. Hydro energy potential is exploited Republic of Srpska 2.985,8 GWh/year, which means that the remaining unused 7.041,7 GWh/year. hydropower potential [9].
In the Republic of Srpska planned about 130 small hydro power ($0.5 < P < 10$ MW), with a total capacity of 360 MW and the potential production of 1,500 GWh. Installed capacity and average annual production of micro and mini hydro power plants up to 500 kW is not currently known[9].
Forests of Bosnia and Herzegovina covers 2,371,062 hectares, which is about 40% of the total area. Of that 1,250,391 hectares or 53% are located in the territory of the Republic of Srpska. The forest is nearly half the territory of the Republic of Srpska. Forests are one of the most important natural resources of the Republic of Srpska. Development of the forestry sector and wood industry is very important for the development of the Republic of Srpska [9].
Agricultural biomass resources come mainly from agricultural residues, including corn, wheat, vegetables, oil seeds (sunflower, soybean and beet), and remnants of orchards and vineyards. To date, in the Republic of Srpska wind energy is not used for energy purposes as it is not built a single commercial wind farms. Regional atlas wind REGIONAL RE-ANALYSIS uses global meteorological data and results obtained by using this model are not verified measurements on the ground. Assimilation of measurements of the characteristic points on the ground to give accurate results, however, and this wind atlas can be considered sufficiently representative for selection and macro location areas for construction of wind farms.
There is significant potential of solar energy in the Republic of Srpska. The number of hours of sunshine (insolation) in the northern part of the Republic of Srpska is about 2.000 hours per year, while the southern part is around 2.500 hours per year [9].
Larger, especially the northern part of the territory in the Republic of Srpska is very promising in terms of the presence of geothermal energy resources and geothermal water. In that stands out Posavina, Semberija and Lijevče fields. The main geothermal sites are located in the Triassic and Cretaceous limestones and making them reservoirs of geothermal water temperature of 35 - 1500^{0}C.

EMPIRICAL RESEARCH OF THE IMPACT SMEs IN THE FUNCTION SUSTAINABLE DEVELOPMENT WITH ASPECT OF THE USE OF RENEWABLE ENERGY

The process of research is conducted on the territory of the Republic of Srpska, regions: Bijeljina, East Sarajevo and Trebinje. Municipalities or local communities in which the interviewing was conducted are: Bratunac, Srebrenica, Milići, Vlasenica, Sokolac, East New Sarajevo, East Ilidza, Gacko, Nevesinje and Trebinje. Interviewed are holders of local/municipal authorities in the area, or by the competent departments municipal services, and associates have spent the survey on the project TEMPUS SD TRAIN.

From the aspect of the survey can conclude that the level of local communities that were the subject of research, knowledge about the subject and the organization are not very high. There are some indications that in the future plans to devote more attention to the segment of renewable energy sources and the development of sustainable energy infrastructure by the relevant departments.

Results and discussion

Results of the research are presented graphically of the Figure 1. to Figure 8. The lack which was discovered is that there is no resor or department in to the municipal service which is competent that engages in with this issue.
From the local community till the local community those problems try to solved individuals from different departments as follows: Department of Economics and Department for Urbanism.
The most common problem that is encountered during the interview is to find appropriate interviewees that is relevant in terms this the survey and who can give answers to questions.

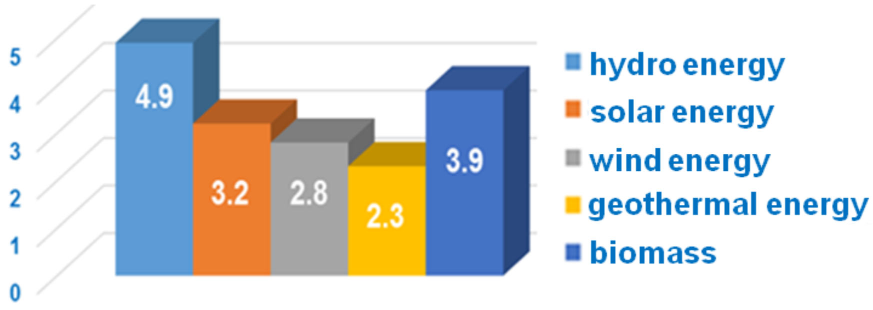

Figure 1. Assessment of potential renewable energy sources in the Republic of Srpska

From Figure 1. it perceives that the hydro-energy and biomass as a potential renewable energy sources have the highest ratings, averaging 4,9 and 3,9.

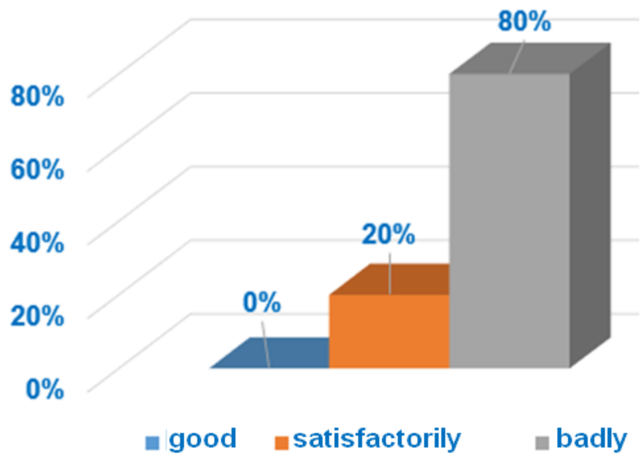

Figure 2. Assessment of current business situation and business activity production from renewable energy sources in the Republic of Srpska

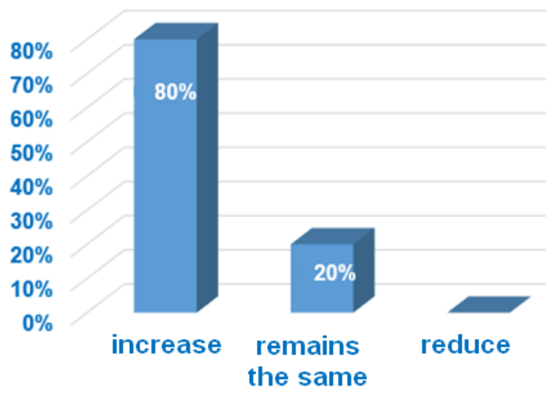

Figure 3. Number of new companies in the sector of energy production from renewable energy sources in the Republic of Srpska in the next 5 years

From Figure 3. it perceives that the number of new SMEs in the sector of energy production from renewable energy sources in the Republic of Srpska in the next five years will be increased, the assumption of 80% of respondents.

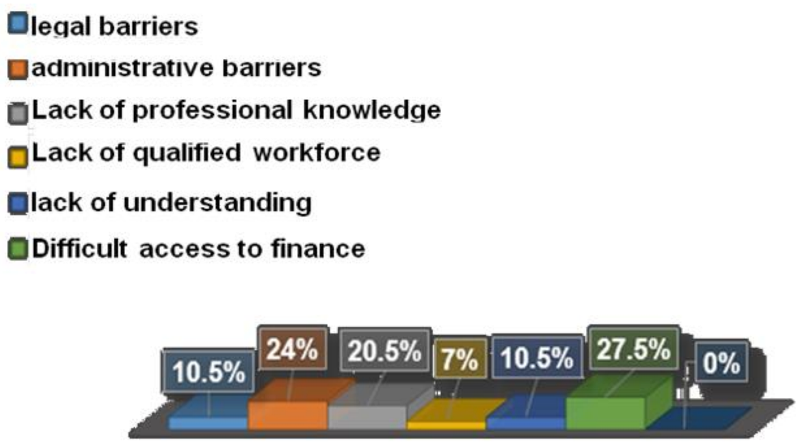

Figure 4. The most common problems encountered by companies engaged in the production of energy from renewable energy sources in the Republic of Srpska

Based on results and analysis of ABC perceives problems encountered by firms involved in the production of energy from RES in the Republic of Srpska, such as difficult access to finance, administrative barriers and lack of knowledge in a given area.

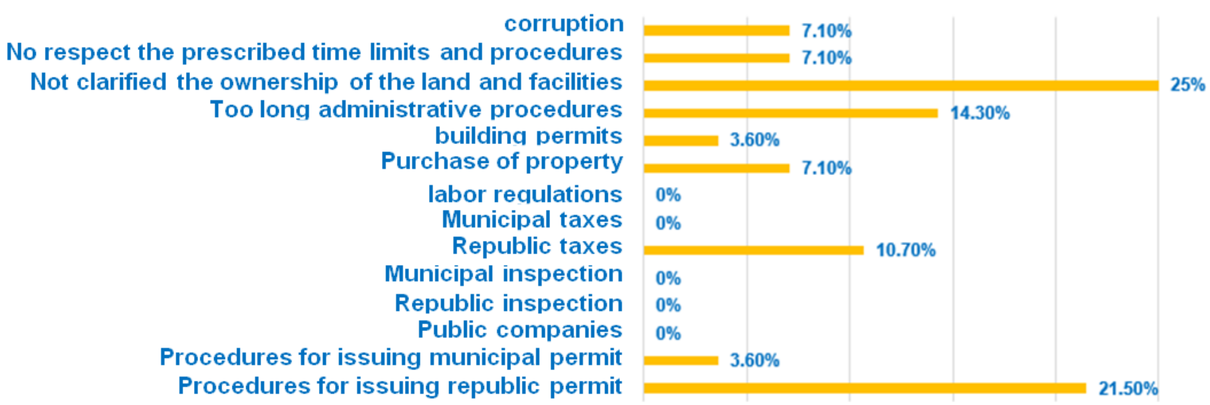

Figure 5. Administrative and regulatory measures which restrict business development firms dealing with production of energy from renewable energy sources

Based on results obtained and ABC analysis can be noted: administrative and regulatory measures which restrict business development firms dealing with production of energy from renewable energy sources, such as unclear ownership of buildings and land, as well as the procedure for the issuance of state licenses, following too long administrative procedures and the Republican taxes.

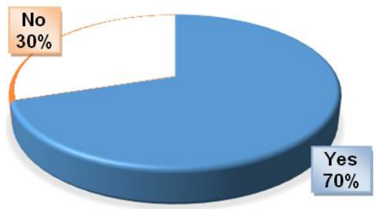

Figure 6. Is there a possibility that producers of RES-apply for some kind of credit for small and medium-sized enterprises in the Republic of Srpska

When asked whether in the Republic of Srpska is possible to producers of energy from renewable energy sources apply for some kind of credit for small and medium-sized enterprises in the area of renewable energy sources, we have received written responses stating institutions that offer some type of loan to IRB RS; Line ministries; International funds; UNDP; Commercial banks and other financial institutions; IPA; Fund for Environmental Protection and Energy Efficiency.

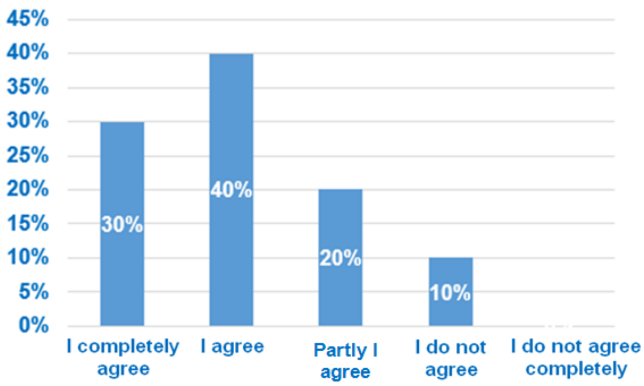

Figure 7. Use of renewable energy sources can provide the improvement of competitiveness of domestic companies in conditions of market globalization

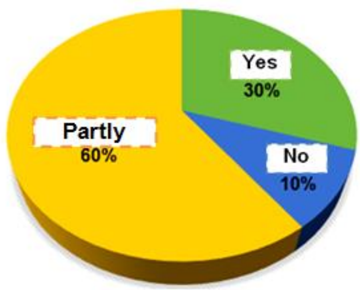

Figure 8. Is there cooperation between local communities and Universities in the Republic of Srpska, Institutes, consultant companies or other scientific knowledge environment from which to seek services in terms of initiating projects based on renewable energy sources and energy efficiency

CONCLUSION

In B&H needs to work on the development of products and services related to renewable energy, or small businesses to design, manufacturing equipment, education, certification, and more. The Republic of Srpska and Bosnia and Herzegovina as a whole should accept the views of the European Union in terms of energy efficiency, not only because of his membership in the EU, but especially because it is the model that gave the best results. In this way the state should implement EU directives in a manner that responds to the social, economic and environmental conditions of B&H, ie on principles of sustainable development of B&H.

Energy efficiency is generally poorly promoted. It needs greater involvement of government and non-government sectors, educational institutions and the media to spread awareness and knowledge in the area of energy efficiency, as well as available sources of funding for projects in the area of energy efficiency and renewable energy sources. Activities to increasing the efficiency of energy use in buildings, industry, transport and others. As well as the use of renewable energy sources are just activities that promote employment. The impression gets that in many areas, especially when it comes to energy efficiency in buildings, the use of biomass is not recognized. Increasing energy efficiency (on energy use) is a measure that increases the cost of business, reducing the cost of the family budget, but at the same time encouraging the development of domestic production, and reduce the demand for imported energy. Using renewable energy sources (mainly biomass and small hydropower) to encourage domestic employment, and also reduce the demand for imported energy. Public-private partnerships are a good way to integrate the public interest and the ability of private management. It is necessary to establish the logistic of biomass (the chain of supply and use) to connect producers of energy (different stages) and equipment. It was pointed out that biomass is the most important renewable energy sources in B&H with the greatest potential and the effect on employment of local labour in the whole chain of exploitation and the technological and economic development of the local economy.

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JUSTIFICATION FOR USE OF GEOTHERMAL ENERGY IN SERBIA

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Abstract: This article aims to highlight the importance of application of geothermal energy in the human community, and the fact that geothermal energy is present everywhere and that there are technological capabilities to get very effectively used. Utilization of geothermal energy potential in Serbia is unsatisfactory, although it is an important resource that is several times greater than the total reserves of conventional energy sources in Serbia. Accent is on showing practical use. Energy strategies and laws, which covers the application of geothermal energy in Serbia in comparison with the countries of the European Union.
Key words: geothermal energy, thermal pump, potential savings, Serbia.

INTRODUCTION

Alternative energy sources no doubt have their place in every real energetic debate, and encouraged European regulations, gaining a significant place in the Serbian energy sector. [1] An alternative renewable energy sources are energy sources that are used for any useful work, and whose reserves are continuously and cyclically updated. Nowadays most people understanding the energy only in the form of coal, oil and gas, and is produced in power plants and hydro power plants. Given that in humans is not fully developed awareness of the different types of energy, geothermal energy, which is the most effective and accessible remains hidden and unused. The term geothermal energy refers to the use of heat to the inside of the Earth in the center is 4000-7000 ° C which is close to the surface temperature of the sun. The heat from a hot core moves towards the surface of the Earth's crust, and for us there is only a small part of the energy in the surface of the deep up to several kilometers. Depending on the environment where there is geothermal energy is called hydro, petro geothermal and magma thermal. The geothermal energy means energy that can be taken from water, soil and rock whose temperature exceeds 10°C.[2] Almost unchanging temperature layers of the Earth's crust can be to a large extent used for indirect heating or cooling residential and commercial buildings.

COST OF APPLICATION OF GEOTHERMAL ENERGYTHROUGH HEAT PUMPS

The technological development of the seventies enabled the efficient use of low-temperature geothermal energy through heat pumps. During this period in Yugoslavia, using domestic equipment fairly large force, working to increase energy efficiency and lower heating costs in our spas. The heat pump uses one of the basic laws of thermodynamics that energy can not be neither created nor destroyed but only change its form and its place of existence. Heat pumps do not produce energy independently. Heat pump itself will have no effect unless it is connected to the power source type of ground, water or air. It's another way of saying, it means that the outside air or the use of low-temperature geothermal energy (ground water or heat of the ground) can be inserted into the heated space 20 kW of heat energy where to spend it only 3-5kWh electricity to operate the heat pump. The heat pump energy for heating produces 80% of the natural environment with the help of 20% share of electricity. Saving energy is evident, and is up to 80%. The efficiency of this system, as compared to conventional heating and cooling systems, could be increased by providing "free" hot water in the house, which further reduces the bill for electricity. Hot vapor flows into a condenser that condenses and at the same time to exothermic. Refrigerant continuing in such physical condition of its journey behind the expansion valve switches to the normal state and the entire process is repeated. Electricity at the same time is not lost, but took the form of the potential energy of the refrigerant.
Energy efficiency of heat pumps is expressed by coefficient of performance (COP). It is the ratio between the energy that is invested and the energy that we get at the output for heating or cooling. Comparison is further carried out in relation to conventional systems. When the ratio is higher, energy efficiency of the system is better, for heat pumps its value is in the range 4-6, and in practice it is proportionally more. Every unit of electricity invested in the launch mechanism of the heat pump

enables it to deliver a minimum of another 4 to 6 units of heat energy, which arrives from natural sources. For example, with the power consumption. Power of 1 kW can produced minimum 4-6kW energy for heating which gives the power factor of 4-6.The coefficient of performance (COP) largely depends on the temperature of water in the system. When the temperature of the water in the installation is lower COP is higher. COP is generally given for the two outlet temperature + 45C to + 35C. Temperature of + 45C is used for heating by fan coil unit, a temperature of + 35 ° C is used for panel heating.

Heat pumps take energy from underground in the following three ways: [2]
1. The water from the well, which is usually at a temperature of 10 to 20 ° C, resulting in a heat pump and after it's cooling it returns in another well, or is poured into the canals, waterways or sewerage systems. This is the most efficient way, the energy point of view, because the temperature of the water that is drawn off in the course of the entire year at a constant temperature. From the standpoint of reliability and simplicity of the whole system, there are some problems and the costs of development wells. Capacity constraint is defined yield of wells is often the case that the locations where it is necessary to perform space heating using heat pump does not have the necessary amount of water or water is not present.
2. Using probes to eliminate the problems with the lack of well water. The longevity of such systems is guaranteed, the possibility of system failure or other problem is minimal, and the ease of handling is reduced to an absolute minimum. Depending on the geological characteristics of the particular location of a probe depth of 200 m it is possible to achieve heat gain up to 13kW. In economic terms the application of the probe is slightly more expensive investment compared to the wells, but its reliability, ease of operation and long-term resolution of the problem of heating and cooling the space at any location imposed by this solution as an attractive and that in the future should be maximally used in Serbia, such as is now the case in the richer European countries.
3. National Collector's solution is very similar to the probe except that it does not drill a well in which the probe is lowered, but the plastic pipes are laid in a grid of land to a depth of about 1.5 m. The energy collected by this method is mainly solar energy stored in the surface of the soil during the summer. This solution is much cheaper than the probe if the installation is performed during the construction of the building and if there is a sufficiently large area of land for the installation of the collector. Disadvantage of this method is that the energy of the land consumed during the winter, and at the end of the heating period reduces the efficiency of the system.

Climatic conditions in Serbia are ideal for the application of heat pumps. Pumps in the winter working in the heating mode, and during the summer in cooling mode. This avoids investment in additional equipment for cooling. Using the heat pump, the heating costs are reduced for 3 to 4 times. If the heat pump used in conjunction with underfloor and wall heating is achieved thermal accumulation effect. In this way it can be a large part of the heating season using electricity per night rate which reduces the cost of heating for another 3 to 5 times. Heating with heat pumps is cheaper 9 to 16 times compared with the equivalent heating with fossil fuels, wood or electricity in conventional boilers. [2] Comparison of heat pumps compared to other fuels is graphically illustrated in figure 1.

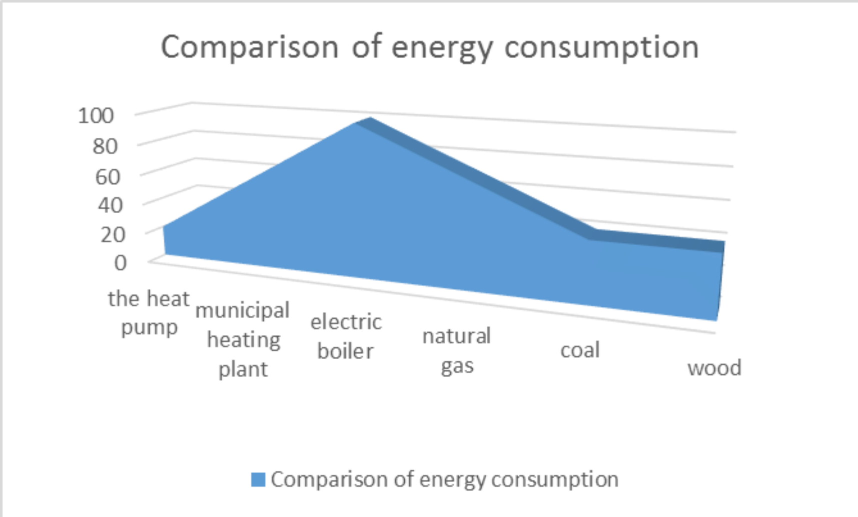

Figure 1. Cost-effectiveness of heat pumps compared to other energy

ROLE OF APPLICATION OF GEOTHERMAL ENERGY IN SERBIA

Geothermal energy in the classical sense (hot springs and wells) is mentioned in terms of declarative commitment to developing the potential of Serbia in that sector. In our conditions, over 50% of generated electricity is consumed by buildings for housing, primarily for space heating and hot water, and what can be effectively used geothermal energy. [3] In Serbia, the great confusion caused by the term "geothermal energy", which means that it refers to hydro geothermal energy, i.e. the hot springs or wells with hot water temperature of 40 ° C. It is the accepted view that colder waters are not geothermal and therefore not suitable for use in heating. In the period from 1974 to 1992, in Serbia was drilled 113 wells. [4] Which has been demonstrated capacity and water quality. This was the period in which they posed a good basis for greater exploitation of hydro-geothermal potential in Serbia. Geothermal wells are made in the process of searching for oil and gas deposits and are often located outside of settlements and roads, which is why their little use in the past. Low prices of other energy sources, especially electricity, wasn't a stimulus for the use of geothermal water in agriculture even though a large number of wells located on the arable land., agricultural Also, agricultural production in protected and heated areas, such as greenhouses and hot houses, in our country is for decades in its infancy, so that in whole of Serbia small number of agricultural buildings heated with hot water from wells.

Geothermal energy in Serbia is symbolically used, with only 86 MW, although with the geothermal potential is one of the richer countries. Estimated power of the existing geothermal wells in Serbia is around 160 MW. [5] Currently used by about 100 MW. With the utilization of heat pumps can be taken from the ground completely clean energy ,as much as we need for example, with the installation of 20,000 heat pumps power of 20 kW for heating residential buildings, we can take out of the ground as much energy as it gives us the thermal power plants of 300 MW. [6] The average values in Europe are about 60 mW/m^2, while in Serbia these values significantly higher: over 100 mW/m^2. Estimated total amount of heat contained in the sites of geothermal waters in Serbia is about two times higher than the equivalent amount of heat that would be obtained by burning all our coal reserves. In Vojvodina, there are 62 artificial geothermal sources (wells) of the total yield of 550 l / s thermal power of about 50 MW. The part of Serbia south of the Sava and Danube there are another 48 wells with an estimated capacity of 108 MW. [7] These data suggest a high potential for the exploitation of geothermal energy, which is now almost fully unrealized.

In Serbia, in the past, and partly in the present because of the lack of laws and bylaws geothermal sources (especially wells) are unavailable to new investors. Not known jurisdiction, or if they are known they are intertwined between various government bodies that it is practically impossible to come into possession of a hot spring and start or improve their use. In Serbia, there are natural and artificial sources of thermal waters in the territory of more than 60 municipalities. This energy

potential due to low water temperature is not sufficient for the production of electricity, but could be used for heat generation in various fields. This energy is low temperature could be used for heating greenhouses, rooms, swimming pools and other purposes. In Serbia, a very significant problem is insufficient energy efficiency and irrational use of existing sources or wells that are in operation. The thermal spas are not paying almost any attention to energy efficiency and large amounts of hot water are discharged as useless, even from using the heat pump can be extracted enough energy for space heating or pool. At the same time the space is heated by coal, oil or electricity If there is rationalization of use heat made from hot springs in the spas, then from the same source of energy could be supplied a new attractive facilities. Also, future users for now sealed wells should be in time acquainted with the methods of rational use of the maximum energy potential. Which will financial analysis show better results Serbia is located in the energy dependence on imports and therefore it is very important to urgently increase the application of geothermal energy. Investing population in the application of heat pumps, even without additional borrowing in the near future could provide over 10% of heat demand at the lowest investment compared with other energy sources. The increasing unpredictability of energy prices derived from fossil fuels, environmental pollution, as well as compliance with the Legislation of the European Union calls on the urgency of establishing a coherent state policy in this field and to integrate measures to stimulate the use of geothermal energy in the energy strategy and its implementation.
Within the Energy Sector Development Strategy of the Republic of Serbia until 2015 is not mentioned directly use heat pumps, but one of the priorities are and renewable energy sources. "Third-specific priority use of NRES (new renewable energy sources) and new energy efficient and environmentally friendly energy technologies and devices / equipment for energy use." [7] Priorities of selective use new and renewable energy and energy efficiency subsequent technologies and devices within which the measures and activities for the more intensive use of biomass, utilization of the remaining hydro potential, especially for the construction of small hydropower plants and multipurpose hydropower facilities, together with the more organized research and use of geothermal resources, as well as the massive use of solar energy for decentralized use of thermal energy."[7] And given that we are in 2014 and people's awareness of geothermal energy and its application is still not satisfactory, therefore it is necessary within the Energy Development Strategy of the Republic of Serbia after 2015 directly incorporated use heat pumps and take the incentives for their implementation. Incentive measures to increase the application of heat pumps for heating residential and commercial properties should start with a media campaign through print, radio, television and internet introducing of the population about the benefits of using heat pumps. The state has incentives to encourage domestic production of heat pumps. Population will only finance new way of heating in their homes, but it is necessary to clearly and accurately explain that the heating with heat pumps is the most economical way that exist and the price of heating will dramatically change depending on fluctuations in energy prices on the world market. Most of our citizens are skeptical about new solutions, especially because in the previous thirty-year period they change the heating system several times. Therefore, the reasons for later use should be clear and provide long-term results.

APPLICATION OF HEAT PUMPS IN THE EUROPEAN UNION

Heating using heat pumps are the primary course in the world and the European Union, because of the increase in energy prices over the past few years. The European Union has made the norm which states that all buildings built after the year 2015 are required to have an energy efficient heating and cooling system which, inter alia mainly based on geothermal energy (heat pumps). Geothermal energy is a renewable source, where the application of geothermal heat pump achieves long-term saving money and energy. Since January 2009, the use of heat pumps is definitely included in renewable energy. This is important because now the application of heat pumps automatically fit into the already established rules, regulations and financial structures that are used for renewable energy. Europe's energy dependence on imported energy is especially expressed in the gas crisis in January 2009, therefore, the developed countries of Europe the emphasis placed on energy conservation. Therefore, the hydro geothermal energy is maximally used for heating residential and office space. Larger application is in agriculture and animal husbandry, because then geothermal energy use at its source and is not required to transport it to cities. Exploitation of hydro power is so perfect that almost every spring or borehole can be used energy effectively regardless of the quality of water and the amount of dissolved minerals and gases in it, and that in comply with environmental requirements. "As Johnson (2005: 257-62) notes, this is in line with the two main strategies that the EU has at its disposal to ensure energy security and reduce energy dependence. The first is to cut spending by introducing new, mainly renewable energy sources and finding new sources of energy suppliers. It is a long-term strategy, while the only one short-term strategy is to develop close relationships and partnerships with key suppliers of energy to the European Union ". [8] Over 40% of primary energy in the EU is spent on heating and cooling. Therefore, it is a broad field where is needed to act and where is necessary to achieve significant results. Aims to reduce primary energy consumption by 20% by 2020, while reducing carbon dioxide emissions by 20% led to the fact that renewable energy sources are considered as the backbone of savings. Council of the European Union adopted a decision that by 2020, every newly built residential or commercial building needs to be energy independent. This means that each object will have to produce as much energy in a year as much that object spend during the year. It is not necessary to emphasize that the heat pump carrier feasibility of this decision and will now follow incentives for their faster development. In those savings application of heat pumps will take a significant share of 22%. The total number of new heat pumps installed in eight European countries in 2008 rose by an average of 50%. In the example of Sweden, where is a legal requirement that every newly constructed building must have a heat pump, in 2007 there was a decline in sales due to a saturated market, that is, because of the reduction in the number of new buildings. There is now a trend that in the old buildings also replace existing heating system and thanks to the incentives already in 2008 sales rose from 93,000 to 128,000 heat pumps. Also, there is a growing installation in buildings with multiple dwellings, while the first round was a massive use in family homes. In the past five years, several European countries have passed legislation and regulations that every newly constructed building structure must have a built-in heat pump for space heating. Also, most European countries provide significant incentives for the installation of heat pumps, from direct payments to producers for each heat pump supplied by tax incentives for users. It is easy to calculate profit from the application of heat pumps at the state level and on the basis of certain incentives in order to achieve the intended effects. Today there are over one million geothermal installations worldwide and over 5,000,000 in the USA only. The following table 1. provides an overview of the number of installed heat pumps and annual changes

Table 1: Sales numbers for different EU countries. (Source: EHPA) [9]

	2003	2004	2005	2006	change 03/04	change 04/05	change 05/06
Austria	3.780	5.129	6.098	8.853	35,7%	18,9%	45,2%
Czech Rep.	1.200	2.400	4.000	4.000	100,0%	66,7%	0,0%
Denmark	0	0	4.000	4.000			0,0%
Estonia	510	750	1.095	2.333	47,1%	46,0%	113,1%
Finland	8.540	12.648	22.307	36.950	48,1%	76,4%	65,6%
Franc	13.700	17.300	25.200	61.510	26,3%	45,7%	144,1%
Germany	15.838	19.636	25.486	51.827	24,0%	29,8%	103,4%
Ireland	1.300	1.800	2.300	2.300	38,5%	27,8%	0,0%
Italy	0	12.131	13.000	13.000		7,2%	0,0%
Netherlands	1.557	1.800	1.891	2.767	15,6%	5,1%	46,3%
Norway	55.081	35.390	40.000	40.000	-35,7%	13,0%	0,0%
Poland	0	0	1.465	1.465			0,0%
Sweden	68.100	100.215	101.350	122.473	47,2%	1,1%	20,8%
Switzerland	8.695	9.796	12.008	15.806	12,7%	22,6%	31,6%
UK	0	0	750	750			0,0%
Total	178.301	218.995	260.950	368.034	22,8%	19,2%	41,0%

The use of geothermal energy following results were achieved: [10]

- Has eliminated 5.8 million metric tons of CO_2 per year
- Eliminated more than 3.6 million tons of other pollutants
- Annually save more than 24 billion kWh of electricity
- Saving is over 40 trillion tons of fossil fuels

CONCLUSION

We can conclude that the use of geothermal energies in comparison to other energy sources is the wright choice of energy. The use of this energy in Serbia would directly impact on the conservation of natural resources that affect the quality of people's lives. Since the estimated quantity of geothermal energy that could be used is much more than the overall quantity of conventional non renewable energy sources, geothermal energy should certainly be given more importance. Especially if you take into consideration that it is a cheap, renewable source of energy, which happens to be environmentally friendly. The use of geothermal energy in Serbia is negligible compared to the potential. Utilization of the hidden potential of Serbia would contribute to increasing the scientific and technological knowledge on the use of heat pumps. Serbia would equally and readily entered the European integration in the field of increasing energy efficiency. In Europe, they set very high goals regarding the use of renewable energy and reduced amount of carbon emissions Geothermal energy is the most suitable for the achievement of these goals and therefore the only one of all renewable energy in several European countries entered into a legal obligation to use the warm-up of new facilities. By joining the European Union, we also must fulfill terms of renewable energy and reduced emissions. It takes a much greater extent to get closer to the citizens the significance of the application of this energy and facilitate its use with various subsidies, vacancies and benefits, and thus will also raise people's awareness on geothermal energy at a higher level. The increasing unpredictability of energy prices derived from fossil fuels, environmental pollution, as well as compliance with the Legislation of the European Union calls on the urgency of establishing a coherent state policy in this field and to integrate measures to stimulate the use of geothermal energy.

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UNIVERSAL SUPER ABSORBING AIR FILTER YXV "AIR BY CORNELIU"

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Abstract: This paper presents the experimental methodology to carry out functional performance tests for an air filter with a particular design of its housing, generically named *Universal super absorbing YXV „Air by Corneliu"*. The tests were carried out in the Internal Combustion Engines Laboratory, within the specialization "Road automotives" belonging to the Faculty of Engineering Hunedoara, component of "Politehnica" University of Timişoara. We present some comparative values of various operating parameters of the engine fitted, in the first measuring session, with the original filter, and then with the studied filter.
Key words: super absorbing air filter, internal combustion engine

INTRODUCTION

The proper filtration of the air entering the cylinders of an internal combustion engine is essential for extending its service life. Preventing various impurities from entering the engine along with the atmospheric air reduces significantly the wear over time of the engine moving parts.
Unfortunately, in addition to the purpose of filtering the air drawn from the atmosphere, the air filter – as a distinct part of the engine – represents a significant gas-dynamic resistance, interposed on the suction route. If it is not regularly cleaned, and the vehicle travels frequently within a dusty environment, the suction pressure p_a is consistently decreasing and the air-filling coefficient η_V suffers penalties.
The design proposed by the authors aims at reducing the shortcomings described above by designing filter housing with particular geometry, enabling the improvement of the gas-dynamic performance at the engine air inlet. We note that this study does not deal with the nature of the filtering element of the filter, which is a standard one.
Therefore, we can say that the innovative design of the air filtration system is essential for a high performance filtration and air flow improvement, with effects on increasing of the engine performance and service life [1].

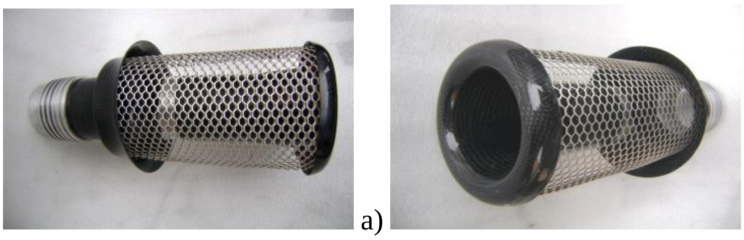
PRESENTATION OF THE EXPERIMENTAL EQUIPMENT

For performing the experimental measurements, we had an engine test stand, produced by Christiani, consisting of a multi-point fuel injection engine, brand VW, 1.4 MPI, used by the *Golf VI 5K1* models, cylinder capacity: 1390 cm^3, power: 59 KW/80 CP, 4 cylinders in line, manufacturing years: 2009-2012.

Figure 1.Overview of the test stand

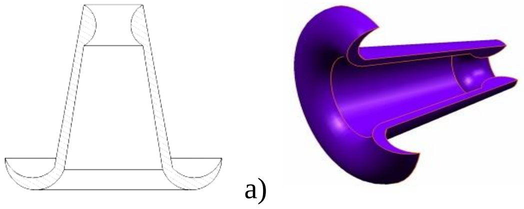
The stand offers the possibility to monitor the engine during its operation. It enables the connection to the OBD port of all the testers usually found in garages, and the measurement of signals and electrical quantities, with the possibility of assessing the obtained parameters.

The related software contains a professional interface that allows the PC to be transformed, via an USB port, into a device to be used for diagnostics and visualization of the functional parameters. Also, it enables the visualization and simultaneous storing of three measuring blocks, and can graphically display the essential features of the engine.
The YXV super absorbing filter consists of one front diffuser (figure 3), the lateral surface with guiding cells (figure 4) and the external diffuser-internal diffuser assembly (figure 5). The filter is a standard one (not shown in the pictures below).
Due to the constructive geometry, it provides a significant increase in the air-filling coefficient of the engine cylinders.



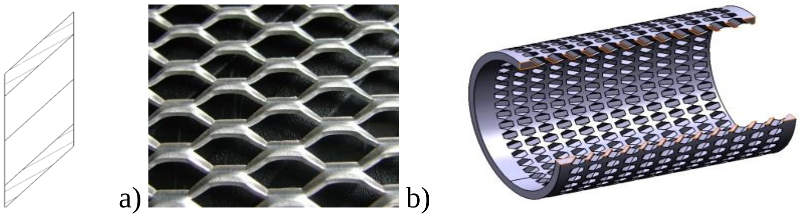
a) b)

Figure 2. Super absorbing YXV filter „Air by Corneliu”[1]. a, b – – physical models



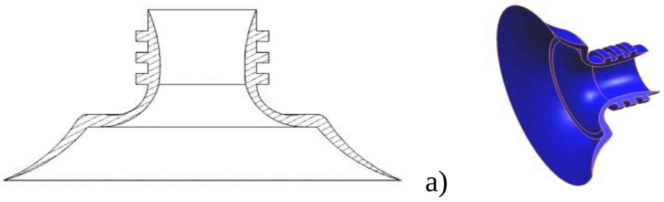
a) b)

Figure 3. The front diffuser. a – sketch, b – virtual model made in AutoDesk Inventor



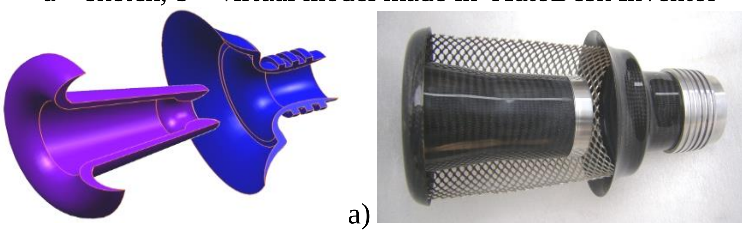
a) b) c)

Figure 4. The lateral surface with guiding cells. a – section sketch of a guiding cell profile, b – guiding cells detail –physical model, c – virtual model made in AutoDesk Inventor



a) b)

Figure 5. The external diffuser-internal diffuser assembly.
a – sketch, b – virtual model made in AutoDesk Inventor



a) b)

Figure 6. The interior of the YXV super absorbing airfilter
a – virtual model made in AutoDesk Inventor, b – physical model

The front diffuser (figure 3) consists of a diverging part, followed by a section in the form of a truncated cone that ends with a convergent - divergent nozzle (at the small base of the truncated cone). The role of convergent – divergent nozzle is to increase air velocity moving inside the truncated cone. The exterior of the truncated cone directs the air flow passing through the lateral surface with the guiding cells (figure 7). The diverging part with the truncated cone forming an "Y" from the outside to the inside of the filter.

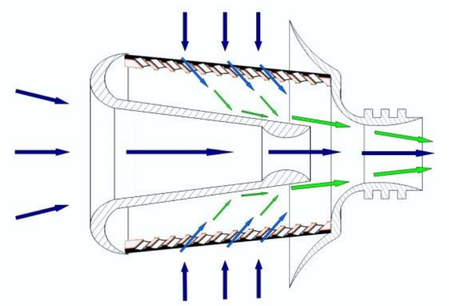


Figure 7. Air through the filter circuit

The side surface with guiding cells is able to direct airflow at aspecific angle to the interior of the filter. In the case of the external diffuser-internal diffuser assembly, the external diffuser captures and directs air through the lateral surface with the guiding cells to the internal diffuser, which is designed to increase air velocity at the outlet of the filter. The internal diffuser is continued with a cylinder pipe which is mounted on the intake manifold. The external diffuser-internal diffuser assembly has the shape of the "V" letter.

TESTING SESSION

The tests consisted in determining the key operational parameters of the engine, at various speeds at idle, the engine being equipped, at a time, with the original filter or with YXV. The measuring sessions were repeated to confirm the results, and the test conditions for the two variants (engine equipped with original filter and with YXV) were maintained strictly constant. The filtering element is the same for both filters.

For the first measuring session, the experimental engine was equipped with the original filter (Figure 8.a). The data acquisition was made at various engine speeds at idle, beginning with the idling speed and continuing with 1500, 2000, 2500, 3000, 3500 and 4000 rpm. We measured:

- engine speed;
- throttle position;
- manifold air pressure;
- coolant temperature;
- manifold air temperature;
- hourly fuel consumption;
- ambient temperature;
- atmospheric pressure.

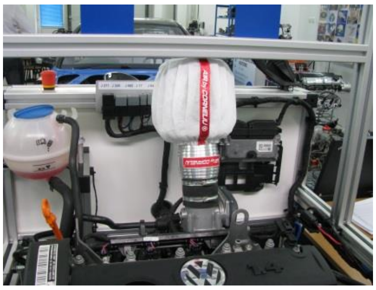
 a)  b)

Figure 8. a –Engine equipped with original filter, b - Engine equipped with YXV filter

The next session of measurements was carried out with the engine equipped with YXV filter (Figure8.b). The same above-specified parameters have been determined, under the same conditions.

We mention that the measuring sessions were conducted inside the laboratory, where the temperature and pressure remained strictly constant.

RESULTS AND CONCLUSIONS

We present below the comparative values of the above-specified parameters on the performance of the engine equipped with original filter and YXV filter, respectively.

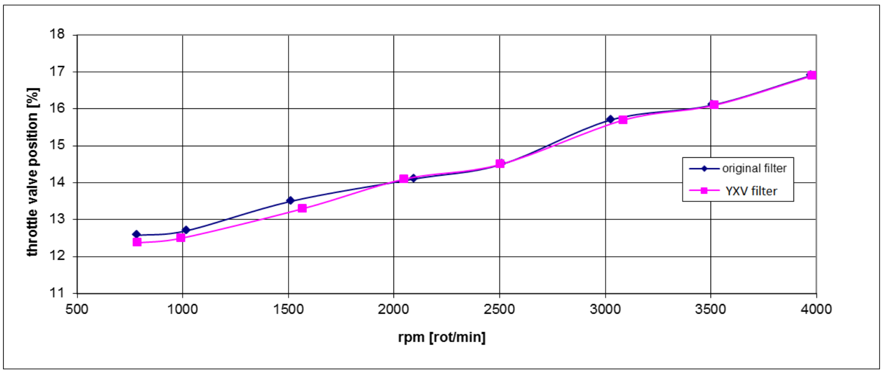


Figure 9. Position of the throttle valve versus engine speed at idle

The chart presented in Figure 9 shows that, at engine speeds below 2000 rpm, when using the YXV filter, the throttle valve opens less, which means less gas-dynamic resistance due to this filter installation, situation beneficial for the process of filling the engine cylinder with fresh load. At higher speed values, it can be seen that the throttle valve position is identical in both cases.

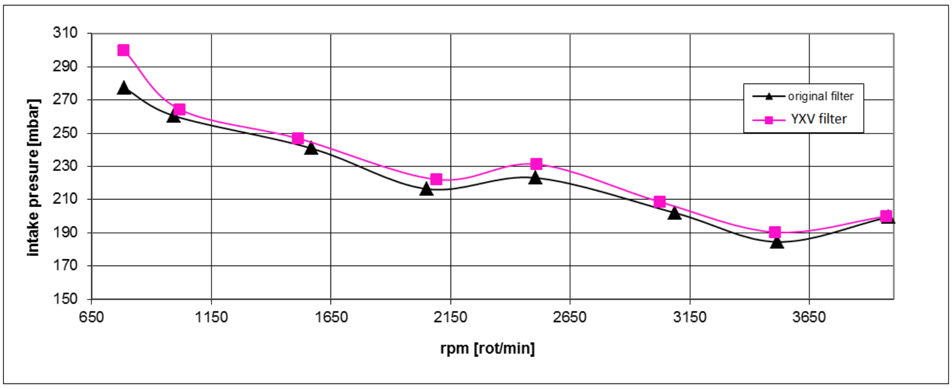


Figure 10. Pressure in the intake manifold versus engine idle speed

From Figure 10, we can deduct that, throughout the range of speeds at which the tests have been performed, the pressure in the intake manifold is higher when using YXV filter than when using the original filter, situation beneficial for the process of filling the engine cylinder with fresh load.

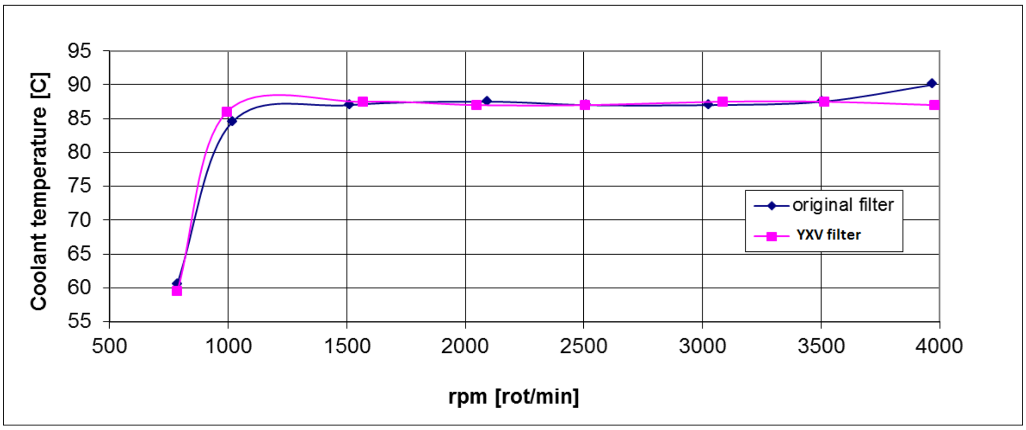


Figure 11. Coolant temperature versus engine idle speed

From Figure 11, we can deduct that there are no major differences in the coolant temperatures when using the two filters.

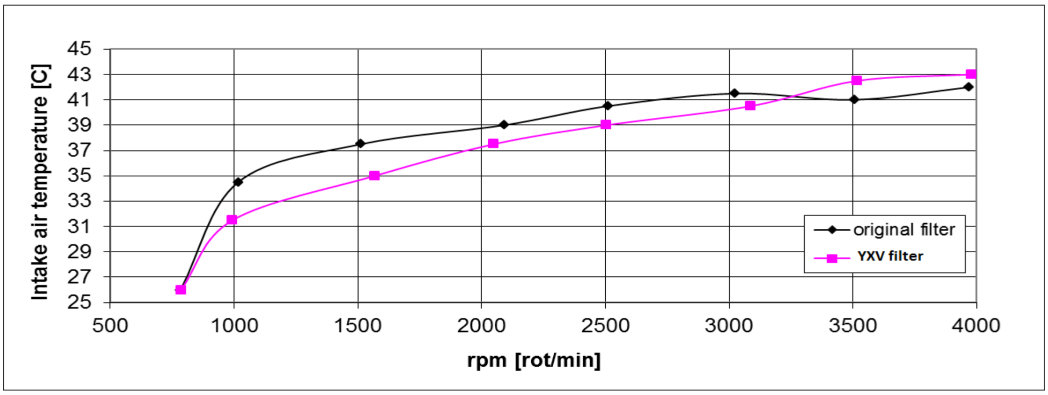


Figure 12. Air temperature in the intake manifold versus engine idle speed

From Figure 12, it can be concluded that, up to a speed of 3300 rpm, the air temperature in the intake manifold, when using the YXV filter, is lower than that obtained when using the original filter, situation beneficial for the cylinder filling process, because a lower air temperature when entering the engine means a higher density, and therefore a larger amount introduced into the cylinders, with beneficial consequences for the engine power.

The most important parameter monitored during the tests was the hourly fuel consumption, in litres/hour. In figure 13, we can see the variation of the hourly fuel consumption with the engine speed, for the cases when the engine is running equipped with the original filter and with YXV, respectively. It appears that, from speed values around 1000 rpm, the fuel consumption begins to decrease considerably when using the YXV filter.

The percentage difference between the hourly consumption with original filter and the hourly consumption with YXV is calculated using the relation:

$$d = 100 - \frac{Ch_{FSU70}}{Ch_{original.\,filter}} \cdot 100 \ [\%] \tag{1}$$

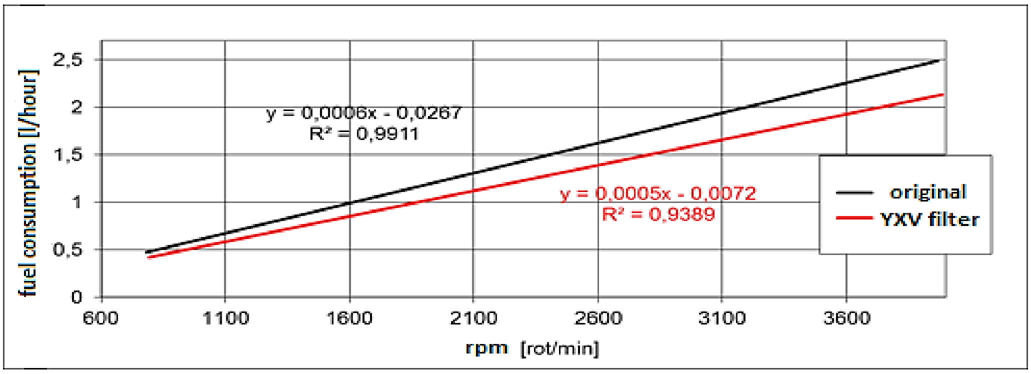


Figure 13. Hourly fuel consumption versus engine idle speed

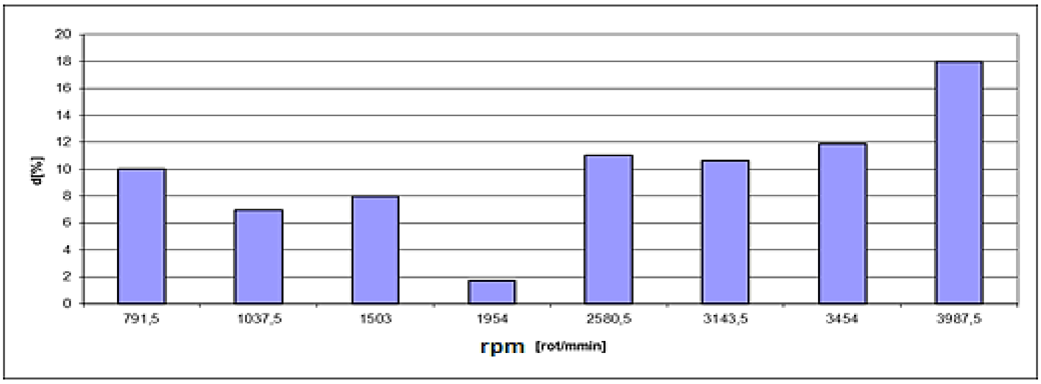


Figure 14. The percentage consumption difference

In figure 14, we can see that the percentage difference is positive at all the engine speeds. The positive values show lower fuel consumption than in case of the original filter.

Throughout the speed range used for conducting the tests, the reduction of fuel consumption by using the universal super absorbing YXV filter is 9.78%.

Following the conducted researches and monitoring of the behaviour when installing the filter on various types of engines, we concluded that this one has a number of advantages, such as:

- being in contact with the air, the filter element ensures a minimum gas-dynamic resistance to the absorbed air, increasing thereby the absorption and capture rates;
- the self-cleaning possibility of the filter element;
- visualisation of the filter element, without the prior removal of the filter, for checking its pollutant loading level;
- the capacity of air filter housing to significantly increase the speed of absorbed air, both at the input and output of the filter;
- the ability to "pre-cool" the air drawn inside it;
- the ability to create a slightly boost, which increases proportionally to the vehicle movement speed.

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ESTIMATION OF GLOBAL SOLAR RADIATION IN SERBIA

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Abstract): The most commonly used parameter for estimating global solar radiation is sunshine duration because it can be easily and reliably measured and data are widely available. This study presents an analysis of the relationship between global solar radiation and the sunshine duration at different locations in Serbia. Several regression methods, which were previously used by researchers, were used to analyze. The global solar radiations estimated from the twelve models were compared with the measured values. The estimated values are compared with the measured values in terms of percent error, mean bias error (MBE), root mean square error (RMSE), and mean percent error (MPE). Comparisons show that the second and the third model performed better than the other models used in the paper, but the second model is preferred due to its simplicity and wider application. Further a general formula which estimates the global radiation over Serbia is suggested. The proposed model shows a good agreement (less than 6 % deviation) and could be used to other locations in Serbia where solar data are not available.
Key words: solar radiation, sunshine duration, measured values, regression models

INTRODUCTION

In the design and study of solar energy, information on solar radiation and its components at a given location is very essential. A global study of the world distribution of global solar radiation requires knowledge of the radiation data in various countries and for the purpose of worldwide marketing, the designers and manufacturers of solar equipment will need to know the global solar radiation available in different and specific regions. Since the solar radiation reaching the earth's surface depends upon the climatic conditions of the place, a study of solar radiation under local climatic conditions is essential. The measurement of solar radiation requires pyranometers, but this instrument is not easily available due to cost, the maintenance and the calibration. The measured data are the best form of this knowledge, but there are few meteorological stations that measured solar radiation, especially in developing countries. In Serbia, global solar radiation data on a horizontal surface is recorded at only 4 stations.

For stations where no measured data are available the practice is to estimate global solar radiation from other measured meteorological parameters. Several empirical models have been used to calculate solar radiation, using variables such as extraterrestrial irradiance and measured and theoretical sunshine duration, air temperature, relative humidity, and wind speed and moisture. In this paper the global solar radiation models available in the literature for the selected locations are presented. The first purpose of the present paper is to validate those models for the prediction of monthly average daily global radiation on a horizontal surface from sunshine duration that can be used later in estimating global solar radiation over Serbia. The second objective is to test the performance of the presented models against the measured global radiation for selected locations and determine the general model for evaluating solar global radiation over Serbia.

MATERIAL AND METHODS

Models and data

For this analysis the measured data of monthly average daily solar radiation, sunshine duration and temperature are used from the Study of Energy Potential of Serbia, published by the Serbian Ministry of Science. The study was based on data collected over 34 years (1957-1991). Measurements of global solar radiation on three different locations were performed with Moll-Gorczynsky pyranometers. For the recording of sunshine duration Campbell-Stokes heliographs were used. The geographical location of stations is presented in Table 1.

Table 1. Geographical location of meteorological stations

Station	Latitude (ºN)	Longitude (ºE)	Altitude (m)
Belgrade	44º 47’	20º 32’	243
Negotin	44º 14’	20º 33’	42
Zlatibor	43º 44’	19º 43’	1029

Twelve different regression models proposed in the literature were applied in this study (linear, quadratic, polynomial third degree, logarithmic and exponential). Coefficient values for models were calculated from regression analysis between H/H_o and S/S_o for a long period of time and each month.

Linear models

Model 1: The most used model for estimation of monthly average daily global solar radiation on a horizontal surface is the Angstrom-Prescott-Page model, [1]:

$$H/H_o=a+b(S/S_o) \quad (1)$$

where H is daily solar global radiation on an horizontal surface, H_o is the monthly average daily extraterrestrial radiation, S is the monthly average daily hours of bright sunshine, S_o is the monthly average day length in hours, and a and b are empirical coefficients depending on location, which can be determined either experimentally or empirically. The regression coefficients of the model 1 for analyzing locations are given in Table 2.

Model 2: Correlation which is proposed to be applicable anywhere in the world is given in Rietveld’s model, [1]:

$$H/H_o=0.18+0.62(S/S_o) \quad (2)$$

Model 3: Glover and McCulloch's model takes into account the latitude effect as quoted by DeMiguel *et al*. [2], which depends on latitude ϕ and is valid for $\phi < 60^o$:

$$H/H_o=0.29\cos\phi+0.52(S/S_o) \quad (3)$$

Model 4: Dogniaux and Lemoine have proposed following equation, where the regression coefficients *a* and *b* seem to be as a function of ϕ in average and on the monthly base in these equations, [3]:

$$a=0.3702-0.00313\phi; \quad b=0.32029+0.00506\phi \quad (4)$$

Model 5: Gopinathan suggested following equation and regression coefficients in terms of the latitude ϕ and the site altitude *Z* (in kilometers), and percent of possible sunshine that is applicable to any location around the world, [3]:

$$H/H_o=[-0.309+0.539\cos\phi-0.0693Z+0.290(S/S_o)]+[1.527-1.027\cos\phi+0.0926Z-0.359(S/S_o)]\cdot(S/S_o) \quad (5)$$

Quadratic models

Model 6: Akinoglu and Ecevit obtained the correlation between H/H_o and S/S_o in a next second order polynomial equation, [3]. The regression coefficients of the model 6 for analizying locations are given in Table 2.

$$H/H_o=a+b(S/S_o)+c(S/S_o)^2 \quad (6)$$

Model 7: Ogelman *et al*. have given the following form of second order polynomial equation, [4]:

$$H/H_o=0.195+0.676(S/S_o)-0.142(S/S_o)^2 \tag{7}$$

Cubic models

Model 8: Ertekin and Yaldiz derived three-order polynomial relationships between the monthly average values of H/H_o and S/S_o, [5]. The regression coefficients of the model 8 for analizying locations are given in Table 2.

$$H/H_o=a+b(S/S_o)+c(S/S_o)^2+d(S/S_o)^3 \tag{8}$$

Model 9: Zabara proposed monthly *a* and *b* values of the modified Angstrom model as a third order function of maximum possible sunshine duration S and day length S_o, [2]:

$$a=0.395-1.274(S/S_o)+2.680(S/S_o)^2-1.674(S/S_o)^3 \tag{9}$$
$$b=0.395+1.384(S/S_o)-3.249(S/S_o)^2+2.055(S/S_o)^3 \tag{10}$$

Model 10: Bahel *et al.*developed a worldwide correlation based on bright sunshine hours and global radiation data of 48 stations around the world, with varied meteorological conditions and a wide distribution of geographic locations, [3]:

$$H/H_o=0.16+0.87(S/S_o)-0.61(S/S_o)^2+0/34(S/S_o)^3 \tag{11}$$

Logarithmic models

Model 11: Ampratwum and Dorvlo used the following equation to estimate the global radiation which includes a logarithmic term, [6]. The regression coefficients of the model 11 for analyzing locations are given in Table 2.

$$H/H_o=a+b\,ln(S/S_o) \tag{12}$$

Table 2. The regression coefficients of models No. 1, 6, 8 and 11

Location	Model No.	a	b	c	d
Belgrade	1	0.259	0.502	-	-
	6	0.174	0.929	-0.494	-
	8	0.096	1.559	-2.068	1.239
	11	0.656	0.203	-	-
Negotin	1	0.254	0.598	-	-
	6	0.202	0.870	-0.315	-
	8	0.660	-2.682	8.232	-6.475
	11	0.727	0.238	-	-
Zlatibor	1	0.339	0.334	-	-
	6	0.358	0.230	0.132	-
	8	0.017	3.062	-7.302	6.251
	11	0.591	0.123	-	-

Model 12: Newland [7] has given the following equation with a logarithmic term:

$$H/H_o=0.34+0.40(S/S_o)+0.17\,log(S/S_o) \tag{13}$$

Statistical tests

The performance of the models was evaluated on the basis of the statistical indicators: the mean bias error (MBE), the root mean square error (RMSE), and the mean percentage error (MPE), [8]. These tests are the ones that are most commonly applied in comparing the models of solar radiation estimations. The MBE provides information on long-term performance and reveals whether a given model has a tendency to under or over predict. A positive value of MBE shows an over-estimate while a negative value represents an under-estimate by the model, with MBE values closest to zero being desirable.

$$MBE=(1/n)\cdot \sum(H_{im}-H_{ic}) \tag{14}$$

where H_{im} is the ith measured value, H_{ic} is the ith calculated value, and n is the total number of observations.
The value of RMSE is always positive, representing zero in the ideal case. The normalized root mean square error gives information on the short term performance of the correlations by allowing a term by term comparison of the actual deviation between the predicted and measured values. The smaller the value, the better is the model's performance, but a few large errors in the sum can produce a significant increase in the indicator.

$$RMSE=[(1/n)\cdot\sum(H_{im}-H_{ic})^2]^{1/2} \tag{15}$$

It is possible to have large RMSE values at the same time a small MBE or vice versa. The use of RMSE and MBE statistical indicator is not adequate for the evaluation of the model's performance but usage MPE in addition to RMSE and MBE give more reliable results.
The MPE is the percentage deviation of the calculated and measured data of monthly average daily global solar radiation. A positive MPE value provides the average amount of overestimation in the calculated values, while the negative value gives underestimation. A low value of MPE is desirable.

$$MPE(\%)==(1/n)\cdot\sum[(H_{im}-H_{ic})/H_{im}]\cdot 100 \tag{16}$$

RESULTS AND DISCUSSION

The accuracy of different models was determined using the data measured at Belgrade, Negotin and Zlatibor for the 34 years. The values of monthly mean daily global solar radiation intensity were estimated using the above models and were compared with the corresponding measured values. The statistical tests of MBE, RMSE and MPE were determined using measures of sunshine hours and monthly average daily solar radiation at given location for the entire period, and the results are summarized in Table 3.

Table 3. Model validations under different statistical tests

Model No.	Belgrade			Negotin			Zlatibor		
	MBE	RMSE	MPE	MBE	RMSE	MPE	MBE	RMSE	MPE
1	0.007	0.069	-2.89	0.015	0.121	-2.00	-0.004	0.078	18.89
2	0.156	0.192	5.45	0.485	0.531	12.84	0.242	0.273	9.26
3	0.337	0.369	9.33	0.643	0.723	15.58	0.349	0.359	11.47
4	0.058	0.102	1.88	0.375	0.435	8.86	0.101	0.154	4.72
5	-0.061	0.242	1.52	0.257	0.301	9.19	0.245	0.363	11.5
6	0.012	0.046	0.10	0.007	0.102	-0.07	-0.003	0.073	0.21
7	0.113	0.138	3.49	0.440	0.498	10.72	0.159	0.194	6.54
8	0.011	0.046	0.60	0.000	0.098	-0.15	-0.013	0.060	-0.04
9	0.084	0.118	2.48	0.403	0.466	9.41	0.132	0.173	5.63
10	0.205	0.228	5.94	0.532	0.598	13.02	0.247	0.262	8.92
11	0.011	0.045	0.02	0.009	0.105	-0.15	-0.012	0.096	-0.04
12	0.180	0.201	5.68	0.511	0.567	13.05	0.236	0.259	8.94

According to the results from the Table 3 it can be seen that the MBE values of all models are close to zero as desired. It was found that the MBE values ranged between the following minimal and maximal values: 0.007-0.337 for Belgrade, 0-0.643 for Negotin and 0.003-0.349 for Zlatibor. Furthermore, models 1, 6 and 8 has the lowest MBE values, while the maximal MBE values for all the stations are obtained from model 3.

The other statistical parameter RMSE shows that there is the permissible error in the measured values using the different models: RMSE values ranged between 0.045-0.369 for Belgrade, 0.098-0.723 for Negotin, and 0.060-0.363 for Zlatibor. The lowest RMSE values for all the stations are obtained using the models 8 and 11, while the highest RMSE values are obtained with models 3 and 5.

The comparison between the models according to the MPE values shows that the estimated values of monthly mean daily global solar radiation are within 10 % for Belgrade, 16 % for Negotin, and within 19 % for Zlatibor. According to the MPE values, the lowest errors are obtained with model 6, 8 and 11, and the highest with models 1 and 3.

Utilizing a combination of 3 stations in Serbia, it has been shown that the global solar radiation across the country can be related to the relative sunshine duration. The values of the regression coefficients obtained for all the stations were found to be different. These differences suggest that the regression coefficients associated with meteorological data changes with latitude and atmospheric conditions.

According to the results, the model 6 (second regression model) is recommended for the estimation of monthly average daily global solar radiation. Averaged measured data from the selected stations were used in developing the second regression model for estimating solar radiation over Serbia:

$$H/H_o=0.254+0.632(S/S_o)-0.175(S/S_o)^2 \tag{17}$$

Comparison of the measured and calculated total monthly global solar radiation using equation (17) for different locations is given in Fig. 1. From the results, it is found that the correlation in autumn and winter have better performance than in spring and summer. The maximum percentage of MPE with new constants goes up to 6 %, while maximum values of MBE and RMSE are 0.291 and 0.369, respectively. Therefore, it is concluded that the new model given by equation (17) can be used to estimate the global solar radiation in Serbia.

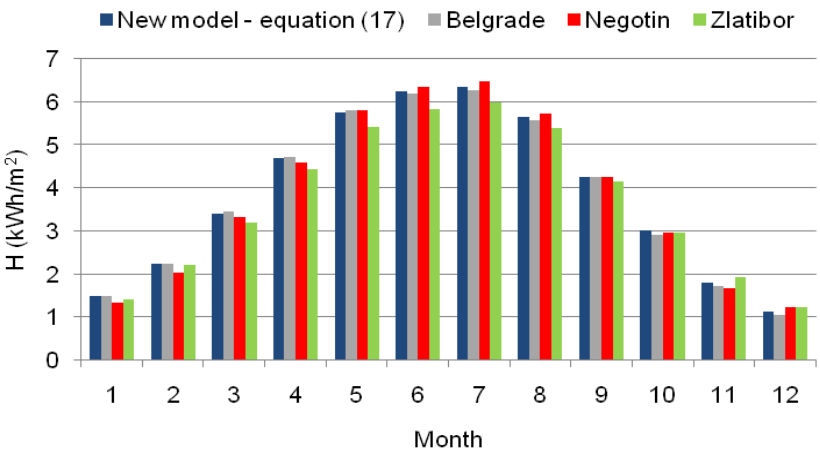

Figure 1. Comparison of the measured and calculated monthly global solar radiation on horizontal surfaces with New-model equation (17)

CONCLUSION

Utilizing a combination of 3 stations in Serbia, it has been shown that the global solar radiation across the Serbia can be related to the relative sunshine duration. The values of the regression coefficients obtained for all the stations were found to be different. These differences suggest that the regression coefficients associated with meteorological data changes with latitude and atmospheric conditions. According to the results new model given by the second regression equation is recommended. A fairly good agreement (MPE $\leq$ 6 %) was noted between measured values and calculated values of solar radiation, which makes proposed equation useful for estimating solar radiation in Serbia. Future work is being carried out with a view to enlarge the scope by increasing the number of the meteorological data.

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DEGRADATION OF POLYMER TRANSPARENTS COVER FLAT-PLAT SOLAR COLLECTORS

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Abstract: The energy efficiency of the solar collectors reduces through the exploitation time. In order to stop it, it is indispensably to identifly the degredation factor and to establish their influence on the energy efficiency. In the paper are given the results of the experimental researches of the degradation influence on the perviousness coefficient of the sun radiation of the polymer trasparent covers. There has been also measured the outlet energy, taking into consideration the age of the transparent cover.
Key words: polymer, transparent cover, solar collector

INTRODUCTION

The energetic characteristics of the solar collectors over the exploitation period succumb to different degradation effects [1]. The result of this phenomenon is the fall of the energy efficiency of the solar collectors. In order to influence on the decrease of this occurrence, it is necessary to perform the identification and the quantification of the efficiency of the degradation factors.

MATERIAL AND METHODS

The transparent cover ought to insulate thermally the space of the receiver from its front acceptor side, along with the simultaneous ensuring as better as (it is) possible the perviousness of the sun radiation being used for the heating of the heat carrier. That means that the material of which was made the transparent, has to have as much as higher the transmittance coefficient. At the same time this material ought to have as low as possible the coefficient of absorption and reflection. The materials most often used for the manufacture of the transparent cover of the solar collectors are: glass and transparent plastic materials. In view of the efficiency and the working time of the solar collector, there should be performed the analysis of the optical, mechanical and thermal characteristics as well as time steadiness (stability) of some characteristics of the transparent. The most important optical characteristics of the transparent cover are the index of the light refraction and the luminous / perviousness. At the space of the sun spectrum the transparent plastic materials also have the sufficient perviousness, while at the infrared (long wave) radiation area, the transparency of glass decreases. The transparent cover of the plastic materials is not liable to that effect. The luminous perviousness of some kinds of plastic materials, except for the plate thickness, depends as well on the molecules complex out of which the plastic is made, in other words of the kinds of connections inside those molecules [2].
The thermal – mechanical characteristics of the transparent have to meet the endurance conditions from the external effects as: loading with wind and snow, the aggressive action of the atmosphere and thermal constraints. The thermal durability of the flat glass is its weaker characteristic, because the glass can crack on account of the “thermo - shock”. The thermo – shock appears due to the sudden changes of temperature, because of abrupt rainfall onto still warm transparent [3]. Some of plastic materials have bad technical resistibility, i.e. high coefficient of thermal expansion. Recently have been achieved the improvements of this characteristic, with so – called fillers (as glass power and the like). These materials are relatively soft [4], so their surfaces can be easily damaged and it, in the course of time, causes dirtiness of the transparent (dust settling and the appearance of numerous micro – cracks), so its luminous perviousness can be reduced. Glass covers have not such drawbacks, but their imperfection is remarkably greater weight and brittleness as well as higher price.
Polymeric glazings offer significant potential for cost savings both as direct substitutes for glass cover plates in traditional collector systems and as an integral part of all-polymeric systems [5,6]. This savings includes both base material cost and costs associated with shipping, handling and installation (due to their lightweight and lack of fragility). Glazings should have high transmittance across the

solar spectrum and must be able to resist long term (10-20 years) exposure to service conditions including elevated operating temperatures (55-90°C) and solar ultraviolet (UV) light [7,8]. They must retain mechanical integrity (for example, impact resistance and flexural rigidity) under these harsh environmental stresses. Recent efforts have emphasized: 1) identification of new/improved candidate glazings, 2) evaluation of optical and mechanical durability during exposure to actual and simulated service conditions, and 3) adoption of a general methodology of accelerated life testing to the durability assessment of polymeric glazing materials. The degradation of the optical characteristics of the transparent cover is caused by different mechanical or physical – chemical processes as [9]: the changes in material because of stabilization, the ultraviolet effects of the sun radiation, the effects of the aggressive substances from the atmosphere and storing of the evaporation– the components from the paint of the absorber onto the internal surface of the transparent.

RESULTS AND DISCUSSION

Experimentally have been tested the samples of the polyester laminate (commercial name "Evalon"), which is according to its chemical composition ortophtal unsaturated polyester with 30% styrone with non – alkaline glass fibre. The samples are of the same geometric characteristics and various age. There has been performed the testing of the perviousness coefficients of the global and diffuse sun radiation depending on the radiation incidence angle. This angle is defined as the angle between the direction of the direct radiation and its projection at the sample plane. The measuring was performed in the environment which is by its characteristics similar to the black body providing the lack of the effect of the reflection of the environment radiation. The diffuse radiation was measured using the screen for the cupola hatching, according to the standard for the gauge (or the measuring standard) of the diffuse radiation. The measurement results were recorded only when the intensity of global radiation has not varied more than 2% - in the measuring period. All the measurement have been performed under the conditions without cloudiness or in the partial presence of clouds – but in that case compulsorily out of the angle 90^0 cone, so not to appear the unstable measuring conditions in regard to the radiation quality. For measuring the luminous perviousness have been used 17 samples. The measuring results for three samples are graphically presented on the diagrams (Fig. 1, 2). The results point out the significant fall of the luminous perviousness of the samples that are 10 and 20 years old in relation to the new material of the direct and diffuse sun radiation. The fall of the luminous perviousness is the result of the aging and the action of the external climatic conditions on the transparent. With regard to the energetic degradation PSE with the plastic materials, the more important is the fall of the luminous perviousness on the direct sun radiation, than the fall of the luminous perviousness on the diffuse radiation (that is only 8% of the total radiation). Interesting is the effect this degradation will have on the collector energy output Qcol. Figure 3 faces the yearly energy output of the collector without taking into account degradation (Qcol standard) with the yearly energy gain delivered by the present simulation with consideration of the degradation process. Qcol standard remains unchanged over the whole period, as no degradation was considered. Even though only an assumed degradation of the parameters was considered, the comparison of both simulations makes clear that the loss due to degradation might constitute a considerable part in the course of 20 years.

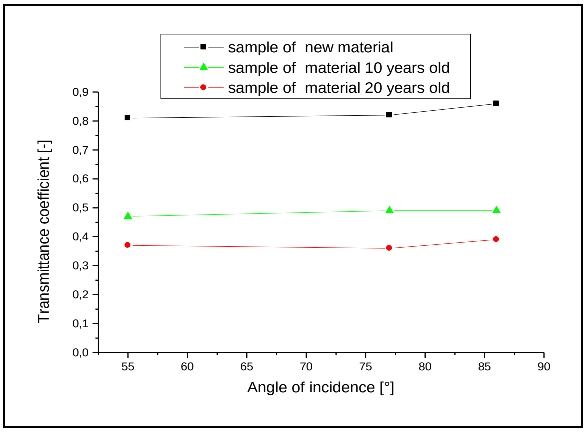

Figure 1. The fall of the transparent characteristic of the global radiation of the various age samples

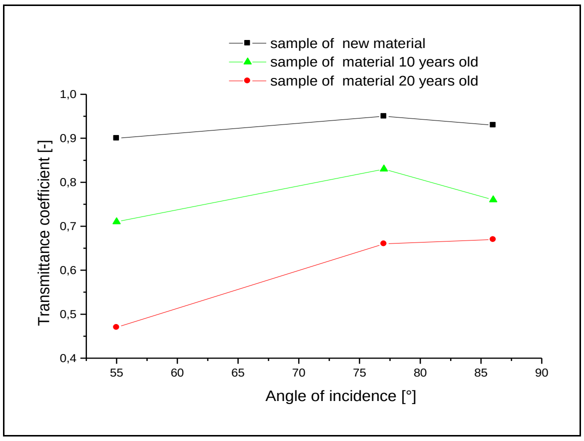

Figure 2. The fall of the transparent characteristic of the diffuse radiation of the different age samples

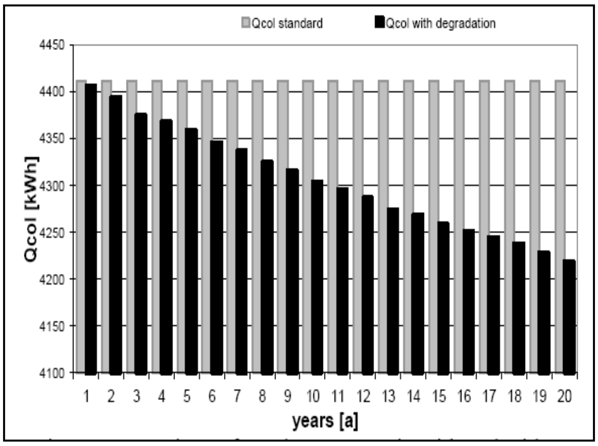

Figure 3. Comparison of yearly energy gain with and without consideration of degradation progress

CONCLUSION

The degradation process has significant influence on the energetic efficiency of the solar collectors during the exploitation time. The energy output of solar thermal collectors can be influenced considerably through degradation processes. In order to be able to calculate the change of performance with time due to degradation effects, the degradation processes have to be implemented in a collector model. In order to be able to give reliable forecasts, additional investigations are necessary so that a uniform accelerated testing procedure can be developed. One important aspect, would be the establishment of a relationship between accelerated ageing in laboratory and ageing under operating conditions.

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SOLAR TECHNOLOGIES IN PRACTICE

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Abstract: This paper presents the evaluation of the potential of solar energy in Serbia. We have shown the significance of use of solar thermal and PV systems with the economic and environmental aspects. An analysis was carried out to determine possibilities of "production" and the use of solar energy.
Key words: solar potential, possibility of "production", solar tehnology

INTRODUCTION

Serbia has the potential of producing energy annually - 700 to 900 and more (depending on the system efficiency, working mode and other) kWh/m2 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.
Solar energy is very attractive and economically justified for use when heating of households, industrial and other facilities is in question. Solar systems provide a considerable energy savings. In this way, for example, solar house saves 40% of the energy for heating, 80% of energy for heating consumable water. It uses significant potentials that are provided by solar roof-covers and facades, for providing additional energy. Solar systems provide:

- better energy efficiency,
- considerable energy savings,
- long-term function,
- energy result,
- through derived energy- pay off of the investment,
- favorable relation of price and performance,
- simple installation.

Thermal and photovoltaic systems

The use of solar energy for heating water in the pools is rather other application in the world. The installation is simply joined to the existing systems for heating water in the pools, and two main concepts are applied. According to one concept solar installation is used separately from the existing conventional installation for pool water heating and the second conception is based on connecting solar installation and conventional installation into one - sequence system. In first case those are usually simpler installations for smaller and open home swimming pools, and they usually use (and cheaper) solar collectors which are not glass-plated (and cheaper) - absorbers which are most often made out of ultraviolet stable plastic masses. In the second case, returned - colder swimming pool water is first preheated by using solar energy (via heat exchangers), and after that it is heated till the needed temperature (if this is the aim) in conventional heating system. In this case classical, glass-plated, flat solar collectors, by which better heating, even in colder weather conditions and that with -

mostly larger closed swimming pools- is provided , can be used. Then the scheme of the installation is similar to the scheme of the previously presented systems for water heating in combination with conventional heat source.
The production of photovoltaic mechanisms doubles every year with average growth of 48% since 2002, so that this line of industry shows the biggest development in the world, in comparison with the rest of energy technology lines. From the economic aspect the price of the electricity derived from solar energy is continuously falling as a result of technological enhancements and growth of mass production, while it is expected that the fossil fuels will become significantly expensive in the near future. At this time for Serbia it is more justified to encourage the use of energy from solar radiation for the production of heating and electricity for households, industry and some agricultural works because of smaller investments. Encouragement and building of larger solar power plants on the basis of photovoltaic systems is justified as well. This policy would, among the rest, be useful for the development of domestic economy as well as the employment of people in the field of clean energies. But viewed long-term, the future of converting solar radiation is in PV technology and its integration with other branches of technology, which is in accordance with the attitudes, plans and current condition in the European Union and other economically leading countries of the world. Due to this, only mechanisms and systems based on photovoltaic conversion of solar energy and suitable program, plans and possibilities for use and development in Serbia, are being discussed in further presentation.
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 payoff 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 payoff 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.

CONCLUSION

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.
It should be implemented that big consumers of energy - especially those who spend more energy per product (have bigger specific energy consumption) - have the obligation of gradual, segmental, partial introduction to the use of alternative sources of energy (solar energy included) - for their own needs. From development funds of electro industry, solar installations in the objects that have better accommodation and exploitation possibilities (refers to private sector, but also public - especially those on the budget) should be financed. This would have benefits for energy system and as an element of broader use of this energy source popularization. Ecological effects are also significant. Law on Energy should be corrected in accordance with previously mentioned.

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Engineering environmental protection and safety at work

BUILDINGS ENERGY CONSUMPTION AND RELATED CO_2 EMISSIONS

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Abstract: Energy is one of the greatest challenges of modern society and fundamental condition for progress in a number of areas and technologies. Energy Management System seeks continuous implementation of energy efficiency measures and sustainable management of resources whose end result is to reduce energy consumption, reduce greenhouse gas emissions and reduce energy financial cost. Paper reviews the impact of energy consumption on the amount of carbon dioxide emitted into the atmosphere as a result of measures taken within the Energy Management System in buildings .
Key words: CO_2 emission, Energy Management System.

INTRODUCTION

Today environmental protection is imperative for every local community and is an integral part of socially responsible behavior. Experience shows that in developed countries buyers leading priority in choosing the products, goods and services is the attitude that manufacturers and suppliers have toward environment pollution protection. Energy consumption is closely related to environmental pollution. The fossil fuels consumption (oil, gas, coal) release in the atmosphere many pollutants, especially CO_2, which is considered as main cause of global climate change. Therefore, any irrational use of energy basically means polluting the environment.
Besides creating the so-called "green" image, i.e. the image that declares a commitment to preserving the environment, the rational consumption of energy will also reduce future costs associated with non-compliance with environmental protection regulations, so called environment pollution taxe rates.

ENERGY MANAGEMENT SYSTEM AND CO_2 EMISSIONS ESTIMATION

Energy Management System (EnMS) is directly related to environmental protection. Useful forms of energy, such are electricity or thermal energy, are usually obtained from burning fossil fuels (coal, oil and natural gas). Therefore, by reducing the consumption of electricity or thermal energy through the Energy Management System implementation, the reduction of burned fossil fuels, and respectively pollutants emissions can be done.
As a result of fuels burning flue gases are emitted in the atmosphere, including carbon dioxide, CO_2, sulfur dioxide SO_2 and nitrogen oxides. Carbon dioxide (CO_2), which occurs as a result of fossil fuels burning, has the greatest impact on global warming. Therefore, the impact of reduced energy consumption on global warming is observed primarily by reducing the emission of CO_2. Fuels contain a certain amount of carbon which in one part is turned into carbon dioxide.
CO_2 emissions associated with the fossil fuels burning can be calculated as follows [1,2]:

$$EM = EF_C \cdot H_l \cdot O_C \cdot \frac{44}{12} \cdot B \tag{1}$$

where:
EM - CO_2 emissions [kg],
EF_C - factors which connect the fossil fuels consumption with appropriate carbon emission rate, [kgC/GJ]
H_l - Net or low heating value of fuel ([MJ/kg] or [MJ/m^3]),
O_C - carbon part which is released during the combustion process
44/12 - stoichiometric ratio CO_2 and C, and
B - amount of fuel used ([t] or [10^3 m^3]).

Table 1. Parameters values needed to calculate CO_2 emissions gained from fossil fuels burning using IPCC methodology

Fuel	$\boldsymbol{EF_C}$	$\boldsymbol{H_l}$	$\boldsymbol{O_C}$	$\boldsymbol{EF_C \cdot O_C} \cdot \frac{44}{12}$
	[kg C/GJ]	[MJ/kg] or [MJ/m^3]	-	[kg CO_2/GJ fuel]
Extra light fuel oil - EL1	20,2	42,71	0,990	73,33
Heavy fuel oil - M1	21,1	40,19	0,990	76,59
Liquefied petroleum gas (LPG)	17,2	46,89	0,990	62,44
Anthracite	25,8	24,30	0,980	92,71
Brown coal	26,2	18,20	0,980	94,15
Lignite	27,6	12,15	0,980	99,18
Natural gas	15,3	34,00	0,995	55,82

Table 1 presents the list of values described above which are necessary to estimate CO_2 emissions created by the fossil fuels burning using IPCC methodology (IPCC stands for Intergovernmental Panel on Climate Change) [1,2].
CO_2 emissions also occur in the biomass or bio fuels burning, but according to the IPCC recommendations it should not be calculated considering that it is CO_2 which plants absorb from the atmosphere during their growth period.

COMMONLY USED CO_2 EMISSION FACTORS

Several different organizations and institutions have proposed various CO_2 emission factors values that should be used for different types of energy and fuels [1-4].

Table 2. Energy value of a certain type of energy and fuel

Type of energy / fuel	[kJ]		[kgoe]		[kWh]	
1 [kg] Coke	28 500		0,676		7,917	
1 [kg] Anthracite	17 200	30 700	0,411	0,733	4,778	8,528
1 [kg] Lignite briquettes	20 000		0,478		5,556	
1 [kg] Brown coal	10 500	21 000	0,251	0,502	2,917	5,833
1 [kg] Lignite	5 600	10 500	0,134	0,251	1,556	2,917
1 [kg] Oil shale	8 000	9 000	0,191	0,215	2,222	2,500
1 [kg] Peat	7 800	13 800	0,186	0,330	2,167	3,833
1 [kg] Peat briquettes	16 000	16 800	0,382	0,401	4,444	4,667
1 [kg] Heavy fuel oil - M1	40 000		0,955		11,111	
1 [kg] Extra light fuel oil - EL1	42 300		1,010		11,750	
1 [kg] Gasoline	44 000		1,051		12,222	
1 [kg] Paraffin	40 000		0,955		11,111	
1 [kg] Liquefied petroleum gas	46 000		1,099		12,778	
1 [kg] Natural gas(1)	47 200		1,126		13,10	
1 [kg] Liquefied natural gas	45 190		1,079		12,553	
1 [kg] Wood (25% moisture)(2)	13 800		0,330		3,833	
1 [kg] Pellets/wood briquettes	16 800		0,401		4,667	
1 [kg] Waste	7 400	10 700	0,177	0,256	2,056	2,972
1 [MJ] Produced heat	1 000		0,024		0,278	
1 [kWh] Electricity	3 600		0,086		1(3)	

Source: Eurostat.
(1) 93% Methane.
(2) EU Member States can apply other values depending on the type of wood mostly used in the respective Member State.
(3) To the saved electricity [kWh], Member States may apply automatically coefficient of 2.5, which reflects the estimate of 40% of the average efficiency of energy produced in European Union standardized values during the period considered. Member States may apply a different coefficient if they can justify it.

These values for the same type of energy or fuel can differ depending on the source, primarily because of the different values of the fuel net (lower) heating value and carbon emission factor contained in the fuel which are input parameters in the calculation of carbon dioxide emission factor per heat energy unit contained in the respective fuel or by fuel unit.

If one can obtain the data on the fuel heating value used in the object which have been analyzed, the emissions estimation should be done using these values. Otherwise, data from Table 2 can be used instead [1].

Table 3 provides values for the CO_2 emission factors per unit of fuel, per unit of heat energy contained in the fuel and per unit of useful heat obtained [2]. When estimating the emission factor per unit of useful heat obtained, average efficiency values for stationary energy devices burning individual fuels are applied. In this way the uncertainty of the estimation is increased, so the recommendation is to use the emission factor per unit of fuel, [kgCO_2/kg(or m^3)], or per unit of heat energy contained in the fuel ([kgCO_2/GJ] or [kgCO_2/kWh]).

Table 3. Certain fuels CO_2 emission factors

Type of fuel	**CO_2 emission factors**		
	per unit of fuel	**per unit of heat energy contained in the fuel**	**per unit of useful heat obtained**
	[kg CO_2/kg (or m^3)]	[kg CO_2/kWh]	[kg CO_2/kWh]
Extra light fuel oil - EL1	3,13	0,264	0,318
Heavy fuel oil - M1	3,08	0,276	0,332
Liquefied petroleum gas (LPG)	2,93	0,225	0,264
Anthracite	2,31	0,334	0,439
Brown coal	1,79	0,339	0,446
Lignite	1,16	0,357	0,470
Natural gas	1,90	0,201	0,236

Table 4 provides the additional values for CO_2 emission factors for different types of energy and fuels, per unit of heat energy contained in the fuel [1].

Table 4. CO_2 emission factors for different types of energy and fuels

Type of energy / fuel	**CO_2 emission factors**
	[t CO_2/MWh]
Extra light fuel oil - EL1	0,267
Natural gas	0,202
Anthracite	0,394
Lignite	0,433
Heavy fuel oil - M1	0,279
Firewood	0
Motor gasoline	0,249
Diesel fuels	0,267
Liquefied petroleum gas (LPG)	0,227
Thermal energy (central heating)	0,259
Electricity from hydropower plants	0,007
Electricity from nuclear power plants	0,016
Electricity from coal fired thermal power plants	1,340
Electricity (CHP)	0,617

These factors are used to estimate the CO_2 amount which is reduced in total emission quantity of this pollutant, based on reduced energy consumption, energy or fuel type substitution, or by the implementation of some measures which can improve energy efficiency.

LOWER CO_2 EMISSION RATES AS A RESULT OF IMPLEMENTED MEASURES WITHIN THE ENERGY MANAGEMENT SYSTEM

Pollutant CO_2 emissions reduction can be estimate as a difference of emissions before and after the application of measures for improving energy efficiency, on annual level, according to the following equation:

$$EM_{RED} = EM_{BEFORE} - EM_{AFTER} \quad (2)$$

where:
EM_{RED} - CO_2 emissions reduction [kg],
EM_{BEFORE} - CO_2 emission, [kg], before the implementation of the measures, calculated by reference declared energy consumption;
EM_{AFTER} - CO_2 emission, [kg], after the measures application.

Thus, the total net savings of final energy per year is multiplied by the appropriate CO_2 emission factor, depending on the type of saved energy (electricity, liquid fuel, fuels used in heating systems etc.).
Total CO_2 emission also depends on the heating system efficiency, because, according to its value, a quantity of fuel consumed is changed. Comparison of CO_2 emissions for different heating systems is given in Figure 1 [2].

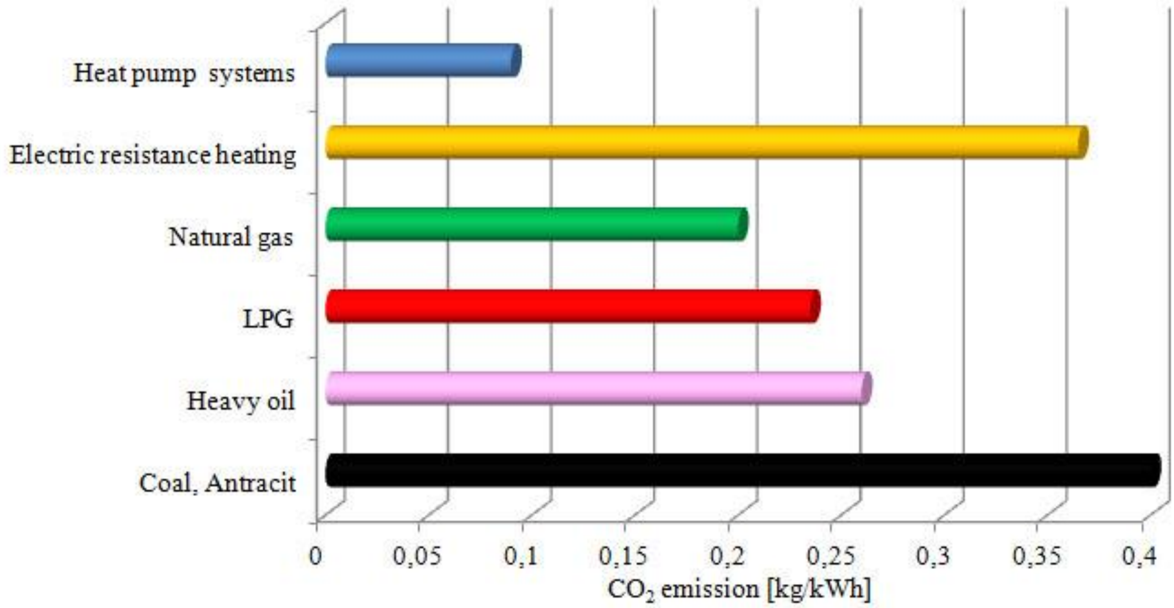

Figure 1. Guidelines on CO_2 emissions for various fuels and heating systems

The Energy Management System can incorporate many various measures which can contribute in improving energy efficiency, decreasing energy consumption, and thus reducing pollutants emission rates, including CO_2 emissions.
One of the possible measures that can be implemented in order to reduce CO_2 emissions into the atmosphere can be the substitution of the classical lamps with energy saving lamps. So, if only one 100 [W] classic lamp which is used 6 hours per day is replaced with energy saving lamp with power of 23 [W], which on other hand has the same light spectrum and intensity as the previous one, in one year the emissions of CO_2 can reduced by about 50 [kg].
Also, energy source/fuel substitution can be one important step that Energy Management System can include in order to reduce financial cost and pollutants emissions form one unit or building.
One such example is shown below.

EXAMPLE OF AN ENERGY SOURCES SUBSTITUTION AND INFLUENCE ON CO_2 EMISSIONS RATE

The building where Faculty of Technical Sciences - Bitola is placed has total heated area of 6000 [m^2], and for energy production for heating and obtaining domestic hot water extra light fuel oil is used.
The analysis considers an option that may be available in the future, replacing extra light fuel oil with natural gas.

Current Status

- To produce thermal energy for heating and preparation of domestic hot water extra light fuel oil is used.
- Annual consumption of extra light fuel oil for heating and preparation of domestic hot water is 60 [tons per year], with an extra light fuel oil energy value of 42.300 [kJ/kg] and density 860 [kg/m^3].
- Pipeline and the heating elements are in good condition, reconstructed two years ago and they have thermostatic radiator valves.
- The development of the infrastructure in the object location made natural gas available for use.
- The existing boiler room according to the characteristics doesn't meet the requirements of the Regulation on technical standards for the design, construction, operation and maintenance of natural gas boiler rooms (SFRY Official Gazette 10/1990 and 52/1990).

A description of the measures taken

- Substitution of extra light fuel oil and instead using natural gas for heat production.

Necessary Investments

Based on the bids submitted by potential contractors a certain amount of necessary investments is equal to a total of 13.530.000 MKD (220.000 Euro).
This amount includes investments in the following items:

- Station for measurements and natural gas pressure reduction (MRS).
- Electrical and mechanical equipment in boiler room (boiler, burner, circulating pumps, mixing valves, gas connection, stack elements etc.), together with the costs of dismantling the old and installation of new mechanical equipment.
- External gas network.
- Internal gas network.
- Construction and reconstruction works.
- Projects for: Station for measurements and natural gas pressure reduction (MRS), gas pipeline and connections, gas boiler room.

Estimation assumptions

- The natural gas energy value is 33.400 [kJ/m^3], and its density 0,69 [kg/m^3].
- Heat energy consumption doesn't depends from fuel type used, and thermal energy which should be provided by natural gas is equal to the thermal energy provided by extra light fuel oil, $E_{e.l.oil} = E_{n.g.}$, i.e.,

$$E_{e.l.oil} = 60.000 \times 42.300 = 2.538.000.000 \text{ [kJ per year]} \tag{3}$$

$$E_{e.l.oil} = 705.000 \text{ [kWh per year]} = 705 \text{ [MWh per year]} \tag{4}$$

- An assumption that long-term price of natural gas will be maintained at the current level of 28,8 [MKD/m^3] (0,49 [Euro/m^3]), VAT included, that is 3,10 [MKD/kWh] (0,05 [Euro/kWh]), is taken into account.
- The price of extra light fuel oil is 54,5 [MKD/liter] (0,89 [Euro/liter]), VAT included, that is 5,4 [MKD/kWh] (0,09 [Euro/kWh]).

Savings

- *Savings in heating energy (SHE):*

SHE = 0 (Heat energy consumption doesn't depends from fuel type used) (5)

- *Financial savings (FS):*

FS = Costs for extra light fuel oil ($C_{e.l.oil}$) - Costs for natural gas ($C_{n.g.}$) (6)

FS = $E_{e.l.oil}$ × 5,4 [MKD/kWh] - $E_{n.g.}$ × 3,1 [MKD/kWh] (7)

FS = 1.621.500 [MKD/year]= 26.366 [Euro/year] (8)

Investment return period (IRP):

IRP = Total investments / Financial savings per year (9)

IRP = 220.000 / 26.366 = **8,3 years** (10)

Used methodology: CO_2 emissions per unit of fuel [kg CO_2/kg (or m^3)]

As the relevant ratios of CO_2 emissions are taken following:
- 3,13 [kg CO_2/kg] for extra light fuel oil and
- 1,90 [kg CO_2/m^3)] for natural gas

Extra light fuel oil consumption: 60 [tons per year]

CO_2 emission as a result from extra light fuel oil combustion:

60.000 [kg] x 3,13 [kg CO_2/kg] = 187.800 [kg CO_2] (11)

Natural gas consumption:

2.538.000.000 [kJ/year] / 33.400 [kJ/m^3] = 75.988 [m^3/year] (12)

CO_2 emission as a result from natural gas combustion:

75988 [m^3/year] x 1,90 [kg CO_2/m^3] = 144.377 [kg CO_2] (13)

- CO_2 emission reduction (ERED) :

ERED = CO_2 emissions using extra light fuel oil - CO_2 emissions using natural gas (14)

ERED = 187.800 - 144.377 = 43.423 kg CO_2 per year = 43,4 [t CO_2 per year] (15)

Assessment gives the result that we should expect. Substitution of extra light fuel oil with natural gas besides financial savings, has benefit on the environment protection resulting on the reduction of greenhouse gases, primarily CO_2.

CONCLUSION

Energy consumption in buildings and its effects, primary on carbon dioxide emission rates, are analyzed in this paper.

Carbon dioxide emission rates caused by the raised energy consumption can be greatly reduced with the application of energy management system and its measures, particularly energy source/fuel substitution.

This measure can also have an effect on building reduced financial cost for energy.

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CRITERIA FOR GREEN AREAS FORMATION

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Abstract: Increase in urban population, environmental and social problems of modern cities and consequences brought by the industrial society including climate changes, require careful planning of cities including benefits of urban green areas in every stage of the city design and development. Environmental, economic and social benefits of green areas are recognized by every city resident, but information about their value finds its way to relevant institutions with difficulty so that already existing green areas are being dilapidated and often do not meet the required function. The aim of this paper is to analyze the criteria for green areas formation, for reaffirmation and improvement of the existing ones as well as for creation of new ones that meet the needs of the gravitating population.
Key words: urban green areas, criteria, green areas design

INTRODUCTION

It is a known fact that even though cities occupy only 3% of the globe surface, they include more than 50% of the world population which has increased from 1.6 billion to 7 billion people over the past 100 years. It is anticipated that this trend will continue and that in 2025 we can expect 8.2 billion people on the planet, of which 60% in the cities. The urban population is increasing much faster than the world one due to transfer of population from rural to urban areas, and the cities are becoming increasingly polluted. The pressure of the population on urban areas contributes to changes in the future planning of communities, cities, regions, etc.[1,8]
Most of environmental impacts of urbanization refer to the loss or degradation of green areas, which can cause major disruptions in the ecosystem such as loss of habitats or reduction of biodiversity. Built-up areas greatly hinder natural processes, and green areas are one of the possibilities to mitigate such interference. Advantages provided to the environment by urban green areas (UGA) are reflected in the local climate stabilization through air purification, cooling and mitigating urban heat islands. Green areas in cities affect noise reduction, CO2 storage, have positive effects on rainwater infiltration and water purification.[9] Urban green areas are a common good of the city and social benefits for residents of urban areas include mental and physical health improvement, stress reduction and relaxation through active and passive recreation. A contact with the nature and a sense of freedom that green areas offer to the population of urban areas is essential for mental health especially in times when we are directed to stay indoors because of our business activities. In addition to the aforementioned benefits of public green areas, economic benefits should not be ignored as city's locations near major parks have a higher value.
Because of their great importance, urban green areas should be designed so that they are qualitatively and quantitatively evenly distributed within urban agglomerations.

MATERIAL AND METHODS

Public green areas include parks and reserves, sports fields, banks of streams and rivers, green corridors and walkways, gardens, street trees, as well as less conventional areas such as green walls, green alleys and cemeteries. Private green areas include private yards, fields surrounding the buildings and the corporate greenery. [9]
Reviewing the literature we have identified the main problems that professionals face having to deal with them in the design of urban green areas related to the size of green areas, then to a proper selection of sites for urban green areas as well as to making a choice of an appropriate design and facilities that ensure proper use and sustainability of a green area. In order to solve the above problems, an analysis of the criteria in Table 1 was done, which was adapted for this study from the Interdisciplinary Catalogue of Criteria "Urban Green Environment" (URGE) Project and the relevant literature.

Table 1. Criteria for green area formation adapted from URGE Interdisciplinary Catalogue of Criteria [10]

No.	Criterion	Class range	Impact function	Remarks
1	Surface area of urban green spaces	<1ha	1	as large as possible a minimum of 4ha is recommended
		1-3ha	3	
		3-5ha	4	
		5-10ha	6	
		more than 10 ha	7	
2	Extent of edge effects Shape index	< 0.1	2	
		0.1-0.2	4	
		> 0.2	6	
3	Isolation from other green spaces Interpatch distance to the nearest neighbouring patch	> 500m	1	as close as possible max 500m
		500-250m	3	
		250-100m	5	
		< 100m	7	
4	Connectivity to other green spaces Presence of different types of green corridors that link a site to other green spaces	0	1	
		1 - 2	3	
		3 - 5	5	
		5+	7	
5	Soil sealing	> 20%	1	the less sealed soil the better
		10-20%	3	
		5-10%	5	
		< 5%	7	
6	Catchment area Number of potential users per urban green space	Class range must be defined according to local circumstances	1	recommendation: maximum number of potentioal users should be the size of greenspace divided by $6m^2$
			4	
			7	
	Accessibility	Number of entrances to the green site	1	
			6	
			7	
		Most common form of acces by users	1	
			3	
			7	
		Number of parking places closer related to the average number of visitors by car	3	
			4	
			5	
		Number and frequency of	1	

		public transport lines that connect the site to the built up area of the city	6	
			7	
		Obstacle to access	1	
			7	
7	Sport and play facilities	no	3	
		yes	6	
	Children's play equipment	none	1	
		some	3	
		many	7	
8	Safety- Existance of patrol/warden in and around the green site	no	3	
		yes	5	

RESULTS AND DISCUSSION

An attractive, safe and accessible park or a green area positively affect social and economic prosperity as well as environmental comfort, improving human health and quality of life. To achieve the greatest possible value of an urban green area and to ensure its proper use, it is necessary to observe certain guidelines and criteria for planning it.

1. The first criterion in formation of urban green areas is the size i.e. the total area of the site. The size of an urban green area determines to what extent it will be able to meet the users' needs and provide the opportunity for a variety of recreational activities. [5] Only a green area big enough can accept different contents such as space for recreational activities, children's playgrounds, events and so on, which will ensure its use.

Application of standards on the size of green areas is very simple and usually refers to the minimum area of UGA per person, however it must incorporate a criterion that relates to the needs of the gravitating population. A connection between designers and potential users should be established, and the needs arising from lifestyle, culture and heritage as well as the demographic structure of the population should be examined. [5]

The World Health Organization (WHO) has recommended min of 9m2 of urban green area per capita, but in developed countries this figure is over 100m2 per capita. The usual presence of greenery in European cities is 40 to 60m2 per capita.[4] Green areas in cities are designed to last for decades, so we should not be satisfied with the minimum area, however the problem of finding a location becomes more pronounced in the central, densely built, urban zones. Many cities in Europe have a high degree of greenery because the plan included and analyzed very large areas that include rural areas around the city. The goal is to evenly distribute green areas that are a part of the so-called "green infrastructure" of the city.

Green areas within the city can produce a cooling effect and improve the microclimate conditions. The air temperature is the most important characteristic of the climate. In urban areas there is a high concentration of areas with a high heat capacity that are strongly warmed up. This causes a significant accumulation of heat in the cities and the increase in temperature is also affected by the heat from industrial processes, combustion engines and the heating from residential homes. A combined impact of these factors leads to formation of a so-called "heat island". Temperature differences between the city and its surroundings is approximately 0.5 to 1.5°C. [2] The size of a park is also important for mitigating the heat island effect. How important is the park size was shown in a study of two different parks in Gothenburg, where the difference in temperature ranged from 1.7ºC in a small park area of 0.03km2, while in a large park area of 1.56km2 the difference was 5.9°C. [7]

2. A shape index of a location is calculated as the ratio of the average width of the site and its breadth where priority is given to a regular shape, i.e. it is desirable that the index is less than 0.2. A regular shape of the site is more adequate because of easier space organization, a better insight by the user, synoptic views and easier noticing the green area. In exceptional cases, the location length allowed is significantly larger than the width if the green area is used for communications connectivity, population movements or longitudinal tracks for recreation (trim trails for jogging or cycling).

3. and 4. Maintaining and restoring the connection between and within the greenery system is a central problem in ecology, nature conservation and territorial planning in order to achieve sustainable development. Urbane green areas should be physically and functionally connected so that each green area is a part of a larger network. Linking does not always mean a direct physical connection between the locations, but also the existence of green corridors in the form of a line of greenery wherever possible. It is necessary that these green corridors permeate the central urban area, as they allow better air circulation. This connection is reflected in two criteria, one is the distance between neighbouring green areas and the other is presence of one or more green corridors. In the current literature, distance between neighbouring green areas greater than 500m is not recommended. [10]

5. The degree of a location coverage refers to the percentage of urban green areas that are covered either with constructed buildings or paving. It is recommended that this parameter does not exceed the value of 10% for public green areas that are moderately used, and 20% for intensively used areas. The lower value of this parameter provides numerous environmental benefits and offers its users a sense of naturalness of the urban green area. [10]

6. Availability of public green areas implies a good traffic infrastructure connection with potential users and has a direct impact on the use of these areas, which can greatly affect their preservation and maintenance. Availability is defined by the number of entrances to the public green area as well as by frequency and quality of the public transport lines in the vicinity of the public green area. Negative impact on this criterion is the existence of certain physical barriers that are difficult to overcome in order to access the location.

Availability is defined through the distance of residence from an urban green area (catchment area). Short distances to the green area (300-400m) are directly related to the intensity of its use. Britain applies the approach where availability of an open space is expressed by distance: playgrounds for young children - accessibility within 90m, playgrounds for children aged 10-13 - accessibility within 300m, playgrounds for children aged 14-18 - accessibility within 1.000m, sports facilities accessibility within 1.000m, parks - accessibility within 400m, open spaces within yards - accessible within 400m. Copenhagen has adopted a strategy that by 2015, 90% of the population shall have accessibility to a green area within the distance of 400m. [3]

Examples of other standards include ANGST "Natural England - Accessible Natural Greenspace standard" by which each person should live no more than 300 meters away from the nearest green area of at least 2 ha, that there is at least one accessible green area of 20 hectares at 2km from home, at least one accessible green area of 100 ha at 5km from home, at least one accessible green area of 500 ha at 10km from home. At least 1 hectare of local nature reserve should be provided per 1,000 residents. [6]

7. By decorating and furnishing urban green areas, their utility value is increased, which contributes to attractiveness of urban areas and improvement of the quality of life in cities, i.e. local communities. Within the public green areas a variety of recreational activities can be accomplished and thus give contribution to better health of the population. In addition, public green areas provide pleasant places for local people to meet, which supports social interaction. [1,9] In order to allow such an activity to take place unhindered, public green areas need to be adequately equipped with mobiliard, then with necessary equipment according to the planned recreational activities and also providing enough space for playgrounds. It is essential that playground spaces are separated according to age. In the assessment activities, different groups of people, including those with special needs, should be included.

8. Safety as a criterion is considered from two aspects. The first, less dominant aspect, is separation of pedestrian and car traffic, which is required in green areas for safer movement of the user. Another, more prominent aspect, is understanding the concept of safety through the growing crime rate, because in the absence of control and surveillance people feel less safe. In numerous studies, the female population has been identified as more vulnerable when it comes to safety, and park areas have been identified as dangerous places.

For this reason, special attention is given to planning the lighting of public green areas, while presence of supervision has a positive impact on this criterion.

CONCLUSION

The analysis presented in this paper points out advantages and opportunities of urban planning and makes a request to all relevant experts and institutions to consider previously stated criteria for planning urban green areas when making decisions. This topic is underrepresented in our legislature, which has led to increasing fragmentation of green areas where many of them are abandoned and devastated.

Public green areas are the common good of all citizens and in order to ensure its conservation, it is necessary to establish adequate monitoring as well as specify the conditions for further development. It is necessary to engage all available locations for green areas in the planning documents, and in the course of design to examine the needs of the local population through research and studies as this would ensure their use and therefore the economic viability of investing in such projects. It is necessary to create new green areas in accordance with the city greenery system and to revitalize the existing, most valuable parks in the central city zones in order to meet their function.

One of the directions of green areas development could be setting up connections between the green and blue areas, i.e. rivers and water surfaces in line with the strategy of flood control as well as in terms of maintenance of green areas because water is a necessary element for their existence. [10]

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REDUCING EMISSIONS OF MOTOR VEHICLES BY USING BIOFUEL AS PROPULSION FUEL

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Abstract: Biofuels (biodiesel and ethanol) are liquid fuels produced from agricultural crops as renewable resources. In our country, biodiesel is more common. Biodiesel is derived from vegetable oils (soybean, rapeseed, sunflower, palm), and from waste oil and fat, by the process of transesterification, in the presence of a catalyst. It can be used independently or in a mixture with diesel obtained by refining of crude oil and in any ratio. Depending on the content of biofuel in the mixture, biodiesel is called B100 (pure, 100% biodiesel), B20 (20% biodiesel and 80% fossil diesel), and so on. In terms of environmental protection, the use of biodiesel compared to fossil diesel provides reductions of greenhouse effect, emission of sulfur oxides, suspended particles and carbon monoxide. The quantification of these effects on the environment is done by popular approach "Well-to-Wheel" (WTW), in which the net emissions over the entire chain of production-consumption are measured. This paper presents the reduction of motor vehicle emissions by using biofuels.
Key words: biodiesel, ethanol, exhaust gases, environmental protection

INTRODUCTION

It is well known that transport almost entirely depends on fossil fuels. The demand for energy in the world is constantly growing, which contributes to the development of the renewable energy sector. Biofuels (biodiesel and ethanol) are a viable alternative. Biofuels do not require production of a new car or a new car engine; they already have a huge advantage over hydrogen technology, which is still in its infancy. This compatibility with existing engines has prompted many countries to turn to biofuels, confident that they will thus be able to reduce the cost of fossil fuels.

ENGINEERING PROPERTIES AND PROCESS OF OBTAINING ETHANOL

According to its chemical composition, ethanol is ethyl alcohol (C_2H_5OH) containing 34.7% of oxygen, and it is completely soluble in water. In pure form it is a flammable, colorless liquid with a sweet smell of alcohol. Ethanol is lighter than water; when its mixture with gasoline comes into contact with minimum quantities of water, ethanol will be separated from gasoline in aqueous layer. Pure ethanol and ethanol gasoline mixtures are heavier than gasoline. Ethanol is highly volatile and will evaporate into the air about five times faster than gasoline. Like gasoline vapors, ethanol vapors are denser than air and they accumulate in lower areas.
When burning, ethanol releases less heat than gasoline. One and a half gallon of ethanol has nearly the same energy of combustion of fuel as one gallon of gasoline. Ethanol has a higher ignition temperature than gasoline (4,500°C to approximately 2,500°C) and has an octane number of about 110, and when added to gasoline, it increases its octane number. The mixture of ethanol and gasoline in ratio 85% ethanol and 15% gasoline (E85) is the one most commonly used in vehicles. Engineering properties of ethanol E85 are shown in table 1.

Table 1. Engineering properties of fuel E85 [1]

Engineering property	Value
Volume percentage of ethanol, %	82
Reid vapor pressure (psi)	6,2
Mass percentage of water, %	0,4
Gross heat of combustion, kJ/kg	32.412,81
Net heat of combustion, kJ/kg	29.649,52
Research octane number	105
Density, kg/m^3	0,78
Mass percentage of carbon, %	57,92
Mass percentage of hydrogen, %	13,02
Mass percentage of oxygen, %	29,06
Conductivity, µS/cm	1,81
pH	7,6

Ethanol E85 has a distinctive scent and pink color. Composition of ethanol E85 is prescribed by standard ASTM D5798. This standard prescribes the additives to prevent corrosion and it set the limits for the regulation of parameters such as vapor pressure and octane number. Table 2 shows comparative properties of E85 and E10.

Table 2. Properties of E85 [1]

Property	E85	E10
Boiling point, °C	900	400÷2.100
Gross heat of combustion, kJ/kg	32.412,81	45.282,57
Net heat of combustion (mass), kJ/kg	29.458,79	41.868
Net heat of combustion (volume), kJ/liter	353.942,27	486.428,26
Heat of evaporation, kJ/kg	830,38	465,2
Octane number: (RON) (MON)	109 91	92 87
Appearance	Pink	Light yellow
Selling price in the USA, \$/gallon	1,39	0,99÷1,05

Suitable raw materials for ethanol production are cereals, wheat, sugar cane, sugar beet, Jerusalem artichokes, etc. However, there is no "best" raw material, since in different regions of a country different cultures from different types of soil are better suited for ethanol production. In addition to cereals, there are other sources of waste from production of cereals and food, which can be used for production of ethanol, but their overall potential is small. Other processes are being developed, which would allow commercial distillation of ethanol from cellulosic raw materials such as residues of harvest, grass, wood and paper from municipal solid waste.

The process of commercial distillation/conversion into ethanol consists of four basic steps (Figure 1). First, raw material is processed to obtain sugar solution. Then, in a separate step, sugar is converted into ethanol and carbon dioxide using yeast or bacteria in a process called fermentation. Ethanol is separated by distillation, which gives a solution of ethanol and water, in which ethanol cannot exceed 95.6% (at normal pressure) due to the physical properties of mixture of ethanol - water (azeotropic mixture). In the final step, the water is removed to produce "dried" ethanol. This is accomplished by adding a chemical that alters the physical properties of the solution and by re-distillation.

The material that remains in water solution after distillation of ethanol, so-called residue after distillation, contains yeast or dead bacteria and a substance from raw material that is neither starch nor sugar. For example, cereals provide high protein residue (called "distillers grains") that can be used as

animal feed, while sugar and cellulosic raw material give residue with little protein and less nutritional value.
From 100 kg of corn in production of ethanol, 19.4 liters of ethanol, 23.2 kg of distillers grains, 5.4 kg of high-protein food, and 2.9 kg of corn oil is obtained on average.

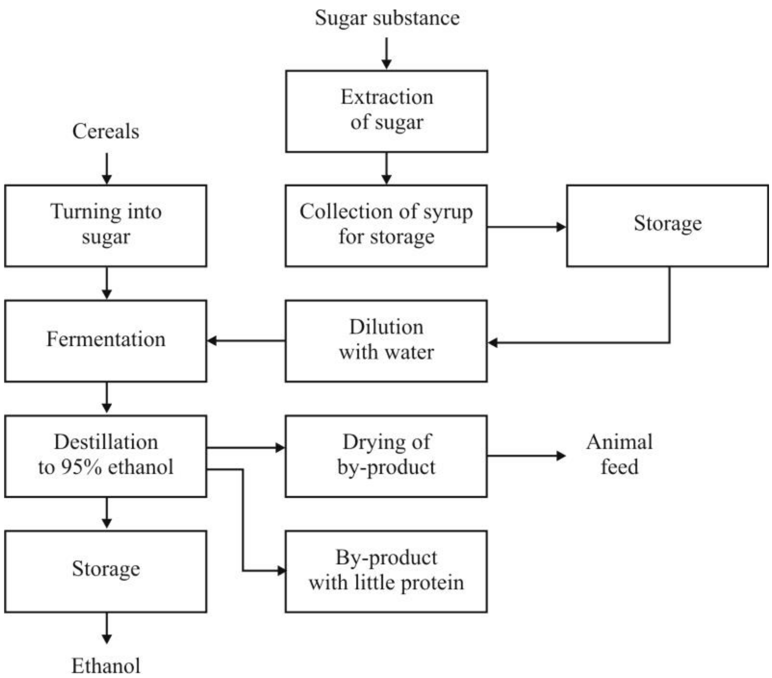

Figure 1. Production of ethanol [2]

It is not rational to modify vehicles designed for fossil fuels propulsion into ethanol propulsion vehicles, due to necessary changes of some materials, especially sealing elements in the fuel system. Hence, it is usual to design multi-fuel vehicles that can use pure gasoline and mixtures of these fuels up to the ratio of 85% ethanol and 15% gasoline (E85). Companies that produce models of vehicles that can run on E85 fuel are: Daimler-Chrysler, Nissan, Ford Motor Co., Mercedes-Benz, General Motors-Chevrolet [3].

ENGINEERING PROPERTIES AND PROCESS OF BIODIESEL PRODUCTION

The term biodiesel refers to a liquid, renewable fuel derived from vegetable oils and its chemical composition is methyl ester (mono alkyl ester). Although the slogan "diesel" is a part of its name, biodiesel does not contain oil derivatives or derivatives of other fossil fuels. In biodiesel, those are non-toxic raw materials, which are biodegradable and renewable. Today biodiesel is used as a pure fuel (B100) or in a mixture with diesel fuel in the amount of 20% biodiesel and 80% diesel (B20).
In comparison to conventional diesel fuel, biodiesel fuel is characterized by higher oxygen content (11%) and a lower content of carbon (77%), and approximately the same proportion of hydrogen. Due to the increased oxygen content, heating value of biodiesel compared to fossil diesel is lower (37 MJ / kg compared to 43 MJ / kg), and combustion of the fuel is improved [4]. The viscosity of biodiesel fuel is higher than that of diesel fuel, but several times reduced as compared to the viscosity of the oil from which it is produced (Table 3). Biodiesel has much poorer properties at low temperatures (thickening), compared to diesel fuel.

Table 3. Engineering properties of biodiesel and diesel fuel [6]

Property	Biodiesel (SRB EN 14214)	Diesel
Density at 15°C, kg/m^3	860-900	820-845
Viscosity at 40°C, mm^2/s	3,5-5,0	2,0-4,5
Carbon residue, % m/m	< 0,3	< 0,3
Ester content, % m/m	> 96,5	-
Free glycerin, % m/m	< 0,02	-
Ignition point, °C	> 120	> 55
Particles content, % m/m	< 0,01	< 0,01
Phosphorus content, mg/kg	< 10,0	-
Sulfur content, mg/kg	< 10,0	< 10,0
Water content, mg/kg	< 500,0	< 200,0
Iodine value, g I2/100 g	< 120	-
Oxidation stability at 110°C, h	> 6,0	-
Cetane number, % v	> 51,0	> 51,0

Biodiesel may be obtained from any type of vegetable oil (rapeseed, sunflower, soybean, palm). In the U.S., biodiesel is mainly produced from soybean oil or recycled cooking oil, but animal fats and vegetable oils can also be used for its production (oil of corn, flax, hazelnut, coffee, rubber tree seeds, cotton, hemp, soy, canola, olive, jojoba, pumpkin seeds, sesame seeds, rice, sunflower, peanut, avocado, oil palm, saffron, oats), which depends on the prices. A mixture of all types of fats and oils will probably be used for production of biodiesel in the U.S. in the future. In Europe, the most popular raw material for production of biodiesel is rapeseed oil, but sunflower and soybean oil can be used as well.

In the selection of raw materials for the production of biodiesel, there are certain standards that have to be met: type of oil, content of free fatty acid, content of phosphorus and insoluble substances. These standards limit the application of used oil from restaurants i.e. they increase the cost of biodiesel production because they require an appropriate pretreatment. On the other hand, the real limit is the availability of raw materials, i.e. rapeseed or soybean oil which are the optimal raw materials for production of biodiesel that meets the quality standard EN 14214. Therefore, as production capacities increase, so does the area of arable land for planting oilseed crops increase.

In oil-refineries, biodiesel is obtained by the process of the esterification of fatty acids with methanol, with the aid of a catalyst (NaOH), and then, apart from biodiesel (fatty acid methyl ester) glycerin is obtained, which is usually further purified to purity of 99% or more, and it is sold to pharmaceutical and cosmetics industry, equation 1 [5].

$$\begin{array}{lll} \mathbf{CH_2-O-CO-R_1} & & \mathbf{CH_3-O-CO-R_1} \quad \mathbf{CH_2-OH} \\ \mathbf{CH-O-CO-R_2} & \mathbf{+\,3CH_3-OH} \xrightarrow{\mathbf{NaOH}} & \mathbf{CH_3-O-CO-R_2} + \mathbf{CH-OH} \\ \mathbf{CH_2-O-CO-R_3} & & \mathbf{CH_3-O-CO-R_3} \quad \mathbf{CH_2-OH} \end{array} \qquad (1)$$

Other by-products in production of biodiesel are:

- hardened cake (remnants after the procedure of extraction of oil from oil seeds that are cleaned and separated from the hull)
- distillers grains (remnants after the procedure of extraction of oil).

For production of 1 ton of biodiesel (as well as by-products: raw glycerin about 128 kg, glycerin for pharmaceutical purposes about 93 kg, industrial grade glycerin about 5 kg) from 1,000 kg of rapeseed, the following is spent:

- vapor about 415 kg,
- coolant (Δt= 10°C) about 25 m^3,
- electrical energy about 12 kWh,
- methanol about 96 kg,

- catalyst (100%) about 5 kg,
- hydrochloric acid (37%) about 10 kg,
- sodium hydroxide (50%) about 1.5 kg,
- nitrogen about 1 m^3 [7].

Complete estimation of energy balance of biodiesel production includes not only energy that is spent in its production, but also the energy that is absorbed/given away by all the processes needed to reach the final product. The overall energy balance depends on the use value of rapeseed stalks that can be cut and used as an energy source or can be plowed. The studies, which were done for biodiesel, show that the total energy balance (including extraction, refining and esterification) is positive (Table 4).

Table 4. Energy balance for biodiesel produced from rapeseed in MJ/ha [7]

Parameters	Value
Seed yield (t/ha)	3,2
Energy input (MJ/ha)	
Soil cultivation	-4.300
Fertilizer	-12.800
Agrochemistry	-600
Seed	-200
Storage/packing	-300
Transportation	-774
Processing/production	-16.071
Total input	-35.045
Energy output (MJ/ha)	
Biodiesel	45.800
Hardened cake	3.700
Total output without stalk	49.500
Energy output/energy input (without stalk)	1,41
Net energy balance without stalk	49.500
Stalk	38.400
Total output with stalk	87.900
Energy output/energy input (with stalk)	2,51
Net energy balance with stalk	52.855

Car manufacturers have a positive attitude about the use of biodiesel. Volkswagen Škoda (Golf IV/V, Vento, Passat, Polo, Fabia, Octavia I), Audi (A2, A3, A4, A6), Seat (Alhambra, Arosa, Leon, Inca, Ibiza) allow the use of B100 in their vehicles produced after 1996. BMW and Mercedes-Benz allow the use of B100 only in some models, but only for an extra charge, as "a package of preparations for biodiesel." Majority of other manufacturers (Peugeut, Citroen, Chrysler, Jeep, Suzuki) allow the use of up to 5% biodiesel in new vehicles.

REDUCTION OF EXHAUST EMISSIONS BY USING ETHANOL IN MOTOR VEHICLES

Emisije Exhaust emissions are one of the main reasons for the use of ethanol. Emissions that can be controlled are nitrogen oxides (NOx), carbon monoxide (CO) and hydrocarbons (HC). Studies have shown that:

- by using fuel with a high ethanol content, hydrocarbon emissions can be reduced by 66%. Hydrocarbons typically represent 80% of total emissions from vehicles.
- CO formation is greatly reduced through the use of ethanol because of the oxygen content in ethanol. Combustion takes less oxygen from the air, thus creating fewer by-products such as CO, so global warming is reduced.
- in comparison with gasoline, formation of toxic compounds from ethanol in atmosphere is relatively slow.

- the main products of incomplete combustion in the use of ethanol are acetaldehyde and peroxyacetyl nitrate, same as in the use of gasoline.
- the use of gasoline containing ethanol may lead to increased emissions of volatile substances as rubber, plastic and other materials are permeable to ethanol; furthermore, ethanol can reduce working capacity of active carbon filter used to control emissions of volatile substances in vehicles.
- current models of vehicles cannot be completely controlled regarding the evaporation of ethanol. Although stricter standards for emissions of volatile substances that apply to models produced until 2006 were adopted in 1998, test procedures apply only to fuel used in the time of the adoption of regulations, and do not include ethanol mixtures. However, due to lower content of harmful volatile components in ethanol fuel, the level of harmful evaporations from these road vehicles is lower.
- the use of ethanol significantly reduces the possibility of environmental accident during transportation in comparison with transportation of gasoline (due to its lower toxicity).
- in comparison with gasoline, ecological convenience of ethanol as a fuel is reflected in less pollution of water ecosystems.

REDUCTION OF EXHAUST EMISSIONS BY USING BIODIESEL IN MOTOR VEHICLES

The values of emission of individual pollutants in the use of biodiesel are:
Carbon dioxide (CO_2): each ton of burnt diesel adds about 2.8 tons of CO_2 into the atmosphere. The specific content of CO_2 from one ton of burnt biodiesel is slightly lower, about 2.4 tons. It can be assumed that this CO_2 will be fully used next year by the crops that will give raw material for production of biodiesel. Therefore, it can be said that the net CO_2 emission when using biodiesel, when viewed on the WTW (Well-to-Wheel) basis, where net emissions over the entire chain of production-consumption are measured, is almost equal to zero (Figure 2).

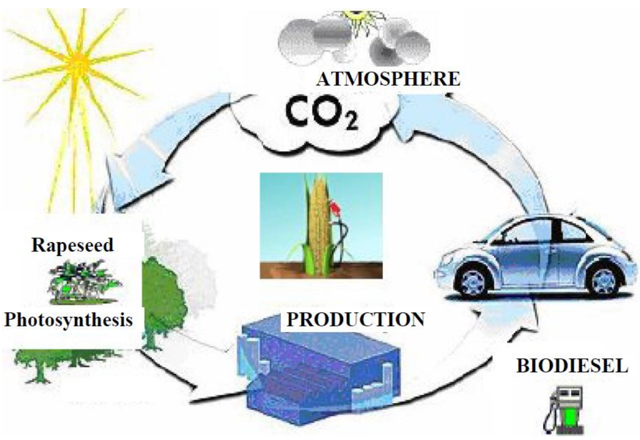

Figure 2. Closed CO_2 cycle [8]

Sulfur dioxide (SO_2): Today, 1 ton of conventional fossil diesel in the EU contains a maximum of 350 ppm sulfur on average. When diesel is burned, the sulfur is released into the atmosphere in the form of sulfur dioxide, contributing to the formation of acid rain. Biodiesel has almost no sulfur (sulfur content 0÷0.0024 ppm). On the other hand, the EU is constantly promoting the use of diesel fuel with low sulfur content (less than 50 ppm in the UK and less than 10 ppm in Sweden), so greater use of biodiesel and its mixtures with diesel will have a major role in the reduction of sulfur.
Nitrogen oxides (NOx): Emission of nitrogen oxides from biodiesel can be increased or decreased in relation to the emission from fossil diesel, depending on the generation of engines and the procedures by which they are tested. Emission of nitrogen oxides from pure biodiesel is increased by about 6% on average compared to fossil diesel. Due to the lack of sulfur in biodiesel, it is possible to use techniques of controlling nitrogen oxides, which cannot be used with fossil diesel.

Carbon monoxide (CO): Biodiesel contains oxygenates that improve combustion process and reduce emission of carbon monoxide by at least 30%.
Solid particles (Pm): Inhalation of suspended particles has proven to be a serious problem and a threat to human health. Emission of these particles in the exhaust gases in biodiesel is about 50% lower than that of fossil diesel.
Hydrocarbons (HC): The emission of hydrocarbons from biodiesel is by 50% lower than that in diesel fuel. Significantly lower hydrocarbon emission in biodiesel is explained by its higher boiling point, i.e. evaporation point.
Perhaps the emission of aldehydes, in addition to the negative impact on seals and colors, is the most important environmental lack of biodiesel, as this substance is a carcinogen. The emission of aldehydes is much higher (about 20%) in biodiesel compared to diesel fuel.
Table 5 shows the emissions of biodiesel (B100 and B20) in comparison to the emission of fossil diesel fuel, taking that the emission of fossil diesel fuel is 100%, wherein only carbon dioxide is viewed from the point of life cycle.

Table 5. Changes in emission of biodiesel compared to diesel emission

Type of emission	B100	B20
Carbon monoxide	-43,2%	-12,6%
Hydrocarbons	-56,3%	-11,0%
Solid particles	-55,4%	-18,0%
Nitrogen oxides	+5,8%	+1,2%
Toxic substances	-60%÷-90%	-12%÷-20%
Mutagenic substances	-80%÷-90%	-20%
Carbon dioxide	-88,3%	-25,7%

Important ecological characteristic of biodiesel is its biodegradability. Fossil diesel dissolves only 50% during the first 21 days after the spillage (e.g., an accident during transport), while 98% of biodiesel decomposes without consequences, within the same time. According to medical literature, substituting or mixing diesel with biodiesel would reduce the risk of cancer in humans (by 94% when using B100, and 27% for B20).
The environmental benefits of biodiesel compared to fossil diesel fuel are reflected in:

- reduced emission of gases that cause greenhouse effect, mainly CO_2, CO, SO_2;
- non-carcinogenicity of exhaust gases (they are free of soot, benzene, toluene);
- biodegradability and non-toxicity (accidental spillage is not an environmental risk).

Environmental effect of the use of biodiesel in buses will be shown by the results of experimental testing done on two buses Ikarbus 103 in City Transport Company Beograd, from March 6-12, 2006, within the project “We are Powered by the Sun“, (table 6).

Table 6. Pollution emissions of buses on biodiesel and diesel [6]

Measured parameters	Idle		50%		100%	
	A-482 biodiesel	A-491 diesel	A-482 biodiesel	A-491 diesel	A-482 biodiesel	A-491 diesel
CO, ppm	33	118	65	165	92	179
NO, ppm	171	178	114	168	113	129
NO_2, ppm	23,9	22	26,3	29,4	26,5	23,4
NO_X, ppm	195	200	141	198	139	153
SO_2, ppm	8	83	5	92	5	102
H_2, ppm	4	3	5	14	11	19
O_2, vol %	18,9	18,8	18,5	17,9	17,7	17,5
CO_2, vol %	1,81	1,83	2,11	2,55	2,7	2,84
Pm, mg/m^3	18,2	74,9	24,5	85,2	31,2	98,3
Benzene, μg/m^3	<10	335	<10	621	<10	825
Toluene, μg/m^3	<10	168	<10	211	<10	398
Xylene, μg/m^3	<10	10	<10	23	<10	40

Table 6 shows that pollution is significantly lower in all three modes when buses use biodiesel instead of conventional diesel fuel.

ACKNOWLEDGEMENTS

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CONCLUSION

Production of biofuel in the world is rapidly growing. Rate of growth of the world market of biofuel will depend on several factors:

- First, the market of raw materials needed for the production of biofuel.
- In addition, the problem of subsidized production of biofuels needs to be solved.
- Last, but not the least important, is the question of growing prices of oil.

Taking into account the European policy for biofuels, critical success factors of implementation can be summarized as follows:

- The availability of arable land for the production of crops for biofuels;
- Tax incentives without which biofuel would not be competitive to fossil fuel;
- Clear state involvement in the long run, by establishing a legal framework and reference objectives of the introduction of biofuel;
- Promotional pilot projects were implemented at the local, regional and national levels.

What this paper irrefutably shows is that the use of biofuel in motor vehicles significantly reduces exhaust gases emissions in comparison to fossil fuels.

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IMPROVING THE WATER COOLING IN COOLING TOWERS BY CHANGING THE PARAMETERS OF WATER AND AIR

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Abstract: This paper shows dependences cold water temperature of coefficient A, height of the filling h_p, and air number λ for different values of temperature of wet thermometer (t_{wB}) and different width of cooling area (Δt_w) in cooling towers with drop type filling. Besides, the basic features of this type of filling are shown, as well as basic of technological calculation of cooling towers. For the purpose of analysis one – dimensional model of water cooling in counter flow cooling tower by Merkel basic equation was applied.
Key words: cooling tower, filling, drop flow,cooling efficiency

INTRODUCTION

Evaporative water cooling is conducted by distributing water throught the nozzle over the filling, which is designed to provide a greater contact surface between the water and the air stream. Water cooling in hyperbolic cooling tower depends mostly on the following relevant factors:
• water distribution in the cross-section of the tower,
• air flux and air flow resistance,
• the contact surface of the water and the air,
• the type of built-in filling,
• dispersing water in different size drops or film-forming water.
To improve the level of heat transfer in the tower is necessary to ensure a larger contact surface between water and air. Part of the tower where there is direct contact between water and air is called a filling. Cooling water, for the most part, is done in the fillings of cooling towers. Therefore, analysis of the application of different types of fillings is an extremely important task, but it also opens the possibility of improving the efficiency of cooling. By the proper selection, taking into account other factors, can be accomplished much better water cooling.
In practice, the following types of fillings used according to the flow of water:
• drop stream
• film stream
• combined (film and drop flow).

FILLINGS FOR THE DROP STREAM OF WATER

This is the simplest type of filling that is made of slats and beams arranged in an appropriate number of horizontal lines at a certain distance. Cross-section of slats or beams can be in different geometric shapes (Figure 1) [2]. Filling beams are usually made from high-quality wood (redwood). Different dispositions of slats in filling for drop flow of water is shown in Figure 2 [3]. In Table 1 are presented numerical values of parametres for this type of filling for caracteristic dimensions c_1, c_2, δ_1, δ_2 [2].

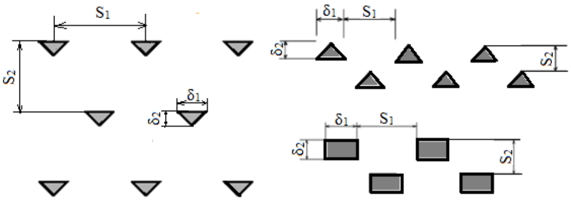

Figure 1. Cross-sections of slats for filling for the drop stream of water [2].

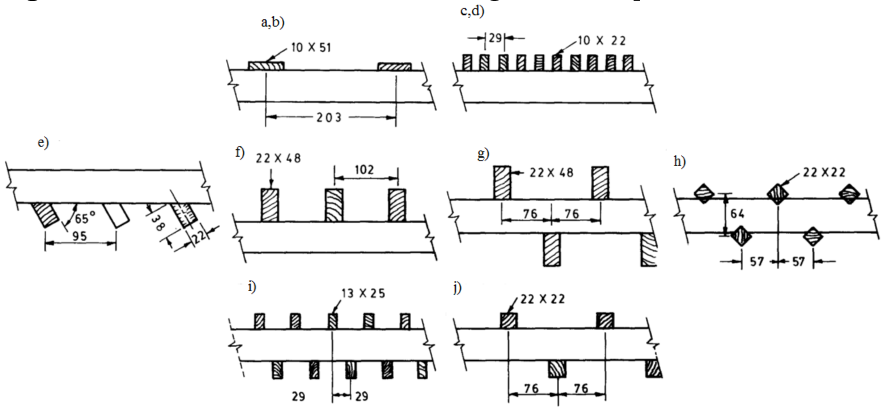

Figure 2. Different dispositions of the slats in filling for drop stream of water (dimensions are in mm) [3].

Height of the filling or number of horizontal rows of slats is calculated according the following equation:

$$\frac{\beta_p aV}{q_{mw}} = 0,07 + A(BR)\left(\frac{q_{mw}}{q_{mv}}\right)^{-p} \tag{1}$$

Where are:

BR- number of horizontal rows of filling slats, A and p are constants for any matrix. In Table 2 are given coefficients A and p for disposion of slats given on Figure 2 and temperature of hot water of 49°C.

If the temparature of incoming water different from specified value we have to calculate corrected value $\frac{\beta_p aV}{q_{mw}}$.

Table1. Numerical value of thermal characteristics for specific (c_1, c_2, δ_1, δ_2) [2]

Iype	$\frac{\delta_1}{\delta_2}$	S_1	S_2	K_{Me}	n
▼	38/33	153 153 153 154	228 153 305 458	0,295 0,308 0,246 0,236	0,5 0,5 0,42 0,47
▲	38/33	153	228	0,275	0,49
■	51/9,5 51/9,5	203 203	228 305	0,52 0,53	0,28 0,26
■	25,4/9,1	81,7 81,7	76,3 152	0,46 0,32	0,5 0,5

Table2. Values of A and p in equation (1) for slats disposition shown on the Figure 2 [3]

Disposition	A	p
a	0,060	0,62
b	0,070	0,62
c	0,092	0,60
d	0,119	0,58
e	0,110	0,46
f	0,100	0,51
g	0,104	0,57
h	0,127	0,47
i	0,135	0,57
j	0,103	0,54

Knowing the number of horizontal rows (BR), row height and vertical distance between the rows given in Table 2, the total filler height in the cooling tower (UV) is calculated according following equation:

UV = BR x (row height + vertical distance between the rows) (2)

The free water surface, which is thereby formed in the cooler is composed from three parts: a) the surface of the water film, formed on the lattice during the water stream around them, b) the surface of large drops, formed on the bottom of the beams, and then they fall down; c) the surface of small drops produced by spraying large drops at the fall of the same from the top to the bottom beams.

For understanding the role of film surface and drops of different diameters in the cooler, is not so important the absolute water surface, but the different coefficients of mass and energy transfer for each of these cases are. It was found that on the observed lattice type 70 ÷ 80% of the free water surface is from film, around 5% of water surface is from large drops and 15 ÷ 20% of water surface is from small drops. But, it was found that 65 ÷ 70% of the total heat transfer is for small drops , 25 ÷ 30% is for film, while large drops in cooling water do not play a larger role [4]. Because of all of the facts presented above, the coefficient of heat and mass transfer for this filling can only be determined experimentally or with empirical correlations that are usually in gradation forms:

$$\beta_{xv} = c \cdot q_r^{\,n} \left(w\rho \right)^m \tag{3}$$

Where are c, n i m constants:
$q_r = q_{mwr}/F$, kg/m^{2}s – hydraulic load of filling
q_{mwr}- amount of spilled water, kg/s
F - filling cross section, m^2
w_f - air velocity, m/s
ρ_v – air density, kg/m
On the Figure 3 are shown experimental determinatted coefficients according [5].

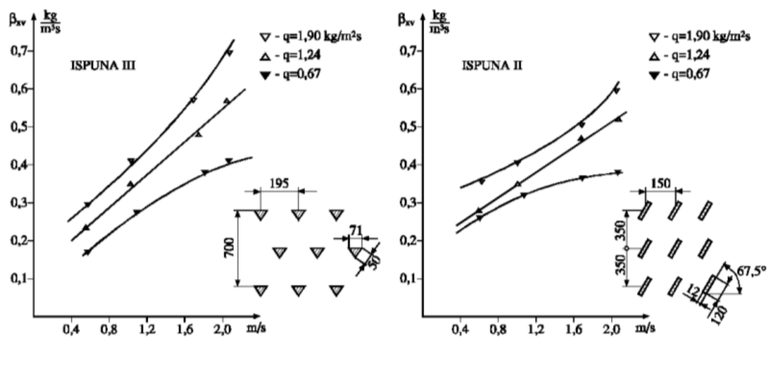

Figure 3. Mass transfer coeficient for filling with spraying [5].

TEHNOLOGY CALCULATION FOR COOLING TOWER

Technology calculation requires full coordination of thermal and aerodynamic calculations, because the air flow through the tower is not known in advance, because it is a function of the structural parameters of the cooling tower and the individual parameters. Technology calculation consists of two parts:

a) Determination of the tower dimensions for the external conditions, water temperature, thermal and hydraulic load.
b) Determination of the cooling tower efficiency (temperature of cold water) with defined geometry for different parameters of outside air.

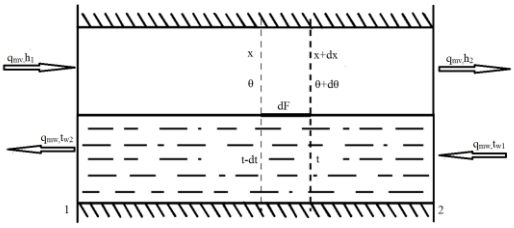

Figure 4. Water surface in contact with air

Consider the free water surface between the section 1 and 2, in direct contact with air (Figure 4) as is the case in the filling of water cooling tower. Air flow is q_{mv} kg/s , water flow is q_{mw} kg/s, water temperature entering in the tower t_{w1}, and the exit water temperature t_{w2}. Enthalpy of the air at the entrance is h_1, and exit enthalpy is h_2.
The basic equation of heat balance for the entire tower is:

$$\int_{t_{w2}}^{t_{w1}} \frac{c_{pw} dt_w}{h_{vs} - h_v} = \frac{\beta_x}{q_{mw}} \int_0^F dF = \frac{\beta_x F}{q_{mw}} \tag{4}$$

If the coeficient β_x given in relation to the volume (as β_{xv}), assuming that β_{xv} does not depend on the thermodinamic parameters of the air and water wich is very close to reality, entirely analogues for the last equation is get:

$$\int_{t_{w2}}^{t_{w1}} \frac{c_{pw} dt_w}{h_{vs} - h_v} = \frac{\beta_{xv} V}{q_{mw}} \tag{5}$$

In the literature integral on the left side of equation 5 is called Merkel's number , *Me*.

$$Me = \int_{t_{w2}}^{t_{w1}} \frac{c_{pw} dt_w}{h_{vs} - h_v} \tag{6}$$

The right side of integral 5 is filling caracteristic and it is usually expresed as:

$$\frac{\beta_{xv} V}{q_{mw}} = A \cdot \lambda^n \cdot h_p \tag{7}$$

Where are: A and n – coefficients obtained experimentally, h_p[m] – filling height

$\lambda = \frac{q_{mv}}{q_{mw}}$ - air number

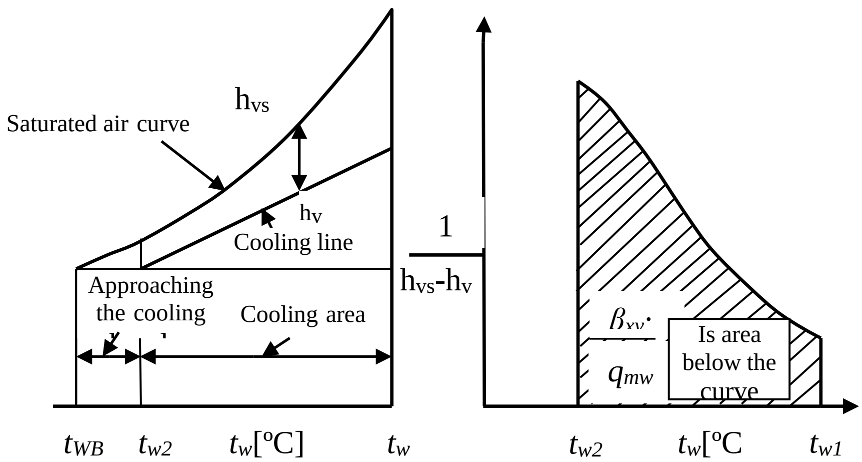

Figure 5. Graphical interpretation of the integral 6

COOLING DIAGRAMS FOR DIFFERENT WATER AND AIR PARAMETERS

This chapter provides an analysis of the filling characteristics for the drop stream of water depending on the coefficient A, filling height h_p and air number λ for various wet thermometer temperature (t_{wb}) and various cooling zone widths (Δt_w). The first is analyzed drop type filling with the following characteristics: A = 1.0; n = 0,5; h_p = 0.9 m; λ = 0.5 for Me = 0.65; λ = 1.0 for Me = 0.86; λ = 1.5 for Me = 1.065 and the following results were obtained.

Figure 7 shows the dependence of water temperature entering in the cooling tower (t_{w1}) and water temperature at the output of the cooling tower (t_{w2}) from λ = 0.5 to 1.5, Δt_w = 5 ° C and t_{wb} = 16,7ºC (Figure 7 a.), t_{wb} = 20 ° C (Figure 7 b.) and t_{wb} = 23,3ºC (Figure 7 c.). Figure 7 d. shows the t_{w2} dependence on λ and t_{wb}.

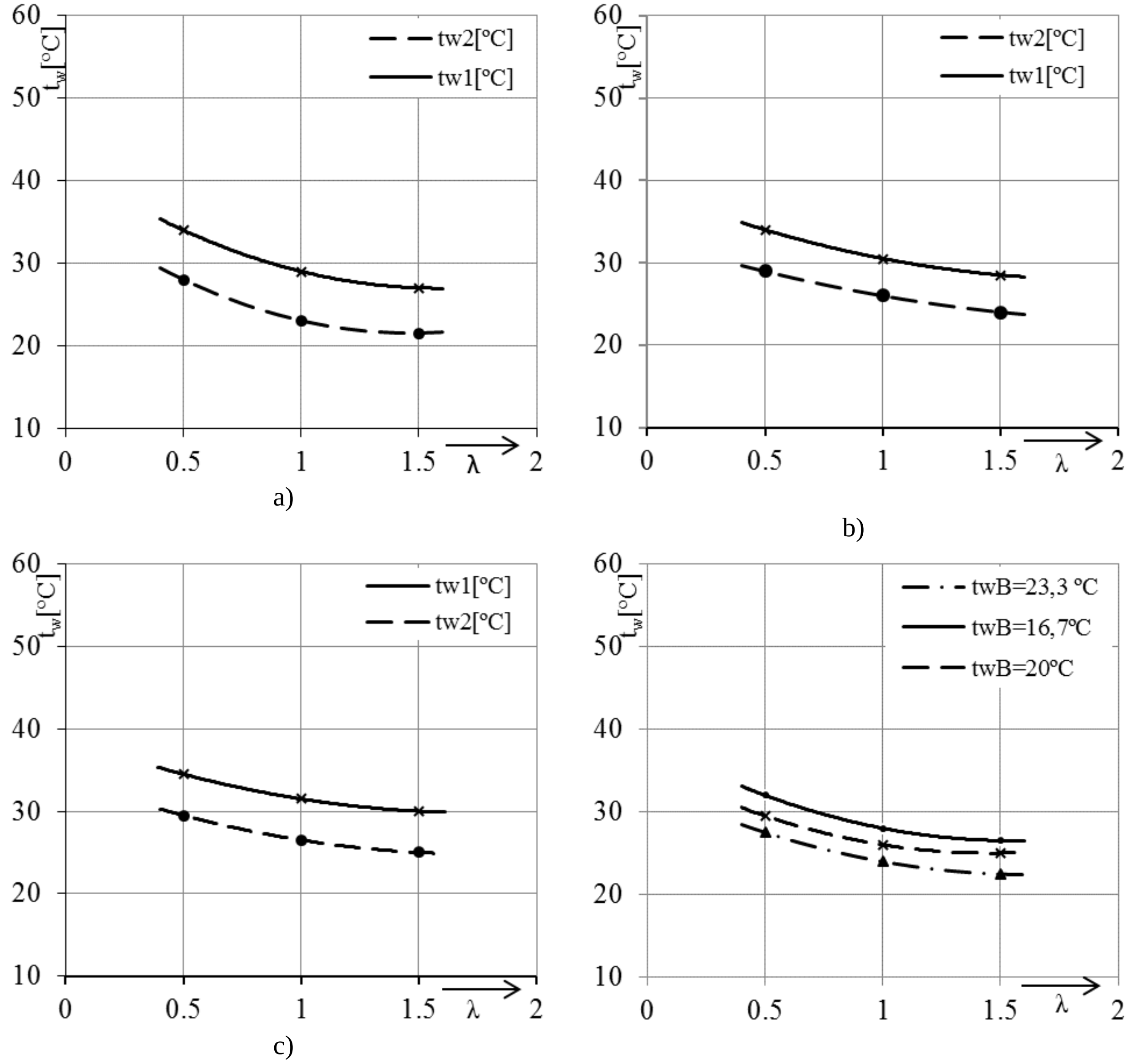

Figure 7. Water temperature dependency at the cooling tower input (t_{w1}) and the water temperature at the cooling tower output (t_{w2}) on λ= 0,5 to 1,5, Δt_w=5 ºC and t_{wB}=16,7ºC (Fig.7a.), t_{wB}=20ºC (Fig.7 b.) and t_{wB}=23,3ºC (Fig. 7 c.)

The Figure 8 shows dependency water temperature at the cooling tower input (t_{w1}) and water temperature at the cooling tower output (t_{w2}) on λ= 0,5 to 1,5, Δt_w=10 ºC and t_{wB}=16,7ºC (Fig. 8 a.), t_{wB}= 20 ºC (Fig.8 b.) and t_{wB}=23,3ºC (sl.8 c.). On the Figure 8 d., is presented dependency of t_{w2} on λ and t_{wB}.

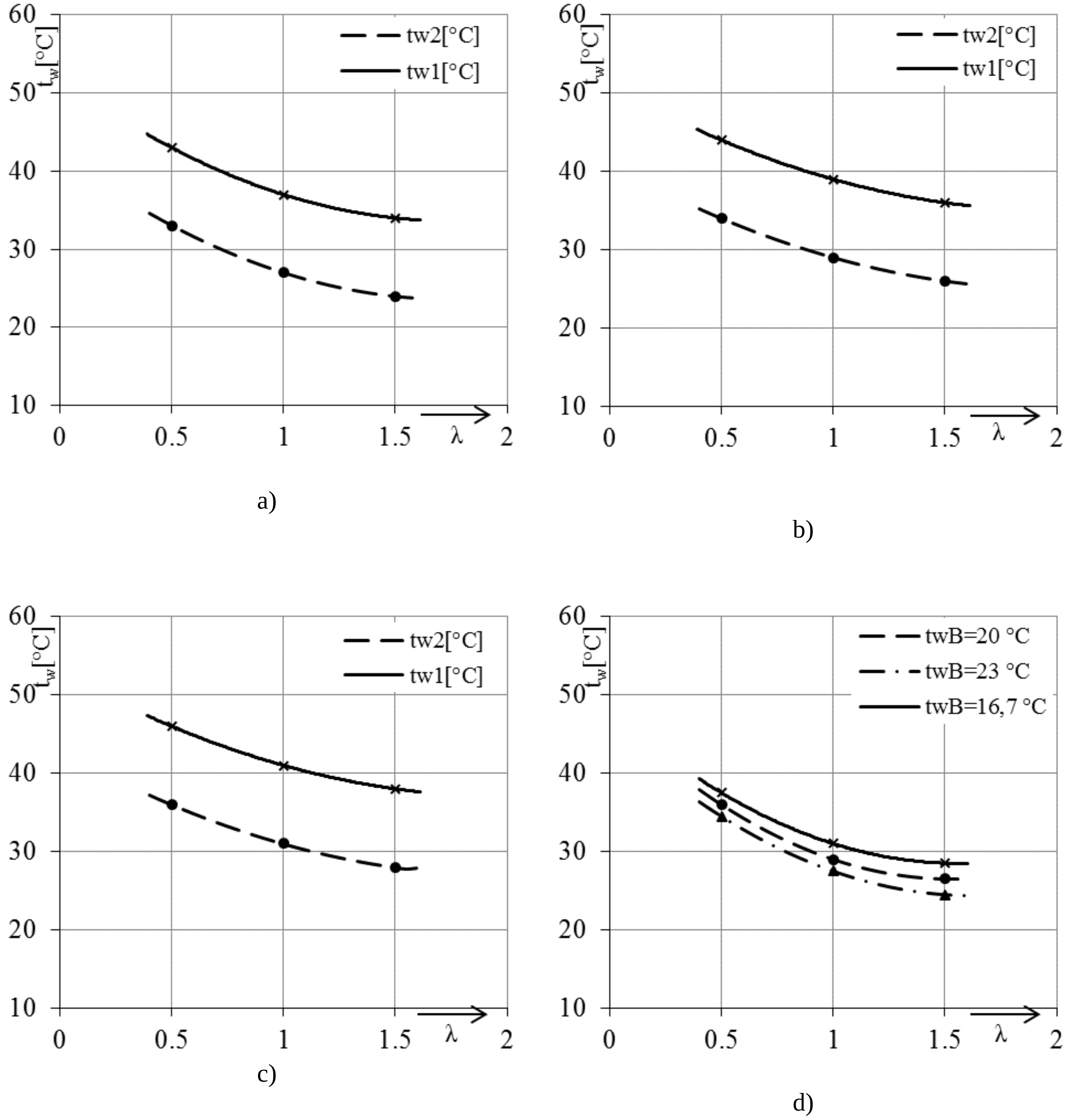

Figure 8. Water temperature dependency at cooling tower input (t_{w1}) and water temperature at cooling tower output (t_{w2}) on λ= 0,5 to 1,5, Δt_w=10 ºC and t_{wB}=16,7ºC (Fig.8a.), t_{wB}=20ºC (Fig.8 b.) and t_{wB}=23,3ºC (Fig.8 c.)

The Figure 8 shows dependency water temperature at colling tower input (t_{w1}) and water temperature at cooling tower output (t_{w2}) on λ= 0,5 to 1,5, Δt_w=15 ºC and t_{wB}=16,7ºC (Fig. 9 a.), t_{wB}= 20 ºC (Fig. 9b.) and t_{wB}=23,3ºC (Fig. 9c.). On the Figure 9 d. Is prezented dependency of t_{w2} on λ and $t_{wB.}$

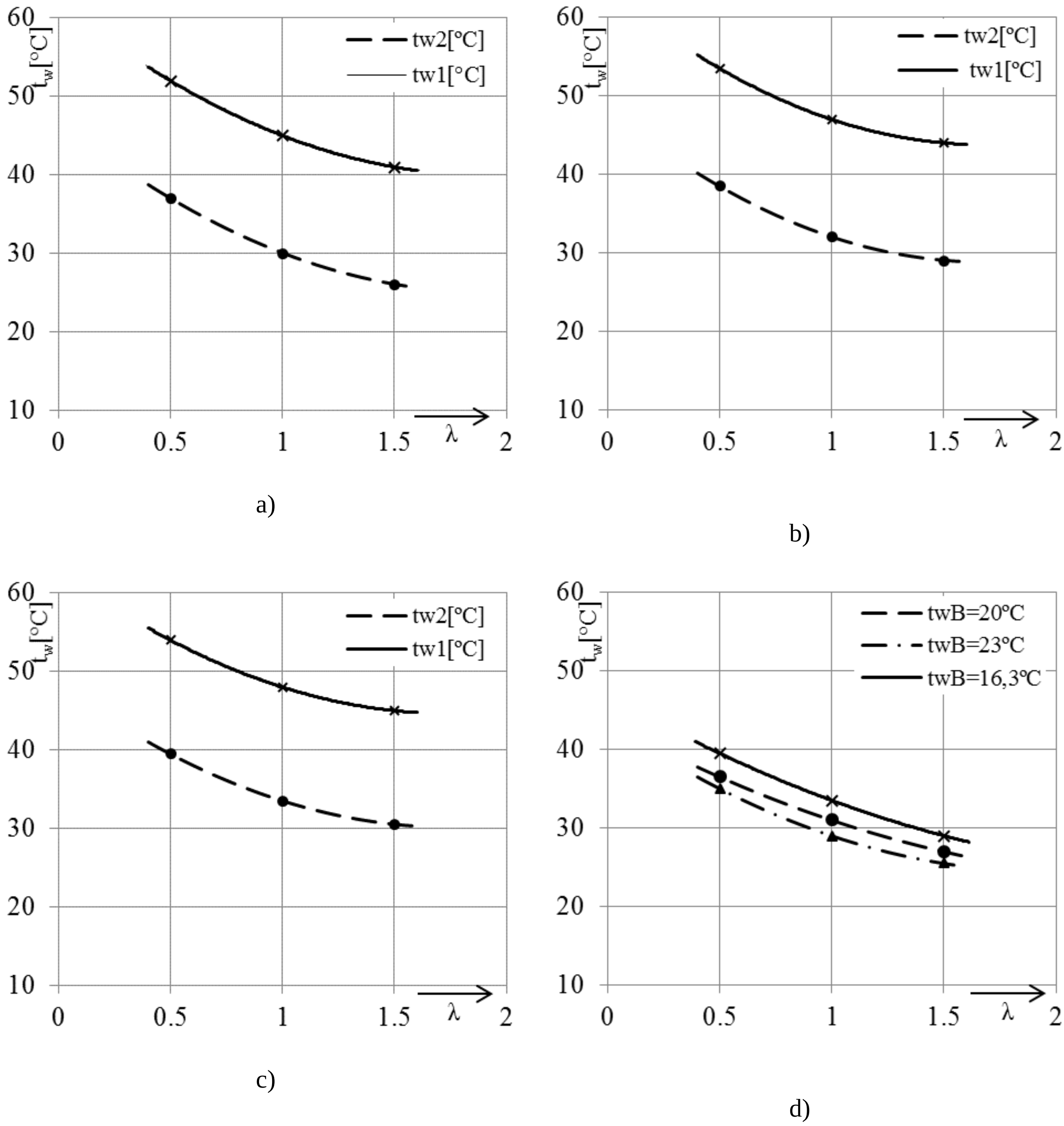

Figure 9. Water temperature dependency at cooling tower input (t_{w1}) and water temperature at cooling tower output (t_{w2}) on λ= 0,5 to 1,5, Δt_w=15 °C and t_{wB}=16,7ºC (Fig. 9a.), t_{wB}=20ºC (Fig. 9b.) and t_{wB}=23,3ºC(Fig. 9c.)

CONCLUSION

In this paper are presented possibilitis of water colling improvement. The analysis of simultaneous heat and mass transfer in counter, wet cooling towers with drop type water stream is done. For the analysis was applied the one-dimensional water cooling model in counter cooling tower by using Merkel basic equation. Also, in the paper are presented the coefficients of heat and mass transfer of the drop type fillings. Tehnology calculation of the cooling tower is given. It was analyzed contribution to water cooling by changing the water and air parameters in cooling tower. The filling height improves cooling, not linearly, but with decreasing gradient. Hight height of fillings are not efficient. The usual height of filling is (0,9 ÷ 1,8) m. For higher value of air number (λ) cooling tower output temperature decreases (t_{w2}), but fall gradient is reduced. This means that high values of λ are unnecessary. Typical values of λ are λ= 0,6÷1,3. Cooling water is in the range (5 ÷ 15)ºC. For smaller values of the output temperature (t_{w2}), lesser Δt_w, higher value of λ and higher filling height are favorable. By the proper selection water and air parameters we can significantly affect on water cooling in cooling towers.

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ANALYSIS OF SOCIAL ACCEPTABILITY OF CERTIAN WASTE TREATAMENT IN CITY OF NIŠ

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Abstract: In assessing the sustainability of certian waste treatment, should take into account all aspects: environmental, economic and social, which are quantified through indicators of sustainable development. Indicators by their nature can be quantitative and qualitative. The major problem is determining the value of the qualitative indicators, such as social acceptability. This paper analyzes social acceptability of waste treatments: landfilling, recycling, composting and waste incineration in city of Niš. A set of questionnaire which comprised of 21 questions was applied as instrument for data collection. The analysis was conducted by surveying 268 respondents in the population the age between 18 – 27. The results show that the recycling has highest social acceptability, as well as strong willingness for active participation of the respondents in the primary selection of waste. The results of this research can be used in assessing the sustainability of certian waste treatment and selection of waste management scenarios in the city of Niš.
Key words: indicators, social acceptability, waste treatment,

INTRODUCTION

The most widely used definition of sustainability refers to three dimensions of sustainability: environmental, economic, and social. For a technical system to be deemed socially sustainable, it should at minimum enjoy wider social acceptance. Hence, the social sustainability dimension is approached from an angle of social acceptance [1]. Measuring sustainability and quantifying the social dimension of sustainability are difficult tasks. The difficulty arises from the need to identify an objective definition of social sustainability, as it is impossible to reach consensus on all the specific ingredients in social sustainability [1].
Implementation of long-lasting, new technical systems, require acceptance by the public. In other words, social (public) acceptance shortens the time between the first discussions of new technical systems and their implementation and make the system sustainable, also.
Social acceptance is not simply a set of static attitudes of individuals; instead it refers more broadly to social relationships and organizations, and it is dynamic as it is shaped in learning processes. The acceptance among various parts of society has to be studied [2].
In democratic societies, decision making needs to consider not only what experts know but also what the public feels and thinks. Depending on the circumstances, there might be an association between what the public feels and thinks; and its knowledge. Different levels of perceptions, to the extent of expressed fear at the public level, can result in a major lag between the time when decision-makers express their interest in going forward with a proposed initiative, and the time the proposal wins acceptance by a majority of the public [1]. This type of delay can manifest itself anywhere in the decision-making process. For example, it took Swedish society more than 20 years to feel a lower level of fear associated with nuclear power, even though the technology has not changed during that time [1].
One study [3] which centered around nine European waste management programs that were seen as advanced programs in their countries concludes that successful waste management programs have one major factor in common: all programs considered the issues of social acceptance and communication to be very important.
Scientists agree that social acceptance is considered most critical for the effectiveness of any integrated Municipal Solid Waste management system. Especially for alternatives widely debated, such as waste-to-energy in areas without any prior experience, the widely discussed "Not In My Back

Yard" (NIMBY) syndrome needs to be considered when planning the development of the required infrastructure [4].

Despite the fact that "it is becoming increasingly evident that a waste management program and especially a waste treatment technique, which ignores the social aspects is doomed to failure", it is only in very recent years that waste management programs and policies are taking the social aspects into account and indicators for sustainable waste management are being developed. These social aspects include the problems of communication, social acceptance, (NIMBY/social compatibility), public participation in planning and implementation, consumer behavior, intergenerational factors and changing value systems [5].

Social acceptance of waste management models has been a key part of many researches. Social aspects of public waste management in Switzerland was investigated and has led to the conclusion that aspects concerning the problems of public acceptance, public participation in planning and implementation, consumer behavior and changing value systems are no less important than the technical or economic aspects in waste management research and decision-making [6]. A comparative study on three environmental policy domains in the Netherlands was done that all deal with legitimizing building and locating infrastructure facilities: renewable energy, water, and waste facilities [2]. Other study investigate public acceptance of a permanent nuclear waste disposal facility in New Mexico [7]. Social acceptance for the development of a waste-to-energy plant in an urban area in Greece was investigated, also [4].

The paper presents a study of social acceptability of certain waste treatment in the city of Niš. The research was conducted within the framework of sustainability research different waste management scenarios in Niš, because there is no adopted model of waste management in addition to waste disposal to landfill. In order to determine the value of social indicators, such as social acceptability survey was carried out of the sample of 268 respondents age between 18 – 27. A set of questionnaire which comprised of 21 questions was applied as an instrument for data collection.

RESERCH DESIGN AND DATA COLLECTION

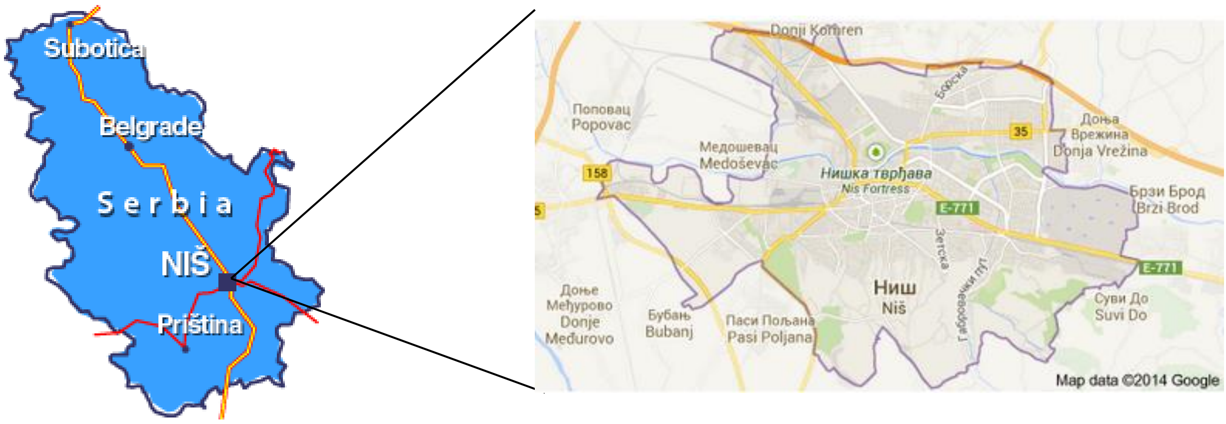
Research area

City of Niš is situated in south east of Republic of Serbia, in the Nišava valley where it joins the Južna Morava River. It is located at the 43°19' latitude north and 21°54' longitude east. The central city area is at 194 m altitude above sea level. The city area covers 596.71 km^2 of five municipalities: Medijana, Palilula, Pantelej, Crveni Krst i Niška Banja [8] (Figure 1b).

In the City of Niš, according to the census of 2011, lived 260,237 inhabitants, while in the populated area lived 183,164 inhabitants [9], so the population of Niš third largest city in Serbia (after Belgrade and Novi Sad). Based on the census of 2011 in the city of Niš live 49,421 populations aged 15 - 29 years old.

City of Niš is one of the most important industrial centers in Serbia, well-known for its industry of electronics and mechanical engineering, and the textile and the tobacco industry. Statistics show that the system of education is quite elaborate in the city: there are 50 000 pupils/students attending 32 primary and 21 secondary schools.

In most cities in Serbia, the waste is disposed of in open dumps or unsanitary landfills endangering the environment and human health. The situation is similar in the city of Niš. At present, the city has a dysfunctional landfill and waste management comes down to the collection and disposal of waste in the landfill. Amount of waste that generated in the city of Niš is 68,656 t per year [10]. The current situation in the city is such that the waste is collected by a public company and disposed of in unsanitary landfill. In the city there are several private companies involved in the recycling of waste (mainly metals, paper, plastics and e-waste). In the city there are several locations with containers for the collection of recyclable materials (plastics, glass, aluminum cans, paper). The waste is collected and transported once a week. Waste collection is charged at the surface of the housing unit.



(a) (b)

Figure 1. Sketch map of Niš: (a) Serbia; (b) Niš

Questionnaire design

A questionnaire composed of 21 questions (statements) with pre-selected answers (1 – Strongly Disagree, 2 – Disagree, 3 – Undecided, 4 – Agree, 5 – Strongly Agree) was used as the main tool of this research. The questionnaire was divided into two sections.

The first section composed of 8 questions (statements) and evaluated people's environmental awareness.

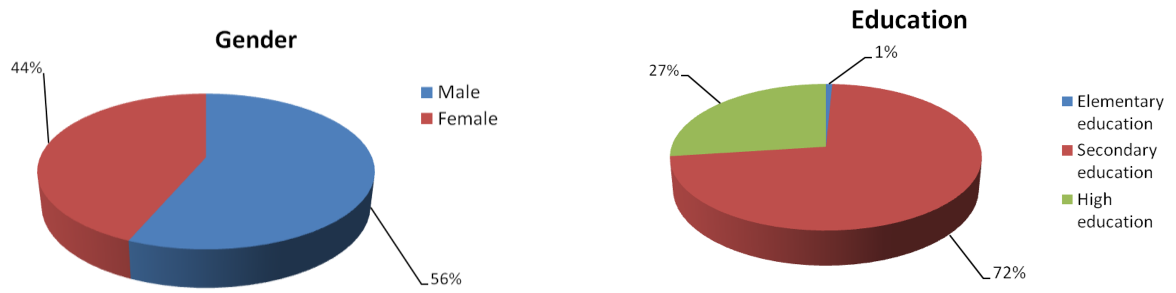
The second part composed of 13 questions (statements) and was designed to examine the public knowledge about certain waste treatment and their attitude about proposed waste treatment and their willingness to participate actively in their process of waste management, and a willingness to accept the construction of waste treatment plants in its neighborhood. The statements are as follows:

9. Waste is a big problem in my city.
10. Waste problem in my city should be solved in other ways other than landfilling.
11. Certain types of waste (paper, glass, metal, plastic) can be recycled.
12. I would do primary selection of waste in my household.
13. Most of my friends would do primary selection of waste in their household.
14. There are a sufficient number of containers of waste that can be recycled (plastic, glass, cans, paper) in my city.
15. Organic waste (plant residues, paper, garden waste, etc.) can be composted.
16. The best way to solve the problem of waste is landfilling, recycling, incineration, composting.
17. I'd agree that over a distance of 10 km from the place I live, build: sanitary landfill, recycling facility, incinerator, composting facility.
18. Most of my friends would agree that over a distance of 10 km from the place they live, build: sanitary landfill, recycling facility, incinerator, composting facility.
19. The biggest polluter is sanitary landfill, recycling facility, incinerator, composting facility.
20. Waste disposal should be charged according to the amount of waste to be disposed.
21. I would pay higher bills for waste collection and removal if they would solve the problem of waste pollution in my city.

The respondents were asked to provide some demographic information including age, gender and education.

RESULTS AND DISCUSSION

The analysis was conducted by surveying 268 respondents in the population the age between 18 – 27 years. Statistical analysis of the survey's results is summarized in Figure 2.



(a) (b)

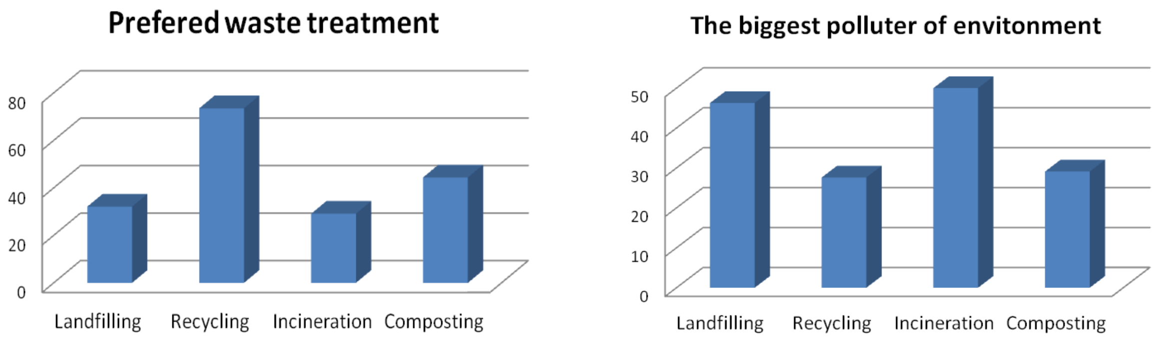
Figure 2. Survey's demographical characteristics.

The survey results show that 70% of respondents are aware that in the city there is the problem of inadequate waste management, and 77% of them know that waste should be dealt with and other waste treatments except landfilling.

Examination of knowledge of waste treatment shows that 66% of respondents know that certain types of waste (paper, glass, metal, plastic) can be recycled, and 51% of respondents know that organic waste (plant residues, paper, garden waste, etc.) can be composted.

69% of respondents would do the primary selection of waste in their household, but only 43% of them believe that most of their friends would do primary selection of waste in their household. Only 29% of respondents agree that there are a sufficient number of containers of recyclable waste (plastic, glass, cans, paper) in the city.

Figure 3a shows the attitude of respondents of prefferable waste treatment. 73% of respondents think that recycling is the best way of waste treatment, while only 29% of them think that incineration is the best way of waste treatment. This may be the result of lack of knowledge related to the benefits of incineration (waste volume reduction and energy recovery from waste), and can also be a result of fear of environmental pollution by burning waste, because 50% of respondents believe that the incinerator is the biggest polluter of the environment, of all waste treatment facility (Figure 3b).



(a) (b)

Figure 3. Attitude of prefferable waste treatment.

During questioning attitude on nearby waste treatment plants, 57% of respondents would agree that over a distance of 10 km from the place they live, build recycling plant, but only 45% think that their friends agreed to it. The minimum number of respondents, 20% of them would agree that over a distance of 10 km from the place they live, build incinerator, while only 18% of them think that their friends agreed to it (Figure 4).

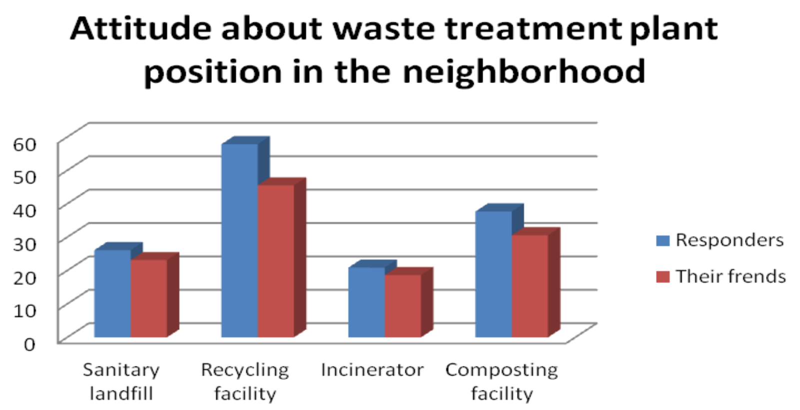


Figure 4. Attitude about waste treatment position in the neighborhood.

48% of respondents considered billing system inadequate, and agrees to the collection and transportation of garbage should be charged according to the amount of waste to be disposed, however, only 49% of respondents are willing to pay higher bills for waste collection and transportation if they would solve the problem of waste pollution in the city.
Conducted research shows the biggest social acceptability of waste recycling, while the minimum acceptable is incineration of waste. This attitude is associated with fear of greater pollution of the environment by burning waste. As interesting conclusion has been that only 32% of respondents considered that the landfillig of waste is acceptable waste treatment. A small percentage of respondents (44%) who declared that the best way of waste tretment is composting of organic waste, shows the lack of knowledge of the respondents and the benefits of composting, which leads to the conclusion that it is necessary to work on educating the population under the age of 27 years, to get acquainted with all the advantages and disadvantages of certain waste treatment, which may affect to their attitude and acceptance of individual waste treatment.

CONCLUSION

In assessing the sustainability of certain waste treatment, the most difficult is to determine the value of social indicators. They are mostly qualitative, such as social acceptability, but can greatly affect the sustainability of the chosen waste management model, as well as the speed of model implementation and the construction of waste treatment facilities. One way to determine the social acceptability is a survey.
In this paper is analysed social acceptability, as one of the indicators of social sustainability, certain waste treatment in the city of Niš. Data collection was done by interviewing a sample of 268 respondents, age between 18 - 27.
The results show that the most socially acceptable is recycling (73% respondents), and that 69% of respondents are willing to actively participate in the primary selection of waste in their households, as well as one of the first steps in implementing model of waste management. At least acceptable (only 29% of respondents) is incineration of waste, most likely due to oppinion of 50% respondents that the incinerator is the biggest polluter of the environment, of all waste treatment plants.
The survey also showed lack of knowledge of the population aged 18 - 27 of individual waste treatment, which leads to the conclusion that it is necessary to carry out continuous education and learning population with possible ways of waste treatment.
This research is part of a larger research carried out in order to assess the sustainability of the waste management model, as well as the selection of indicators that clearly and fully sublimate the most important influential factors, as well as their values.

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REVIEW OF RELEVANT KNOWLEDGE ABOUT THE TECHNOLOGY OF RECYCLING CARS

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Abstract: Using recycled materials saves energy and natural resources. Recycling creates less air and water pollution than primary production of raw materials. Recycling saves storage space, create new jobs in companies engaged in the collection, production and distribution of raw materials. In the paper the analysis of the recycling of motor vehicles. Motor vehicle recycling industry contributes to sustainability, environmental protection and energy saving. Recycling of cars includes a variety of procedures, which allow obtaining products floricane materials (metals, plastics, rubber, glass), suitable for the production of new material goods.
Key words: motor vehicles, sustainability recycling.

INTRODUCTION

Also, the introduction of system solutions in the field of automobile recycling contributes to the renewal of the fleet and the consequent reduction of pollutant emissions, traffic safety and saving energy and raw material resources (Bian et al., 2010; Aleksic et al., 2011). Huge amounts of automotive scrap today a major issue in all countries of the world. To ensure the successful recycling of motor vehicles is necessary to create an appropriate legal framework and basic infrastructural requirements, which undoubtedly contributed to its development through attracting investments and building technology resources in accordance with the regulations. With the start of mass production of cars and waste from the car, which ended his life, the idea emerged that certain parts of such cars can be re-used (as spares). However, the number of these parts are so small that they appeared large dump cars. These landfills affect the environment, and on the other hand represent a large amount of raw materials that could certain technological processing be re-used for different purposes. Thus, in recent years in developed countries (the U.S., Japan, etc.)., There are large corporations that take on the responsibility that this job entails. One of the major contributions of this new industry is to reduce environmental pollution. On the other hand, recycling of cars has been hiring large numbers of workers. These problems occur in all parts of the world so that in all countries a need for companies to deal with the recycling of old cars (Trumic et al., 2008; Puric et al., 2011; Milic and Jovanovic, 2011).

ANALYSIS OF SCIENTIFIC KNOWLEDGE IN THE LITERATURE

Energy consumption for the production of secondary raw materials from the recycling process produced significantly lower than those used to obtain material from mining primary production (Ilic, 2002; Krinke et al., 2005). Recycling of used motor vehicles (ELV) in high-income countries is very successful, especially after the introduction of the shredder in the recycling process of used cars. The rate of recycling in developed countries more than 90% of the used motor vehicles. ELV Recycling helps protect the environment (Hempfl, 2010; Jovanovic et al., 2008). ELV recycling reduces the minerals from natural sources and generates a source of raw materials for the production of new products derived from recycled materials (prawns, et al., 2005; Tadic et al., 2010). Removing environmentally harmful components and materials, specialty oils, brake fluid, antifreeze, air bags, mercury, freon and similar substances require special treatment and expertise in areas such waste dismantling. In Germany, Centers for dismantling vehicles covering a circle with a radius of 50 kilometers. In Serbia there are about 1.4 million passenger cars and light commercial vehicles. The estimated number of annual waste produced by 120.000 cars a year, which means that a larger number of equipped recycling operators. (Junbeum et al., 2007; Medic, 2011). Recycling of used motor vehicles in the world, is an efficient process which recycles more than 75% of the cars, along with the rate of used cars collected by 95%. In the United States, is recycled about 11 million units, representing a $ 5 billion of revenue. Automobile Recycling Industry in the United States employs more than 40.000 employees in more than 7.000 companies. In the EU, the number of recycled car reaches 9 million per year, equivalent to 2.2 million tons of waste. As in the U.S., profit mainly by selling used parts and metal. Based on the data (Tolmac et al., 2011a), the number of used cars in the Republic of Serbia, is approximately 100.000 per year. Taking this estimate of the number of used cars, as well as the percentage utilization of certain materials per vehicle, obtained 68.000 tons of ferrous metals, nonferrous metals 6.000 tons, 8.000 tons of plastics and composites, 1.400 tons of fluids, 5.000 tons of rubber, 3.500 tons of glass, 1.000 tons of textiles, 1000 battery tons and 6.100 tons of other waste from the used car. In the Republic of Serbia, during the process - recycles 14% of used motor vehicles, because the capacity for industry remains underdeveloped. In the domestic market ELV recycling, demand for secondary raw materials is high, and the level of recycling of 14%, should increase to European levels by 75%. On the basis of the ELV recycling system, we need new investment of over 20 million, in several plants shredder and mobile Balir presses, and increase the efficiency of the (Subaru and Pavlovic 2006; Djordjevic and popcorn, 2004).

CAR RECYCLING TECHNOLOGIES

In Serbia, there are over a million vehicles whose average age is over 10 years. The collection and disposal of waste vehicles mostly depends on supply and demand. Parts with use value is extracted in smaller amount, depending on their age and condition of end. The automobile recycling facilities in the world it is possible to recycle about 80% by weight of the car. The process of recycling cars is complex because of the variety of materials that are part of the car. Middle-class car, on average, consists of 76% metal, plastic 8%, 4% rubber, fluid 6%, 3% glass and other materials 3% (Trumic et al., 2004). Apply two car recycling technologies, which differ in the way of sorting the material that make up the car. The first technology is based on optical (manuelnoj) separation, and other technology uses multiple methods (grinding, gravity separation methods and special). A third possibility is that the whole car pressed in one piece, using mobile Balir presses (Trumic et al., 2008).
Further classification of non-metals and non-ferrous metals in fruiting material, achieved through a combination of gravity and special separation methods (electrostatic, optical, etc.)., (Trumic, et al., 2009).

RESULTS AND DISCUSSION

Motor vehicle recycling of end of life, according to (Tolmac et al., 2011), is still at an early stage and does not engage a significant number of workers. The research within the project of technological development is defined by a model of integrated and sustainable recycling of motor vehicles at the end of the life cycle (Pavlovic et al., 2011). Thus the set basis for the development of new industries and thus create real conditions for intensive employment in jobs recycling. These tasks include collection and transportation of waste motor vehicles, their removal, selection of components and materials, recovery of components for reuse, crushing shells and chassis, separation of materials, recycling materials, the final disposal of waste. All this requires a different structure of professional personnel, various recycling technologies and the different composition of objects and corresponding requirements for their location (Bian et al., 2010; Afgan et al., 2009).In Serbia, so far no systematic not address this problem in solving environmental and social, and economic problems when it comes to preserving the natural resources of our country. The project aims to (Pavlovic et al., 2011) to localize potential waste motor vehicles, which can be recycled or used for energy. The most important thing is to determine the scope and structure of the permanent disposal of motor vehicles, especially hazardous waste and suggest measures for their removal or safe storage (Pavlovic, 2009; Pavlovic and Subaru, 2006).The project (Pavlovic et al., 2011), is predicted to form an appropriate centers for the breakdown of used motor vehicles by the respective regions. The significance of the project is big, because it provides savings in the form of recycled materials. If we know now about 120 thousand cars a year off, and thus are ready for the recycling process, the weight of every vehicle around 1 ton, of which about 70% feromagnetics materials, there are also non-ferrous metals, plastics, rubber; We can not imagine how it is stored resources. Obtaining metals from recycling leads to saving power generation, such as: steel 74%,aluminum 95%, copper 85%, lead 65%. Getting metal recycling reduces water consumption by 40%, reduces water pollution by 76% and air pollution by 86%. In developed countries (35 to 45)% of the new steel is obtained by recycling (Stojanovic et al., 2004). Recycling is the future to solve the problem of waste motor vehicles, in terms of sustainable development. A clear example that proves the previous statement is given in Table 1 (Tolmac et al., 2011b; Trumic et al., 2008):

Table 1. Saving energy by using recycled materials

Materials	**(%)**
Copper	85
Lead	65
Zinc	60
Aluminum	95
Iron and steel	74
Magnesium	98
Titanium	58
Paper	64
Plastic	80

As can be seen from Table 1, the energy savings by using recycled materials is very important. The investment costs for the construction of waste treatment plants and metal production only (16 to 20)% of the cost to build a plant for processing the raw materials - minerals. In addition, manufacturing technologies based on the processing of secondary metals are much easier and more acceptable for the environment as the example of iron and steel clearly seen in Table 2

Table 2. The benefits of using iron and steel from waste materials

Benefits	**(%)**
Energy savings	74
Saving material from ore	90
Reducing air pollution	86
Reduction of water consumption	40
The reduction of water pollution	76
Reduction of mining waste (tailings)	97

CONCLUSION

Motor vehicle recycling of end of life, according to the proposed model is based on the principles of sustainable development (Pavlovic et al., 2011). The establishment of this model in Serbia, in addition to environmental and economic effects of providing a high level of employment, which is very important for social policy. Thus, the number of employees in the entire cycle of recycling of motor vehicles at the end of the life cycle ranges from 6.000 to 20.000 employees. Number of employees varies as a function of:

- ELV available number in the current year,
- the degree of recyclability,
- the level of motor vehicle dismantling,
- available recycling technologies,
- new products from materials provided by ELV.

Since the operators are to be deployed on the territory of Serbia, so that citizens in their old cars can be submitted at the nearest recycling center which will be issued and a receipt which can be realized certain benefits when purchasing a new car. In this way, the action will involve all those involved in the recycling of batteries, waste oil, antifreeze, glass, plastic and everything that makes a car, and it is necessary to invest a total of over 20 million Euros (Medic 2011; Kozic and Sudarević 2005; Gareth and Shahin, 2006).

Metals and energy consumption in the world has a great trend. The reserves are rapidly being depleted. Scrap metal is a very important secondary resource, whose collection and return of the reprocessing process significantly reduces the consumption of primary raw materials, extends the life of the reserves and reduce environmental pollution. Re-use of metals from waste and general reuse of other materials has great economic justification.

ACKNOWLEDGEMENTS

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RISK ASSESSMENT FOR SCAFFOLDS AND LADDERS

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Abstract: The subject of this paper is to give a brief overview of the risk assessment for the scaffolds and ladders workers as part of the risk assessment for the project comprising building of new motorway from the town of Demir Kapija down to the village of Smokvica, Republic of Macedonia. That is the last un-upgraded section of the existing motor road/motorway E-75, that runs through the Republic of Macedonia and connects Republic of Serbia and the Republic of Greece. Construction of the remaining section of this motorway will enable faster and more safe transportation of people and goods from Central Europe to Greece, or to Turkey and Near East since it will be connected to "Via Egnatia" (West-East) motorway in Greece. Team from the Faculty of Technical Sciences – Bitola prepared risk assessment for the whole project comprising 30 different work places and is constantly is engaged as a consultant for Health and Safety at work related issues, [1]. According to identified risks (hazards) during works on the bridge constructions, scaffolds and ladders used very often and there is proposed some recommendations to reduce or eliminate these risks of falling from high.
Key words: risk assessment, construction, scaffolds, ladders

INTRODUCTION

The motorway section is passing through the Demir Kapija canyon and the remaining gorge and through the more or less flat area from the village Miravci to the village Smokvica. In total, the project involves construction of 28.2 km of new dual carriageway, including two twin tunnels of a total length of 4.5 km, 6 major river bridges/viaducts, 2 interchanges and 12 overpasses/underpasses. The main Contractor on the project is AKTOR S.A., the largest construction company in Greece.
Risk Assessment is a structured process to identify risks, assess risks and define safety measures or arrangements to remove/isolate or reduce risk as far as it is reasonably practicable and control residual risks..
This is confirmed by the fact that the in 2011, 786 serious accidents at work and 16 fatal accidents are registered by the State Labor Inspectorate [7], while by the Institute for Public Health 1520 serious accidents are registered, [7]. In the annual report for accidents at work for 2011 by Macedonian Occupational Safety and Health Association were registered 79 serious and 44 fatal accidents at work, [7]. In the R. Macedonia, in 2012, the total number of accidents at work was 161 from which there were 116 serious accidents that resulted in more than three days of absence from work and 45 fatal accidents at work, [7],where the falling from the scaffolds produced 13 fatal accidents. For that reasons, the scaffolds m ust be threated separately, with the special risk assessment. There are different types of scaffolds like: stationary wooden or metallic scaffolds, mobile wooden or metallic scaffolds and suspended scaffolds. The selection of the appropriate type of scaffold to be used depends on the nature of the work, the activity itself and the height at which it is going to be executed. Usually for outdoor work at height of 4m and above, stationary scaffolds are used and for work height below 3,5 m indoors or outdoors mobile scaffolds. Usage of wooden scaffolds for work at height above 6m is not allowed. For the buildings such as bridges (Fig.1, 2), i.e. pillars, usually is practiced the usage of set of scaffoldings (Fig.2) to perform assembled steel construction. Working on the scaffoldings without proper measures result most often with fatal accidents, therefore the standard protection and working procedures of safety are essential of preventing accidents with death such as falling from heights.

THE RISK ASSESSMENT METHODOLOGY

The Risk Assessment methodology presented in this paper is comprised of four levels, [2, 3].

- HAZARD IDENTIFICATION

At the first level, for each construction activity, a method statement has to be developed. Based on the method statement potential hazards are identified.

Figure 1. A distance view of a bridge No.5 at Motorway construction Demir Kapija - Smokvica

Figure 2. Scaffolds and ladders established on the bridge No.5 at Motorway construction Demir Kapija - Smokvica

- RISK ASSESSMENT

After having identified the hazards we calculate the risk per hazard. This calculation can be a qualitative or quantitative or both, if practicable. It is proposed that the occupational risk assessment is calculated qualitative, but without excluding other forms of similar competence.

According to the Risk Assessment methodology each activity is broken down to tasks, it considers the hazards associated with each task and assesses the risk by assessing the likelihood of an event of a particular severity to occur and multiplies this likelihood with the corresponding severity (see sample risk assessment in the next page). Always the worst case scenario is considered.

The Severity is specified qualitatively by setting classification criteria which determine how serious the impact of a hazard is. Severity is rated into five levels as shown in Table 1.The assessment of the likelihood of a risk is made by using Table 2.

Table 3 is the Risk Matrix which incorporates the criteria for assessing the severity and the likelihood, and is an effective tool for assessing and presenting the risk that can be understood at all levels.

- SAFETY MEASURES EVALUATION

Completing a risk assessment with safety measures proposed, it is expected that the residual risk is trivial or minor. If this is not the case, then further measures are proposed.

- SAFETY MEASURES REVALUATION – REVISION

The final stage of the Risk Assessment is about revaluating and revising the assessment depending on the nature of the Hazards and the various changes in the method statements.

Table 1. Rating Severity

Rating		Severity
1	Trivial	Trivial, minor first aid treatment. Back to work same day
2	Minor	Minor woods, first aid treatment. Back to work within three days from incident
3	Moderate	First aid treatment. Hospital treatment. Back to work after 3 days from incident. No operation
4	Major	Hospital treatment. Operation is required. Back to work after 60 days from incident or requirement for changing post due to injury
5	Severe	Change work, Death

Table 2. Rating Likelihood

Rating		Likelihood
1	Almost zero	Impossible or almost impossible to happen
2	Low	The likelihood is very low
3	Possible	It is possible to happen
4	High	It is very likely to happen
5	Almost certain	It is almost certain or certain

RISK = SEVERITY x LIKELIHOOD

Table 3. Rating Risk Summary (see table 4)

Assessment	Risk	Rating (Quantification)
Acceptable risk. No additional safety measures required.	**Trivial**	1 (1-2)
Acceptable risk. No additional safety measures required apart. A more close supervision and safety measures implementation might be required.	Minor	2 (3-5)
Not acceptable risk. Action is required. Measures should be fully implemented within a month.	Moderate	3 (6-8)
Not acceptable risk. Action is required. Measures should be fully implemented within a week.	Major	4 (9-14)
Not acceptable risk. Action is required. Works must be stopped Immediately Measures should be fully implemented immediately.	Severe	5 (15-25)

Table 4. Risk classification

Risk = Likelihood X Severity			**Severity**				
			Trivial	Minor	Moderate	Major	Severe
			1	2	3	4	5
Likelihood	Almost zero	1	**1**	2	3	4	5
	Low	2	2	4	6	8	10
	Possible	3	3	6	9	12	15
	High	4	4	8	12	16	20
	Almost certain	5	5	10	15	20	25

RISK ASSESSMENT FOR THE SCAFFOLDS AND LADDERS

A. SCAFFOLDS

A1) Before assembling

AKTOR SA discipline engineer responsible for scaffolds has to:

- ❖ Ensure that the scaffold supplier has provided all necessary information concerning safety instructions for design and erection.
- ❖ Verify that the type of scaffold selected is appropriate for the specific work to be performed.
- ❖ Ensure that the scaffold is accompanied by all the necessary quality certificates, manuals providing information about assembly/dismantling etc.
- ❖ Check and ensure that the required quantities of elements are available on site to erect a complete scaffold and all are **I** good condition.
- ❖ If it is a standard type (approved type} scaffold, follow the instructions of the manufacture to erect.
- ❖ If the scaffold is not a standard type then calculate the structure. Make the calculation and ensure they are followed precisely.
- ❖ Ensure the stability of the scaffold
- ❖ Ensure the safe access to the scaffold.
- ❖ Check and verify before safety of the scaffold before use.
- ❖ Foremen are informed in details about:
  - The purpose for which the scaffolds is erected
  - The location of erection point
  - The materials to be used for its construction
  - The number of stages required
  - The suitability of the ground; any arrangements needed
  - Where and how the scaffold has to be anchored
  - The safe access and egress on the scaffold during erection, use and disassembly

A2) Assembling

During erection of the scaffold the foreman in cooperation ensures that:

- ❖ The workers assembling the scaffold are trained and experienced and use the suitable
- ❖ Personal Protective Equipment required.
- ❖ Mobile scaffolds are secured against overturning and accidental dislocation. The scaffold brakes must be used and their good operating condition must be ensured.
- ❖ The scaffold is put up on stable and even ground.
- ❖ Stationary scaffolds are secured against horizontal shifting.
- ❖ The scaffold is not used before assembly is completed.
- ❖ Supervision during erection and implementation of instructions and calculations.

A3) Work on scaffolds

The engineers and foremen supervise works on scaffolds at all times and regular inspections are carried out in cooperation with the HSS Officer ensuring that:

- ❖ Any other equipment used during civil works construction (electricity generators, mixers etc.) must be located at a place which does not interfere with the stability of scaffolds.
- ❖ Workers use at all times the suitable Personal Protective Equipment according to the specific work activity.
- ❖ Scaffolds must not be used for storing materials or equipment.
- ❖ Loads on scaffolds will be evenly distributed to avoid disturbing of its stability.
- ❖ Safe access and egress on scaffolds is available.
- ❖ No work activities are performed with adverse weather conditions when working outdoors.

- Scaffolds are fully boarded.
- Full fall protection is provided.

A4) Dismantling

During scaffold dismantling the foremen have to make sure that:

- No works are performed on the scaffold.
- Trained and experienced workers are employed for this work.
- Dismantling of the scaffold is done according to the supplier's/manufacturer's instructions.

B. LADDERS

AKTOR SA foremen are responsible for ensuring that:

- Ladders are of the appropriate type and in good condition. In any other case the ladders must be fixed (if repairable) or destroyed removed from site.
- Ladders are put up on stable and even ground or surfaces. Use always the kerb stones.
- They are put up away from openings or excavations and in a way that they do not obstruct other activities in the same space and there is no hazard of impact or destabilization.
- The supporting angle of the ladders with the ground must be approximately 75 degrees.
- Ladders are secured or tied by the vertical sides and not by the ladders' steps.
- When larger than 6 meters ladders are used, these are also tied in the middle (3m) and employees using them are required to wear a safety harness.
- Ladders are used by the separately by every worker and not at the same time.
- Ladders project at least over one meter distance above the reaching point of the workplace to ease access to it.
- Ladders are regularly inspected for damages or wear.
- Electricians are required to use ladders only with all supporting points of the ladder insulated.

Employees are required to:

- Use toolboxes or bags hanging by the solder when climbing a ladder with tools or equipment.
- Not use equipment or tools that require the use of both hands on ladders
- Check the ladder before use.
- Inform their foreman for any damages.
- Place the ladder properly before using it.
- Fix ladder or get another person at the base to hold it before climbing.

Due to pages limitations, in this article only an excerpt from the detailed risks assessment for the static or mobile scaffold and worker that uses ladders is given in Table 5.

Table 5. Recognizing the dangers and hazards and risk assessment at work – Worker on static or mobile scaffold, worker that uses ladders

Activity / operation	Health & Safety (HS) and Environmental (E) risks	Risk severity	Protective Measures	Technical or Organizational Measures for the Control of the Remaining Risk
Worker on static or mobile scaffold, worker that uses ladders embankment)	Mechanical hazards of fall from scaffolding	H	Assembling the scaffolding is in accordance with the manufacturer's instructions. Tests by a certified engineer for installation of scaffolding and the properties of the base. No overload is permitted on the scaffold. Use of checked scaffolding only. No workers on the scaffolding when it moves. Probe-examination and properties of the base which will be a set scaffolding.	To use appropriate and certified scaffolding. Assembling the scaffolding is in accordance with the manufacturer's instructions. Inspection by a civil engineer before using scaffolding whether it is corectly assembled. Do not overload

			Tests by a certified engineer for installation of scaffolding and the properties of the base. No overload is permitted on the scaffold. Use of respondents checked scaffolding. Dismantling of scaffolding to execute against previously written instructions. Parts of the scaffold to be checked before use. Setting warning for protection (barriers) in the area where outsiders have access. Check all components of scaffolding before its installation.. Approvals for proper use of materials. Before using scaffolding to review by a panel of experts to determine whether the scaffold is designed for technical documentation, safety regulations at work, technical regulations and relevant standards. Assembling the record for review of scaffolding which is part of the documentation. Check the correctness of scaffolding periodically during operation and at least once a month. Mandatory inspection of scaffolding after repairs, renovations, weather and movement. Check to make head or a certain raotnik that results of the test should enter the control book.	the scaffolding. The ratio of the shorter side for height of the scaffolding is in 1:3 ratio. Check whether the selected type of scaffold match the specifics of the job. You have to use the brakes on the scaffolding and they should be in good working condition. Do not use scaffolding before it is fully assembled. Supervision of installation and implementation of instructions and calculations. The equipment used for the execution of construction works kit at all times (electricity generators, mixers, etc..) must be located on the site and shall not endanger the stability of the scaffold
	Mechanical hazards of stroke in structures with a height above the height of the scaffolding when moving the movable scaffolding	H	Before moving the mobile scaffold always check if there is free space from the top of the roof or any other material, structure or equipment. When works are underway extending the scaffold installations near the scaffolding is not allowed. Before beginning work on the scaffolding (after completion of the shift or cessation of work) to check whether there is enough free space..	When working on scaffolding at night use proper lighting
	Hazards from falls when using ladders	H	Ladder used to be in good condition. Ladder must be placed on a stable surface. The final part of the ladder is over 1 m above the highest point. When using the ladder, observe the location of other persons. Fix the ladder at the top end. The angle of inclination of the ladder should be approximately 75^o. Ladder is secured or tied on the vertical side.When using ladders higher than 6 m, it should be tied to the middle (3 m), and workers must use protective elastic belt.	When using a ladder, use system (technique) with 3 contact points. Regular checking of ladder from damage or wear. Inform the engineer in charge about damages on the ladder. Ladder to be left in proper condition after its use. Workers must be trained in the proper methods of setting the ladder. Ladders should not pose an additional risk in the workplace. Regular and periodic control.
	Hazard of impact with the equipment used during lifting	H	Safe placement of equipment used for lifting in order to impacts on mobile scaffold. Lifting operations always to be performed under supervision. To avoid similar activities. Supervision of work at all time.	Safe placement of equipment used for lifting in order to impacts on mobile scaffold. Lifting operations always to be performed under supervision. To avoid similar activities. Supervision of work at all time.
	Mechanical hazards of breaking down the scaffolding (gear) fails	H	To use appropriate and certified scaffolding. Assembling the scaffolding is in accordance with the manufacturer's instructions. Inspection by a civil engineer before using scaffolding whether it is correctly assembled. Do not overload the scaffolding. The ratio of the shorter side for height of the scaffolding is in 1:3 ratio. Lighting to be in compliance with applicable standards. Check whether the selected type of scaffold match the specifics of the job. Scaffolding can not be used until it is checked by an authorized person.	To use appropriate and certified scaffolding. Assembling the scaffolding is in accordance with the manufacturer's instructions. Inspection by a civil engineer before using scaffolding, whether it is properly assembled. Do not overload the scaffolding done. The ratio of the shorter side for

				height of scaffolding is 1:3. Check whether the selected type of scaffold match the specifics of the job. The distance between the elements of the scaffolding should be used only with funds provided technical documentation and scaffolding conjunction with typical elements are made in accordance with the manufacturer's instructions. Binding of individual elements of scaffolding in general constructive is done in a way to reduce the payload or payload elements of scaffolding as a whole
	Mechanical hazards due to fall of items and materials from scaffolding	H	Assembling the scaffolding is in accordance with the manufacturer's instructions. Using experienced installers of scaffolding. Continuous supervision. Providing safe transport of material at level. The area around scaffolding at a radius of 2 m to be fine. Monitor weather conditions-wind speed. Editing can be performed stage-by-stage. Use proper equipment for lifting. Workers who mounted the scaffold are trained and experienced in the use and personal protective equipment at work. Use of protective platforms and platforms for complete protection. Hand tools and other fine material is always stored in a box. Setting the fence (with warning tape) at a distance of 3 m around the scaffold platform. Scaffolding must not be used to store materials or equipment. Mandatory use of the funds for personal protection. Employees who work on scaffolding required to wear a helmet and protective shoes. As protection from falling material to use network, built protection, range, protective side panels.	As protection from falling material network, built protection, range, side protective boards etc., with width of at least 150 mm should be used. Use of protective scaffolding platform to accept or network level so that the receiving platform bearing scaffolding not less than 3 m from the edge through which employees can fall. Protective scaffold with overhang to protect workers from items can fall from the height should be at least the height of 2.5 m above the ground at which workers move. Protective scaffolding with overhang should be so dimensioned and designed so that they can maintain and heaviest object as well as to prevent its rejection and breaking up the surrounding area. The width of the receiving platform or protective overhang must not be less than 1,5 m.
	Hazards that occur due to the workplace characteristics - risk of worker falling from height	H	Assembling the scaffolding is in accordance with the manufacturer's instructions. Using experienced installers of scaffolding. Continuous supervision. Providing safe transport of material at level. Monitor weather conditions-wind speed. Editing can be performed stage-by-stage. Use proper equipment for lifting. Workers who mounted the scaffold are trained and experienced in the use and personal protective equipment at work. Use of protective platforms and platforms for complete protection. Mandatory use of personal protective equipment. Employees who work on scaffolding required to wear a helmet and protective shoes. As protection from falling material to use network, built protection, range, protective side panels. Inspection by a civil engineer before using scaffolding whether it is corectly assembled.	It is prohibited to step down, hang or tilt over the platform of scaffolding. To use fixed ladders for approach and exit of scaffolding. Do not move the scaffolding when it is has workers on it. It is prohibited to use rafters for heights over 6 m. Workers at all times are required to wear appropriate personal protective equipment (especially safety protective belt, helmet and safety shoes) in accordance with specific conditions. It is prohibited to use docks on excavation places (trenches) where workers can

			Use of access ladder in the phase of construction of scaffold. Secure safe access and egress to scaffold	fall from a height greater than 4.5 m. All handles over 3.6 m height must be fixed to the building or to provide stability otherwise. All platforms to have width of at least 450 mm

Dismantling

During scaffold dismantling the foremen have to make sure that:

- ❖ No works are performed on the scaffold.
- ❖ Trained and experienced workers are employed for this work.
- ❖ Dismantling of the scaffold is done according to the supplier's/manufacturer's instructions.

It should be noted that the conducted risk assessment is only part of the total H&S plan implemented by the Contractor which also involves permanent health and safety related campaigns, on-site trainings and education of the staff.

CONCLUSION

There are several conclusion produced by the previous risk assessment of the scaffolds and ladders work places:

- ❖ The scaffold is accompanied by all quality certificates, load bearing ability study, assembly/disassembly manuals, supplier/manufacturer safety instructions etc.
- ❖ Only experienced personnel must be involved in scaffold assembly/disassembly operation.
- ❖ The use of Personal Protective Equipment like hard hut and safety boots is compulsory for workers on scaffolds.
- ❖ The scaffolds have guardrails and toe boards to prevent objects and people from falling.
- ❖ The work floors have the appropriate width without any voids.
- ❖ Safe access and egress is secured.
- ❖ The scaffold is secured against overturning.
- ❖ The parts of the scaffold are thoroughly checked before use.
- ❖ Regular inspections of the scaffold are carried out by the HSS-Officer.
- ❖ Ladders used for light and brief work activities.
- ❖ Ladders must be regularly inspected.
- ❖ Employees must be trained on the correct methods of putting up and fixing a ladder.
- ❖ The ground must be stable and even.
- ❖ Ladders must not create additional hazards to the workplaces.

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SITUATION REGARDING ACCIDENTS AT WORK IN THE EUROPEAN UNION AND IN THE REPUBLIC OF MACEDONIA

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Abstract: In this paper, some of the statistical indicators which refer to serious and fatal accidents at work in the European Union (EU-28) and in the Republic Macedonia are presented. The performed statistical analysis shows that the number of serious and fatal accidents at work in EU-28 and in the Republic Macedonia, in 2012 was decreased in comparison with 2008. Nevertheless, the Republic of Macedonia has high incidence rate for fatal accidents at work compared to highly developed European countries. The activities of public administration and defense, construction, manufacturing, transportation and storage sector and the activities of households as employers are the economic sectors in which it is possible to prevent injuries caused by serious accidents at work. The activities of households as employers, construction sector, transportation and storage sector and agriculture, forestry and fishing are the economic sectors in where prevention of injuries at work caused by fatal accidents must be addressed.
Key words: accidents, fatal, serious, incidence rate.

INTRODUCTION

Accidents at work are directly related to the characteristics of the work process and workplace conditions. According to the European Agency for Safety and Health at work, occupational diseases and accidents at work, that is a consequence of inadequately organized system for safety and health at work, each cost the country between 2.6 to 3.8% of GDP, [7]. This is the basis for serious concern, and the problem grows further if we consider that many occupational diseases and workplace accidents remain unregistered. In 1990 the Eurostat harmonization project of European statistics was initiated on accidents at work (European Statistics on Accidents at Work - ESAW) to develop methodologies for the collection of comparable and significant data within the European Union, [5]. In European Statistic for Accidents at Work methodology an 'Accident at work' is defined as 'a discrete occurrence in the course of work which leads to physical or mental harm'. The phrase 'in the course of work' means while engaged in an occupational activity or during the time spent at work, [5]. The following types of accidents are included: cases of acute poisoning, wilful acts of other persons, accidents that occurred on the premises of an employer other than that which employs the victim, accidents in public places or public means of transport during a journey in the course of works. According to this methodology, accidents in workplace do not include: commuting accidents (accidents that occur during the normal journey to or from home and place of work), deliberate self-inflicted injuries, accidents from strictly natural causes (accidents caused solely by a medical condition, e.g., cardiac or cerebral incidents), accidents to members of the public, even if such an accident is due to a work activity within a company, [5]. In the European methodology a 'fatal accident' is defined as an accident which leads to the death of a victim within one year of the accident. It should be emphasized that according to the European methodology, in the statistical analysis of data in order to provide comparative data, only injuries at work that has caused an absence from work for more than three calendar days, are analyzed. In the Directive 89/391/EEC, [4] on the safety and health of workers at work is contained provision for the employer to keep records of accidents at work resulting in an inability to perform their duties for more than three days. In accordance with national law regulations, employer is obliged to drawn up reports for occupational accidents suffered by his workers. In Macedonia this area is regulated by the Rulebook on keeping records of Occupational Safety and Health at Work (Official Gazette of RM, No. 136/2007), [8]. There are several specialized organizations and institutions in the Republic of Macedonia dealing exclusively with working conditions. These include State statistical office, the Labour inspectorate, Institute for public health, the Macedonian Occupational Safety and Health Association, Organization of the employers of Republic of Macedonia and the Trade unions. In this paper, some statistics indicators which relate to accidents at work in Republic of Macedonia and in the European Union are given.

SITUATION REGARDING ACCIDENTS AT WORK IN THE EUROPEAN UNION

The accident at work has a high degree of variability within the European Union, which is influenced by different social and legal practices, [3]. The European Statistics on Accidents at Work (ESAW) methodology considers two main types of indicators on accidents at work: the number of accidents and the incidence rate. To define the frequency of accidents i.e. incidence rate, it is necessary to define the relationship between the number of accidents and the reference population which ideally is the number of persons in employment (persons exposed to the risk of accident at work). The incidence rate is defined as the number of accidents at work per 100 000 persons in employment, [5]

$$\text{Incidence rate} = \frac{\text{Number of accidents (fatal or non-fatal)}}{\text{Number of employed persons in the covered population}} \text{ x100000}$$

This rate can be based on the variables that classify the victims of an accident (e.g. economic activities, age, etc.), it could be calculated for the whole European Union, for a Member State or any other subdivision of the population, and the type of injury (injured body part, etc.). For a more than-three-day injury which results in the injured person being away from work or unable to do their normal work for more than three days'; or for fatal accidents, the incidence rates are calculated separately. In 2012, there were just over 1.8 million serious accidents that resulted in more than three days of absence from work and 2797 fatal accidents in the EU-28, [5]. It is a considerable reduction of number of accidents in relation to 2008, when there had been approximately more than 1.3 million serious accidents and 604 more fatal accidents (based on time series for the EU-27). Across the EU-28 there were, on average 2.03 fatal accidents per 100 000 persons employed in 2012 (Fig. 1).

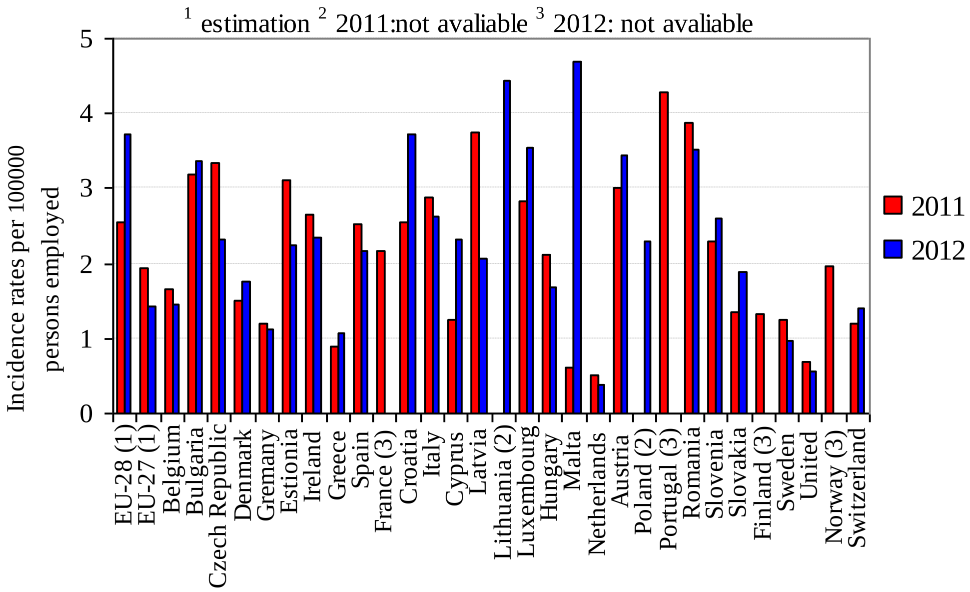

Figure 1. Number of fatal accidents at work, 2011 to 2012-Source: Eurostat[6]

Among the EU Member States, the highest incidence rate of fatal accidents at work in 2012 was recorded in Malta (4.70 deaths from accidents at work per 100 000 persons employed), followed by Lithuania with 4.50, Croatia with 3.73, Luxembourg with 3.55, Romania with 3.53 and Bulgaria with 3.37 deaths from accidents at work per 100 000 persons employed. On the other hand, the

Netherlands, Sweden and the United Kingdom, recorded the lowest incidence rates, below 1.0 fatal accidents at work per 100 000 persons employed. In EU-28 there were 932 serious accidents at work per 100 000 persons employed (Fig. 2). The incidence of serious accidents at work in 2012 was highest in Spain reporting in excess of 2594 serious accidents per 100 000 persons employed. This trend was followed by Denmark with 2148 serious accidents. In the second group, Switzerland, (1837), Germany (1867), Luxembourg (1814), Netherlands (1794) Belgium (1740) and Slovenia with (1697) accidents per 100 000 persons employed, can be classified. By far the lowest rates were reported in Bulgaria (78), Latvia (89), and Romania (42), below 100 serious work accidents per 100 000 persons employed. To explain these differences deeper statistical analysis is needed.

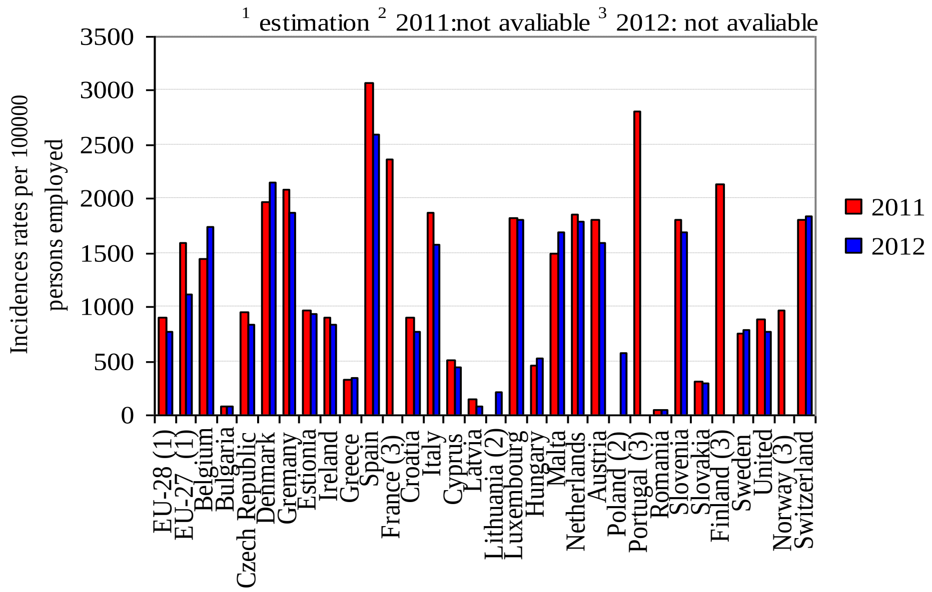

Figure 2. Number of serious accidents at work, 2011 to 2012-Source: Eurostat[6]

The number of accidents at work varies considerably depending upon the economic activity. In Fig. 3 the fatal and serious accidents at work by economic activity in the EU-28 in 2012 are shown.

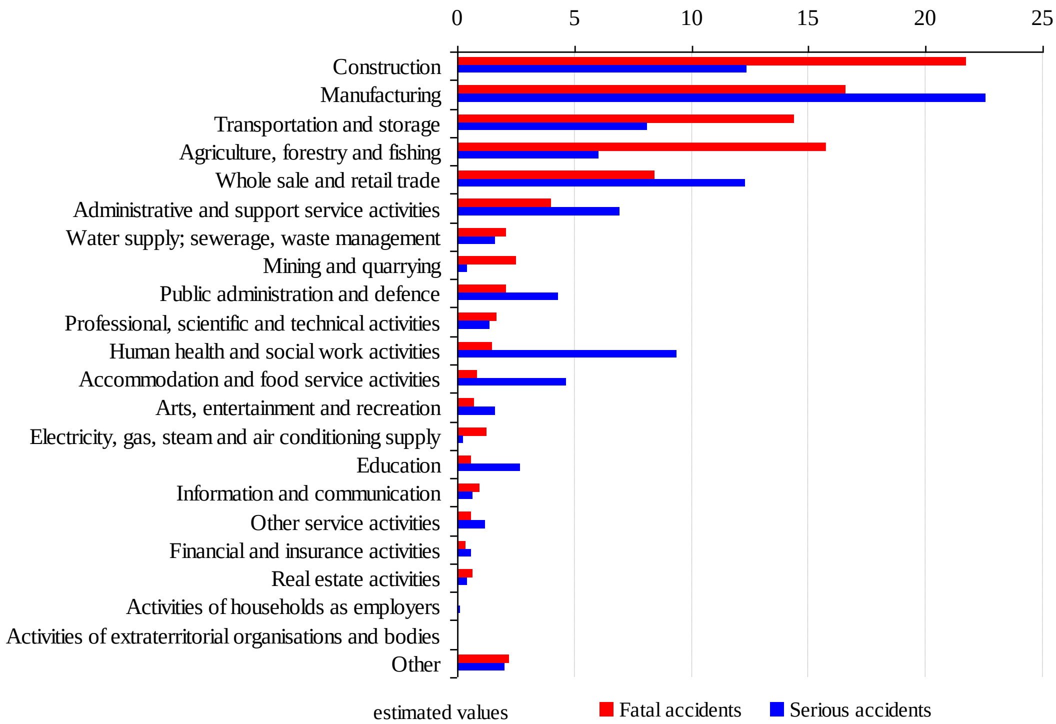

Figure 3. Fatal and serious accidents at work by economic activity, EU-28, 2012-Source: Eurostat[6]
(% of fatal and serious accidents)

In the EU-28 in 2012, the construction, manufacturing, transportation and storage, and agriculture, forestry and fishing sectors together make 68.4 % of all fatal accidents at work and 49.0 % of all serious accidents. The construction sector with 21.7% of all fatal accidents at work is on the first place, followed by manufacturing sector with 16.6% of all fatal accidents at work. Agriculture, forestry and fishing with 15.7% and transportation and storage sector with 14.4% of all fatal accidents at work are in the top four sectors. After that follows whole sale and retail trade and repair vehicles and motorcycles 8.4% and administrative and support service activities with 4%. Nevertheless, serious accidents were relatively common within water supply; sewerage, waste management and remediation activities, mining and quarrying, public administration and defense, professional, scientific and technical activities, human health and social work activities, electricity, gas, steam and air conditioning supply (between 2.51% to 1.27%). The rest fatal accidents at work in all other sectors are under 1%. With 22.5% of all serious accidents at work manufacturing sector took first place. Follows construction 12.4%, whole sale and retail trade 12.3%, human health and social work activities 9.4%, transportation and storage 8.1% and agriculture, forestry and fishing sectors with 6.0% of all serious accidents at work.

Data according to the type of injury sustained during the accident in the EU-28 is shown on Fig. 4.

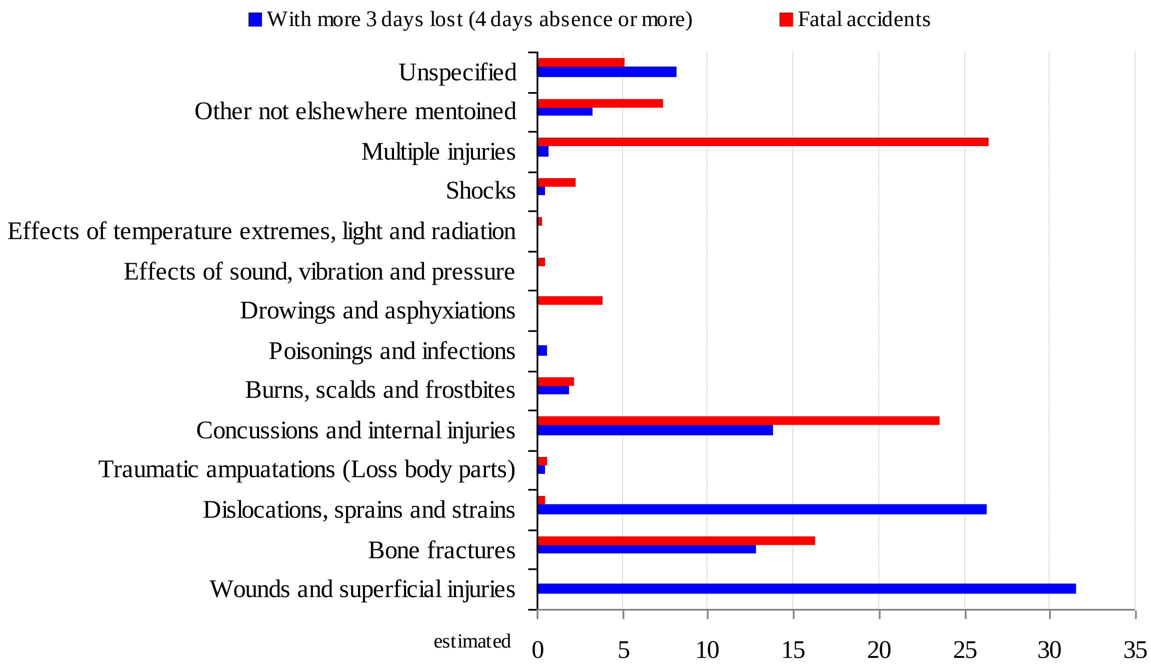

Figure 4. Accidents at work by type of injury, EU-28, 2012 (%), -Source: Eurostat[6]
(% of fatal and serious accidents)

The data for the EU-28 for 2012 shows that there were two types of common injury which caused more than 3 days lost (4 days absence or more), wounds and superficial injuries 31.5% of the total and dislocations, sprains and strains 26.4 %. Next are accidents which caused concussion and internal injuries 13.8%, while a similar proportion of accidents concerned bone fractures 12.8%. After that accidents which caused unspecified injuries 8.1% and burns, scalds and frostbites 1.8 %, follow. All other injuries are below 1%. The highest percentages of injuries that are caused as a result of fatal accidents were multiple injuries 26.4% and concussion and internal injuries 23.6%. Follow accidents which caused bone fractures (16.3%), other not elsewhere mentioned 7.4% and unspecified with 5.1%.

SITUATION REGARDING ACCIDENTS AT WORK IN THE REPUBLIC MACEDONIA

The data on the number of accidents at work in the Republic of Macedonia is not confidential for the reason that different relevant institutions (State statistical office, Institute for public health, State Labour Inspectorate, Institute for occupational health of Republic Macedonia, and Macedonian

Occupational Safety and Health Association) published various statistical data. This is confirmed by the fact that the in 2011, 786 serious accidents at work and 16 fatal accidents are registered by the State Labour Inspectorate [7], while by the Institute for Public Health 1520 serious accidents are registered, [7]. In the annual report for accidents at work for 2011 by Macedonian Occupational Safety and Health Association were registered 79 serious and 44 fatal accidents at work, [1].

In the Republic of Macedonia, in 2012, the total number of accidents at work was 161 from which there were 116 serious accidents that resulted in more than three days of absence from work and 45 fatal accidents at work, [1]. In comparison with 2008 when 178 total accidents at work were registered, [2] it is a reduction of 10%. This is due to the reduction in the number of fatal accidents at work that in 2008 year consisted of 62 fatal accidents at work.

The incidence rate of fatal accidents at work in 2012 in the Republic of Macedonia were 6.8 deaths from accidents at work per 100 000 persons employed. In comparison with Malta with the highest incidence rate of fatal accidents, 4.7 deaths from accidents at work per 100 000 persons employed in the E-28, it may be concluded that Macedonia has a fairly higher incidence rate of fatal accidents at work. The incidence rate of serious accidents at work in the Republic of Macedonia in 2012 was 17.2 serious accidents per 100 000 persons employed. This means that the Republic of Macedonia can be classified in the group of EU countries that have less than 100 serious work accidents per 100 000 persons employed.

In Fig.5 the fatal and serious accidents at work by economic activity in the Republic of Macedonia in 2012 are shown.

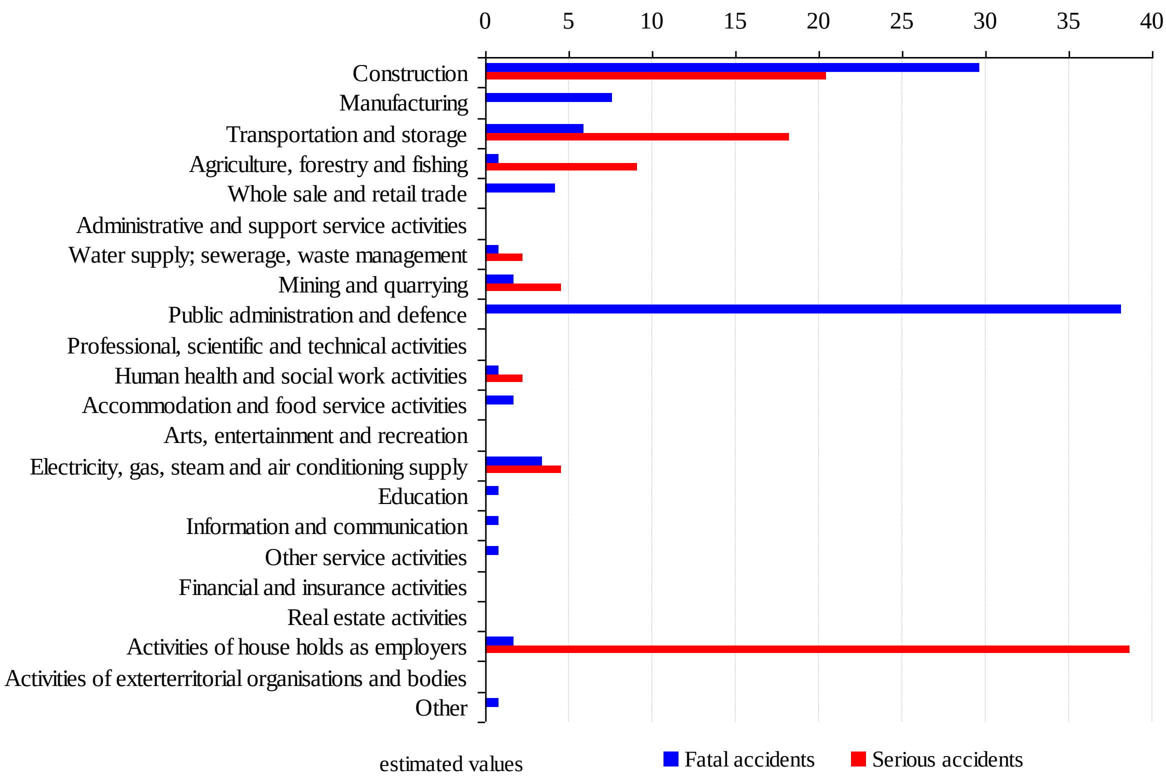

Figure 5. Fatal and serious accidents at work by economic activity, the Republic of Macedonia, 2012- Source: Macedonian occupational safety and health association (% of fatal and serious accidents)[7]

The activities of public administration and defense, construction, manufacturing and transportation and storage sector together accounted for 81.4% of all serious accidents. As far as serious accidents at work in 2012 for the Republic Macedonia are concerned, the public administration and defense sector with 38.1% took first place, followed by construction sector with 29.7%, manufacturing with 7.63 % and transportation and storage sector with 5.9% serious accidents. As far serious accidents at work Republic Macedonia in 2012, the activities of households as employers with 38.6% took first place, followed by construction sector with 20.5%, and transportation and storage sector with 18.2% and agriculture, forestry and fishing with 9.1% serious accidents at work.

In Fig. 6, the data according to the type of injury sustained during the accident in the Republic of Macedonia for 2011 is presented, mainly because there is no relevant statistical data for 2012. The data for the accidents at work by type of injury in the Republic of Macedonia for 2011 shows that there were two types of common injury which caused more than 3 days of absence and fatal accidents at work, and the total number of accidents at work with more than 3 days lost (4 days absence or more), bone fractures 45.4% of the total and other not elsewhere mentioned 28.2%. After that follow accidents which caused concussion and internal injuries 9.5%, wounds and superficial injuries 6.0%, injuries to the head and neck 4.8%, burns, scalds and frostbites 2.2% and injuries to the eye 1.9%. The fatal accidents participated with 2.1% of the total number of injuries.

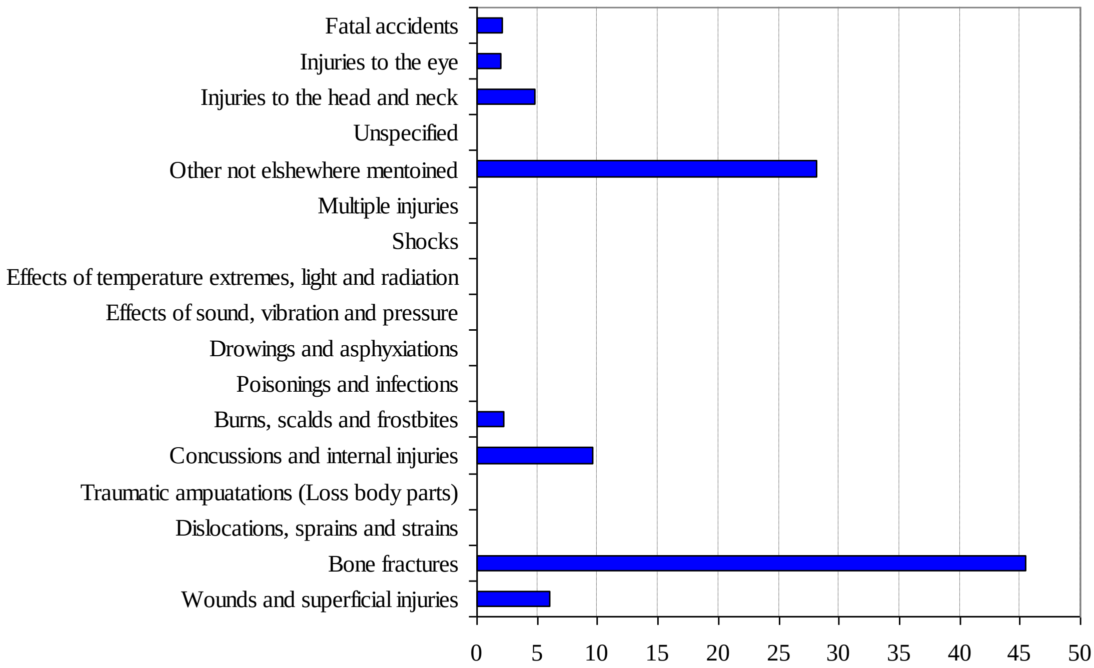

Figure 6. Accidents at work by type of injury, Republic of Macedonia, 2012 (%), -Source: Information for workplace injuries and occupational diseases in Republic of Macedonia 2010-2011[7] (% of fatal and serious accidents)

CONCLUSION

From the performed statistical analyses for the number of serious accidents at work in the European Union and in the Republic Macedonia in 2012, it may be concluded that there is considerable reduction of number of accidents at work in relation to 2008. But the high value of incidence rate of fatal accidents at work (6.8) ranks the Republic Macedonia as the country above the European average. While with the incidence rate of serious accidents at work (17.2 serious accidents per 100 000 persons employed), Republic of Macedonia can be classified in the group of EU countries that have less than 100 serious work accidents. The construction, manufacturing, transportation and storage sectors and agriculture, forestry and fishing are the top four sectors in which fatal and serious accidents of work in the EU-28 occurred. With 21.7% fatal accidents at work in the EU-28 in 2012 the construction sector took first place, while manufacturing sector with 22.5% was first in the rank of serious accidents at work. In the Republic Macedonia in 2012, top four sectors in which serious accidents at work happened are: the activities of public administration and defense, construction, manufacturing and transportation and storage sector, while for fatal accidents at work, the sector households as employers is on the first place. In EU there were two types of common injury which caused more than 3 days of absence and fatal accidents at work, the total number of accidents at work with more than 3 days lost (4 days absence or more), wounds and superficial injuries and the total and dislocations, sprains and strains. The highest percentages of injuries that are caused as a result of fatal accidents were: multiple injuries and concussion and internal injuries. This analysis cannot be done for Macedonia because of the unmatched injuries and work according to the Eurostat classification of injuries. But, we can say that bone fractures are the most common injuries, while the fatal accidents at work participated with 2.1 % of the total number of injuries.

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VARIOUS APPROACHES TO DEFINING THE CRITERIA OF DUCTILE CRACK IN COLD BULK FORMING PROCESSES

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Abstract: In the process of metal forming continuous development and accumulation of material microstructure damage takes place. Reaching the critical level of damage, macroscopic damages occur which is manifested by crack and destruction of specimen (i.e. the crack) in metal forming processes. Optimal and rational design of technological forming processes means recognizing the location the crack occurs and strain limiting value. Ductile crack criteria is used for the purpose of solving this very complex task of material formability. In this paper we provided overview of theoretical and experimental approaches used for the purpose of defining the criteria of ductile crack based on reference literary resources.
Key words: ductile crack, cold bulk forming, damage microstructures

INTRODUCTION

In the metal forming process various types of microstructure damage occur, and with the increase of forming level they take macroscopic proportions. Generally speaking, macroscopic damage occurs during forming in cases when properties of metal components are not in line with specific features of construction solution and designed technological process. There are many reasons why they occur: a) wrong choice of material which includes chemical composition, microstructure state, volume content of microstructural constituents, presence of non-metal included materials and other secondary phases, size of crystal grain, mechanical and physical characteristics, history of thermal treatment, b) inadequate defining of forming conditions and parameters (number and sequence of operations, forming temperature, strain rate, non-technological properties of the product, tribological aspects, mechanical processing of the workpiece, state of tools (geometrical precision and adequate thermal processing), state of equipment regarding precise positioning of tools and workpiece etc. Types of macroscopic damage in forming processes are provided in the study by Arentoft et al. [1]. Nevertheless, the most common type of material damage in bulk forming processes are cracks formed on free surface of the specimen and internal cracks.
From the standpoint of production, occurrence of cracks and breaks is very negative feature, except in certain forming processes where it is necessary for realization of certain operation with the final aim of obtaining products with certain demanded characteristics (for instance, production of seamless tubes etc.). On the other hand, in general terms, in case ductile crack occurs, any further forming has to be stopped and that makes it main limiting factor to increase in productivity in metal forming processes.
Possibility to predict location on the workpiece and level of strain at which the initiation and development of ductile crack occur has very important role in optimal projecting of technological processes in metal forming. Experimental research has validated that mechanisms of nucleation, growth and coalescence of micro-voids which control the level of microstructure damage and lead to activation and expansion of the crack are under the influence of various factors out of which the largest influence is presented by state of stress in the critical forming zone.
Based on the available literature, in this paper are systematically presented some of the most commonly used criteria of ductile crack which are used for the purpose of predicting the exact location of critical damage to microstructure and forming limit in cold bulk forming proceses. Various approaches used for the mathematical formulation of the processes are also used in the course of the paper.

THEORETICAL ASPECTS OF DEFINING DUCTILE CRACK CRITERIA

It is common fact that there is large number of criteria which in various ways presents the possibility of detecting critical level of damage to microstructure with the aim of detection of initiation of crack or ductile crack available in scientific literature. Term damage or degradation is used here in the sense of deterioration of possibility of material microstructure to take load during forming process.

Ductile crack criteria have the purpose to describe material damage that occurs on macroscopic level using experimental data or through mathematical and physical models. Their basic aim is to predict the location of occurrence of the crack and critical value of forming level during specific forming phase. In the meanwhile, it is necessary to define the parameter which describes the intensity of damage and which reaches its maximum value in the moment the crack occurs.

Nevertheless, it is clear that critical value of damage which can be defined as total accumulated damage to microstructure until the moment the unwanted forming occurs at the critical location of the metal component varies depending on the forming process applied, the forming conditions and material used. In the literature there are no available suggestions for critical values of damage for the specific material nor the conditions to be fulfilled while using certain criteria. Difficulties also occur while trying to establish general values of limit strains for the tested material because nucleation of micro-voids (the start point of crack forming) and their growth predominantly depend on generated stress state and history of stress state indicators.

It is generally accepted that while defining the ductile crack criteria we have to take into consideration the following [2]:

- Strain path (history of stress state indicators) because currently generated stress state is not sufficient to characterize the level of material's level of microstructure damage,
- Hydrostatic stress, considering the fact that material formability is very sensitive to variations of σ_H,
- Adequate ratio of σ_H/σ_e, making plasticity and level of damage to microstructure easier to be more comprehensively described.

In the general case, function of damage to material microstructure D_{th} can be described in the implicit form [2-4]:

$$D_{th} = \int_0^{\varphi_e^g} f\left(\sigma_H(t), \sigma_e(t), \varphi(t), \dot{\varphi}(t), \dots \right) d\varphi_e \rangle D_{th,cr}. \tag{1}$$

Where: σ_H – is hydrostatic stress, σ_e – is effective stress, φ – is logarithm strain, $\dot{\varphi}$ - is strain rate, $\varphi_e{}^g$ – is limi value of effective strain, $D_{th,\,cr}$ –is critical value of material microstructure damage.

According to equation (1), the crack in the material starts to develop when calculated value of damage D_{th} is larger than critical value $D_{th,cr}$.

With the respect to recognizing the complexity of this issue various criteria of ductile crack have been developed in the past. Their models of damage to material's microstructure can be divided into two groups. The division was performed depending on approach used in their defining [5]:

- Uncoupled approach – damage models are described in the manner to indirectly, through values of certain process parameter during various numerical analysis, influence material properties. Ductile crack criteria whose formulation is based on the energy needed to establish limit strain and models where material's damage to microstructure occurs due to nucleation, growth and coalescence of micro-voids are used in this approach.
- Coupled approach – damage models in forming process progressively take into consideration level if damage to microstructure material strength. In that process output values of every consequent numeric iteration depend on value of current damage to microstructure or history of indicators of stress state. In this group are the criteria based on porosity theories and continuum mechanics.

According to the available literary resources [2-3, 5-13], in the following paragraphs is provided overview of ductile crack criteria which provide prognosis of the place the crack occurs in the material and strain level at which critical damage occurs with different level of success.

DUCTILE CRACK CRITERIA BASED ON CUMULATIVE ENERGY OF METAL FORMING PROCESS

One of the earliest attempts to define ductile crack criteria is based on the assumption that initiation and expansion of the crack occurs at critical value of energy absorbed in the process of metal forming - Freudenthal (1950.):

$$D_{th} = W_p = \int_0^{\varphi_e^g} \sigma_e \, d\varphi_e \tag{2}$$

where: W_p – specific work of deformation,
σ_e – effective stress,
φ_e^g – limit value of effective strain at the place the crack occured.

Criteria suggested by Datsko (1966.) suggests that activation of the crack occurs when effective strain reaches critical value. Criteria is mathematically formulated in the following form:

$$D_{th} = \varphi_e^g = \int_0^{\varphi_e^g} d\varphi_e \tag{3}$$

Criteria suggested by Cockroft and Latham (1968.) assumes that the most relevant impact on initiation of the crack is influence of main normal stress σ_1, or critical value of energy spent per volume unit in the process of workpiece tension:

$$D_{th} = \int_0^{\varphi_e^g} \sigma_1 \, d\varphi_e \tag{4}$$

where: σ_1– is maximum normal stress.
Ct that there is limited number of cases where criteria (4) enables reliable prediction of crack, Oh and Kobayashi suggested normalized version where stress state does not possess purely tension character:

$$D_{th} = \int_0^{\varphi_e^g} \frac{\sigma_1}{\sigma_e} \, d\varphi_e \tag{5}$$

Later on Brozzo, De Luca and Rendina (1972.) modified the criteria (5), defining its explicit dependence on the function of maximum normal stress σ_1 and hydrostatic stress σ_H:

$$D_{th} = \int_0^{\varphi_e^g} \frac{2\sigma_1}{3(\sigma_1 - \sigma_H)\sigma_e} \, d\varphi_e \tag{6}$$

Norris et al. (1978.) suggested empirical system based on the influence of hydrostatic stress to development of cracks in the following form:

$$D_{th} = \int_0^{\varphi_e^g} \frac{1}{(1 - c_N \sigma_H)} \, d\varphi_e \tag{7}$$

Where: c_N – is a constant depending on type of material.
When it was determined that criteria (7) did not have the potential to provide reliable prediction of occurrence of crack in processes of deep drawing and forging, Atkins (1981), introduced explicit dependence of ductile crack indicator values from strain path in defining the new criteria:

$$D_{th} = \int_0^{\varphi_e^g} \frac{1 + 1/2\alpha}{(1 - c_A \sigma_H)} \, d\varphi_e \tag{8}$$

Where: $\alpha = \dfrac{d\varphi_1}{d\varphi_2}$ – is main strains accession ratio
c_A – is constant depending on the material.

DUCTILE CRACK CRITERIA BASED ON MODEL OF GROWTH AND COALSCENCE OF MICRO-VOIDS

Nucleation, growth and coalescence of micro-voids are considered to be main reason for occurrence of ductile crack in metal forming processes. Criteria inspired by this hypothesis can be based on various physical aspects like geometry of micro-voids, nucleation mechanism and micro-voids growth mechanism or model of material constitution.

McClintock (1968.) was one of the first researchers who defined the criteria of ductile crack for cylindrical micro-voids with parallel orientation in relation to tension stress axis using the above mentioned approach:

$$D_{th} = \int_0^{\varphi_e^g} \left\{ \frac{\sqrt{3}}{2(1-n)} sinh\left[\frac{\sqrt{3}(1-n)}{2} \cdot \frac{\sigma_a + \sigma_b}{\sigma_e} \right] + \frac{3}{4}\left(\frac{\sigma_a - \sigma_b}{\sigma_e} \right) \right\} d\varphi_e \tag{9}$$

Where: σ_a and σ_b – are main stresses in direction of extreme values of micro-void strain
n – hardening coefficient

Equation (9) defines critical level of damage to microstructure caused by merging of micro-voids into macro-void in the process of metal forming on the part of material characterized by plane strain.

Guided with the results of previous research, Rice and Trasey (1969.) established more realistic criteria of ductile crack according to the analysis of increment growth of spherical micro-voids taking into consideration ratio of hydrostatic and effective stress, i.e. interaction and unstable coalescence of neighboring voids. The criterion is defined in the following form:

$$D_{th} = \int_0^{\varphi_e^g} A \cdot exp\left(\frac{3\sigma_H}{2\sigma_e} \right) d\varphi_e \tag{10}$$

Where: A – is material constant which is experimentally determined.

Assuming that in the metal forming process generating, increment growth and coalescence of micro-voids occurs which leads to final material destruction, Oyane et al. (1978. i 1980.) developed ductile crack models for compact and porous materials. In case of compact material criteria of ductile crack is presented in the following relation:

$$D_{th} = \int_0^{\varphi_e^g} \left(1 + \frac{\sigma_H}{A\sigma_e} \right) d\varphi_e = C \tag{11}$$

Where: A and C – are constants depending on type of material and they are experimentally determined.

Value of effective strain in the moment the crack occurs is determined according to the expression (12):

$$\varphi_e^g = -\frac{1}{A} \int_0^{\varphi_e^g} \left(\frac{\sigma_H}{\sigma_e} \right) d\varphi_e + C \tag{12}$$

DUCTILE CRACK CRITERIA BASED ON THEORY OF POROSITY

According to the theory of material porosity, change in density can be advantageous parameter for characterization of material damage. Gurson [14] was one of the first researchers who defined the ductile crack criteria based on porosity concept. Observing the material as porous medium where the impact of stress-strain state and the flow forming to nucleation and growth of micro-voids cannot be neglected, he defined scalar measurement (f) as a ratio of average volume of micro-voids and total volume of material which actually represents volume value of micro-voids in the material (Figure 1). Primary concept of describing porous properties of material is based on this assumption, where internal variable *f* is used for characterization of damage to microstructure.

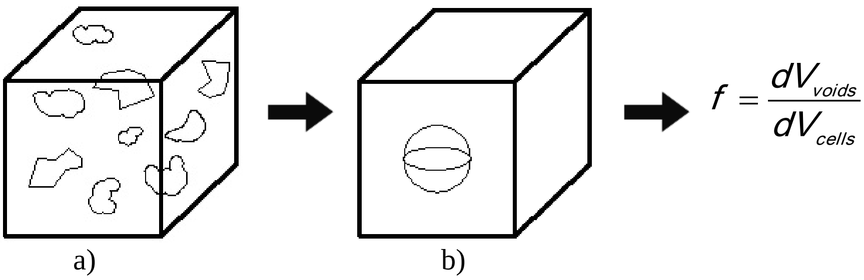

Figure 1. Gurson's model: a) material porosity, b) average measure of fraction of micro-voids [14]

Gurson's model idealizes the actual distribution of generated micro-voids in unit aggregate of material through one spherical micro-void (Figure 2.).

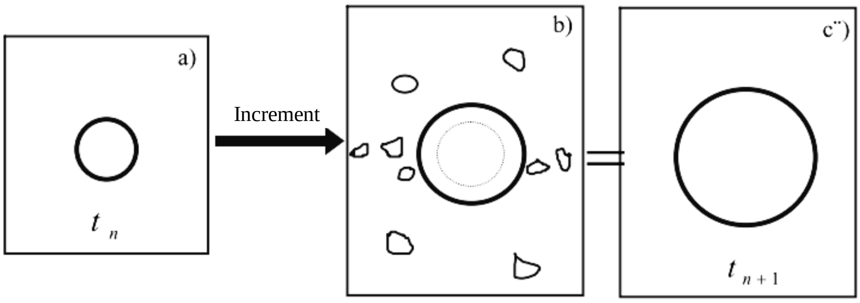

Figure 2. Gurson's model – graphical interpretation of nucleation and increment of micro-void [14]

Using the upper bound method, Gurson defined the function of plasticity potential which depends on fraction of micro-voids (13):

$$\Phi = \frac{\sigma_{ef}^2}{\sigma_M^2} + 2f\cosh\left(\frac{3\sigma_m}{2\sigma_M}\right) - 1 - f^2 = 0 \tag{13}$$

Where: f – is fraction of micro-void (Figure 1.)
σ_m – is mean normal stress
σ_{ef} – is conventional effective stress (von Mises)
σ_M – is flow stress.

From the equation (13) is obvious that with the increase in damage to microstructure the reduction in flow stress occurs. For the compact material (f=0), Gurson's model is identical to conventional von Mises' model.
In its core, oroginal Gurson's model mathematically interprets continuous process of damage to microstructure with the increase of fraction of micro-voids, where total loss of flow stress can occur only if the fraction of micro-voids reaches theoretical final value, i.e. when *f=100 %*. Such possibility is not realistic because in physical sense material should completely disappear.
In order to take into consideration effect of coalescence of the neighboring micro-voids to occurrence and growth of the crack Tvergaard and Needleman [15] conducted the modification of Gurson's model of microstructure damage. Gurson-Tvergaard-Needleman (GTN) model has a goal to enable modeling of nucleation, growth and coalescence of micro-voids mechanism through accumulated damage to microstructure. It is based on hypothesis that micro-mechanical characteristics of development of ductile crack can be macroscopically described by addition to von Mises' theory of plasticity taking into consideration effects of porous properties of the material.
Unlike Gurson, who models porous properties in the material through fraction of one single isolated micro-void, Tvergaard and Needleman represent the change of volume content of micro-voids in the material in a form dependant of nucleation of new micro-voids, but also of effect of growth of the existing ones[14-16]:

$$\dot{f} = \dot{f}_{nukleacija} + \dot{f}_{rast} \tag{14}$$

$$\dot{f}_{nukleacija} = A\dot{\varepsilon}_M \tag{15}$$

$$\dot{f}_{rast} = (1-f)\dot{\varepsilon}_{kk} \tag{16}$$

Where:
A – is function of effective strain for fully compact material ε_M, defined in such manner that distribution of generated micro-voids responds to normal division,
ε_{kk} – is strain tensor representing the change in volume.
Modified equation (13) represents mathematical representation of GTN model (17):

$$\Phi = \frac{\sigma_{ef}^2}{\sigma_M^2} + 2q_1 f^* \cosh\left(\frac{3q_2\sigma_m}{2\sigma_M}\right) - \left[1 + (q_1 f^*)^2\right] = 0 \tag{17}$$

GTN model predicts that describing of ductile crack takes place through fraction of micro-voids f^* which takes into consideration the effects of coalescence, and two constants for the material, q_1 and q_2. Function of fraction of micro-voids f^* is defined with the following expression:

$$f^* = \begin{cases} f & za\ f \le f_c \\ f_c + \left(\dfrac{1/q_1 - f_c}{f_f - f_c} \right)(f - f_c), & za\ f_c \prec f \prec f_f \end{cases} \tag{18}$$

Where: f_c –is critical fraction of micro-voids – reaching the value f_c coalescence starts,
f_f – fraction of micro-voids at the moment the crack occurs.

DUCTILE CRACK CRITERIA BASED ON THEORY OF CONTINUUM MECHANICS

Generally speaking, ductile crack criteria (variables of microstructure damage) are defined according to constitutive equations for the damaged material considering certain specific traits of dominant mechanisms of growth and nucleation of micro-voids. In this part of paper we analyzed the aspects of application of this approach in the area of defining the criteria of ductile crack. In the course of process are avoided rigorous mathematical formulations.
Starting from the schematic overview of the model of damaged material, Lemaitre [2, 5, 9], (Figure 3.) defined the variable of damage to microstructure where size of representative element of volume on micro level is large enough to contain a lot of damage but small enough to be considered material point in continuum mechanics with the following equation:

$$D = \frac{A_{voids}}{A_0} = 1 - \frac{A_{ef}}{A_0} \tag{19}$$

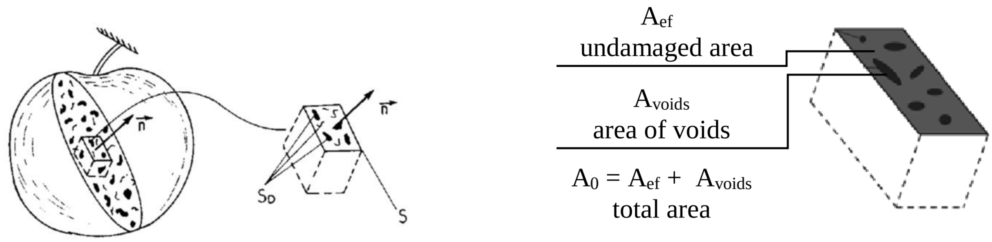

Figure 3. Representative element of volume of damaged material [5]

When material is not damages value of variable is D=0, and when ductile crack occurs its critical level is reached $D=D_C$ ($0,2 \le D_C \le 0,8$ – for metal materials). If value of damage variable is available than in a specific case it is possible to determine equivalent stress by calculating the nominal stress σ, as a measure of force effect to the entire area A_0:

$$\sigma_{ef} = \frac{\sigma}{1-D} \tag{20}$$

According to Lemaitre [5], constitutive equations of damaged material are identical to equations for undamaged material where nominal stress is replaced with equivalent stress. Characteristic example are equations in the area of linear elasticity:

$\varepsilon = \dfrac{\sigma}{E}$ - undamaged microstructure; $\varepsilon = \dfrac{\sigma_{ef}}{E} = \dfrac{\sigma}{E(1-D)}$ - damaged microstructure.

For characterization of ductile crack Lemaitre suggested criterion based on critical amount of elastic energy released from damage material microstructure (Y_c), [2]:

$$-Y_c = \frac{\sigma_{ef}^2}{2E(1-D)^2} \left[\frac{2}{3}(1+\nu) + 3(1-2\nu)\left(\frac{\sigma_M}{\sigma_{ef}} \right)^2 \right] \tag{21}$$

Analyzing Lemaitre criterion for ductile crack from the aspect of adequate energy use in process of predicting the location of critical damage, Vaz et al. [17] suggested the indicator of ductile crack based on total work done on damaged microstructures. Pires et al. [11] modified the previously mentioned criterion so it took into consideration the impact of closing the micro-cracks under the influence of pressure components of stress. In this criterion, amount of released energy from the place the critical damage occurred is expressed through main stress which enables the ability that using the parameter of closing the micro-voids, the development of damage for tension and pressure states would be treated differently.

CONCLUSION

Issue of defining the criteria of ductile crack is very complex area of research in formability. For that reason various theoretical and experimental approaches were used in the past for description of development and accumulation of critical level of damage to material microstructure in metal forming processes. According to the available literary resources, in this paper is analyzed the state of contemporary research in this area. From it we can draw following conclusions:

- Criteria of ductile crack whose mathematical interpretation is based on the amount of accumulated energy in the forming process are mostly defined according to research results about specific processes of metal forming. Implementation of such approach in numeric simulations is relatively simple and fast, but precise predictions about the moment (level) and place of deformation can not be achieved unless the realization of forming process is performed under conditions identical to the ones where certain criterion was defined. If the history of stress-strain state is different from the referential values, the criteria is not able to predict the exact spot where the crack occurs.
- Regardless of the simplified representation of growth in micro-voids due to plane stress state, McClintock's forming model has the potential to describe the level of damage through numerous experimental conditions and provide insight into certain findings regarding the impact of ratio (σ_H/σ_e), flow stress and history of stress-strain state to the development of ductile crack.
- Oyane's criterion of ductile crack is advantageous for application in various conventional metal forming processes, therefore it is incorporated in a large number of commercial numeric applications.
- Regardless of the simplification in using the numeric procedure, it is assumed that micro-voids do not interact, which is the basic limitation to Gurson's model. Specifically, model of ductile crack which Gurson suggested does not allow modeling of the final phase of increment growth when the coalescence of voids occurs due to local stress.
- Modification of Gurson's which takes into consideration the effects of merging neighboring micro-voids to occurrence and increment of crack is defined in GTN model. On the basis of these results a lot of research has been conducted which validated the ability of GTN model to successfully predict the development of damage and ductile crack in metal materials.
- Characterization of damage to material microstructure based on the application of continuum mechanics theory is a powerful and reliable approach to successful prognosis of initiation and development of ductile crack. In such manner the integral approach to the research of this matter is made possible because effects of progressive damage to the material to its properties in the forming process ae taken into consideration. Although the calculus is challenging, criteria of ductile crack based on theory of continuum mechanics enable analysis of complex strain paths which provides better approximation of realistic forming process and gaining of more reliable prognosis.
- Although there are great scientific advancements in this area, it is common opinion that there is no unified and universal approach which can comprehensively describe all the conditions under which ductile crack occurs in the metal forming processes.

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COMPARISON OF THE MICROSTRUCTURE OF WELD METALS IN WELDED JOINTS MADE WITH RUTILE ELECTRODES BASED ON DOMESTIC RAW MATERIALS AND ELECTRODES OF A WELL-KNOWN MANUFACTURER

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Abstract: This paper presents the results of comparative testing of the quality of the weld metal of welded plates of low carbon non alloyed steel using rutile type coated electrodes produced in IHIS and electrodes JADRAN-S produced in Jesenice. The aim was to master the technological process of producing electrodes coated with a rutile coating based on domestic raw materials. For experimental testing used was an electrode with a medium thick rutile coating with a core of solid wire Ø 2.0 mm in diameter marked IHIS E 35 R. Based on comparative analysis of the weld metal test results of welded joints made with electrodes produced in IHIS in relation to the electrodes of the well known manufacturer the appropriate conclusions are given.
Key words: rutile electrodes, solid wire, manual metal arc welding process

INTRODUCTION

Coated rutile electrodes for arc welding and surfacing have a metal core. The cores of the coated rutile electrodes as part of the electric circuit transmit power and also serve as a filler. The main functions of the electrode coating are: protection of the welding zone from the surrounding oxygen, nitrogen and hydrogen, stability and ionization of the electric arc, slowing down cooling of the weld metal, refining and alloying of the weld metal, allowing welding in forced positions. These are achieved in several ways: the drops of molten metal as they pass through the electric arc are covered by parts of the liquid coating of the electrode and the formed gases protect the surface of the drops from the surrounding atmosphere, while the metal bath is protected by slag which floats on the surface.
By the ratio of the total diameter (including the coating) D, and the core diameter d, the electrodes can be divided into thinly coated ($D/d<1.2$), medium coated ($1.2<D/d<1.4$) and heavy coated ($D/d>1.4$).
Metal cores of rutile coated electrodes consist of solid wires on to which a designed rutile type coating is applied using an appropriate technological process. The basic component of the rutile-coated electrodes is the mineral TiO_2. The coating consists mainly of components such as: rutile sand, marble, granite, kaolin, ferromanganese and ferrosilicon, mica, feldspar, talc, calcium fluoride, magnesite and Lucel. The means of transfer of filler in the E process is mostly influenced by the thickness and type of coating and current strength. By increasing the thickness of the coating and adding ingredients which reduce surface tension the transfer of droplets is improved. A stronger current also enables the transition from large to small drops, because it enhances the pinch effect and gas pressure.
In order to master production of coated rutile electrodes with a solid wire core, based on domestic raw materials, a medium coated electrode of solid wire marked IHIS E 35 R Ø 2.0 mm in diameter was experimentally produced. After that, to compare features, arc welding of low carbon steel plate was performed with the produced electrode labeled IHIS E 35 R and the rutile electrode JADRAN S Ø 2.5 mm in diameter from the manufacturer in Jesenice.
This paper presents the results of a comparative analysis of the weld metal of welded joints of low carbon steel plates made with the new rutile coated electrode produced from domestic raw materials and the rutile electrode from the well known manufacturer [1-4]. The new quality coated electrodes are expected to provide the most favorable microstructure of the weld metal and optimum mechanical properties, because the safety of the welded structure depends on the mechanical properties that are directly related to the microstructure [5-10]. The weld metal with a high proportion of acicular ferrite

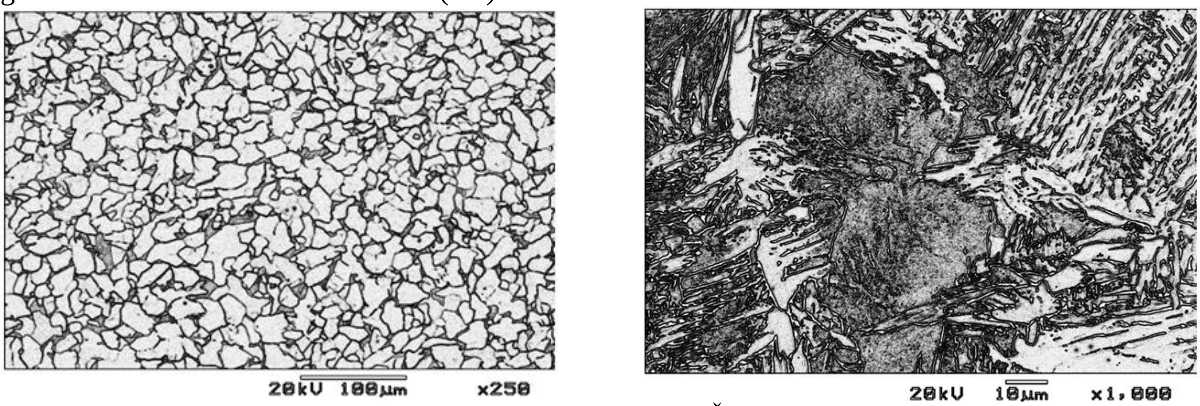
has the optimum microstructure and mechanical properties [11]. The chemical composition and cooling rate directly affect the microstructure of the weld metal [12-14]. The chemical composition of the weld metal is largely determined by the type of filler, and in smaller proportion determined by the base metal that melts during welding.
Results of comparative studies of the microstructure of the weld metal (WM) of welded joints performed with the rutile coated electrode produced in IHIS and rutile electrode JADRAN - S confirmed that the weld metal (WM) has a microstructure which enables its practical industrial application

MATERIAL AND METHODS

For examination of the microstructure of the weld metal (WM) of welded joints a coated rutile type electrode with a core of solid wire marked IHIS E 35 R Ø 2.0 mm in diameter with a medium thick rutile coating was used. For the production of medium thick coated electrodes of solid wire IHIS E 35 R, for the cores, selected was drawn steel wire marked Sv-08 and Sv-08A according to GOST standard containing C ≤ 0.10%, Si ≤ 0.03% and Mn 0.35-0.60%.
For comparison of the microstructure of the weld metal (WM) of welded joints, used as a parallel electrode was a coated rutile electrode JADRAN S - Jesenice Ø 2.5 mm in diameter with a core of solid low carbon steel wire marked Č.1931 (JUS C.B6.012) containing 0.80-0.89% C, 0.10-0.30% Si, 0.30-0.6% Mn, P and S ≤ 0.040%. The coated electrodes were standard length of 350 mm designed for manual arc welding and surfacing.

RESULTS AND DISCUSSION

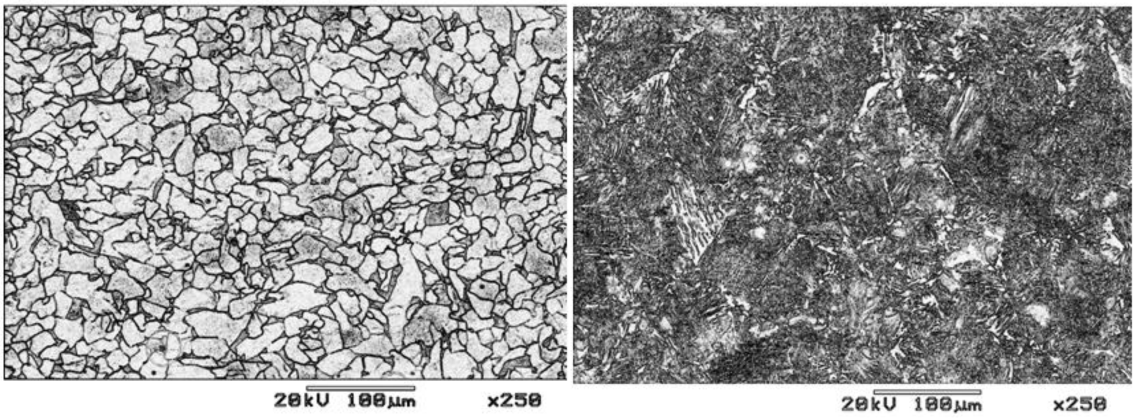
Examination of the microstructure of the base metal (BM) and welded joints of weld metal (WM) was performed on a scanning electron microscope (SEM). Examination of the microstructure of welded joints of low-carbon steel plates was done in accordance with standard SRPS EN 1321. Etching of microstructures was carried out in a solution of 3% Nital.
The microstructure of weld sample No1 with a rutile electrode produced by coating a solid wire marked IHIS E 35 R Ø 2.0 mm in diameter is shown in Figure 1a, b. The microstructure of the base metal (BM) is fine grained ferrite-pearlite, with a very small proportion of pearlite, Figure 1.a (250x). The thermal cycle of welding was optimal so there was no intensive growth of primary austenite grains. The microstructure of the weld metal (WM) consists of multiple morphologies of ferrite, Figure 1.b (1000x). The ferrite, which is distinguished by grain boundaries in the form of intermittent layers, is polygonal ferrite (PF).
In the interior of the grain two types of plate-like ferrite can be observed, ferrite with a directional secondary phase (FS) and Widmanstätten ferrite (WF) of a needle plate-like shape which increases in depth of the grains of polygonal ferrite, which is located on the grain boundaries. In the interior of the grains fine needles of acicular ferrite (AF) are observed.



a) OM b) MŠ

Figure 1. Microstructure of weld sample No.1: a) base metal (BM), 250x; b) weld metal (WM), 1000x

The microstructure of the welded joint in sample No. 2 with a standard rutile electrode JADRAN S from Jesenice Ø 2.5 mm in diameter is shown in Figure 2.a, b. The microstructure of the base metal (BM) of low carbon steel is ferrite-pearlite shown in Figure 2.a (250x). In the weld metal (WM) the ferrite, which is distinguished on the grain boundaries is in the form of intermittent layers and within the grain the ferrite is polygonal. The most common term for this type of ferrite is polygonal ferrite (PF) [15]. In the interior of the grains, found was a number of types of ferrite, such as a needle - acicular ferrite (AF) with a proportion of Widmanstätten ferrite (WF), or as it is also called side plate ferrite. It is plate needle-shaped and grows in depth of the grains directly from the polygonal ferrite which is located on the grain boundaries. In some crystal grains, ferrite with a directional secondary phase (FS) is present.



a) OM b) MŠ

Figure 2. Microstructure of weld sample No 2: a) base metal (BM), 250x; b) weld metal (WM), 250x.

Comparative analysis of the microstructure of the weld metal (WM) in welded joints derived from the coated electrode IHIS E 35 R Ø 2.0 mm in diameter and the electrode JADRAN S from Jesenice Ø 2.5 mm in diameter, were identical and in accordance with the contents of C, Si and Mn and solid wire that is was used for coating.

CONCLUSION

Based on the comparative analysis of the test results of the microstructure of the weld metal (WM) of welded joints made with rutile electrodes with a core of solid wire based on domestic raw materials marked IHIS E 35 R Ø 2.0 mm in diameter with a medium thickness of rutile coating in relation to an electrode of a known manufacturer labeled JADRAN S from Jesenice Ø 2.5 mm in diameter the following conclusions can be made: Produced rutile-type electrodes from solid wire marked IHIS E 35 R Ø 2.0 mm in diameter with a coating based on domestic raw materials showed satisfactory quality compared to the standard rutile electrode of solid wire Ø 2.5 mm in diameter marked JADRAN S from Jesenice.

The microstructures of the weld metal (WM) of welded joints were identical and along the weld metal there were no visible deviations observed in the microstructure. The results confirmed that the new coated electrode of solid wire marked IHIS E 35 R Ø 2.0 mm in diameter with coating based on domestic raw materials can be successfully applied for welding low carbon non alloyed steel as well as low carbon low alloyed steel.

ACKNOWLEDGEMENTS

This paper is supported by the Serbian Ministry of Science and Technological Development (project number TR34016) "Development of covering and core production technology based on local raw materials for manufacturing of special coated electrodes designed for steel arc welding" & TR 35002 "Development of new methodologies for revitalizing turbine and hydro mechanical equipment of hydroelectric power stations depending on the cause of degradation of the material".

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APPLICATIONS OF THE RAPID PROTOTYPING TECHNOLOGY TO MANUFACTURE INDUSTRIAL PARTS MADE OF PHOTOPOLYMER

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Abstract: The paper presents an application of the Rapid Prototyping technology using a 3D Printer based on PolyJet process to manufacture two industrial parts that are destined for educational purpose and future researches. The procedure is defined within the work conducted in the international IPA Cross-border Cooperation Programme Romania - Republic of Serbia project where Rapid Prototyping (RP) technology were studied.
Keywords: Rapid Prototyping, PolyJet, 3D Printer, industrial parts, photopolymer

INTRODUCTION

The principles and early technologies of Rapid Prototyping were introduced to the world more than 20 years ago. Even though principles remain very similar, the technologies themselves improve greatly, new materials, ways of manufacturing and application prospects are constantly introduced, this allows 3D manufacturing technologies to advance into and takeover an increasing market share among conventional manufacturing technologies. Moreover the development of electronic and computer technologies has dramatically changed RP processes and products. On the other hand, rapidly developing technologies and the variety of new materials made it perfectly suitable not only for serial production of small complex parts, but also for such specific areas as biomedicine, aviation, and aerospace industry. Fundamentally, RP technology has hardly changed in recent years.
The most recent "new" commercial technology is probably the Objet PolyJet process, which deposits photopolymers using droplet deposition print heads. PolyJet process already has found its fields of application in industry. Yet, a shortage of information on conditions of application of materials is observed as well. Objet company offers a great variety of photopolymers with different qualities, yet there‘s a great shortage of information on the change of the properties under different conditions. In order to fulfill customer requirements, the esthetic qualities of the prototype, color, price must also be supplemented with material qualities, [1].
The aim of this study were to analyze the preparation of the models and the parameters of the printing process as well as the manufacturing of two industrial parts using PolyJet process. Industrial parts were made of photo-polymer VeroBlue FullCure840 by PolyJet process using Objet Desktop 30 machine. This RP machine was acquired by "Eftimie Murgu" University of Resita, and it is intended to be used in Centre for Numerical Simulation and Digital/Rapid Prototyping to prototype different parts.
Centre for Numerical Simulation and Digital/Rapid Prototyping (http://www.csnp.roedu.ro) is established at the "Eftimie Murgu" University of Resita, financed by European Union, through the "Romania - Republic of Serbia IPA Cross-border Cooperation Programme". The project's partners were "Eftimie Murgu" University of Resita – Romania and Technical College of Applied Sciences in Zrenjanin – Republic of Serbia. The project offers the possibility to create a centre based on new technologies, to achieve the necessary equipments and to apply these technologies in the engineering student's education. The endowment of the Centre offers the wide range of 3D services: Rapid Prototyping, Reverse Engineering, Dimensional Control, Structure maintenance.
The prototypes manufactured in this study were intended for education of the students and for further researches.

THE DESCRIPTION OF THE 3D PRINTER

Objet Geometries machines build parts layer by layer combining inkjet technology with photo-polymerisation (UV curing) process, as shown in Fig. 1.

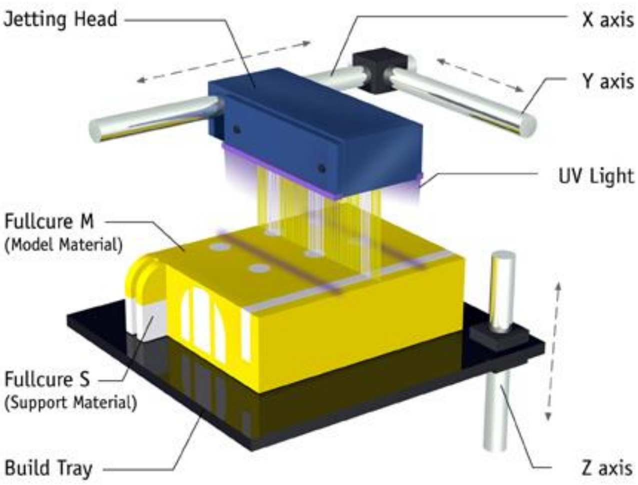

Figure 1. Polymer jetting printing process, [2]

Objet 3D Printer Multifunctional Desktop 30, Fig. 2, used in this study has maximum print size defined by the parallelepiped 294 mm x 192.7 mm x 148.6 mm, with a resolution of 600 dpi in the X, Y axis respectively 900 dpi in Z axis. The layer thickness on Z-axis direction is 28 microns. Accuracy can vary depending on the geometry, orientation and size of the object, up to 0.1 - 0.2 mm. The models do not require further finishing, but can still be processed by drilling, soldering, metal coating, painting. The wall thickness is 0.6 mm and minimum diameter of the holes is 1 mm.

Figure 2. Objet 3D Printer Multifunctional Desktop 30

The range of material model (material used to print the full part of a model) available include Objet FullCure materials: VeroWhite, VeroBlue, VeroBlack, VeroGray, DurusWhite, TangoPlus, TangoBlack and FullCure®720. In this research was applied VeroBlue - FullCure840 material, and its properties are shown in Table 1.

Table 1. Material properties VeroBlue - FullCure840, [3]

Property	**ASTM**	**Units**	**Metric**
Tensile Strenght	D638-03	MPa	50-60
Elongation at Break	D638-05	%	15-25
Modulus of Elasticity	D638-04	MPa	2000-3000
Flexural Strenght	D790-03	MPa	60-70
Flexural Modulus	D790-04	MPa	1900-2500
HDT, °C @ 0.45MPa	D648-06	°C	45-50
HDT, °C @ 1.82MPa	D648-07	°C	45-50
Izod Notched Impact	D256-06	J/m	20-30
Water Absorption	D570-98 24 hr	%	1.5-2.2
Tg	DMA, E″	°C	48-50
Shore Hardness (D)	Scale D	Scale D	83-86
Rockwell Hardness	Scale M	Scale M	73-76
Polymerization density	ASTM D792	g/cm^3	1.18-1.19
Ash content	USP281	%	0.21-0.22

As support material (material used to print a model empty space) were used FullCure®705 Support a non-toxic gel-type photopolymer, that can be easily removed by Objet Waterjet System, Fig. 3, the equipment being included in the printer configuration. Waterjet use pressure water jet to remove material support.

Figure 3. Objet Waterjet System

MODELLING OF INDUSTRIAL PARTS

The CAD models of two industrial parts were created using the SolidWorks software. The geometries of the Lappet and Disc with teeth are presented in Fig. 4 and Fig. 5. The maximal dimensions for the Lappet are 28 mm x 41 mm x 63 mm and for the Disc with teeth are 18 mm x 18 mm x 6.46 mm.

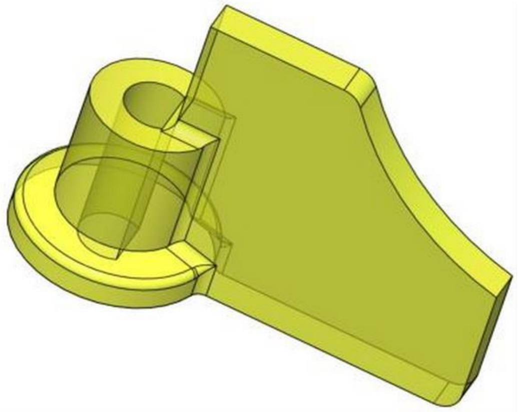

Figure 4. The CAD model of the Lappet

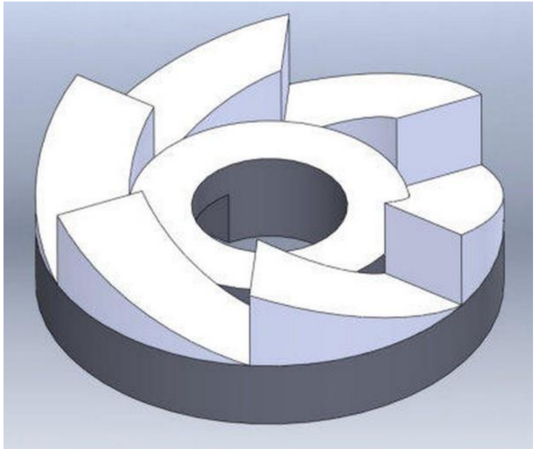

Figure 5. The CAD model of the Disc with teeth

The CAD geometry of the parts was exported on an STL file, resulting in 25184 triangles for the Lappet, Fig. 6, and 12424 triangles for the Disc with teeth, Fig. 7.

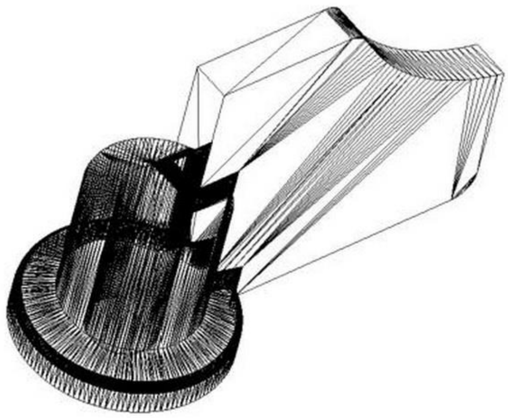

Figure 6. The STL format of the Lappet (25184 triangles)

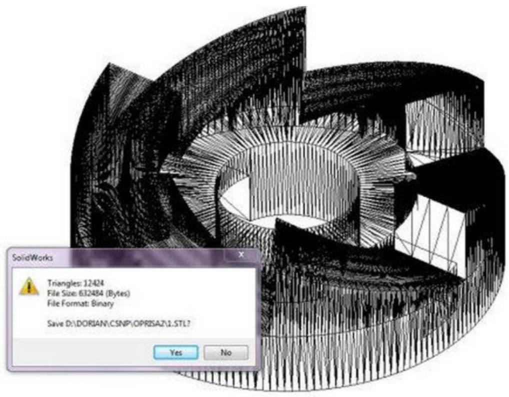

Figure 7. The STL format of the Disc with teeth (12424 triangles)

RAPID PROTOTYPING OF INDUSTRIAL PARTS BY POLYJET PROCESS

Models that are saved in a CAD program as STL files may be inserted into the Objet Studio tray. Fig. 8 and Fig. 9 shows the STL files loaded in Objet Studio software. The orientation of models on the build tray affects how quickly and efficiently they will be produced by the 3D printer, where and how much support material is used, and whether or not model parts will have a gloss finish. To minimize printing time [4]:

- the longest dimension of a model must be placed along the X-axis;
- the smallest dimension of a model must be placed along the Z-axis;
- the tallest model must be placed on the left of the tray.

When a tray is ready to be printed, it is sent to Job Manager, where it is placed in the print queue. When the job reaches the head of the queue, Job Manager pre-processes the tray file to create slices, and feeds them to the 3D printer.

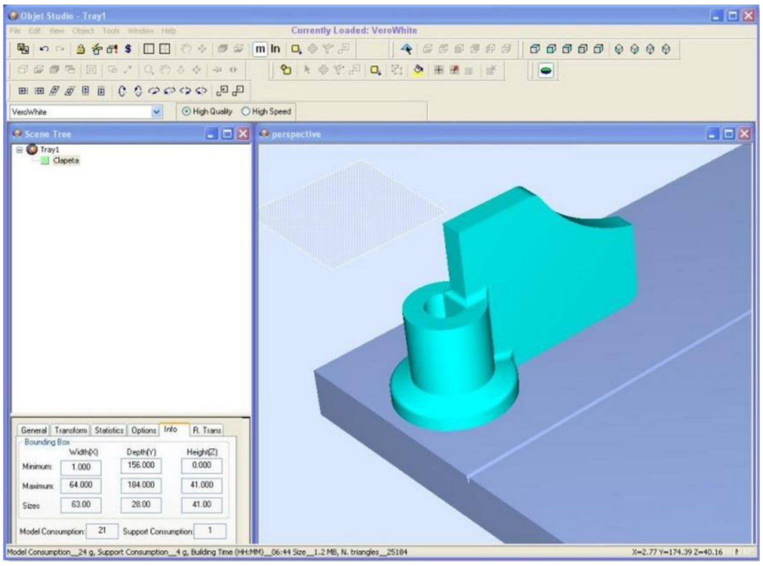

Figure 8. The STL file of the Lappet loaded in Objet Studio and placed on printer tray

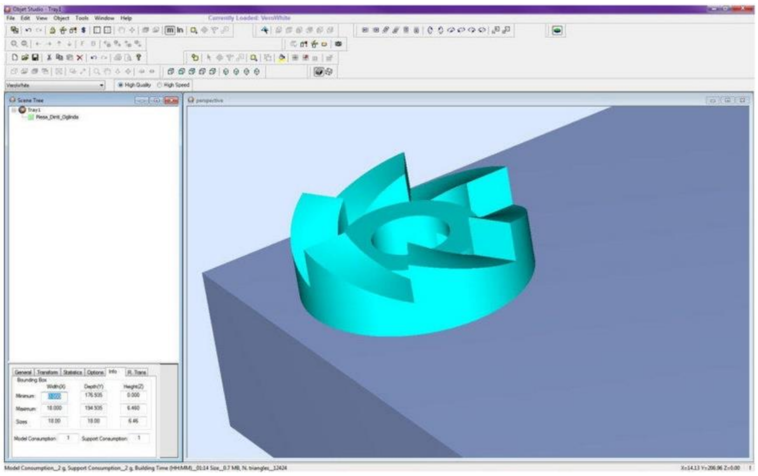

Figure 9. The STL file of the Disc with teeth loaded in Objet Studio software and placed on printer tray

Objet Studio software offers the following additional features [5]:

- dividing objects – to produce objects larger than the build tray by dividing the model into separate parts.
- choosing the support strength – when producing models, support material fills some hollow and empty sections.
- smartcast – filling models with support material.

The PolyJet process has the ability to simultaneously jet multiple materials with different mechanical and optical properties. 3D printing could be considered a fully controllable process, since the majority of the process parameters can be altered on user's demand. Consequently the quality of the part does depend on a number of factors. As basic quality indicators for the specific processes two can be considered as major i.e. the model's surface roughness and model's dimensional accuracy. Both depend on the machine and the process variables. Several attempts have been made to make a systematic analysis of errors and the quality of the prototypes, [6].

Experimental analysis of dimensions, surface roughness, and mechanical properties of PolyJet processes have been investigated in study [7]. Determination of surface texture parameters Ra and Rz for horizontal surfaces of parts produced by PolyJet have been performed in [8]. The results indicate that for mate surfaces Ra equals approximately 1.04μm while Rz about 5.6μm. For glossy surfaces Ra is approximately 0.84μm and Rz 3.8μm.
Mechanical properties of parts produced by PolyJet, has been investigated in [9]. The study concluded that the part orientation has an effect on mechanical properties due to the heterogeneity of light energy by the photopolymer material during jetting process. The variability in the mechanical properties of parts manufactured via PolyJet process has also been examined in [10]. It has been concluded that part orientation affects tensile strength and tensile modules with highest tensile modulus occurred in the XZ orientation.

The printing parameters for the two industrial parts used in this investigation are shown in Table 2.

Table 2. Printing parameters for the two industrial parts

Parameter	UM	Lappet	Disc with teeth
Material	**-**	**VeroBlue**	**VeroBlue**
Maximal Dimensions	**[mm]**	**28 x 41 x 63**	**18 x 18 x 6.46**
Triangles	**-**	**25184**	**12424**
Layer Thickness (Z-axis)	**[μm]**	**28**	**28**
Layer's number	**-**	**2250**	**230**
Build Style	**-**	**Glossy**	**Glossy**
Scale	**[%]**	**100**	**100**
Model Material	**[g]**	**24**	**2**
Support Material	**[g]**	**4**	**2**
Printing Time	**[h/min]**	**6 h 44 min**	**1 h 14 min**

Fig. 10 shows the final stage in the printing of the Lappet. Fig. 11 shows the final stage in the printing of the Disc with teeth. For optimal efficiency, the both parts were manufactured along with a number of other parts.

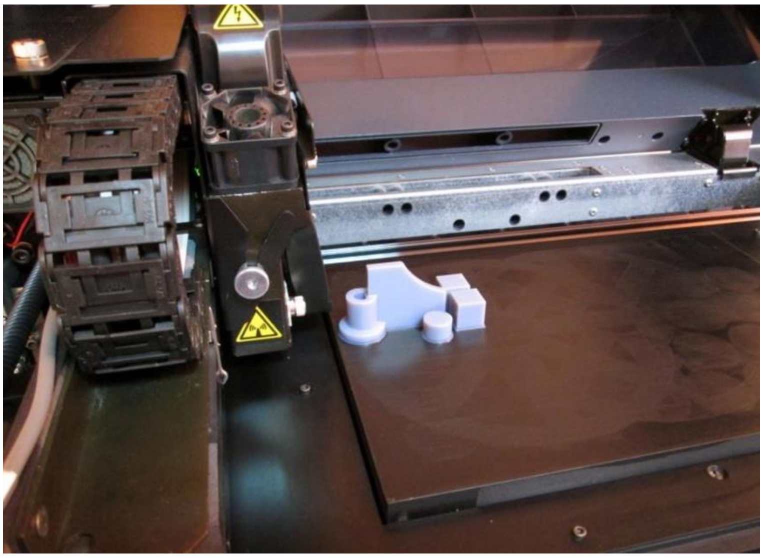

Figure 10. Printing process of the Lappet

Figure 11. Printing process of the Disc with teeth

Figures 12 and 13 shows the final shapes of the two industrial parts.

Figure 12. The final shape of the Lappet

Figure 13. The final shape of the Disc with teeth

CONCLUSION

The Rapid Prototyping technology can be used to create product prototypes, like Lappet and Disc with teeth and to use these objects in initial phases of product development. During the investigation, most important factors influencing manufacturing cost were determined – dimensions of the part and placement in the work area. The following advantages are important: surface quality, smoothness details, great level of accuracy and reduced manufacturing time.

Further research will be focused on the improvement of the dimensional accuracy using the PolyJet technology, machine and material. A set of special benchmark samples will be prototyped using different process parameters like: layer thickness, build style and scale of the model. Dimensional accuracy and surface quality, as well as bulk density, internal microstructure and mechanical properties will be analyzed. A global evaluation of the studied features will lead to set up the optimal process parameters.

Repeatability represents another limitation of RP technologies. Thus, taking into account the influence factors that affect the dimensional accuracy, a study of the process repeatability will be developed.

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EFFECT OF THE THERMOMECHANICAL TREATMENT ON CHARACTERISTICS OF THE AlMgSi ALLOYS

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Abstract: In the paper are given the results of researches of composition and treatment parameters effects on hardening rolled sheets of the AlMgSiCu alloys. It is found that the hardening value depends on degree of deformation, deformation programmed and copper content. It is shown that alloys subjected to less intensive deformation and those with larger copper concentration display a characteristically larger hardening effect.
Key words: thermomechanical treatment, hardening.

INTRODUCTION

It has long been known that it is possible to strengthen AlMgSi alloys by means of theat treatment and plastic deformation. Investigations in that direction, such as [1, 2], resulted in the discovery of very interesting alloys with high physicomechanical parameters.
Although thermmechanical treatment is widely used, ther are still many questions associated with the influence of cold plastic deformation, and particularly of a deformation programme combined with alloying, on hardening of AlMgSiCu alloys which remain unanswerwd. One would expect a change in the cold rolling programme to affect not only hardening but also the structure and residual stresses in the material [3].
Investigation made on copper [4], steel [5] and AlMgSi alloys [3,6,7] show that the distibution of stress at the deformation centre during rolling resulting from defferent deformation programmes gives rise to local changes at the deformation centre.
We know [8] that the stress distribution at the deformation centre during rolling is determined by a set of geometric parameters; for instance, the pressure distribution depends on the ratio l/x_m (l is the length of the deformation centree; x_m- mean thickness of deformed specimen). The deformation is inhomogeneous at the centre and that has a strong influence on turn of the crystallites and on hardening [9, 10].

EXPERIMENTAL

We have investigated two AlMgSiCu alloys. The first (denoted L_1) contained 0-57%, the second (L_2) 1-0,4% copper. The two alloys contained the same quantity of Mg_2Si phase – 1-5%. The aluminium used in preparation of the alloys was 99-99,5% pure.
After homogenization for a day at 520 ^{0}C and preliminary rolling with annealing (15 min, 520^0) and quenching in cold water, sheets of the alloys were deformed to different degrees: 15, 30, 50, 70 and 80%. After preliminary annealing for 30 min at 520^0 in salt bath and quenching in water the specimens were aged for 10 min at 160^0.

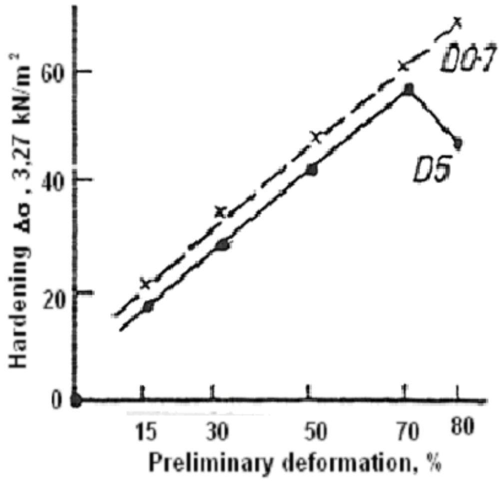

Figure 1. Relative hardening of alloy L_1, as a function of degree of deformation and deformation programme: • - D5; × – D0,7; □ - IA; φ=40^0

The aged specimen was deformed in twee programmes. The first, with $l/x_m \geq 5$, involved a small number of passes, and will be denoted as programme D5. The second, D0-7, with $l/x_m \cong 0\text{-}7$, involved a large number of passes. In both cases the rate of deformation was constant – *0,73* sec^{-1}. Hardening of the specimen was examined after initial ageing (IA) and initial ageing and deformation (IA+D).
In order to determine hardening, the specimens were subjected to variable deformation by bending with a given maximum angle of bend [10].

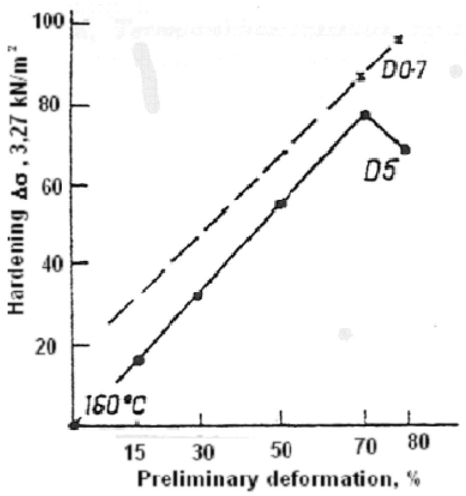

Figure 2. Dependence of relative hardening of alloy L_2 on degree and programme of deformation: ● - D5; × – 0,7; ■ - IA; φ=40^0

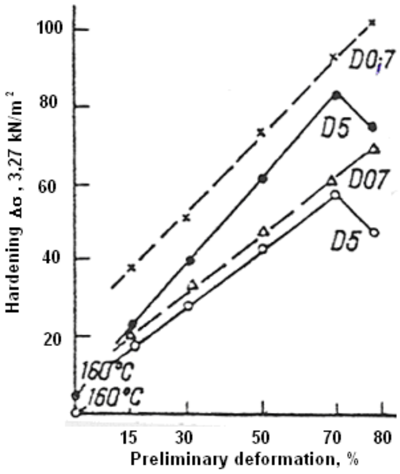

Figure 3. Relative hardening of alloys L_1 and L_2 as function of degree and programme of deformation separately: alloy L_1: ▵– D 0,7; ☐ - IA; ● - D5; alloy L_2: ■ - IA ; × - D0,7; ○ - D5; φ=40^0

The increment of flow stress Δσ was determined relative to the flow stress for specimens after IA with angle bending φ=40^0. In order to eliminate the contribution of bending to hardening, the angles of residual bending φ_r were verified to be the same for the same instantaneous angle of bendφ.

RESULT AND DISCUSSION

The results are shown in Figures 1, 2 and 3. Figures 1 and 2 shows the dependence of relative hardening of the alloys as a function of degree of deformation and programme. The dependence of hardening of the alloys on copper content and degree of deformation and programme. The dependence of hardening of the alloys on copper content of deformation and programme is shown in Figure 3.

For both alloys, maximum hardening is obtained at 15% deformation (see Fig. 3). Hardening continues to grow with further increase in degree of deformation, but at a lower rate relative to the initial increment at 15%. A difference is first seen in the curves for the IA+D specimens after 70% deformation: for the less intensive deformation programme (Fig. 3, D0,7) hardening is greater than that achieved at 70%, while for the more intensive programme (Fig. 3, D5) it is lower.

The Δσ value for programmes D5 and D0,7 can be compared with the hardening value after IA+D.

It turns out that the hardening effect is greater for programme D0,7 than for D5, and greater for alloy L_2 than L_1.

The results show that, other conditions being equal, the copper content in AlMgSi influences hardening of the alloys (see Fig. 3). The hardening value of specimens of alloy L_2 after IA and IA+D is higher than for similar specimens of alloy L_1 (see Fig. 3). We assume that copper is responsible for higher dispersion of the inclusions, increasing the number of nucleation centres [11, 12] and thereby improving corrosion resistance and the mechanical parameters of the AlMgSi alloy.

CONCLUSION

All the specimens had identical treatment before deformation, that is, they had identical structure, and identical thickness after rolling. We can therefore say that the observed differences in hardening of AlMgSi alloys are due to: a) difference in copper content and b) use of different deformation programmes.

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THE EFFECT OF HEAT TREATMENT REGIMES ON THE PROPERTIES OF BIMETALS FOR INDUSTRIAL KNIVES

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Abstract: This paper examines the influence of heat treatment on the properties of explosive welded bimetal many types for different areas of application and operating conditions.
Key words: explosive welding, bimetalls, cutting tools

INTRODUCTION

Multi-layer construction materials in recent years has been developed and used for various purposes. They united the collection of good qualities, which mono-metal materials, whatever the alloy, do not possess. Their characteristics have extended the application, thus meeting the growing demands of technology, particularly in equipment operating under high pressures, temperatures, and aggressive actions of the working environment, dynamic loads and the like [3-5].
Multi layered materials possess good weldability, are suitable for all types of machining and heat treatment and are economically attractive because it saves on expensive high alloy metals up to 90%.

EXPERIMENTAL

For the experimental tests, Fig. 1. sheets of steel quality 50CrV4, X155CrVMo121 (OCR12ex), 60WCrV7 of 3-5mm thickness and steel S355J2G3 were used.

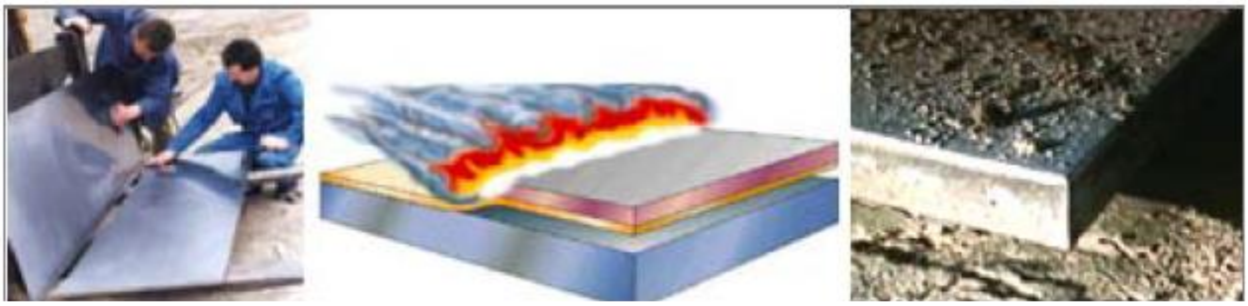

Figure 1. Technological process for production of bimetal for a blade

A typical shape of the line of the welded joint is undulating with mutual penetration of the base metal into the other metal, followed by a high degree of plastic deformation.
Upon explosion welding and after heat treatment of the bimetal, carried out were examinations of microstructure in the joint zone, non-destructive testing of macroscopic faults, shear, braking, bending and toughness testing and also measuring of hardness distribution.

RESULTS AND DISCUSION

After annealing, as per regimes for given alloyed steels, the expected hardness distribution in the zone of the explosion welded joint is achieved, shown in Fig. 2-5. It is assumed that the increase in hardness is primarily due to a high degree of plastic deformation during welding.

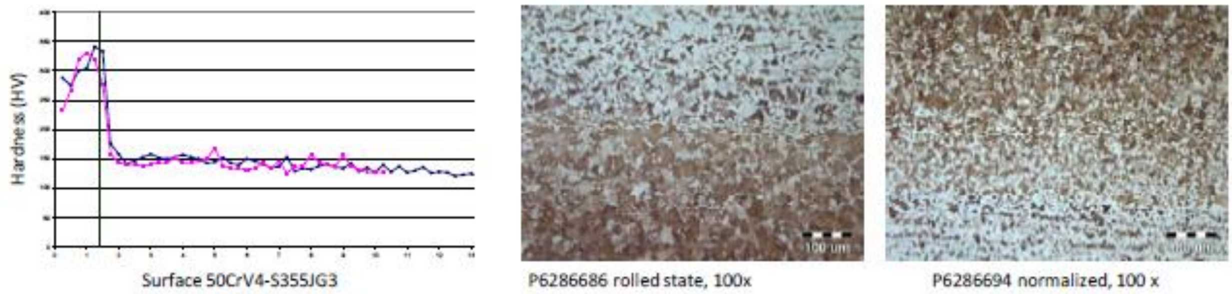

Figure 2. Hardness of intersection of explosion welded joint 50CrV4 + S355J2G3, the boundaries of the joint (50CrV4-down S355J2G3 -up), rolled and normalized state, 100x

Table 1. Result of metallographic testing of bimetal 50CrV4 + S355J2G3

Sample	State	Grainze	Decarbonizing	Microstructure
50CrV5	Biometal rolled	5.0	0.20	Sorbite+fine lamellar pearlite+ferrite
5355J2G3		6.0	0.15	Ferite+pearlite+martensite
50CrV4	Normalized state	6.5	0.20	Sorbit+ferite
S354J2G3		8.0	0.00	Ferite+perlite

Figure 3. Schematic of measuring hardness of HV5, joint boundaries Č0562 (S355J2G-3)-10mm and Č4850 (x153CrMoV12)-3mm. State: explosion welded (1), tempered in furnace (2)

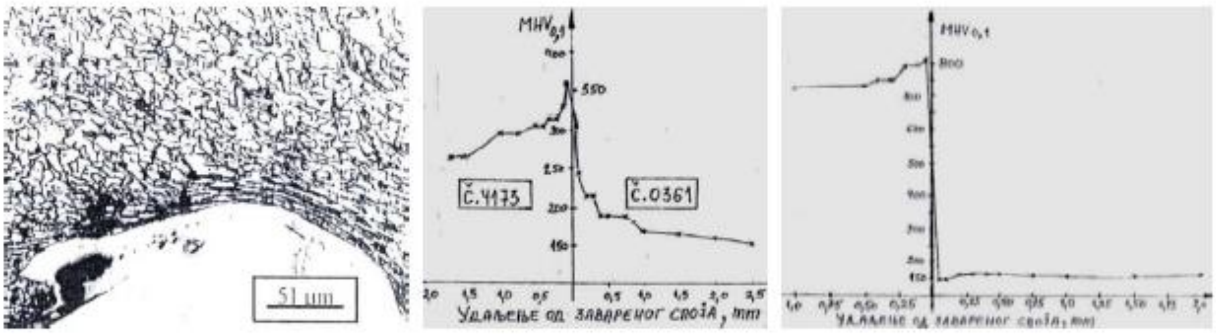

Figure 4. Microstructure of explosion welded joint Č4173, 2mm and Č0361, 8mm, Microhardness distribution in the joint area. State: welded, heat-treated

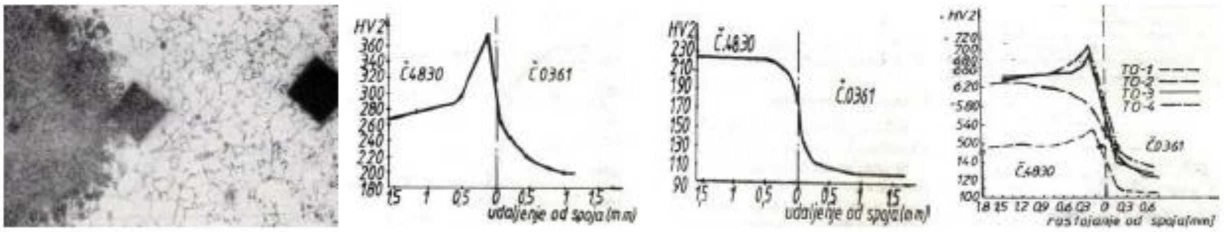

Figure 5. Microstructure of the zone of welded joint Č.4830 + Č.0361 (in a tempered state and annealed),

Hardness distribution in the zone of the welded joint (State: explosion welded, soft annealed, tempered)

Table 2. Results of testing of mechanical properties and technological properties of the explosion welded joint Č.4830 with Č.0361

	Testing metod				
State	Tensil force (kN)	Shear force (kN)	Force (kN)	Bending angle (^{0})	ρ
Welded	242	9.5	11.5	12.5	19.5
Annealed	521	7.5	13.8	90 no cracs apear	73.7
TO-1 Tempered at 840 ^{0}C in oil	528	9.7	14.7	29	44.8
TO-2 Tempered at 840 ^{0}C in molten pool	672	11,7	11	15	41.2
TO-3 Tempered at 840 ^{0}C in molten oil	-	11.2	-	-	42.2
TO-4 Tempered at 840 ^{0}C in molten pool	509	12.6	11.2	12	45.6

Bimetal is used in making self-sharpening plowshares and industrial knives, Fig. 6.

Figure 6. Blades and knives made of multi layer steel

CONCLUSION

1. During welding, metals under the effect of shock waves, obtain entirely new favorable characteristics, which in heat treatment give greater hardness, with the possibility of maintaining while in service. These bimetal features allow that certain knives (graphic and knives for peeling softwood - veneer knives) be successfully made even with blades of steel 50CrV4, which is more accessible and cheaper than tool steel.

2. The bimetal is made with a layer of tool steel, thickness 3-5 mm. This coat is evenly hardened at the cross section, with a minimum level of residual stress and the fear of appearance of initial cracks in the closing stages of production of the blade is reduced.

3. The bimetal allows heat treatment to be done before milling of the blades, grinding and sharpening of the knife. As heat is intensely channeled down the sides of the bimetal base, it is impossible to burn out the blade and fray it during exploitation.

4. Bimetal knives are easily flattened, ground faster with a minimum amount of abrasive material used. With bimetal there is no risk of cracking of the knife and injuries during use, especially with scissors where the blade is in direct contact with the worker.

5. In general, the process of making a knife is faster, more reliable, with less scrap. Consumption of high alloyed (expensive) steel is reduced to 15-20%. All this contributes to a lower production price and a more acceptable market price than mono metal knives, of now present foreign manufacturers.

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Session 4.

Maintenance

DETERMINATION OF LOAD AND LOAD CAPACITY BASED ON DESIRED RELIABILITY

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Abstract: Design for reliability, a partial approach that allows determination of design parameters based on pre-defined level of reliability. That means defining reliability in a specific way which is suitable for this purpose. Reliability of design structure and elementary reliability of design components are used as a functional requirement of automotive gearbox (in relation with service life and service conditions) and also as a design constraint in analytic relations. In these circumstances, carrying capacity as a functional requirement is related to service conditions and service regime. This paper presents the results of load spectrum for representative operating conditions of the gearbox, which served as the basis for design parameters determination. The experimental results of the probability of destruction of the gearbox components, as well as processing of the probability of working conditions and as components of reliability for design, are some of the methods used in this paper. On the basis of the developed model the software for the structural optimization has been made.
Key words: gear, gearbox, service condition, reliability

INTRODUCTION

Design for reliability is one of the partial approaches in the engineering design of components and technical systems and the whole of their structure. This is one of the wider systems of partial approaches known as Design for X, which includes design for manufacturing, Design for Cost, Design for vibration and noise and so on. Functional requirements of design structures, for instance, carrying (load) capacity, reliability, service life etc. are strongly related to service conditions that are, as a rule, random and very often uncertain. The aim of this approach lead to the optimal level of each of these properties of technical systems separately, variation, interrelating or optimization of design parameters. The basic idea is to apply a set of methods in Engineering Design to develop methodology for carrying capacity identification concerning service conditions. An automotive gearbox has been taken for a case study, because it represents the design structure with very variable service conditions.
The aim of this paper is to apply this approach and specific settings of reliability model for gear box, define the optimal design parameters or load defined for the given deign parameters for representative operating conditions. In advance given level and trend of reliability gear box is a limitation (design constraint) from which we begin in this approach. Reliability of structures such us gearboxes is one of the main indicators of quality and important functional requirement.
To achieve this aim, different methods and approaches were taken into account such as robust design [6], [13], [2], axiomatic design [14],[15], property-based design, design for X [4], [7], [9], [1] and investigations in the field of automotive gearboxes[12], [3], [8], [10], [11], gears [16]-[18] etc.
Work is also continuing studies that were presented in the paper [10] that includes reliability model of gear box and paper [8] who related to the specific way of defining the reliability of gear pairs and bearings in the gearbox. Analysis of possible failure of components of gear box preceded the definition of these models. They conclude that the failure of tooth flank gear, pitting in bearings, seals wear, difficulty in synchronic couplings and mechanisms for inclusion, the main causes of failure gearboxes. Potential failures of tooth flanks of gears and bearings are essential for caring capacity. Failure of flank tooth gear depends on the material of the gears and heat treatment, processed in the work [5].

ANALISYS OF THE DRIVING CONDITIONS

Vehicles in which this type of gear (trucks, bus, etc...) is installed exploit in the diverse and changing conditions. The same vehicle can be exploited under favorable or unfavorable conditions, when it

comes to quality of roads, terrain, vehicle capacity utilization, quality of drivers handling and so on. These conditions vary from vehicle to vehicle, and change during life of the vehicle. Representative sample of the exploration service conditions is necessary that would be relevant for defining the design parameters or load design solution which is developed using empirical experience. In this research it used the following approach. We analyzed the conditions of exploitation depending on the terrain, the quality (level) of the road network and capacity utilization. We formed spectra participation of each travel speed along with the size of torque at output shaft gear. Example of the results of this analysis for a ride and exploitation in extremely difficult conditions is given in Figure 1. Based on this set of views consisting of a variety conditions the representative shown in Figure 2, is made with numerical values given in Table 1 Representativeness was obtained by the adopted transmission will be exploited with 30% in the driving conditions in mountainous terrain, 40% for plain terrain and driving on the freeway 30%.
The representative sample shows no significant differences in the use of gears, except first and seventh speeds that are used exceptional. This will affect the election results design parameters of each gear. This means that they will be similar to each other. Since the real exploitation does not follow a representative sample rather than to the individual one that is used to obtain representative, the damage components gear in operation will carry out by the component spectra. Upon completion of work life, or at the end of the work life for an operating conditions will be damaged some of the component and for the other conditions other components will be damaged. Overall reliability, according to the participation speed will be close to the reliability of most damaged components.

Table 1. The participation speeds and the output torque for representative operating conditions and maximal output torques measured in service conditions

Transmissions gear	Speed participation in %	Output torque in Nm	Maximal output torque $T_{\text{outp-max}}$ in Nm
I	1,16	684	4824
II	23,33	645	4630
III	22,1	596	1987
IV	19,27	566	820
V	18,27	584	710
VI	15,67	686	550
R	0,2	880	4900

The second part of the identification of the gearbox exploitation conditions is measurement of the output torque on the Cardan shaft, which is connected to the output of gearbox shaft, for each corresponding gear. The measurements were made using the strain gauges mounted on the Cardan shaft and connected with the software for data processing. In table 1. the values of the measured maximum torque on the Cardan shaft are given. Combining the results obtained by interview for the percentage participation stages of transmission and statistically analyzed results of measurement, load spectrums for all gear pairs were formed (Figure 2) (except for the sixth speed, direct gear) on which the participation of torque in one million rotation of the gears was presented. The gear pair 0 participates in work of all stages of transmission, except when working sixth gear pair.

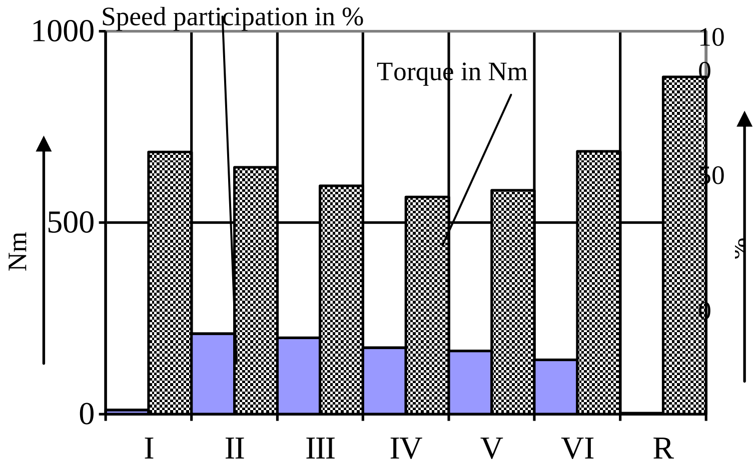

Figure 1. Participation speeds and torque for representative operating conditions

Ratio $x_i=T_i/T_1$ is in relation 0…1, T_1 is maximal torque of the pinion of gear pair, T_{10} for gear pair 0, T_{11} for gear pair 1, T_{12} for gear pair 2, etc. Torque T_i is variable torque. Maximal torque T_1 for the pinion of every gear pair is obtained by recalculation (deduction) of gearbox maximal output torque presented in table 1.

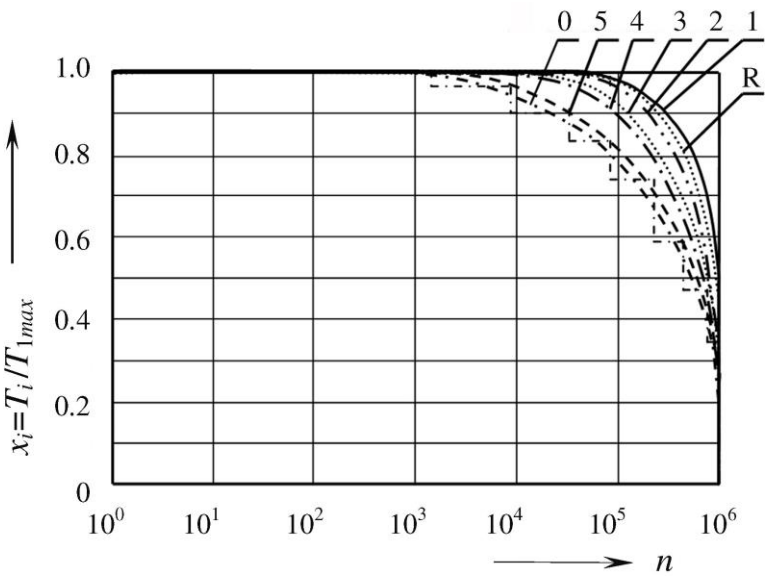

Figure 2. Load spectrums for the pinions of every gear pairs

RELIABILITY OF GEARBOX

Total reliability of the box gear consists of individual reliability gear, the reliability of coupling, bearings, seals, etc. [8] [9][10]:

$$R = R_g R_b R_c R_{se} R_{lm} \tag{1}$$

Where are R_g - reliability of the gears against teeth flanks wear, R_b - reliability of the bearings, R_c - reliability of couplings, R_{se} - reliability of the seals, R_{lm} - reliability of the steering assembly. If the gearbox includes r components, which are introduced in the model of reliability, assuming that the elementary reliability is same, the reliability of each of them is:

$$R_j = \sqrt[r]{R} \tag{2}$$

Where are:
r=g+b+c+se+lm=7+7+4+2+1=21
g- number of gear pairs;
b- number of bearings;
c- number of the couplings (three synchro couplings and one sleeve coupling for drive in reverse);
se - number of the seals
lm - number of the steering assembly
In this model, the partial reliability of the gear can be represented by following equation:

$$R_x = R_{g0}R_{g1}R_{g2}R_{g3}R_{g4}R_{g6}R_{gR} \tag{3}$$

In (3) each of the elementary reliabilities R_{g0}, R_{g1}, R_{g2}, R_{g3}, R_{g4}, R_{g6}, R_{gR} is reliability of gear pairs embedded in gearbox, which when damaged should be replaced in pairs. The number of these reliabilities corresponds to the number of gear pairs x=7. Elementary reliability of each pair of gears is R_g=R_j according to the equation 2.
As for the gears, the reliabilities of synchro-couplings and bearings make a serial connection of elementary reliabilities.

$$R_y = R_{c1}R_{c2}R_{c3}; \quad R_z = R_{b1}R_{b2}R_{b3}R_{b4}R_{b5}R_{b6} \tag{4}$$

Number of synchro couplings is y = 3, and the number of bearings in this gearbox is z = 6. Control system in terms of its failures is treated as one component p= 1. Number of the seals on the input and the output shaft is m=2.
Reliability of one pair of gears R_{gx} is complement of its unreliability F_{px}.

$$R_{gx} = 1 - F_{px} \tag{5}$$

LOAD CAPACITY CALCULATION

Calculation of load capacity implies that all design parameters, design properties of components and characteristics of materials and parts are known and defined. The load capacity of automotive gearbox is the result of load capacities for every speed of level that has to correspond to service load. The relation between load capacity and design parameters for a certain gear pair is:

$$b_x = \frac{T_{x1}}{2\left(\sigma_{Hdes}\right)^2 d_{x1}^2}\frac{u_x+1}{u}Z^2K$$

$$T_1 = \left(\sigma_{Hdes}^2 \frac{d_1^2}{2KZ^2}\frac{u}{u+1}\right) b = a\, b \tag{6}$$

In the formulas T_1 is the torque at the pinion (less gear in gear pair), d_1 is pitch diameter of the pinion, b is the gear pair width, u=z_2/z_1 is transmission ratio, z_1 – teeth number of the pinion, z_2 – teeth number of the gear. Load distribution in the gear teeth contact and load dynamics effect is included by value K, and contact conditions by value Z, all according to standards about helical and spur gear calculation ISO 6336 and DIN 3990. Design allowable stress σ_{Hdesj} is calculated in relation to elementary reliability for a corresponding gear pair j and all material and service characteristics including variation and randomness. For all gear pairs in the gearbox this relation has the form.

SOFTWARE DRAG

Based on previously developed model for load capacity calculation of gear pairs, software DRAG, in which users have the possibility to calculate gear width or load capacity, is developed. In both cases, a limitation is the reliability that gearbox needs to meet after crossing a certain number of kilometers. In both variants constraints may vary. The software is consisted of five modules that allow solving the appropriate tasks. The first of these is the definition of allowable stress, the second module relates to the identification of gearbox load capacity with known design parameters, the third module in the software is the inverse calculation in relation to the other module where calculates the load or load capacity is carried out. The software is interactive, which means that the user during its application must make numerous decisions and enter certain information in the iterative approximation to the solutions. In this regard, the fourth module provides iterative optimization of design parameters and gearbox load capacity, while the fifth module enables calculation of gearbox bearings.

CONCLUSION

Reliability model of automotive gear box, specially designed and application-oriented for approach to Design for Reliability, is given in short form. This model is based on the application of experimental results in conditions (load spectra) in the exploitation of gearboxes, and application of the results of extensive research in the probability of failure of tooth flanks of gears, bearing and other components. The paper presents the load spectrums formed on the basis of experimental results for certain conditions of exploitation, as well as the way of determining the load capacity and load. For developed model the software for structural optimization was made.

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COMPLEX SYSTEM RELIABILITY MODELLING (SPLIT SISTEM APROACH)

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Abstract: This paper focuses on SSA reliability prediction methodology to quantitatively assess the effectiveness of a PM strategy on the reliability improvement of a complex system, and thus support optimal PM decision making. A particular concern of the research is to explicitly predict the reducing amount of probability of failure of a system over a certain period due to PM, compared with the probability of failure without PM. In this paper, maintenance includes repair and replacement. From now on, when "repair" is mentioned, it usually indicates maintenance and includes "replacement".
Key words: reliability, SSA model, PM, complex system

INTRODUCTION

Today, Preventive Maintenance (PM) is often conducted in industries to reduce the probability of unexpected breakdown of assets during a certain period. An asset can be subject to multiple PM actions over its operational life-span. Many companies develop their PM strategies at the stage of acquisition of assets. Observation from industries has revealed that different PM activities can have different effects on the reliability of assets. If PM is conducted at the right time and in the correct way, it can improve the reliability characteristics of assets. Otherwise, PM may not have an effect on the reliability of assets or even worse - decrease the reliability of assets. The majority of physical assets in industries such as machines, buildings and vehicles are repairable. Hence, there is a need to investigate the effects of PM on the reliability of repairable systems comprehensively.
A complex system is normally composed of several components. These components can have different life cycles - a fact that leads to the result that different components may have different failure patterns and distributions at the same time. The conduct of PM of a system usually comprises PM on individual components in the system according to the states of their conditions. Accurate estimation of the effects of PM of these components on the reliability of systems is essential to the optimal decision making of PM strategy.
The issues associated with repairable systems have attracted much attention of researchers. The research about repairable systems is focused on two aspects: reliability predictions of repairable systems and the optimal maintenance policy for repairable systems.

CONCEPTS OF SSA AND ASSUMPTIONS

The basic concept of the SSA is to separate repaired and unrepaired components within a system virtually when modelling the reliability of a system after PM activities. This concept enables the analysis of system reliability at the component level, and stems from the fact that generally when a complex system has a PM action, only some of the components are repaired.
In the analysis, the following assumptions were made:

1. The failure of repaired components is independent of unrepaired components
2. The reliability function of a new repairable system is known. The reliability functions of repaired components are also known.
3. The topology of a repairable system is known.
4. The repair time is negligible.
5. The PM time is a deterministic variable.

MODELLING

In this paper, the SSA is developed based on model developed using a simple scenario where always the same single component is repaired in all PM activities.

RELIABILITY BLOCK DIAGRAM (RBD)

RBD is a logic network used to describe the function of a system. For a system with multiple functions, different RBD might be established. In most cases, a fault tree can be converted into a RBD, and vice versa. Generally, fault tree is more suitable for root cause analysis and RBD is more suitable for quantitative analysis. When used for quantitative analysis, RBD can be used to calculate exact system reliability at a given time *t*. Many methodologies have been developed to analyse and calculate RBD.

THE SAME SINGLE COMPONENT REPAIR

In this scenario, the original system can be described using two virtual parts: the repaired Component 1 and the remainder of the system - often referred to as the subsystem. The PM strategy is to repair Component 1 whenever the reliability of the system falls to a predefined control limit of reliability R_0. The term "control limit of reliability" indicates the required minimum reliability level of a system. Although this scenario is mainly used to demonstrate the basic concepts and procedures for SSA, the models based on this scenario can be applied in industrial cases. For example, a system has a vulnerable Component 1, i.e., this component is more likely to fail than the rest of the system. Both series and parallel systems are considered.

Series system

A series system is shown in Figure 1. The repaired component is connected with the subsystem in series, but the subsystem can be any complex system. In Figure 1, $R_1(\tau)_i$ and $R_{sb}(\tau)_i$ are the reliability functions of the repaired Component 1 and subsystem after the i^{th} PM interval, respectively. In this thesis, the second subscript *i* is used to denote "after the i^{th} PM action". Subscript $i=0$ stands for no PM. Sometimes, for simplicity, subscript 0 will be omitted if the meaning of no PM is clear. Two time coordinates are used in the modelling (refer to Figure 2):
Absolute time scale $t: 0 \le t < \infty$.
Relative time scale $\tau: 0 \le \tau \le t_i \left(i = 1, 2, ..., n\right)$.

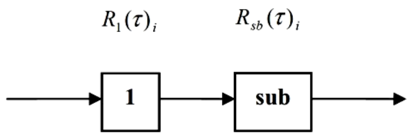

Figure 1. Series system

Usually, the reliability of a system after a PM action cannot be restored to its original state, i.e., not "as good as new". The most common phenomenon is that the reliability of a system after a PM action is lower than its original reliability, leading to an imperfect repair. After imperfect repairs, the reliability of a system declines in a manner shown in Figure 2.
In Figure 2., R_0 is the predefined control limit of the reliability for the system, Δt_i is the interval time between the (*i*-1)th PM action and the i^{th} PM action $\left(i = 1, 2, ..., n\right)$.
Parameter t_i is the i^{th} PM time and also the start time for a system to run again after the i^{th} PM action. Therefore

$$t = \sum_{i=1}^{n} \Delta t_i + \tau \tag{1}$$

Let $R_s(\tau)_i$ represent the reliability function of the system after the i^{th} PM action.
Using reliability theory, the following expression can be obtained:

$$R_s(\tau)_i = R_1(\tau)_i \, R_{sb}(\tau)_i, \quad (i = 1, 2, ..., n) \tag{2}$$

Initially, the reliability function of a system can be expressed as:

$$R_s(\tau)_0 = R_1(\tau)_0 \, R_{sb}(\tau)_0 \tag{3}$$

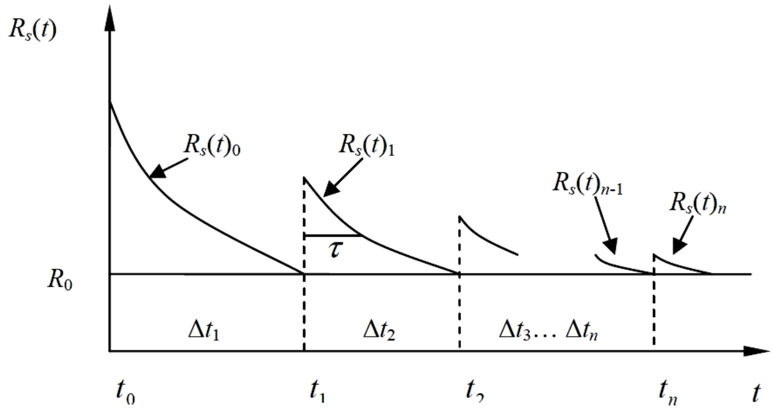

Figure 2. Changes of the reliability of an imperfectly repaired system

The reliability function of the subsystem can be derived from Equation 3:

$$R_{sb}(\tau)_0 = \frac{R_s(\tau)_0}{R_1(\tau)_0} \tag{4}$$

Equation 4 implies that $R_1(\tau)_0 \neq 0$. The reliability functions for typical failure distributions such as exponential distribution, normal distribution, lognormal distribution and Weibull distribution all meet this requirement.

At time t_1, the reliability of the system falls to the control limit R_0 and Component 1 is repaired as requested by the PM strategy. After the first PM action, the reliability function of Component 1 becomes $R_1(\tau)_1$, but the reliability function of the subsystem remains the same since it is not repaired. Considering the cumulative effect of time, the reliability function of the subsystem after the first PM action, $R_{sb}(\tau)_i$, is $R_{sb}(\tau + \Delta t_1)_0$. Hence, the reliability of the system after the first PM action becomes

$$R_s(\tau)_1 = R_1(\tau)_1 \, R_{sb}(\tau + \Delta t_1)_0 \tag{5}$$

If $R_1(\tau)_1 = R_1(\tau + \Delta t_1)_0$, $R_s(\tau)_1 \, R_s(\tau + \Delta t_1)_0$.

This indicates that the system is repaired as bad as old.

If Component 1 is repaired or replaced by an identical one so that $R_1(\tau+\Delta t_1)_0 < R_1(\tau)_1 \le R_1(\tau)_0$, then Equation 5 represents the situation where the system is repaired imperfectly because $R_s(\tau+\Delta t_1)_0 < R_s(\tau)_1 \le R_s(\tau)_0$ in this case.

If the reliability of Component 1 after the repair is better than its original reliability, $R_1(\tau)_1 \ge R_1(\tau)_0$, so that $R_s(\tau)_1 \ge R_s(\tau)_0$, Equation 5 then represents the case where the state of a system after repairs is improved to be as good as new or even better than original new one. As a result, Equation 5 can describe all possible states of a system after PM (The case that a repair decreases the reliability of a system is not considered in this thesis).
The reliability function of system after the nth PM interval can be derived as:

$$R_s(\tau)_n = R_1(\tau)_n R_{sb}\left(\tau+\sum_{i=1}^{n}\Delta t_i\right)_0 \tag{6}$$

Substituting Equation 4 into Equation 6 gives

$$R_s(\tau)_n = \frac{R_1(\tau)_n R_s\left(\tau+\sum_{i=1}^{n}\Delta t_i\right)_0}{R_1\left(\tau+\sum_{i=1}^{n}\Delta t_i\right)_0} \tag{7}$$

Equation 7 can be rewritten using absolute time scale as follows:

$$R_s(\tau)_n = \frac{R_1\left(t-\sum_{i=1}^{n}\Delta t_i\right)_n R_s(\tau)_0}{R_1(t)_0}, t \ge \sum_{i=1}^{n}\Delta t_i \tag{8}$$

where, $R_s(t)$ is the reliability of the system after the nth PM interval.
Note that Equation 7 and Equation 8 both describe the reliability of a system which has been preventively maintained for n times, i.e., these two equations both describe the conditional probability of survival of a system with n PM intervals. Neither of these two equations considers the cumulative effect over time of the repaired components. To predict the probability of survival of a system over its whole life time, these cumulative effects need to be considered, i.e., the probability of survival of these repaired components until their individual repair times need to be considered. The probability of survival of a system over its whole life time is termed as the cumulative reliability of the system. The cumulative reliability function of the system with the first PM action is

$$R_{sc}(\tau)_1 = R_1(\Delta t_i)_0 R_s(\tau)_1 \tag{9}$$

where, $R_{sc}(\tau)_1$ is the cumulative reliability of the system after the first PM action.
$R_1(\Delta t_1)_0$ is the probability of survival of Component 1 until t_1.
Generally, the cumulative reliability of the system with n PM intervals can be expressed as:

$$R_{sc}(t) = \prod_{i=0}^{n-1} R_1(\Delta t_{i+1}) R_s(t),\ \ t \ge \sum_{i=1}^{n}\Delta t_i \tag{10}$$

where $R_{sc}\left(t\right)$ is the cumulative reliability of the system with *n* PM intervals.

A low reliability of the unrepaired components of the system, or poorly repaired components, or both will cause a low $R_s\left(0\right)_n$. Obviously, the system should not be repaired any more if

$$R_s\left(0\right)_n = \frac{R_1\left(0\right)_n R_s\left(\sum_{i=1}^{n}\Delta t_i\right)_0}{R_1\left(\sum_{i=1}^{n}\Delta t_i\right)_0} \leq R_0 \tag{11}$$

i.e., a PM action is unworthy if the reliability of the system after this PM action cannot recover to excess the required reliability level.

Parallel system

In this case, the repaired component is connected with the subsystem in parallel as shown in Figure 3.

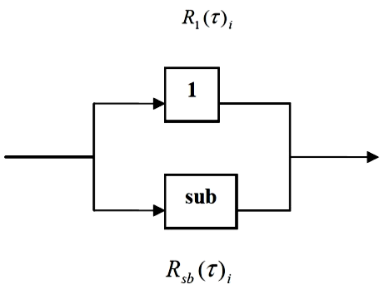

Figure 3. Parallel system

The relationship of reliability functions $R_1\left(\tau\right)_i$, $R_{sb}\left(\tau\right)_i$ and $R_s\left(\tau\right)_1$ is given by

$$R_s\left(\tau\right)_1 = R_1\left(\tau\right)_i + R_{sb}\left(\tau\right)_i - R_1\left(\tau\right)_i + R_{sb}\left(\tau\right)_i, \quad \left(i = 0,1,2,...,n\right) \tag{12}$$

To simplify mathematical operations, let $F_1\left(\tau\right)_i$, $F_{sb}\left(\tau\right)_i$ and $F_s\left(\tau\right)_1$ be corresponding failure distribution functions of Component 1, subsystem and the system after the ith PM action respectively. According to reliability theory, Equation 12 becomes

$$F_s\left(\tau\right)_1 = F_1\left(\tau\right)_i F_{sb}\left(\tau\right)_i, \left(i = 0,1,2,...,n\right) \tag{13}$$

Based on the same derivation procedure as in Subsection 5.1, the following results can be obtained (see Figure 4.):

$$F_s\left(\tau\right)_n = \frac{F_1\left(\tau\right)_n F_s\left(\tau + \sum_{i=1}^{n}\Delta t_i\right)_0}{F_1\left(\tau + \sum_{i=1}^{n}\Delta t_i\right)_0} \tag{14}$$

$$F_s\left(t\right) = \frac{F_1\left(t - \sum_{i=1}^{n}\Delta t_i\right)_n F_s\left(t\right)_0}{F_1\left(t\right)_0}, \quad \left(t \geq \sum_{i=1}^{n}\Delta t_i\right) \tag{15}$$

where, Functions $F_s(\tau)_n$ and $F_s(t)$ are the failure distribution functions of the system after the nth PM interval described in the relative time scale and the absolute time scale, respectively. Functions $F_1(\tau)_0$ and $F_1(\tau)_n$ represent the failure distribution functions of Component 1 before any PM and after the n^{th} PM interval, respectively. Function $F_s(t)_0$ is the failure distribution function of the original system. In Figure 4, F_0 is a predefined control limit of the failure probability of a system.

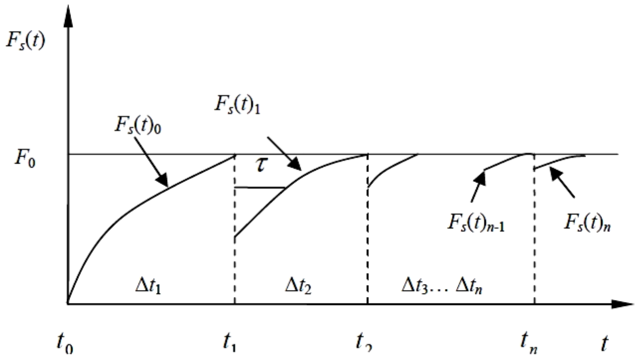

Figure 4. Changes of the failure distribution function of an imperfectly repaired system

Equation 15 can be rewritten in the term of reliability function as follows:

$$R_s(t) = 1 - \frac{\left[1 - R_1\left(t - \sum_{i=1}^{n} \Delta t_i\right)_n\right]\left[1 - R_s(t)_0\right]}{1 - R_1(t)_0}, \quad \left(t \geq \sum_{i=1}^{n} \Delta t_i\right) \tag{16}$$

Generally, $F_1(\tau)_i \leq F_1(\tau + \Delta t_i)_{i-1}$ and $F_{sb}(\tau)_0$ increases monotonously with the increase of operational time, so

$$F_s(\tau + \Delta t_i)_{i-1} > F_s(\tau)_i > F_s(\tau_i)_{i-1}, \quad (i = 1, 2, ..., n) \tag{17}$$

Equation 17 indicates that a system is repaired imperfectly. It is noted that Equations 14 and 15 or 16 can represent all different states of a system after PM due to the similar reasons mentioned in Subsection 5.1.
The cumulative reliability of the system can be derived as follows:
The cumulative reliability of Component 1 with n PM intervals is

$$R_{1c}(\tau)_n = \prod_{i=0}^{n-1} R_1(\Delta t_{i+1}) R_1(\tau)_n \tag{18}$$

The cumulative reliability of the subsystem is $R_{sb}\left(\tau + \sum_{i=1}^{n} \Delta t_i\right)_0$ since it is not repaired as assumed by the PM strategy. Hence, the cumulative reliability of the system with n PM intervals is

$$R_{sc}(t) = 1 - \left[1 - R_{1c}(\tau)_n\right]\left[1 - R_{sb}\left(\tau + \sum_{i=1}^{n} \Delta t_i\right)_0\right] \tag{19}$$

Equation 19 can be rewritten using absolute time scale as follows:

$$R_{sc}(t) = 1 - \frac{\left[1 - \prod_{i=0}^{n-1} R_1(\Delta t_{i+1})_i R_1\left(t - \sum_{i=1}^{n} \Delta t_i\right)_n\right]\left[1 - R_s(t)_0\right]}{1 - R_1(t)_0}, \quad \left(t \geq \sum_{i=1}^{n} \Delta t_i\right) \tag{20}$$

CONCLUSION

In SSA, the changes of reliability are calculated based on individual system and repair condition rather than assumed or estimated by human experience. Therefore, the rate of change may not be constant. Compared with existing models, the model developed in this chapter has the following advantages:

1. Ability to explicitly predict the reliability of a repairable system with multiple PM actions over multiple PM intervals and to decide when the system has deteriorated to a point where it is unworthy of further PM from the reliability view of point. Most of the existing models are applied to predict the next PM time, MTTF or/and the expected number of failures. SSA is hence more suitable for supporting long term PM decision making of complex repairable systems in industry.
2. Ability to deal with the individual contributions of different parts in a system and the influence of system structures on the reliability of a repairable system. This ability provides an understanding of PM of a system in more depth.
3. Ability to model different states of a system after PM such as “as good as new”, “imperfect repair”, “improvement repair” (i.e., better than new) and “as bad as old”.
4. No restrictions on the forms of failure distribution.

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RELIABILITY ASSESSMENT AND ANALYSIS

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Abstract: In this paper are explained the main reliability assessment and models. For explaining conclusions are made.
Key words: reliability, model, preventive maintenance

INTRODUCTION

In order to reduce maintenance costs and to optimize a maintenance strategy, it is necessary to understand reliability and its variations, the consequences of failures, the factors affecting maintenance and the relationship between the maintenance tasks and production or other performance of assets to be maintained. Reliability is the ability of a system to perform a required function under stated conditions for a given period of time. It is usually measured by determining the probability that a system survives in a time interval (0, t]. The most direct expression to describe the properties of reliabilities of systems is the reliability function R(t) . The reliability function is also called as survivor functio. Another mathematically equivalent way of specifying the reliability of systems is in terms of failure distribution function F(t) or failure density function f(t) . “Failure” in this thesis means that a system or a component fails to meet its performance requirement. This “failure” will naturally lead to a need for maintenance. The models and techniques for reliability assessment and analysis can be classified into two categories: The mathematical models and the conceptual models and techniques.
Analitical models are related with the repairable systems. A repairable system is usually defined as one which will be repaired to recover its functions after each failure rather than to be discarded during continuous operation. A complex system usually means that it is composed of multi-components which can be connected with each other in either series or parallel or in a complex way. This review is concerned with classifications and characteristics of analytical reliability prediction models of repairable systems. Some major limitations in these models will be identified.

CONDITION MONITORING AND FAULT DIAGNOSIS (CMFD)

CMFD has been playing an increasing role in maintenance research so that a new term - condition based maintenance (CBM) is now used. CBM is currently the best preventive maintenance strategy because it enables maintenance decisions to be made based on the current status of the equipment, thus avoiding unnecessary maintenance and thus facilitating timely maintenance when there is a strong indication of impending failure. Condition monitoring is popular and has a wide range of applications.

FAULT TREE AND ROOT CAUSE ANALYSIS

Root cause analysis is used to find out causes of failures. The classic technique is Fault Tree Analysis (FTA). A related technique is Event Tree Analysis (ETA). A fault tree is a model that graphically and logically represents the various combinations of possible events, both fault and normal, occurring in a system that leads to the top event.It can be used for qualitative analysis, quantitative analysis or both. FTA enables one to find the most likely causes of system failure, but it is costly and time consuming. This method will also fail to identify some important causes and effects. It is difficult to apply Boolean logic to describe failures of items that can be partially successful in operation and thereby have effects on the performance of the system.

RELIABILITY BLOCK DIAGRAM (RBD)

RBD is a logic network used to describe the function of a system. For a system with multiple functions, different RBD might be established. In most cases, a fault tree can be converted into a RBD, and vice versa. Generally, fault tree is more suitable for root cause analysis and RBD is more suitable for quantitative analysis. When used for quantitative analysis, RBD can be used to calculate exact system reliability at a given time t. Many methodologies have been developed to analyse and calculate RBD.

FAILURE MODES, EFFECT AND CRITICALITY ANALYSIS (FMECA)

The FMECA is a combination of Failure Mode and Effect Analysis (FMEA) and criticality analysisThe basic task of FMEA is to identify and list the modes of failures and the consequences. FMEA is very important in the application of RCM. Criticality analysis is generally used to evaluate the severity of harmful effects of a failure on the function and operation of a system, on other components, on the environment, and more importantly on mankind so that the most suitable maintenance policies can be made.

MONTE CARLO METHODS

Monte Carlo methods are possible to be used to solve the reliability prediction problems that cannot be solved analytically. With increasing computing speed and memory size of computers, Monte Carlo methods have received more attention from maintenance researchers. However, efficient Monte Carlo algorithms are often difficult to develop.

ADVANCED TOOLS AND METHODOLOGIES

Some maintenance research uses advanced tools and methodologies which havefound wide applications in other fields such as fuzzy logic, neural network, the Kalman filter, the genetic algorithm, data fusion, Monte Carlo or combination of those techniques. The application of data fusion techniques in maintenance is attractive, because there is an increasing demand for the accuracy of prediction and decision. Using computer techniques to enhance maintenance analysis ability is another attractive respect of maintenance research. Software packages such as EXAKT and RELCODE are programmed to determine the failure model and to carry out maintenance optimization. Relax (Relax software corporation) and Reliability Workbench integrate the performance of reliability prediction, maintainability prediction, FMECA, RBD analysis, FTA, ETA and Markov analysis.

BASIC PRINCIPLES OF PROBABILITY

Several models for the reliability prediction of a repairable system have been developed using the basic principles of probability. The time-dependent maintenance model mentioned is an example. According to this model, a system is always replaced at a fixed time T or failure, whichever happens first. The models based on basic probability principles were developed to determine the most appropriate preventive maintaining time T according to the reliability function or failure distribution function of the system. The most common distribution function in use is the Weibull distribution due to its ability to fit a greater variety of data and life characteristics by changing its shape parameter. Normal distribution and exponential distribution are two popular models as well.

MARKOVIAN THEORY

The Markov model plays an important role in the reliability evaluation of engineering systems. A Markovian stochastic process with a discrete state space and discrete time space is referred to as a Markov chain. If the time (index parameter) space is continuous, it is referred as the Markov process.
The model based on the Markov process assumes that a system has a finite state space and a series of possible transitions between these states. The functions, various failure modes, standby and various

maintenance activities all can be described as different states. If the transition between the states can be approximately described by a stochastic process with Markov property, the Markov method can be used to determine the reliability of the system after several states. Therefore, it is fairly common using Markovian theory to model the reliability prediction problem of a repairable system.

POISSON PROCESS

The Poisson point process is a kind of Markov process. This model assumes that the failures are independent of each other and the number of failures in each time interval follows a Poisson distribution. The Homogeneous Poisson Process (HPP) model requires stationary increments whereas a Non-Homogeneous Poisson Process (NHPP) model does not require these increments. Therefore, the NHPP is more favorable for modelling imperfect repairable systems. The NHPP can also be used to study the Rates of Occurrence Of Failures (ROCOF) when they are time dependent, and the times between failures are neither independent nor identically distributed.

CONDITION MONITORING DATA BASED MODELS

With increasing applications of condition monitoring techniques, maintenance personnel naturally wish to improve reliability prediction accuracy using monitoring data. The Proportional Hazard Model (PHM) is currently the most popular condition based model. Another similar model is Proportional Intensities Model (PIM). PHM is more flexible and avoids some of the problems related with PIM, but the latter has a clearer mathematical and physical justification. The advantage of PHM is that it includes both the age of a system and its condition in the calculation of the hazard of the system at time t.

BAYESIAN THEORY

The Bayesian model allows using the knowledge of designers, operators and maintenance engineers to reduce the uncertainties when modelling the reliability of a system. An observed value is used to update the priori (the prior density) of the Bayesian model. Bassin developed a Bayesian block replacement model for a Weibull restoration process under the assumption that repair costs are known. Mazzuchi and Soyer extended this model to the traditional age replacement policy and the block replacement policy with minimal repair under the assumption that repair cost is constant and the scale parameter and shape parameter are initially independent.

CONCLUSION

The models and methods presented above have found their applications in maintenance. However, they have fallen short of finding practical applications. He found over 100 applications of maintenance optimization models. Most of them cannot meet the demands of today’s industry.
There is a lack of effective methodology to analyse the relationship between a failure and its root causes quantitatively, especially when reliability information is incomplete, e.g., new equipment.
Improper maintenance activities such as repeatedly deferred inspections or repairs result in very costly failure. On the other hand, too often inspections or unnecessary monitoring may also cause high cost. One needs to estimate the states of a system more accurately. Current maintenance models including PHM, FMECA and FTA usually do not specify which items fail. However, the real situation is, more often, that a system fails because some and not all items fail. One therefore may not need to repair the entire system or all of items in the system. In order to carry out actions particular to business goals, one needs to get information which is perception, or recognition and localization, of structures. It involves the spatial-temporal form of components and their relationships.
It is a challenge to scientists to develop an appropriate model which can take account of historical failure records, monitoring data and other available information to enhance the accuracy of predictions.
Historical records are valuable, but they are often incomplete and inaccurate. The records normally contain the activities of maintenance rather than the causes of failures. They may have erroneous

records. On the other hand, condition monitoring is more expensive and in many cases the monitoring techniques may not be available. Hence new approaches and models are needed to overcome these limitations.

As a result of the above discussion, future research directions are identified as follows:

1. New methodologies and models need to be developed which can bridge the gap between theoretical research and industry applications. Most of reliability models have been developed for mathematical purpose or computational convenience, rather than solutions to real industry problems. Most case based research focus on short term solutions and lack vision on whole life cycle modelling.
2. A number of topics for complex repairable systems are still in their infancy and need further research, such as, investigating dynamic component-system relationship, releasing the assumption of “as good as new”, and predicting multiple failures of whole life.
3. Models dealing with very small set of data or zero failure data need to be developed more intensively.
4. The accuracy of reliability prediction needs to be improved. Reliability prediction of systems and maintenance decisions making should be based on comprehensive considerations of current conditions of a system together with historical maintenance/failure records and other information.
5. Little attention has been paid to integrated spare parts inventory management, which is important especially to asset intensive industries.
6. The integration of maintenance, monitoring and production is a major issue and needs to be addressed.

An intensive literature review has been conducted on the analytical reliability models. The literature review indicates that analytical models for reliability were mainly developed based on stochastic process and probability theory. However, analytical reliability models were also empirically developed based on experience or experiments, or derived from failure mechanism. In existing models, the renewal process and minimal repairs are still two basic assumptions although more and more attention has been paid on imperfect repairs in recent years.

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APPLICATION OF CORRECTIVE MEASURES FROM THE ASPECT OF INCREASED LEVEL OF RELIABILITY OF CASTING MACHINES UNDER HIGH PRESSURE

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Abstract: This thesis shows corrective measures taking place in order to increase the level of reliability of casting machines under high pressure. The complex structure of press molding, their high cost, high costs of the "state of failure", as well as high maintenance costs, indicate the great importance and the need for research and development of design methods for analysis and reduction of failures on complex technical systems, as one of the most important part of the system for continuous exploitation.
Key words:

INTRODUCTION

"State of failure" may be caused by insufficient quality and unreliability of all the system components, as well as the impact of the "environment" in the sense of failure caused by design solutions, installed materials, production methods, control methods, operating procedures, quality of maintenance, characteristics of the working environment, physical, chemical, atmospheric and other relative factors.
To prevent the above effects, and thus avoid many problems, especially related to the total life-cycle costs, it is necessary to provide vast information about the behavior of each of the technical system, especially throughout its exploitation.
Using mathematical statistics, new methods have been discovered that allow during design stage, development and exploitation of elements, significant level of reliability to be achieved. Therefore, reliability research problems of technical systems may be established during early design stage.
Establishing reliability during concept design as well as through design stage itself, occurrence of system failures and the state of failure during exploitation is reduced. The reliability must be taken into account throughout the whole process of design. We may say that the reliability is established during design stage, ensured during development, and utilized throughout the process of exploitation. Established level of reliability during design and production stages should sustain during the exploitation without change in the structure.

DESIGN PROCESS OF MECHANICAL SYSTEMS

The function of the system design, through a series of planned and systematic activities, establishes and defines the key features of the system such as the ability to function, reliability, lifetime, maintainability, ability to support the maintenance and availability. System design consists of several phases of work, which makes the design process transparent, rational and independent of specific industries. Analysis of any existing project will show that the main stream of design flows from the market, which belongs to the field of marketing research activities, thereby life-cycle of the mechanical system begins with identifying the needs, requirements and deficiencies, subsequently being translated into technical specifications.
Principles of construction with respect to the functionality, as distinctive characteristics of the system to perform the required function with prescribed physical characteristics (strength, speed, acceleration, bandwidth) and properties (weight, volume, size, shape), are easily understandable and quite perfected. Also, the problems of strength and "packaging" of the structures were solved by computational techniques development and mastering the methods of exploitation and laboratory tests, which is basically directed towards improvement of the system durability. However, reliability design principles are a time-consuming and hard-labor task, involving a series of procedures and modes of

performance which essentially have the character of prediction and confirmation of certain conditions that must be carried out in different phases of design process and development of the system.

The only constant denominator that system designers need to reconcile with is the project uncertainty, mostly emphasized in the early stages of the design process, and it is reflected through analysis resolution implemented at the later stage, all the way till important decisions and choices have been made.

PROCESS OF DESIGN RELIABILITY OF CASTING MACHINE UNDER HIGH PRESSURE

At the beginning of the design process of mechanical system, uncertainty arises as a result of the "gap" between the commitments on one side and specific project awareness of the designers on the other. Sources of uncertainty in the beginning of the design process are imprecise identification of user needs, inaccurate translation of those needs into qualitative and quantitative requirements at the system level, and imprecise and unclear requirements priority at system level.

Design specification of mechanical systems is essential in all areas of project activities, from architecture to shipbuilding, from electronics to mechanical engineering. Also, for any stage of design process, it represents basic reference with its integral elements.

Design specification of mechanical systems is the starting basis for design of the system, and the synthesis and analysis of all the identified needs of customers and markets ... Many studies have shown that over 90% of the observed problems in system design can be directly attributed to errors in the design specifications. The term specification is the total set of data needed to define and describe user requirements. It should be noted that the specification itself has a dynamic character, and is treated as an evolutionary and developmental document.

Also, the overall composed and unambiguously defined specification is the starting point and the necessary basis for the start of the design process.

Simple pressure vessels are serially produced welded containers that are exposed to higher internal overpressure of 0.5 bar, which are designed for air or nitrogen, which are not intended for exposure to flames.

IMPLEMENTATION OF CORRECTIVE MEASURES FOR RELIABILITY LEVEL INCREMENT

Technical requirements relating to the design, development and conformity assessment of simple pressure vessels are laid down in the Standard of technical requirements for design, development and conformity assessment of simple pressure vessels ("RS Official Gazette", No. 87/2011)

Because of the occurrence of overheating problems of casting machines under high pressure, it is necessary to apply the two corrective measures, the implementation of the means for control of algae and other impurities in the system design, and design of second additional heat-exchanger.

Application of the first corrective measure

Use of funds for water conditioning - Hidrocid 306
Hydrocid 306: - broad spectrum biocide for the control of algae, bacteria, fungi and slimes in water systems.

Area of application:
Hydrocid 306 is a growth inhibiting medium against algae, fungi and bacteria in industial cooling systems. Hydrocid 306 can be used as an agent for the removal of large amounts of slimes in the plant, and as inhibiting medium.

Technical description and features:
Hydrocid 306 reacts on substantially developed algae, bacteria and fungi. The product acts in a wide pH range. Active components are isothiazolin. Application Hydrocid a 306 does not include foaming at the facility.

Method of application:
Hydrocid 306 is an addmixture to the water in the system as periodic dosage when large amount of slime is present, used with a constant dose and frequency, e.g. once a week. When adding, additional care must be taken that the product reaches all parts of the system treated. The dose depends on the condition of the system. In systems with substantial slime increament, product must be added at a dose of 250-400 ml/m3 of water in the system. With frequent pulse dosing: add 100-200 ml /m3 of water in the system.

Description of chemicals:
Hydrocid 306 is a growth inhibiting medium against algae, fungi and bacteria in industial cooling systems.
The effect of this product is based on the physical-chemical effects. Application of Hydrocid does not imply foaming at the facility. The active components are isothiazolin contained in an aqueous solution (pH of the solution is 4), and causes the hazards to persons and environment during accidental release:

- Must not be swollowed
- Causes burns to skin, mucous membrane and respiratory system when inhaled
- Must not reach water and sewage systems

Method of dosing and container discharge:
Hydrocid 360 is added to the water as a single dose or as continuous proportionate doses according to predefined quantity. When adding, care must be taken that the product reaches all parts of the system treated. The amount of dosage depends on the condition of the system. The effect of treatment may be determined by using a blade for biological growth, and if necessary, by laboratory analysis of bacteria amount after treatment. If bacteria / fungi are still present after treatment, the dosage is repeated.
If the dosage is not automated, it shall be proportioned over existing dosing-pumps with monitoring of pH; controlled by a technician. Any transfering of Hydrocid 360 from the canister into the container for dispensing is done by the transfer-pumps with application of HSE measures.
One of the corrective measures for machine overheating is application of water conditioner Hydrocid 306.

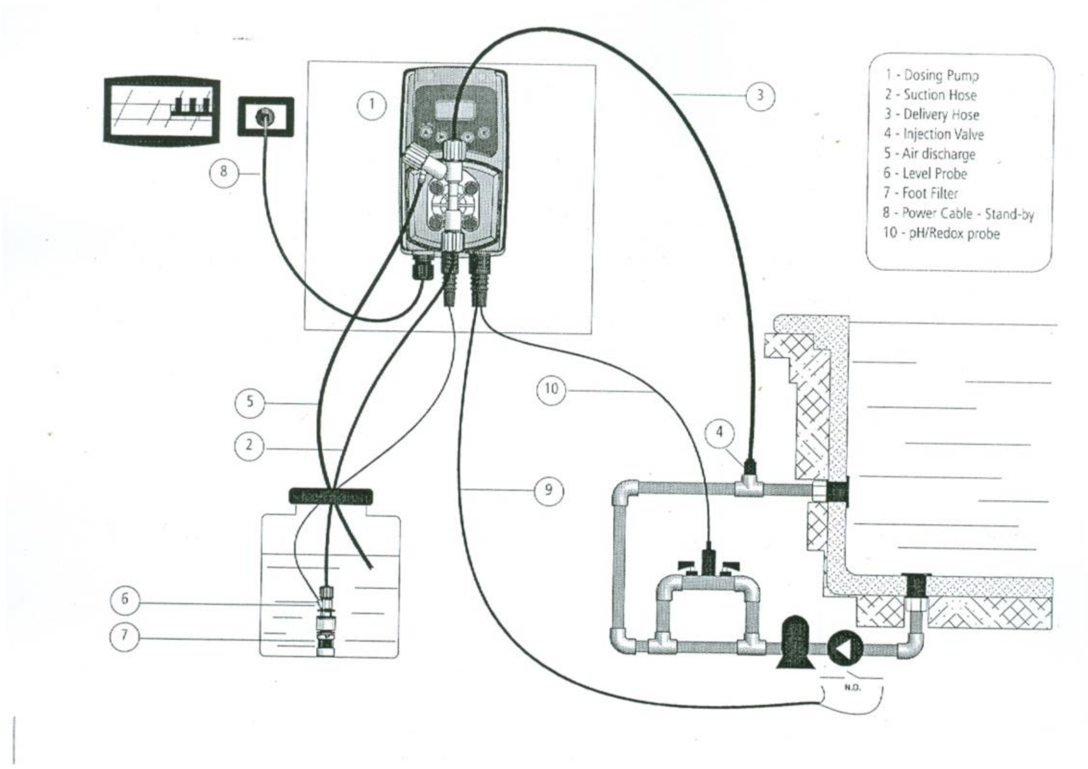
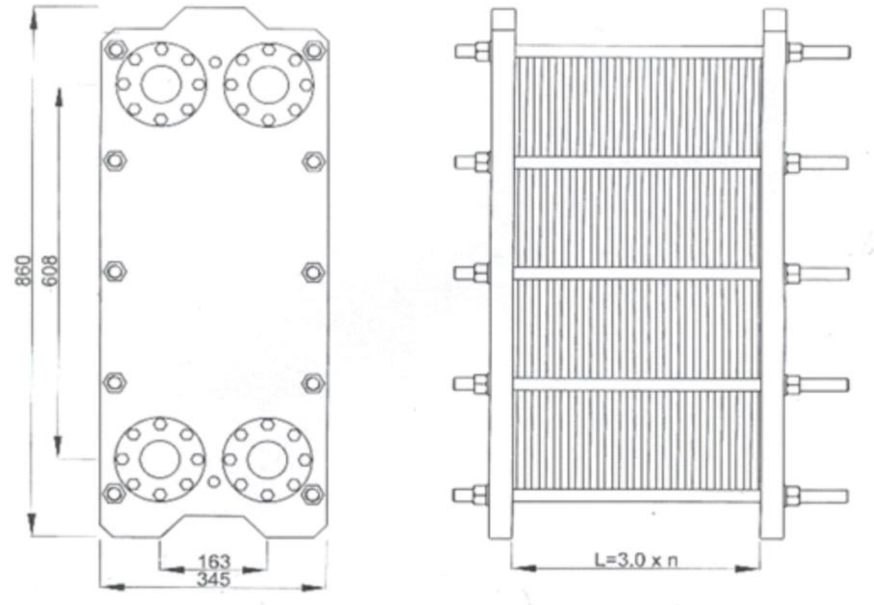


Figure 1. Schematic view of resources for water conditioning

The use of second corrective measure

The use of plate heat-exchangers TR 200
Second corrective measure for overheating of casting machines under pressure is the additional use of plate heat-exchanger TR 200 (Figure 2).



TEHNICAL CHARACTERISTICS

Connection/plug	NO65
Maximum flow rate	60
Dimensions	345 x 860 x L
End plates thickness	40
Inner plates thickness	0,6
Maximum number of plates	200
Threaded rod	10 x M20
Length	3,0 x n*
Exchanger weight	164,3 + 0,89 x n*
Nominal preassure	NP25, NP16, NP6
Test preassure	32
Maximum operating temperature	150 °C

MATERIALS

End plates	Č.0351
Inner plates	Č.4580, Č.4576 (AlSi 304, AlSi 316)
Threaded bars	Č.1531 (8.8)
Gaskets	EPDM

Figure 2: Schematic view with technical characteristics of plate heat-exchanger

CONCLUSION

When designing technological systems / equipment and processes, it is necessary to take into account the required reliability as one of the important data, given that todays design from the standpoint of reliability is not sufficiently saturated through practice by the designers.
As an example, machines under high pressure can be effectively used as the basis for reliability analysis of many processes in the industry, both in the period of exploitation and in the design phase. The main reason for this is that records are kept regularly about the process, with an information systems and databases for process in place, which makes it easier to collect the necessary data needed for design reliability.
Knowing the general causes of failure of casting machines under high pressure, and in case reliability activities are established during design stage, technology of maintenance is more effectively conducted during exploitation. This provides a small number of failures and malfunctions of the system, thereby increasing the level of system reliability and reduce maintenance costs. Use of medium for water conditioning - Hydrocid 306 and second corrective methods; use of plate heat-exchanger TR 200 inevitable lead to increment of reliability levels.
With the use of medium for water conditioning Hydrocid 306 and plate heat-exchanger TR 200, overheating problems of casting machine under high pressure are solved.

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APPLICATION OF FAILURE MODES AND EFFECTS ANALYSIS METHOD (FMEA) ON CASTING MACHINES UNDER HIGH PRESSURE

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Abstract: In this thesis, and based on the known failure analysis methods developed primarily for the electronic resources, possibility of their application to complex mechanical resources has been introduced. Therefore, failure analysis of specific mechanical resources, resulted in the creation of "adjusted" procedure for failure analysis process. Method of Failure Modes and Effects Analysis (FMEA) for monitoring is shown herein, with functionality analysis of casting machine under high pressure, and it is demonstrated that with the implementation of certain corrective measures, grade of level of criticality for system failure will reduce to the satisfactory grade.
Key words:

INTRODUCTION

Due to weather conditions and environmental impact, technical system designed for the execution of the functional objective in a certain period of time is usually adversely affected. Under this influence, working disorders firstly come to its state of appearance, followed with certain failures, and finally with the cessation of process, resulting in the system "state of failure". One of the ways of providing these information is conducting certain methods of failure analysis on the technical system. When it comes to failure analysis, FMEA method is widely accepted. Analysis of modes and effects (consequences) of failures is based on consideration of all potential failure of system components, thus their failure effect on the overall system. This thesis covers the reliability of machines under high pressure during their exploitation throughout certain period of time, which is shown hereinafter within graphs of failures and distortions of technical systems in process.
Conducting FMEA on the complex mechanical resources can be time-consuming and hard-labor task, primarily because of the large number of system components. It is known that all parts do not have the equal importance on the performance and reliability of the system itself. Therefore, it is justified, in order to achieve particular operability during the implementation of the method, to rank system components in accordance to its significance, however from the aspect of reliability.

TECHNICAL SYSTEMS RELIABILITY

Reliability troubleshooting requires the determination of many factors, on which reliability indicators depend. Time factor and mode of system technical exploitation are considered as the basic factors. Technical systems of today are characterized by its complexity, which means that they include many of diverse technologies (mechanical engineering, electronics, energy, etc.). By virtue of introduction of certain assumptions, establishment of regular maintenance procedures, and organizational data collection of failures, altogether with widespread use of statistical methods, we now can determine the reliability of such complex technical systems. For predicting the reliability of the technical systems, information on the change of the working ability of system components during the planned period of operation is required. Such information is necessary at all stages of their creation; during design, construction, testing, operation, maintenance and finally their disposal.
Statistical information on the reliability of system component in the process of exploitation allows us to determine the index of reliability for a particular type of model, taking into account its mode and exploitation conditions for a certain interval of time.

Totality of the factors that determine the reliability of the system components is characterized by random variables, therefore indexes of reliability also appear as random variables, and are determined based on the method of probability and mathematical statistics.

APPLICATION OF FAILURE MODES AND EFFECTS ANALYSIS METHOD (FMEA)

FMEA is a method used for the evaluation of modes and effects of potential failures of subsystems, sets, components or functions within the system. FMEA is an inductive team method that requires time and good knowledge of the system being analyzed. The aim of the method is to identify failures that may adversely affect the reliability of the system as whole.

The aim of FMEA application (Figure 1) is to detect potential failures as well as the collection of knowledge and experience over the character of failure and failure impact on the quality of technical system. The most complex application FMEA analysis has found in the automotive industry.

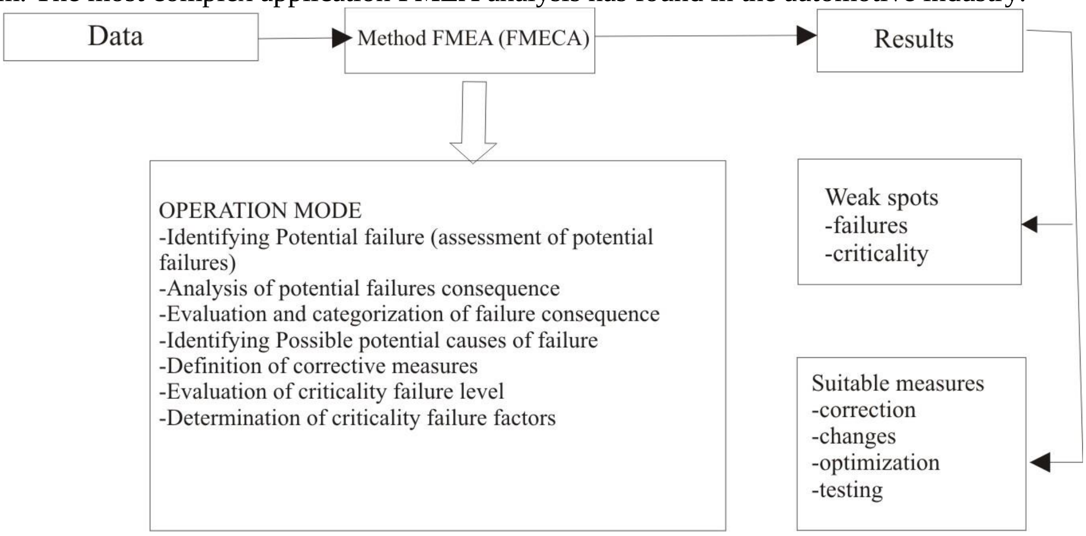

Figure 1. Purpose of FMEA application

FMEA procedure for casting machines under high pressure

Number of risks (priorities) - Risk Priority Number

To determine the Risk Priority Number (RPN) it is required to:

- Evaluate the severity of each failure effect
- Evaluate the likelihood (probability) of occurrence of each effect of failure
- Evaluate the likelihood (probability) of detecting each effect of failure (likelihood - probability).

Problems should be detected before the product reaches the end-user.

RPN is defined by multiplying the following three:

RPN = Severity * Occurrence * Detection

RPN can be used to compare failure during the analysis and prioritization of corrective measures (action).

Table 2.1. and Table 2.2. represent an analysis of modes and effects of failure through FMEA procedure (severity, occurrence, detection), applied to casting machines under high pressure. Table 2.1 provides a tabulation of specific technical system prior to corrective measures (action), whereas Table 2.2 provides a same tabulation of specific technical system upon correction measures (actions) took place.

Noticeable, corrective measures (actions) are applied wherever the RPN was over 100, which is specifically seen in Table 2.1. Upon the corrective measures took place, RPN reading is less than 100, and as shown in Table 2.2.

Table 2.1 Functional FMEA method of casting machines under high pressure prior corrective measures

Part	Function	Mode of failures	Failure effects	Seriusness	Cause of failure	Probability of occurrence	Detection of failure	Detection	RPN	Action
Third phase multiplier	Third phase pressure	Insufficient third phase pressure	Casting drip porosity	9	Battery leakage	5	Pressure gauge	2	90	Check-ups on hourly basis
Dosing furnace heathers	Maintenance of casting temperature in the furnace	Faulty heater	Temperature (casting) under the limit	8	Cracked heater	4	Furnace ammeter heater display	2	64	Read parameters on hourly basis
Second phase valve	Regulation of second phase speed	Second phase valve failure	Second phase low (excessive) speed	8	Operation blockage (dirty oil)	4	Second phase display	2	64	Preventive cleaning once a month
Heat exchanger	Cooling of hydraulic oil in the machine	Poor or insufficient flow	Machine malfunction (oil overheating)	8	Insufficient cooling capacity	7	Casting machine display	2	112	Introduce additional cooling
Tools coating (cooling) device	Tool heat dissipation	Poor tools spraying	Overheated tool	9	Nozzle contamination (algae in the system)	6	Digital thermometer (temperature measurement tools)	2	108	Use biocide within the system (anti-algae)
Casting tool	Casting Drips	Tools insufficient cooling flow	Cracked pieces (casting drips)	9	Algae within the system (clogged cooling channel)	6	Float (for water flow)	2	108	Use CARB bearings C2314 (vibration resistant)
Realization pump (hydraulic pressure)	System pressurizing	Pump failure	Insufficient system pressure	8	Axis vibration in gear pump (pump overheating)	5	MIKROLOG CMVA 65 (Thermal imaging)	4	160	Replace gear with wing pumps

Table 2.2 Functional FMEA method of casting machines under high pressure upon corrective measures

Part	Function	Mode of failures	Failure effects	Seriusness	Cause of failure	Probability of occurrence	Detection of failure	Detection	RPN	Action
Third phase multiplier	Third phase pressure	Insufficient third phase pressure	Casting drip porosity	9	Battery leakage	5	Pressure gauge	2	90	Check-ups on hourly basis
Dosing furnace heathers	Maintenance of casting temperature in the furnace	Faulty heater	Temperature (casting) under the limit	8	Cracked heater	4	Furnace ammeter heater display	2	64	Read parameters on hourly basis
Second phase valve	Regulation of second phase speed	Second phase valve failure	Second phase low (excessive) speed	8	Operation blockage (dirty oil)	4	Second phase display	2	64	Preventive cleaning once a month
Heat exchanger	Cooling of hydraulic oil in the machine	Poor or insufficient flow	Machine malfunction (oil overheating)	7	Insufficient cooling capacity	5	Casting machine display	2	70	
Tools coating (cooling) device	Tool heat dissipation	Poor tools spraying	Overheated tool	8	Nozzle contamination (algae in the system)	4	Digital thermometer (temperature measurement tools)	2	64	
Casting tool	Casting Drips	Tools insufficient cooling flow	Cracked pieces (casting drips)	8	Algae within the system (clogged cooling channel)	4	Float (for water flow)	2	64	
Realization pump (hydraulic pressure)	System pressurizing	Pump failure	Insufficient system pressure	7	Axis vibration in gear pump (pump overheating)	4	MIKROLOG CMVA 65 (Thermal imaging)	3	84	

CONCLUSION

In light of this method, and throughout its analysis, we came to some specific results in terms of grade of level of criticality. We may say that based on such grade, we easily determine the priority of action or corrective measures required for certain components or sets by prioritizing the known failures. Thus, this method therefore identifies all the failures that may adversely affect the reliability of components, sets or complete system of casting machines under high pressure. Results of diagnosis may allow us to evaluate the condition of the machine at a given point of time, to detect deviations from the performance mode, from technical maintenance, as well as to notice the first signs of excessive wear-and-tear that may cause the machine overall system failure.

Irregularities discovered during diagnostics are eliminated throughout the regular daily maintenance, as well as through planned technical maintenance and repairs. Prompt and qualitative execution of control-regulation works during daily maintenance will significantly contribute to the overall reliability of the casting machines.

Based on the assumption that the implementation of certain remedial measures and their monitoring during exploitation of casting machines for a particular time period will provide significant results, we arrive to certain conclusions in terms of improving the performance of such machine for a specific period, and for which the results obtained upon corrective measures took place already confirm. This can be easily noticed in the table prior corrective measures (Table 2.1), with a high RPN score (>100), and in the table upon corrective measures (Table 2.2), where RPN score dropped to some optimal level of reliability (<100).

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MAINTENANCE AS LOGISTICS OF SUSTAINABLE DEVELOPMENT

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Abstract: Problem solving and sustainable development have a global character, but also a result of the huge number of activities individually. In the sphere of global character gives a brief overview of the industrial policy of the EU Sustainable Development.Industrial processes and logistics of these processes, maintenance before all elements have a broad base of activities that impact on sustainable development. Integrated standards and their application in function of achieving quality of life, are an important condition for sustainable development.
Key words: sustainable development, health, industrial processes, logistics, maintenance, environmental aspects

DEFINITION AND IMPORTANCE OF SUSTAINABLE DEVELOPMENT

The concept of sustainable development leads to the most common, in connection with environmental protection, social development planning, environmental, economic and political issues (Figure 1) [4]. The concept of sustainable development is a new development concept, a new strategy and philosophy of social development.

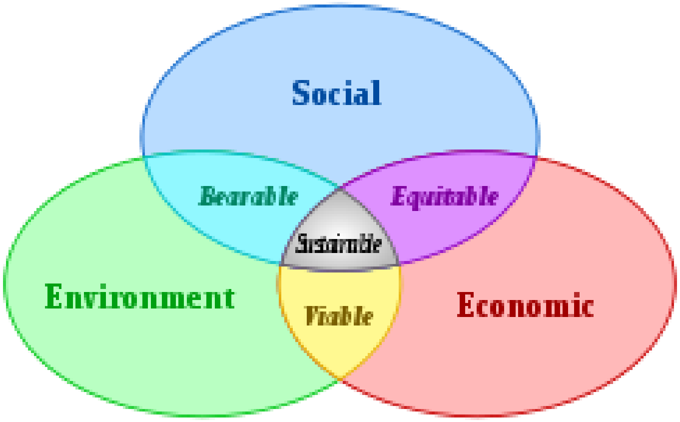

Figure 1. Spectrum impact on sustainability – sustainability as a cross-section of influential factors

Sustainable development combines both care for wildlife on Earth and to preserve the capacity of natural systems (natural resources), social and environmental challenges, which are located at every society, state and mankind as a whole
The major challenges of sustainable development are: global warming, depletion of the ozone layer, "the greenhouse effect", the disappearance of forests, conversion of arable land into desert, the phenomenon of acid rain, extinction of animal and plant species.

DEFINITIONS OF SUSTAINABLE DEVELOPMENT

There is no unique and universally accepted definition 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 cited definition of sustainable development is in the report "Our Common Future", which is, at the invitation of the United Nations prepared by the World Commission on Environment and Development (the so-called. Brundtland Commission) in 1987.

The definition reads:
"Sustainable development is development that meets the needs of the present without question the ability of future generations to meet their own needs."

Per second, sustainable development implies a balance between resource consumption and the ability of natural systems to meet the needs of future generations.
A comprehensive definition of sustainable development as follows: Sustainable development is an integral economic, technological, social and cultural development, in line with the need to protect and improve the environment, which enables current and future generations meeting their needs and improving the quality of life.
Agenda 21 (the 21st century) is one of the key documents adopted at the Earth Summit (United Nations Conference on Environmental and Development UNCED, also known as „ Earth Summit „ was held in June 1992 in Rio de Janeiro, Brazil).It is a declaration of intent and commitment to sustainable development in the twenty-first century. At about 500 pages there are 40 chapters; of issues of poverty, health issues to waste [2].

Basic principles of sustainability:
- Intergenerational equality - the present generation should not diminish the chances for the development of future generations,
- The precautionary principle, in terms of global environmental uncertainty
- The principle of conservation of natural resources with minimal damage to the environment
- Suppression of pollution at the source
- The principle that the polluter pays, through the internalisation of eco-costs through charges, fees and permits
- Using the best available technology,
- Prevention and elimination of creating unnecessary wast,
- Isolation and control of waste that can not be recycled is still used
- Inclusion of environmental analysis and assessment, decision-making in the economy;
- Respect for the capacity of the environment and eco-space

Sustainable society can be seen as a society:
- That recognizes that economic growth has its limits and that they are certain main capacity resources in the environment,
- That values the cultural diversity,
- That cultivates respect for all forms of life and encourages diversity of wildlife,
- That wider social system the values through education about sustainability,
- That should hire experts for the environment when making all development decisions,
- That makes plans balanced development, respecting the social, health, economic and environmental needs,
- That used local resources and capacities of the long term the best way,
- That using renewable and reliable energy sources,
- That strengthens the activity in which the materials are recycled.

MAINTENANCE - THE MOST IMPORTANT LOGISTICS COMPANY TO WORK FOR SUSTAINABILITY

Steady growth in industrial production and manufacturing systems (Figure 2) in developed countries has led to a tightening of environmental protection, use of energy and natural resources, and waste disposal [3].
The current trend is to manage the process of being fully verifikivan and assessed in accordance with the requirements of the standards of the ISO 9001 standard.

From this point of view it is necessary to monitor the crucial processes in the maintenance and focus on their performance, such as cleaning machines and equipment, lubrication and oil change, monitoring and diagnostics, safety checks, replacement of machinery and equipment, the possibility of monitoring and assessment analysis of effectiveness, internal and external maintenance planning, control, spare parts, restoration of damaged parts, check-ups, etc..
Maintenance is the basic logistics of industrial systems, both in terms of their capacity to work, and the aspect of meeting the requirements of environmental protection and sustainable development in general.
Maintenance is a multidisciplinary collection of indirect (preparatory) and direct (executive) activities in the prediction, prevention and elimination of failure of machines and equipment in order to achieve an optimal level of effectiveness of the system.

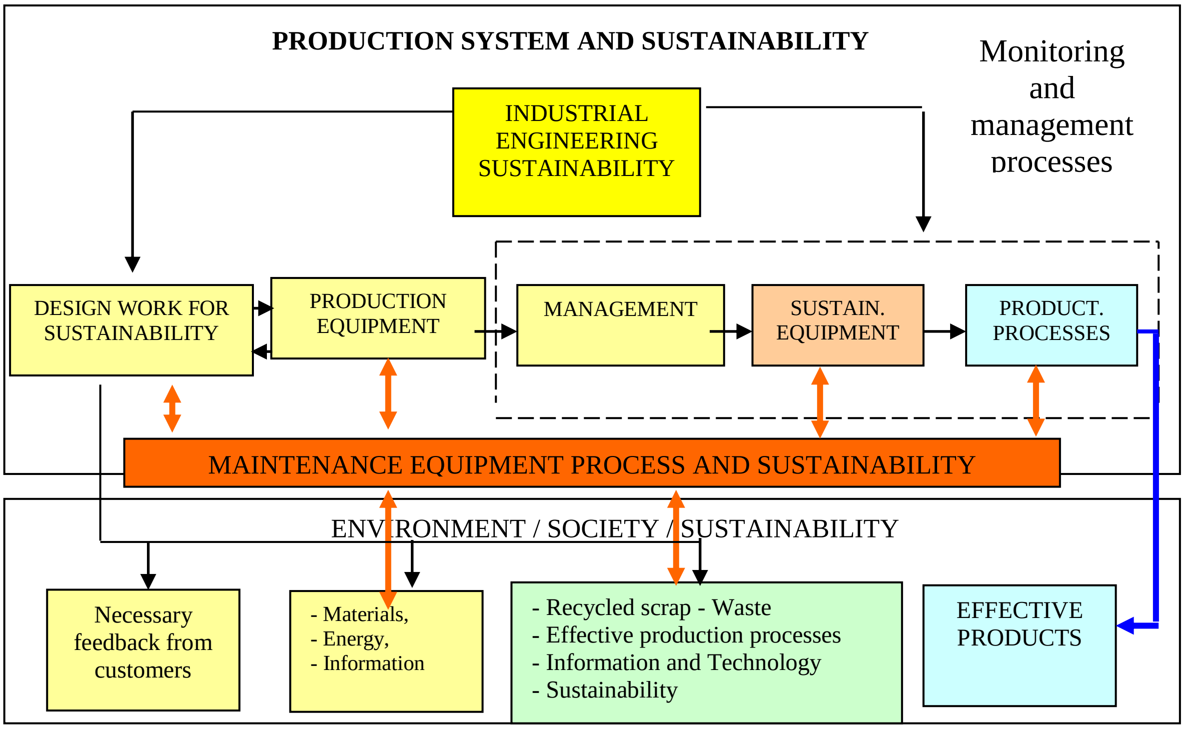

Figure 2. The functional structure of the production system

Maintaining a process model (Figure 3) acne is caused by the multiple roles that each of them has its place in both the standards of the ISO 9000 and in the standards of the ISO 14000, and in terms of sustainability [1]:

a. Maintenance as the main productive activity in the company

The process of maintaining a basic production activity of enterprises in terms of providing services to third parties, and result in a final product companies. Then maintenance has a fundamental responsibility to protect the environment.

b. Maintainance the logistics of production activities of the company

The process of maintaining a basic logistics of the manufacturing sector. Results in facilitating the production process
Then the maintenance involved in protecting the environment with the dual responsibility:

- *the secondary* - that its function prevents the technological equipment that threatens the environment (piping, pumps, motors, gearboxes, crushers, mills, furnaces and many others.) and
- *primary* - to their function in the technological and system maintains the function of the equipment that prevents contamination of the environment (filters, sedimentation tanks, separators, collectors, purifiers, etc..).

c. **Maintain its own production and development function**

Maintenance functions has activities of designing and developing their own capacities and their products out to the external market.

Then maintain a fundamental role in protecting the environment as a potential manufacturer of environmental protection as its servicer.

d. **Maintenence to the basic services.**

Maintenance functions has its own elementary utility task (legal and financial advice, education and training, public relations, consulting services, craft character etc..).

In this case the maintenance is emerging as a service technician and assumes a secondary role in protecting the environment. The primary role of a user equipment for environmental protection.

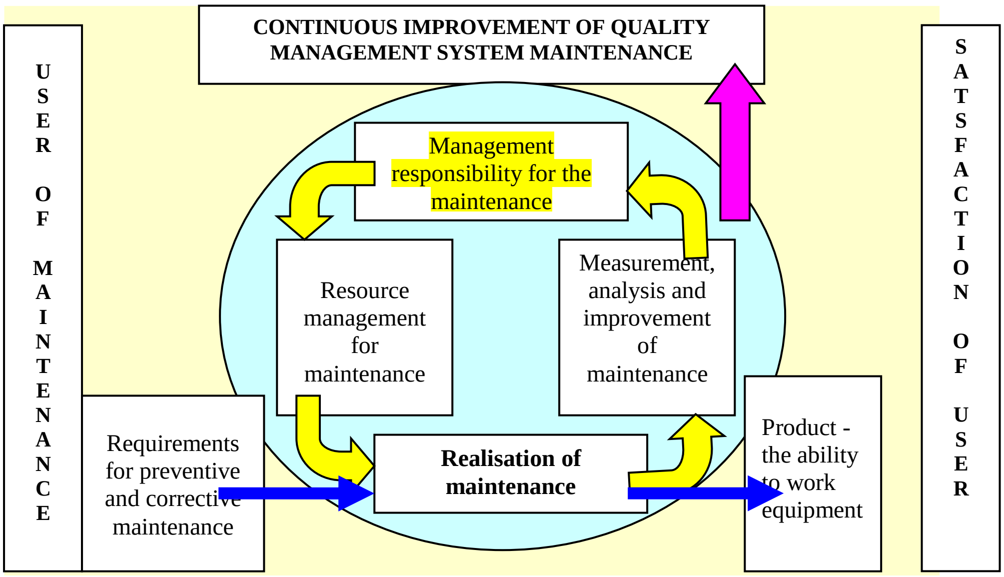

Figure 3. The process model in the management of the Quality Maintenance

CONCEPT AND DEFINITION OF CLEANER PRODUCTION

Cleaner production is a preventive approach.

This approach aims to meet human needs without endangering lives or integrity of the ecosystems on which we depend.

The main goal of cleaner production (fig.4) that focuses on the prevention or reduction of waste and inefficient use of energy and resources [4].

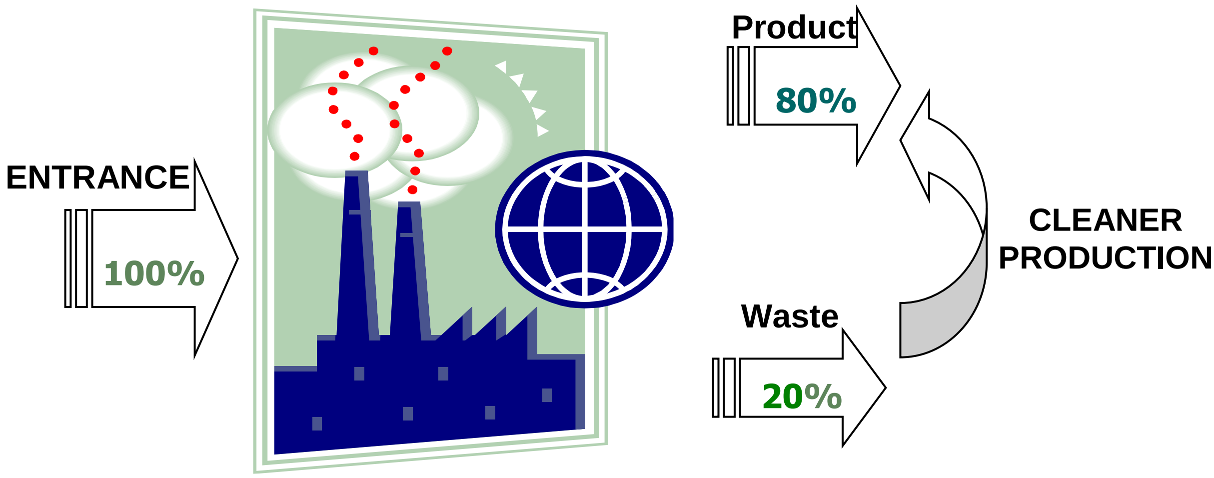

Figure 4. Terms of cleaner production

In essence, cleaner production can be written as:

- reducing the amount of waste, or avoiding production of the same,
- efficient use of energy and resources,
- production of environmentally friendly products and services,
- achieving smaller quantities of waste produced, lower prices and higher profits.

CONCLUSION

Sustainable development is a process of change in which the exploitation of resources, the orientation of technological development and related activities in a certain harmony with each other,

Sustainable development will increase the possibilities of meeting the needs and expectations of current and future generations, focusing on the balance of social, economic and environmental factors.

A strategy for sustainable development of the EU has a significant impact on the adoption of policy development at all levels, while requiring an integrated and balanced approach to the important economic, social and environmental aspects.

Production logistics system is a set of actions that achieves the requirements of sustainable development.

Maintenance functions, as particularly significant logistics of manufacturing processes, has an impact on a wide range of environmental aspects

From the standpoint of maintaining internal character realizes immediate impact in a narrow environment of its operations.

Maintenance has a direct and indirect impact on the wider environment, depending on whether the maintenance logistics of a production process or the main production process of the company.

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METHODOLOGY FOR APPLYING THE DIFFERENTIAL QUADRATURE (DQ) METHOD TO THE FREE VIBRATION ANALYSIS

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Abstract: A methodology for applying the differential quadrature (DQ) method to the free vibration analysis of arbitrary quadrilateral plates is developed. In our approach, the irregular physical domain is transformed into a rectangular domain in the computational space. The governing equation and the boundary conditions are also transformed into relevant forms in the computational space. Then all the computations are based on the computational domain.
Key words: differential quadrature method; vibration analysis; arbitrary quadrilateral plates; coordinate transformation

INTRODUCTION

A methodology for applying the differential quadrature (DQ) method to the free vibration analysis of arbitrary quadrilateral plates is developed. In our approach, the irregular physical domain is transformed into a rectangular domain in the computational space. The governing equation and the boundary conditions are also transformed into relevant forms in the computational space. Then all the computations are based on the computational domain.
In recent years, the differential quadrature method has become one of many popular ways of solving the problem of initial and boundary conditions [2]. The advantage of the differential quadrature method is that it is easy to use and flexible in regards to any spatial coordinate system. In comparison to the conventional computation techniques of lower order, such as finite element methods and finite difference methods, the differential quadrature method gives precise solutions with more mesh points.

THE DIFFERENTIAL QUADRATURE METHOD

One of the moot points in differential quadrature method is defining its impact coefficients. For the differential of function *f(x,t)* n- order, in comparison with x and mesh point X_i the approximity of the differential quadrature method can be presented as:

$$f_x^n(x_i,t) = \sum_{k=1}^{N} c_{ik}^n f(x_{k},t) \qquad (1)$$

$n=1,2,\ldots, N-1,\ i=1,2,\ldots,N$

where *N* is number of mesh points in the whole domain, and $C_{ik}^{(n)}$ is the impact coefficient determined by the differential quadrature method.

PLATES VIBRATION EQUATION IN CURVILINEAR COORDINATE SYSTEM

The plates vibration equation in curvilinear coordinate system which will be presented in this section, can directly apply the traditional rules of the differential quadrature method to the problems of vibration of plates with irregular quadrangle domains. The equations of vibration plates conditions can be expresed as follows:

$$w_{xxxx} + 2w_{xxyy} + w_{yyyy} = \Omega^2 w \qquad (2)$$

where

$$\Omega^2 = \omega a^2 \sqrt{\frac{\rho h}{D}}$$

D- plate rigidity
h-plate thickness
ρ-thickness
w-plate buckling, and
ω-frequency of its own free vibrations
Equations of condition (2), can be transformed in *(ξ,η)*system (computing space) in form of:

$$\begin{aligned}\Omega^2 w = {} & \overline{D}^{(41)} w_{,\xi\xi\xi\xi} + \overline{D}^{(42)} w_{,\xi\xi\xi\eta} + \overline{D}^{(43)} w_{,\xi\xi\eta\eta} \\ & + \overline{D}^{(44)} w_{,\xi\eta\eta\eta} + \overline{D}^{(45)} w_{,\eta\eta\eta\eta} + \overline{D}^{(31)} w_{,\xi\xi\xi} \\ & + \overline{D}^{(32)} w_{,\xi\xi\eta} + \overline{D}^{(33)} w_{,\xi\eta\eta} + \overline{D}^{(34)} w_{,\eta\eta\eta} \\ & + \overline{D}^{(21)} w_{,\xi\xi} + \overline{D}^{(22)} w_{,\xi\eta} + \overline{D}^{(23)} w_{,\eta\eta} \\ & + \overline{D}^{(11)} w_{,\xi} + \overline{D}^{(12)} w_{,\eta}\end{aligned} \qquad (3)$$

The domain of changeable Eq. (3) is quadrangle. That is shown in Eq. (3) with changeable coefficients $\overline{D}^{(ij)}$which are much more complex than in the form of Eq. (2). When the computing domain is regular, Eq. (3) can be solved in the same way as the problem of regular domain by using the differential quadrature method.
Simply supported and clamped boundray conditions will also be discused in the present work. They are presented as following:
For clamped:

$$w = 0 \qquad (4a)$$

$$\frac{\partial w}{\partial n} = 0 \qquad (4b)$$

For supported:

$$w = 0 \qquad (5a)$$

$$\frac{\partial^2 w}{\partial^2 n} + v\frac{\partial^2 w}{\partial^2 \tau} = 0 \qquad (5b)$$

n and τ mark the normal and tangent direction, respectivelly. Eq. (4a) and (5a) present null point bending, Eq. (4b) present null point of normal rotation and Eq. (5b) present null normal moment. Null bending condition can be applied easily. In the works of Bert and Malik [1], null point of normal rotation and moment conditions in clamped and simply supported bounderies can be presented as follows:

$$w_{,x}\cos\theta + w_{,y}\sin\theta = 0, \qquad (6)$$

$$(\cos^2\theta + v\sin^2\theta)w_{,xx} + (\sin^2\theta + \cos^2\theta)w_{,yy} + 2(1-v)\cos\theta\sin\theta w_{,xy} = 0 \qquad (7)$$

where θ - is the angle between the normal to the plate boundary and x – axis. That is shown in Eq. (6) which is equivalent to Eq. (4b), and in the Eq. (7) which is equivalent to Eq. (5b). The following passage presents simplification of Eq. (6) and (7) along *ξ*-constant and *η*- constant boundary in the curvilinear coordinate system.
For clamped and simply supported edges, w buckling is always equal to null. The results are as follows:

$$\frac{\partial w}{\partial \eta} = 0, \qquad (8a)$$

$$\frac{\partial^2 w}{\partial^2 \eta} = 0, \qquad (8b)$$

within *ξ*- constant boundaries, and

$$\frac{\partial w}{\partial \xi} = 0, \tag{9a}$$

$$\frac{\partial^2 w}{\partial^2 \xi} = 0, \tag{9b}$$

within η - constant boundaries

On the other hand, θ is the angle between normal to the plate boundaryand x-axis. As a result, along ξ- constant boundary there is:

$$\cos\theta = \frac{y_\eta}{\sqrt{\alpha}}, \tag{10a}$$

$$\sin\theta = \frac{x_\eta}{\sqrt{\alpha}}, \tag{10b}$$

By using Eq. (8) and (10) the null of normal rotation condition (6) along ξ- constant boundary can be simplified as follows:

$$\frac{\partial w}{\partial \xi} = 0, \tag{11}$$

And the null of normal condition moment *(β)* along ξ-constant boundary can be simplified as follows:

$$\frac{\partial^2 w}{\partial^2 \xi^2} - \frac{2\beta \partial^2 w}{\alpha \partial \xi \partial \eta} + s\frac{\partial w}{\partial \xi} = 0 \tag{12}$$

where:

$$s = \frac{1}{J\alpha^2}\begin{bmatrix} (\alpha^2 y_{\xi\xi} - 2\alpha\beta y_{\eta\eta} + \beta^2 y_{\eta\eta})x_\eta \\ -(\alpha^2 x_{\xi\xi} - 2\alpha\beta x_{\xi\eta} + \beta^2 x_{\eta\eta})y_\eta \end{bmatrix} + \frac{\nu J}{\alpha^2}(y_{\eta\eta}x_\eta - x_{\eta\eta}y_\eta)$$

Along η - consatant area, cos Θ and sin Θ can be expressed as follows:

$$\cos\theta = \frac{y_\xi}{\sqrt{\gamma}} \tag{13a}$$

$$\sin\theta = -\frac{x_\xi}{\sqrt{\gamma}} \tag{13b}$$

Because the Eq. (6) is reduced to:

$$\frac{\partial w}{\partial \eta} = 0 \tag{14}$$

the Eq. (7) is reduced to:

$$\frac{\partial^2 w}{\partial^2 \eta^2} - \frac{2\beta \partial^2 w}{\gamma \partial \xi \partial \eta} + t\frac{\partial w}{\partial \eta} = 0 \tag{15}$$

where:

$$t = \frac{1}{J\gamma^2}\begin{bmatrix} (\beta^2 x_{\xi\xi} - 2\gamma\beta x_{\xi\eta} + \gamma^2 x_{\eta\eta})y_\xi \\ -(\beta^2 y_{\xi\xi} - 2\gamma\beta y_{\xi\eta} + \gamma^2 y_{\eta\eta})x_\xi \end{bmatrix} + \frac{\nu J}{\gamma^2}(x_{\eta\eta}y_\xi - y_{\eta\eta}x_\xi)$$

APPLICATION AND DISCUSION

In this section, the differential quadrature method used for solving the Eq. (3), by defining transversal vibrations of irregular shaped plates, will be presented. Dependant changeable ξ *and* η *in* quadrangle comuting domain take values in a range -1 to 1. The result of the application of the differential quadrature method to Eq. (3), is as follows:

$$\begin{aligned} \Omega^2 w_{i,j} = {} & \bar{D}_{ij}^{(41)} \bar{D}_{ik}^{\xi} w_{,kj} + \bar{D}_{ij}^{(42)} C_{ik}^{\xi} A_{jm}^{\eta} w_{km} + \bar{D}_{ij}^{(43)} B_{ik}^{\xi} B_{jm}^{\eta} w_{,km} + \bar{D}_{ij}^{(44)} A_{ik}^{\xi} C_{jm}^{\eta} w_{,\xi\eta\eta\eta} \\ & + \bar{D}_{ij}^{(45)} \bar{D}_{jm}^{\eta} w_{im} + \bar{D}_{ij}^{(31)} C_{ik}^{\xi} w_{,kj} + \bar{D}_{ij}^{(32)} B_{ik}^{\xi} A_{jm}^{\eta} w_{km} + \bar{D}_{ij}^{(33)} A_{ik}^{\xi} B_{jm}^{\eta} w_{km} \\ & + \bar{D}_{ij}^{(34)} C_{jm}^{\eta} w_{im} + \bar{D}^{(21)} B_{ik}^{\xi} w_{kj} + \bar{D}_{ij}^{(22)} A_{ik}^{\xi} A_{jm}^{\eta} w_{km} + \bar{D}_{ij}^{(23)} B_{jm}^{\eta} w_{,\eta\eta} \\ & + \bar{D}_{ij}^{(11)} A_{ik}^{\xi} w_{kj} + \bar{D}_{ij}^{(12)} A_{jm}^{\eta} w_{im} \end{aligned} \tag{16}$$

where i,j =3,...,(N-2), and A_{ij}, B_{ij}, C_{ij} and D_{ij} with exponents ξ *and* η which mark weight coefficients of matrix of first, second, third and fourth order derivation along ξ *and* η direction. N and M are numbers of mesh points along ξ and η direction respectively. Index *k* which is repeated presents the total from 1 to *n* along ξ *and* η direction, and index *m* which is also repeated present the total from 1 to *M* along η direction. Here are presented all the imporatnt coefficients of the differential quadrature method in the Eq. (16), which are obtained the same way as when the differential quadrature method is applied on problems in regular domian. This means that the Eq. (16) only additionally includes N^2M^2 of the scalar product.

There are four types of approaches available for application of multiple boundary conditions. The oldest is called δ-technique, suggested by Bert and his assiciates [3], which is widely used is literature. In this approach, the geometrical boundary conditions are applied on the present boundary points and on the derivative boundary conditions in δ- point, which are at a little distance ($\delta \cong 10^5$ in the units without dimensions [1] from the respective boundary. As already mentioned, the approximately chosen value δ can cause the unexpectd oscilations in the achived results. To overcome the deffects of δ –approach, Wang and Bert [4] developed a new technique, which includes boundary conditions in matrices of impact coefficients of the differential quadrature method in advance, and than the impact coefficients with implemented boundary conditions are directed towards discretisation of the comprehensive equations for the problems in question.

The main idea of this approach is that the boundary conditions, applied during the formulation of the impact coefficients of matrix, are used for inner mesh ponts. The technique increases the accuracy of the differential quadrature method for the problems with simply supported boundary conditions.However, the technique is limited to simple problems, since it can not be applied to problems with discontinuos geometric forms and the measures that are found in derivative boundary conditions.

The validity of the methods was proved by compering the presented results and those of Bert and Malik [1], who have used different approaches for transformation of the coordinates and application of the multiple boundary conditions. We made this program by using the approach in [1], then, we started the program on the personal computer Pentium IV generation and compared the speed of the methods. The Fig. 2 shows the ratio between the processing time and the number of mesh points (N) in direction of *x*-axis for vibration analysis of occasionally excentric plates [5]. In this approach, the same number of mesh points in direction of x and y is adopted. As a result of using our method, much less CPU time was needed for the same number of mesh points than by using the method proposed by Bert and Malik. It is also relevant that computing weight in solving the result scalar, for which there is such non-null vector that the scalar multiplicaton of vectors equals to the vector value under given linear transformation of the equation system is the same in the presented approach as in the Bert and Malik approach.

The comuting efficiency of the presented method lies in the fact that it is not included in the order N^2M^2 of scalar product for obtaining quantization matrix for derivations of of higher order. The Fig. 1. shows that for the solution of the result scalar, for which there is such non-null vector that the scalar multiplicaton of vectors equals to the vector value under given linear transformation of the equation system, less CPU time is used in our present work, while on the contrary, the multiplication of matrices in Bert and Malik's approach require more CPU time (Fig 2) [5]. On the other hand, by comparing it with the solutions for plates with changeable boundary conditions, it can be seen that the processing time, when the same number of mesh points is used, does not change much.

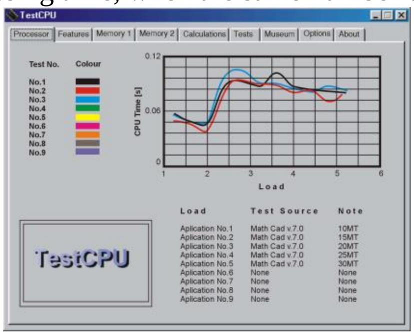

Figure 1. The relation between the processing time necessary for solving problems and the number of sytem points for vibration analysis of occasionally excentric plates (MDRII)

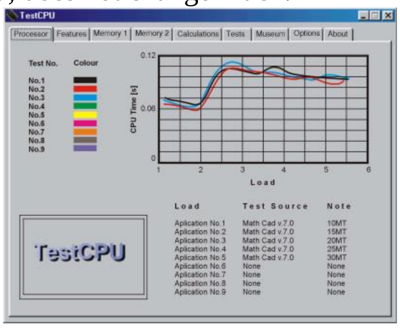

Figure 2. The relation between processing time necessary to solve the problems and numbers of system points for vibration analysis of occasionally excentric plates (Bert&Malik)

The solution for plates with CCCC edges (C-clamped, SS-simply supported), by using PV-2 Ritz method is also included in table 1. Thus we also compared the solutions we achived by using differential quadrature method and Ritz PV-2 method, and came to the conclusion that the difference is very small and insignificant. We came to the same conclusion as regards to symmetric parabolic trapezoidal plates with simply supported boundaries, the present method has faster convergence using uneven number of mesh points than by using even number of mesh points along ξ *and* η direction. This coincides with the approach of Bert and Malik.

Table 1. The convergence of the solutions for the first six frequencies of flexural vibrations of parabolic trapezoidal plate (Fig. 2. $a/b=3.0,\ b/c=2.5,\ \Omega=\omega a^2/\pi^2\sqrt{\rho h/D}$)

	FREKVENCY					
N=M	1	2	3	4	5	6
Approach	U-U-U-U					
MDRII	9.3723	13.9641	19.7460	21.8375	27.2672	29.1650
Bert & Malik	9.3645	13.9770	19.7990	21.8430	27.3340	29.1390
PV-2	9.3428	14.1186	20.0527	21.6208	27.6616	29.2138
	JO-U-JO-U					
MDRII	8.5709	12.880	18.0984	20.7258	24.6152	27.7824
Bert & Malik	8.5694	12.886	18.1540	20.7460	24.6910	27.7570
	U-JO-U-JO					
MDRII	5.4742	9.9289	15.4196	16.1466	21.930	24.2740
Bert & Malik	5.4831	9.9535	15.4240	16.1780	21.942	24.3060

At the very end of this discussion, we present the table 2, with the first ten frequencies of the clamped rhombic plates which ratio between the bigger and smaller diagonal of length (b/a) is 1.5:1. In this case, Bert and Malik were not able to get closer to the third frequency [1]. Maybe it was due to the fact that one of the double boundary conditions at certain edges was performed under the influence of δ- point, which is not precisely on the boundary.

Table 2. The convergence of the solutions for the first six frequencies of flexural vibrations rhombic plate (Fig. 5. $\Omega=\omega a^2/\pi^2\sqrt{\rho h/D}$)

Approach	FREKVENCY									
N = M	1	2	3	4	5	6	7	8	9	10
MDRII	12.703	23.369	28.254	34.738	45.948	48.969	49.794	61.130	65.361	74.533
Bert & Malik	12.703	23.369	-	34.738	45.948	48.969	49.794	61.130	65.362	74.535
Gorman	12.70	23.37	28.25	34.74	45.95	48.98	49.79	61.13	-	74.54

CONCLUSION

This work presents a new approach to the study of vibrations of irregular-shaped plates with simply supported or clamped boundaries. In this approach, the irregular physical domain is transformed into regular physical domain (square) in curvilinear coordinate system (computing space), and through accompanying equations, the conditions are transformed into relevant forms of curvilinear coordinate system. In this way all the computing is within certain computing domain. As long as the computing domain is correct, the application of the differential quadrature method on the irregular-shaped plates in computing space is also correct, as well as the application of the differential quadrature method on the irregular-shaped plates in physical space. The only difference is that there are more members included in the accompnying equation as well as there are more boundary conditions in the curvlinear coordinate system. By using the present method big operations with matrix multiplications, used by Bert and Malik [1], are avoided, and as a result, the computing weight has been noticably reduced as well as the size of virtual storage necessary for the important operations. The presentation of the above mentioned is performed by using the application test on the presented approach, which proved to require less than 1/10 of the processing time in comperison with Bert and Malik's approach when comparing the same number of mesh points. The comparison of speed characteristics of these methods

is performed by using the service program Test CPU, and the comparison of the memory space needed for computing the vibration frequenc of four-sided plane plates of irregular shape is performed by using service program *Ram Booster* vl.6. The service program *Ram Booster* vl.6 is also used to establish the involvment of computer processor -Pentium IV, in solving the above mentioned problems.
This work presents a simple way for application of the differential quadrature method on the simply supported and clamped boundray conditions , which avoid weight determination of the angle between the normal to the plate boundaryand the *x*-axis, used in the Bert and Malik approach. From this work, it can be concluded that applying differential quadrature method on the problem of vibration of quadriangle plates of irregular shape is more promising way to improve the efficiency and flexibility of numerical techniques for solving practical engineering problems.

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MONITORING THE STATE OF THE TECHNICAL OF SYSTEM IN THE EXPLOITATION

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Abstract: Different inventions are very much contributed to emergence modern machines, as well as to their further development and improvement. Applying machine greatly simplifies the operation because it is eliminated a large physical strain, has been increased productivity and quality, design, variety of shapes of products, as well as of all other relevant factors related to the product. However that of machinery could meet all the requirements must be maintained properly. There are several research studies the state of how the technical systems in exploitation as well as experimentally, and represents the most frequent problems that lead to the damage to of certain parts of the technical systems. Faults and problems which occur in this systems of, leading to maintenance problems, environmental problems, and management problems. Regularly Machine maintenance and the organization itself of maintenance includes a broader area of and should be understood as permanent task of of experts to reliably and quality manage physical resources and properly to maintain them throughout the entire lifetime.
The working life of machines depends on the maintenance process and if one machine better maintained working life a longer, and the basic goal is that the technical system in exploitation is always in a state of working ability.
Key words: Machine maintenance, lifetime of machine, roughness of the surface

INTRODUCTION

The accelerated development of modern technology resulted in the expansion of the number of services and applications in smaller as large companies, in order to achieve efficient of utilization production resources, and the serious reduction in errors of, manufacturing and of maintenance of mechanical systems that are interconnected phases of the total the life cycle of technical systems.
Qualitative process of maintenance is achieved only if it is still under development - mechanical system enable maintenance. Behavior of mechanical systems in exploitation depends on not only on the design solution, but also the quality of maintenance. Service represents a technology that allows the optimization of the system, increase safety, easier maintenance. Constructional solutions modern machineries and plants tend reducing the dimensions, increasing the movement speed and of specific load elements which are in mutual contact and relative motion, increase security and reliability, increased service life etc. that order to achieve higher the productivity of and efficiency of exploitation. Such technical systems and solutions in addition to adequate of materials of elements require safety and reliability of automated systems for monitoring failure. Modern machinery and industrial plants, as well as increased level of mechanization and automation in various areas of industrial production and application have led to the rapid development of devices and systems for the maintenance and monitoring the status systems of control and diagnostics. On the importance of and the needs of for quality and a precise of diagnostic devices tells us the experience, because, on average, every sixth defect in the mechanisms of tribological reason, a benefit generated by the low quality access diagnosis, unprofessional diagnosing, and often times insufficient lubrication can amount up to 60 % of the total maintenance costs [1, 6].
Maintenance in industrial conditions, implies the maintenance of critical equipment for the production of operating condition or restoring the same to the operating state. However, the technical diagnosis should be considered at a higher level - in the 21st century will largely be necessary determined management strategy equipment. Will be necessary to work each department and the individual to be fully coordinated and implying mutual support so as to achieve maximal reliability and reached a the maximum production capacities critical equipment during the entire its the life cycle [1].

MATERIAL AND METHODS

Determining the situation of the technical system is one of the main problems in the process of maintenance. It is necessary to follow change of the state of individual parameters of assemblies and elements that over time leads to weakening, and if do not taken and the to failure or interruption of work. Is also necessary that in case of sudden failure discover what the cause is, what the defect is and how to eliminate them. Avoiding the consequences of failure by applying the intelligent of tools and applications modern technologies, particularly monitoring the situation and conditions, and effective use accurate, timely and complete information is an of effective method of using the information. Diagnostics and maintenance the technical systems in exploitation is complex functional system. Their intended uses as of adequate maintenance to the desired goal, the inspection, testing and determining of technical system, as well as maintenance in a condition. The technical state of the system in the process of exploitation affecting the following factors [2, 15]:

- climatic conditions,
- workload of the technical system and the speed of rotation,
- production quality of parts,
- quality of maintenance and repair,
- quality of constructions of mechanical systems,
- method of operation and maintenance.

A good portion of these factors does not depend on whether you the technical system is managed by a qualified worker or someone else. Contemporary technical systems in production systems have a higher intensity of exploitation, and This is why a shorter century, more of repairs and etc. The intensity of exploitation of the industrial system, who often has a seasonal character, such as pumps, to which affect the needs of individual business activity (energy, water, mining, etc.), Without going into the technical correctness and the need for maintenance is considerably higher in winter than in summer months.

To the desired goal, there are preventive and corrective maintenance. Preventively consists of activities in order to prevent the emergence of the state of „in failure“. Corrective maintenance is applied after the onset of the disorder in the system, to the state of „failure“ returned to the state of „in work“. It follows that the there is a planned and unplanned maintenance.

According to sources of funding - there are current (cleaning, lubrication, control examinations, eliminating weak points) and investment to (high repairs to funded from of amortization of assets) maintenance.

THE TECHNICAL MANAGEMENT SYSTEM PREVENTIVE OF MAINTENANCE

Systems of is operated in order to achieve a certain goal system, based on the receipt, transfer, processing and use of information. The objective is regulation of a process that allows the functioning of mechanical systems. Its regulation of increases with authoritative information. Task of management system for preventive maintenance is to achieve the of optimal technical state of and exploitation of reliability.

The project information system is necessary to include data of information bearers of who determine the state of the technical system, and form the databases, processing data and the information, methods of analysis of the information obtained and decisions. How this information is used for the operational management of the effectiveness of the process of technical exploitation of the system, they will be useful only if their flow is the timely. Continuous flow of information to allows their use for the forecasting of the reliability of mechanical systems. The same data are used in the elaboration of the technical requirements of for a new generation of mechanical systems [3].

METHOD OF EFFECTIVE USE OF INFORMATION

The method of effective use of information is a base which contains the results measurements of relevant information about the state of the system. The number data carriers and information has to be as small as possible, but sufficient for a total consideration of the state of the system. The main carriers of data and information are:

- the structural map system (with an overview of component parts whose maintaining monitored, as well as characteristic information to them,
- map of conduct mechanical system (with data on the recall),
- overview of the reliability of the system (the by statistical indicators),
- temporal picture of the situation (with data on mechanical system ,, in work“ and the ,,in denunciation over“ for 24 h.) [14].

The mentioned information, at the same time, serve for prediction reliability, control and determination of maintenance costs. For parts with the changing intensity of failures helpful to determine the statistical distribution.

Basic documentation of system maintenance is a database information system and maintenance management functions and consists of:

- assembly drawings of mechanical systems, assembly drawings, shop drawings, schemes installations, etc.;
- technological documentation (including the technological maintenance procedure, map lubrication, etc.);
- planning documentation (working orders, maintenance instructions, accumulated spare parts, etc.).

For the rational implementation of maintenance are needed and other documents. One of such document is a guide for operation and maintenance that describes the method of assembly - disassembly of component parts of mechanical systems. The goals of each of Maintenance Programs are the following:

- Elimination of the failures of the machine. It is very common that a malfunction causes significant damage to the accompanying the machine, whereby can significantly increase the cost of repairs. Complete elimination of failures is not possible in practice, however, to this goal can be closer to a systematic approach to the maintenance.
- Substantiation the ability to predict and correct planning needs maintenance. This includes minimizing the of inventory of spare parts and a significant reduction of overtime. In the ideal case, the repairs of mechanical systems are being planned for the time of planned downtime of the plant.
- Increasing the operational readiness of installations, so as to significantly reduce the chance of failure occurrence during operation, and maintenance of the system capacity by reducing time downtime of critical machines. In the ideal case, the working condition of machines to be familiar and documented.
- Ensuring of predictive and reasonable working hours for personnel engaged in the maintenance. How do would the obtained a representation of modern maintenance programs based on technical diagnosis, it is necessary to examine in more detail the historical experience.

The earliest type of maintenance has been working to failure, which meant operation of the machine to the occurrence a fault that has stopped. Such approach is obviously expensive, with the bulk of cost occurs due the unpredictable the state of machines. It is surprising how this approach is in the application even today in our industry [12].

Gradually came to the idea of periodic preventive maintenance, which included dismantling and repair of machines at regular intervals. According to this theory, the machine will be less spoil in work, if the repairs. Preventive maintenance is existed debt of time, but it became increasingly present in the early eighties years old last century. Undisturbed work machines is not interrupted by the theory of ,,improve is if it is not defective“.

The latest knowledge in the field of maintenance are known as ,,pro-active“, and include a technique called ,,analysis of the root causes of failure“, according to which it is necessary to detect and eliminate the underlying cause of machines failure [7].

In 1991 he was performed an international analysis of most of types of industrial plants and found that all of indicated techniques for maintaining the application and to the following the scope:

- Several than half of the hours spent on maintenance is a reactive manner, carrying out emergency repairs to unplanned time,
- Less than 10 % on the maintenance hours been spent on preventive maintenance,
- Less than 40 % of maintenance activities is planned character and
- Very little has time is spent on active techniques, including techniques and of diagnostic methods.

Based on these data it can be seen that maintenance procedures are still not systematically came to the last quarters the 20 th century, let alone entered into 21st century. It is reasonable that a modern the program of maintenance of the entire of industrial equipment include elements of all of these techniques, and the reason for that is between other things, the economic nature [3, 4, 5].

MONITORING OF MECHANICAL SYSTEMS OF EXPLOITATION

In the research represents the result of testing of the mechanical vibration the state of pumping installations. In Fig. 1. is presented the centrifugal pump way intended for the suppression of the working fluid in the technological process in the framework of the pump station TEC 2. „ Energetics – Kragujevac“ [4].
Evaluation of mechanical vibration condition of tested pumping installations was carried out in accordance with the recommendations of ISO 2372. On the basic of installed capacity electric motor drive (P = 250 *kW*) tested the technical system has been classified in groups III.

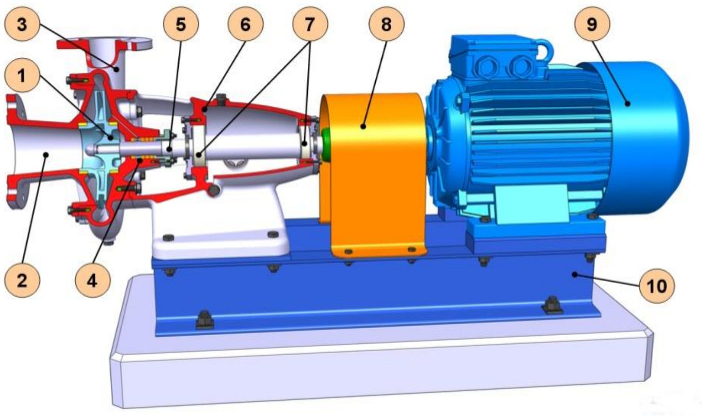

Figure 1. Side view of the cross section of centrifugal pumps: 1-the impeller, 2-suction apparatus, 3-the spiral conductive device, 4-sealing system,5-drive shafts, 6-pump housing, 7-bearings, 8-elastic couplings, 9-electric motor, 10-pedestal pumps.

The impeller pump (1) is attached to the drive shaft (5), who rely on antifriction bearings (7). The drive is realized across flexible couplings electric motor (8), centrifugal pump work the of the rotor number of revolutions n = 1479 min^{-1}, which is the couplings (8) connected to the pump shaft and the electric motor. In further considerations we will point out the causes of disorders of balance rotating mass of the rotor by centrifugal pumps, monitoring the work systems in exploitation and ways to of removing imbalances rotating mass of the rotor [4, 9].
The most common causes of pumps problems are those that create an imbalance:

- unequal accumulation of dirt on the rotor blades,
- the lack of homogeneity in the cast iron parts, such as the bubbles, air vents, a porous parts,
- eccentricity of of the rotor,
- bending of rolls,
- errors in machine design,
- uneven distribution of mass on the electric motor of the rotor or the wings,
- uneven the erosion and corrosion of the impeller pumps,
- lack of of weight of balance,
- bent shaft.

In addition to imbalances vibrations are the basic indication of the state of the system. At the level of vibration of pumps, in addition to rotating mass unbalance of the rotor affect the dynamic occurrence of which occur in the bearings, and aerodynamic occurrence, as well as the transmission of vibrations from the drive motors, couplings and other external exciter. Particularly is unfavorably if it appears resonance imaging between of Individual harmonic evoked in some of the listed parts of the pump. The main causes of increased levels of vibration in the pump operating conditions are: corrosion of materials, creating the adhesives at various parts of the pump, as well as changes in bearings [13].

Influence of corrosion: During transport of the working fluid can create a variety of concentrations causing corrosion of the material. The treatment of surfactants corrosion of metal parts to eroding. That process can be so intense that in extreme can be completely damage the shoulder blades of the impeller. At the same time, some parts of the rotor will be adversely affected differently. So it disturbs the initial balance of rotating masses and the disorder will be even more more expressed if the corrosion process intensive.
Influence of the binding agents: Despite the filtration, working liquid containing metal particles, of iron turnings or other impurities which cause the creation of influence of the binding agents of the spiral in the space between the casing and the impeller, the of impeller between screws and carrier plate, and on the pump shaft. On periodic reviews of the working parts of the pump are observed unequally formed by influence of the binding agents, resulting in, among other things, a of balance disorder of engines.
The impact of bearings: Journal bearings of are suitable due the reduction of rolling forests and vibration, which is more more pronounced in shaft with a higher number of revolutions. On the occurrence of vibrations in these bearings is influenced by numerous factors: the radial clearance in the bearing, drafting the accuracy of the and surface quality of the sleeve shafts and the bearing bushings, accuracy assembly and the like.
If you are satisfied with the newly built pumps hydrodynamic lubrication conditions in bearings after a specified the period those conditions are deranged. Due to the disturbance of balance rotor substantially grow additional dynamic forces acting on the pump shaft and transmitted to the bearings. That is why in some time periods of the total size of the force that is transmitted to the bearing sleeve will not be balanced with a hydrodynamic oil film force of educated. As a result, the sleeve begins to swing additionally and it will in some points in time be destroyed by the oil film and the sleeve will touch the bearing the casing. This causes a increased wear of the bearing casings and affect, among other things, the increased vibration. That process will continue and intensifies if it fail to timely intervene until they-bearing bushing completely damaged.
A vibration control: The impact of working conditions and the exploitation time to increase in the level of vibration pumps the most manifested through changes in of balance rotating masses. That is confirmed experimentally by measuring the of vibration of the pump bearings. Vibration measurement was carried out the device Vibrobalance 5000 BNL which allows vibration analysis according to recommendations ISO 10816-1: 1995/Amd 1:2009 [8, 17]. Analysis of obtained results can be noted changes and critical points in accordance with ISO 2372 standards and recommendations about permitted levels of vibration in machines ISO 10816-1:1995/Amd 1:2009. Measured is the dominant vibration amplitude corresponding to frequency of working speed of the rotor and is 18 μm. If you take it during the occasional balancing of the rotor achieves balance of that matches the equivalent amplitude who do not exceed the value of 6 μm, it is dependent on the intensity of creating influence of the binding agents and corrosion this initial an imbalance can increase several times. It can be concluded that in order to increase the efficiency of the maintenance service necessary continuously control the level of vibration, respectively - introduced continuously control the vibration levels. For determination a limit level of vibration when is necessary to exclude from the pump operation and maintenance warned, using the recommendations VDI-2056. According to them the adopts solution solution that includes luminous signaling when the vibration amplitude reaches 20 μm. Vibration level of 30 μm indicates to noise and the pump automatically switches off the drive [3, 4, 5].

THE PROBLEM THE PUMP INSTALLATIONS BEARING WITH MOTORS

In this case, the pump was tested in the engine speed 1479 min^{-1}, and based on the installed power of the electrical drive power P = 250 *kW*. Pump is a operated 3276 hours of work (one season). Pump at the measuring point M1 has at the end bearing type SKF 22317 barrel shaped roller, self adjusting bearing, where the bearing of the measuring point M2-type 29417 SKF. The frequency of the various components of each bearing is calculated. All in all vibration level measured is 4,34 *mm/s*, which is above limits in accordance with ISO 10816-1. Dynamical analysis was performed automatically spectrum shows different levels of vibration tops of which implies either a hydraulic problem or the problem of bearing. It is also a constant percentage of flow confirmed the same trend of higher levels of vibration acceleration for maximum amplitude A, 1,7 m/s^2 at the end of the season measuring point

M1 and M2 at the measuring point, 1,9 the end of the season. Spektar envelope was a was made and showed vibration tops of 100 Hz and its harmonics, which involves identification of the defect on the outer ring bearings on the M1 place the end of the pump shaft in accordance with the calculated with exciting frequencies. The injured party bearing is not replaced, and the envisaged corrective measures. Measuring the vibration have shown improvement in dynamic performance, where the vibrations tops of the excitation are almost very insignificant as shown in Figs. 2, [4].

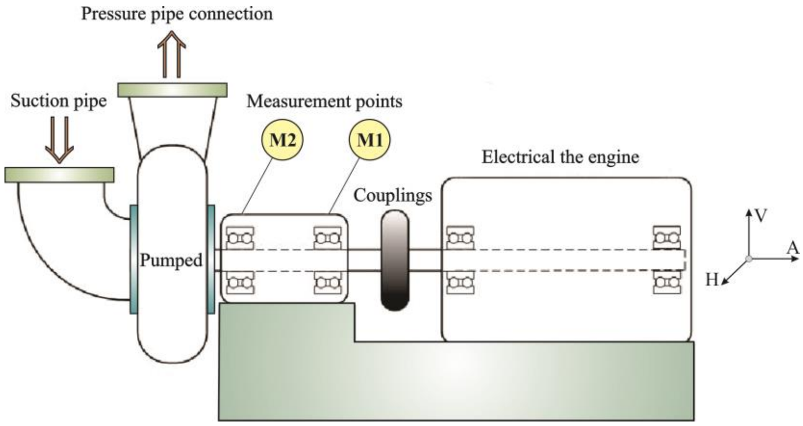

Figure 2. Schedule of measuring of the vibration in the pumps installation

DEVICE FOR MEASURING AND ANALYSIS OF VIBRATIONS

There are several cases studies that have explored the exploitation and in the laboratory, and they represents the most frequent problems that lead to of failure and damage to individual components of the pumping installations. Faults and defects that occur in these pumping plants, leading to maintenance problems, environmental problems as well as problems water management, Vertically mounted axial of flow pumps indicate a higher level of vibrations and the of noise in relation to the horizontal. A common cause of these occurrences on pumping plants was a problem of imbalance, and the problem of bearing pumping system. Also the case for laboratory studies pumps is a model with a variable speed, where they modal test and forced vibration analysis realized at different speeds, the by simulating of problems of imbalance at different angles [10, 11]. Measurements of vibration and dynamic analysis were tested on a physical model of horizontal centrifugal pumps, such as the measured velocity and acceleration of horizontal, vertical and axial vibrations and temperature of bearing assemblies. General vibration level indicates severity of the vibration compared to ISO 10816-1 [16, 17]. According to ISO 10816-1, class III is been used as a guide or limitation the application of the pumping system. The good the effective (RMS) limits the vibration velocity is to 1,12 *mm*/*s*, the speed of is acceptable limits to 2,8 *mm*/*s*, is simply the limits tolerable to 7,1 *mm*/*s*, and the unacceptable limit is greater than 7,1 *mm*/s. Vibratory signals were recorded on different components of the pumping system, and axially and radially , [5, 18].

As device for measurement and analysis of vibration system was used Vibrobalance 5000 BNL. The device provides a simple, yet extremely effective way of checking machine condition by measuring the vibration and noise measurement bearings (BNL) to evaluate the operating state. When of vibrations are measures of size speed and acceleration. The average speed of vibration is an excellent indicator for determining the rotational and structural problems like imbalances, unbalance, looseness in, etc. The vibration acceleration extent high frequencies that are usually associated with problems of bearings.

For measuring the temperature of bearing assemblies was applied as a non-contact infrarod the thermometer device. Transferable the infrared the laser thermometer containing air for better special orientation and the sighting of the measuring object. Contactless temperature measurement is used where it is necessary to quickly and accurately measure the temperature as well as moving objects and objects under voltage and hardly available places [5].

RESULTS AND DISCUSSION

Measurement of vibrations were performed on a horizontal installed pumps, of axial of flow type in the field of energy. Grades vibrating mechanical state of the test the pump installations was carried out in accordance with the recommendations of ISO 2372. The general assessment of the state of a particular of pump installations was determined on the basis of measurement of with the highest level of vibration. The vibrations measurements were carried out at 2 measuring points (locations) on the pump, and the bearing and basics foundation in the axial and radial and horizontal directions as shown in Figure (2). At the motor and foundation the vibrations are not analyzed. In Fig. 3 is shown are measurement of bearing shaft 3D, [4].

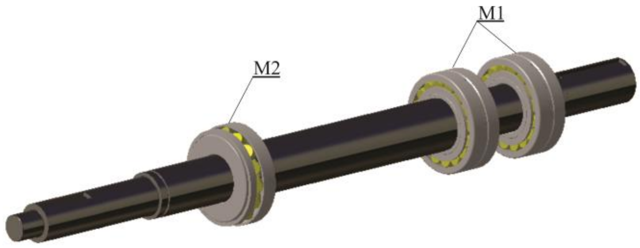

Figure 3. The shaft of the pump unit in 3D

Pump station has been monitored in the initial stage of operation (start season of mode) at full load and at the end of the season (Table 1).

Table 1. Measured values of of parameters

Measured values of of parameters of the mechanical vibrating condition of of the pumping installations					
Measuring point	Direction of vibrations	Velocity V_{eff} [mm/s] P	K	BNL [-]	Two progress assessment
M_1	V	2.29	3.17		Is still allowed (III)
	H	4.34	4.24		
	A	1.82	1.95		
M_2	V	1.55	1.78		Allowed (II)
	H	2.41	1.93		
	A	1.53	2.1		
Overall two progress assessment from the aspect of vibrations:					Is still allowed (III)
Measured temperature of at the measuring point M1[°C]:					65[°C]
Measured temperature of at the measuring point M2 [°C]:					60[°C]

Comparing system health status at the beginning and end of the heating season of (in order to conclude that the system is behaving in progress each The seasonal exploitation of), according to standard ISO 2372 the general condition of of pumping installations P was assessed as allowed (II). Compared with previous by checking condition of (at the beginning of the season) were not reveal any large deviations (system has remained in the same set of standards), and it can be concluded that one hi season exploitation did not derail the state of the system.

Given that the system is at the upper limit set of standards allowed (II), and that these measurement points had been problematic, an analysis of diagrams from which one can conclude the following:

- the measuring point M1 vertically, the dominant of pik vibration occurs at the 8 th the accordion, followed by low-intensity peaks which occur at higher frequencies (815 and 840 *Hz*);
- the measuring point M1 horizontally, the dominant of pik vibration occurs at the 8th the accordion, follows him a peak at the primary frequency and a lower of pik intensity occurs on higher frequencies (815 *Hz*);

Pump station was in its initial phase of the work which marked a high level of vibration and noise, in addition been observed a problem bearing failure which often occurs during the final operation of the plant (Abdel-Rahman et al. [18]). Measurements were made on 1 pumping unit without any additional loading conditions, where the engine is completely switched off of a pump across couplings and under full load. At unladen condition, vibration measurement is performed on 2 measurement points on the pump at full load.
The total vibration measurements were carried out on the pump unit under normal operating conditions and showed that vibration level is not allowed on some places the measuring sites on the a pump units. So that we determine the exciting the source of vibration and to find out if the vibration level is high due to the excitation force of or due to system resonance, the engine was turned off by the system pump and insulated from any source of resonance pumps or structures. Motor driven in these conditions and the vibration level was not measured.
A maximum vibration levels without any loading conditions occurs at point 1, in Fig. 4: the for unit 1 V for vertical of vibrations the beginning of work is 2,29 *mm/s*, and eventually work 3,17 *mm/s*, a unit of 1 horizontal of vibrations (H) is 4,34 *mm/s*, at the end of 4,24 *mm/s*, the axial of vibrations of unit 1 the beginning of work 1,82 *mm/s*, and at the end of season 1,95 *mm/s*. However, the maximum vibration level was measured in unit (1) for the unit pumps P is the level of 4,24 *mm/s*, according to the VDA is unsatisfying.

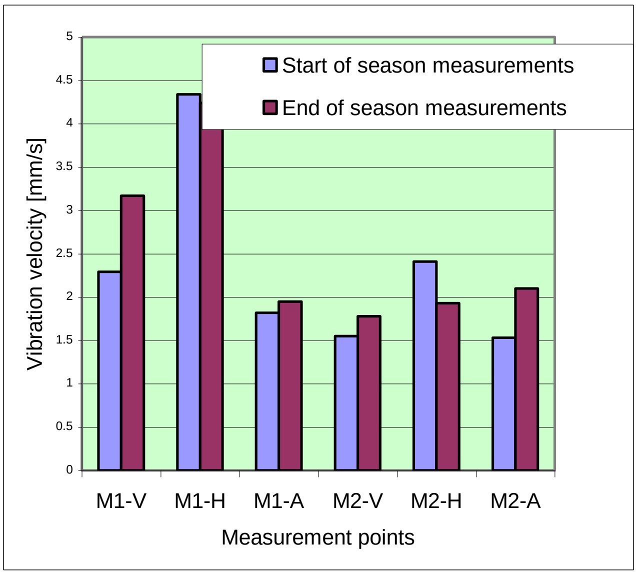

Figure 4. Results of measurements of the vibration

The overall vibration level measured at full load is presented in Figure (2). It is obvious that the measured vibration levels in progress full-load slightly larger than the in progress no load conditions at the appropriate locations. However, the maximum vibration level was measured in unit (1) for the pumping unit P increases for 7 % for the position of V at the end of season level 3,17 *mm/s*. In addition, many the load conditions produce other sources of high levels of vibrations 1,95 mm/*s*, due to improper alignment and pumps bearings and the problems of for some pumps units. Connecting the motor with the pumps system has little effect on the level of vibration measured on the engine.

Therefore, the source of of vibrations motor itself is, whether it is connecting with the load or is not. There was a problem in keeping the motor for for more than 5 years in the horizontal direction of in accordance to the mounting and functioning of the applied areas. Also, there is another problem of attaching the the motor to the fundament through the ribs of weak.
These large pumps should be connected with the foundation through strong fundamente-carrie. Otherwise, they work as a console fixed at the bottom of the fundamentals of vacuuming of swimming pool and the free on the top end of the. Since it is not subject to the work of research engine vibration, but it turned out that the the level of vibration at the end of of the motor without actuator in the radial the direction of, and the upper and lower determining the direction of movement, the bearings show expressed in vibration forces at those locations.
Given the the excitation sources, motor drives that were not in operation and end of the pump bearings the level of vibration on these areas is made usually changing by the presence of defects and problems in these areas and work during of these failures, increases the the level of vibration and can lead to damage and of failure.

CONCLUSION

The method represents of effective use of the information on which contains the result of measurement of relevant information about the state of the system (temperatures, vibrations, noise), as well as causes of occurrence of such occurrences. Number of data subjects and information should be as small as possible, but sufficient for a total consideration of the state of the technical system. The choice of such optimal model of optimization of method Vibrodiagnostics is a complex procedure which is based both on theoretical and the empirical data.
During measurement is followed by the proper working of pumps bearings and vibration levels which occur due to of the nonlinear of oscillation of complete of pump aggregates. On the basis of the measurements, and adequate information about the state of the system can be said that this approach monitoring the work pumping systems allows determining of working propriety the vital organs of pump aggregates and their control, and the use of information in order to prevent of large failures in the fields of energy-pumping systems, at which the survey was conducted. Based on the of measurement results for the observed pumping systems are recommended the corrective measures. When repair manual of the pumping systems additional attention should be paid to:

- The geometry of impeller pump (able blades);
- Of clearance between the of impeller and housings;
- Connection between the pump shaft and impeller;
- The state of rolling bearings.

It can be emphasized that vibrations levels generated on the horizontal pumps is high a dangerous, is not permitted in accordance with the standards (ISO 10816-1). The maximum vibration level measured without the loads of an increased level at the end of the motor without actuator. However, the maximum vibration level are increases 7 % at full load at the end of the drive motor. The pump creates other sources of vibration level due to improper alignment and problems pump bearings (imbalance not shaft alignment, the imbalance, temperature). A damaged bearing manufactures high vibration levels 4,1 mm/s velocity vibration. Replacement of damaged bearing increases the dynamic behavior and reduces of vibration 95 %.
The tendency of using the variables velocity drives in pump systems increases the necessity of the application of the predictive maintenance and periodic controls in order to increase the vibration levels with the by increasing the velocity and vibration amplitude is increasing greatly with increasing the excitation force. In normal operating conditions, the level of vibration increases with increasing velocity of movement, both with minor problems unbalanced, and with the moderate and severe unbalanced.
To ensure proper functioning during exploitation and safe operation of the pumps it is very important to be known source of damage to the of components of the pumping systems. Industry Specific techniques can be applied for identifying problems such as unbalance pumps, centering, the turbulence, cavitation, and many others. Knowing the causes of vibration and using appropriate diagnostics the tools, one can easily savings on with spare parts and the personnel. With the proper applying the vibrational techniques and diagnostics, pumps can operate with a greater reliability and efficiency.

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Session 5.

Design and maintenance of process plants

STAND FOR THE STUDY OF VEHICLE BRAKING PHENOMENON: STATIC ANALYSIS OF THE HELICAL COMPRESSION SPRING

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Abstract: In this paper is determined the maximum values of Von Mises equivalent tension, respectively the displacement produced by a single-action hydraulic cylinder to a spring (suspension). This spring is mounted on a didactic stand showing the interaction between the tire and the rolling way, while having the opportunity to study the braking phenomenon. The variation of the speed of the tire is achieved using a electric power actuation, and the loading of the suspension is achieved by supplying the hydraulic energy by a manually operated pump by means of a single action hydraulic cylinder.
Key words: braking phenomenon, equivalent tension, helical compression spring

INTRODUCTION

Together with increasing the road traffic density and average traveling speeds, there have also increased the number of traffic events, thus increasing of the security level has become a priority for the car builders.
The brake system is designed to reduce the vehicle speed totally or partially, immobilization of the parked vehicle or to ensure a constant speed at downhill going.
Slowing or stopping of the wheels is obtained by friction between a fixed element, connected in one way or another to the body or chassis of the vehicle (brake pads or shoes) and an integral element with the moving wheels (brake discs, drums).
In this paper, will be analyzed the tire loading in the conditions that must be fulfilled by the main geometrical parameters of a roller brake stand so as to ensure actual braking conditions. For this, the didactic stand will include:

- ✓ a hydraulic press for tire loading;
- ✓ a frequency electric converter for speed control of the electric motor for driving the roller, in order to simulate different traveling speeds of the vehicle;
- ✓ a belt transmission (the connection between the motor and driving roller).

Figure 1. Didactic stand for braking study

STATIC ANALYSIS OF HELICAL COMPRESSION SPRING

We shall refer to determining of the maximum values of Von Mises equivalent tension and respectively the displacement, produced by the force F that actions on the spring (suspension) by the piston of the single-action hydraulic cylinder.

The helical cylindrical compression springs take axial forces and the guiding surface is cylindrical. For preparation of the analysis model with finite elements in Figure 2 is represented a helical cylindrical compression spring with geometric parameters:

- ✓ exterior diameter D = 90 mm;
- ✓ coil diameter d = 10 mm;
- ✓ unloaded spring length H0 = 140 mm;
- ✓ spring pitch t = 20 mm;
- ✓ total number of turns N = 8.

The force acting on the spring is F = 50 N.

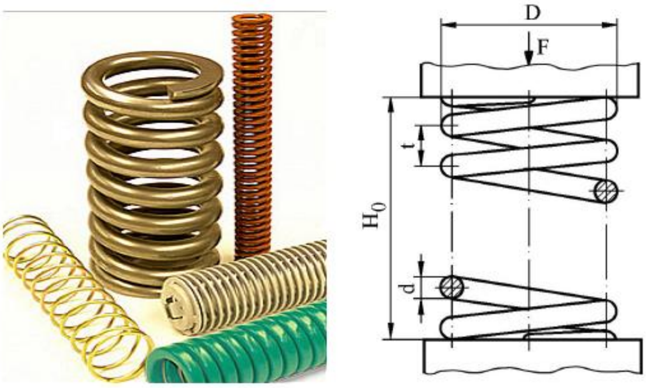

Figure 2. Constructive elements of the springs

In this respect, the modeling of the link with the spring base is achieved through a restriction that requires the cancellation of the 6 possible degrees of freedom of the spring bearing surface.

The spring is made of spring steel 38Si7, with the following mechanical properties: modulus of longitudinal elasticity E = 2.1•105 N/mm^2 and the transversal contraction coefficient (*Poisson*) n = 0.3.The value of the allowable tear resistance for the helical cylindrical compression spring made of spring steel 38Si7 is σ_r=1180 MPa, and the allowable torsion resistance τ_{at}=660,8 MPa.

Preprocessing of analysis model

This includes the following stages:

a) *Geometric modeling* includes:

- ✓ defining of the spring coil and selecting the reference plane;
- ✓ getting the coil;
- ✓ link between the supporting coil and the active coils of the spring;
- ✓ getting the active coils of the spring;
- ✓ selecting the connecting point between the active spring coils and bearing coil;
- ✓ obtaining the bearing surfaces;
- ✓ the bearing surfaces of the spring;
- ✓ the bearing areas of the spring.

Modeling of the material – input of the values of the material characteristics necessary for finite element analysis is done using the materials library of CATIA environment, from which it is selected the metallic material from the group of steels (**Steel**), for which are modified the values of modulus of elasticity (*Young* modulus) and *Poisson* coefficient, taking into account the values given as input data *selecting the assembly* **Part.1** _ (**Apply Material**) _ **Libray (ReadOnly) Metal**, **Steel** *double selection_* **Properties, Feature Properties**, **Feature Name**: **Steel**; **Analysis**, **Young Modulus** 2,1e+011N_m2, **Poisson Ratio** 0,3, **Cancel**, **OK**.

b) Finite Elements Modeling

To generate the finite elements model are performed the commands Start_ Analysis & Simulation _ Generative Structural Analysis _ New Analysis Case Static Analysis, OK that involve the static analysis of the structure under imposed constraints and of some loads independent of time. The size of finite element Size is chosen of 15 mm and the maximum admissible deviation for Sag geometric modeling is required to be 5 mm (menu activation is done by double clicking on OCTREE Tetrahedron Mesh.1: part.1 of specifications tree) (Figure 3).

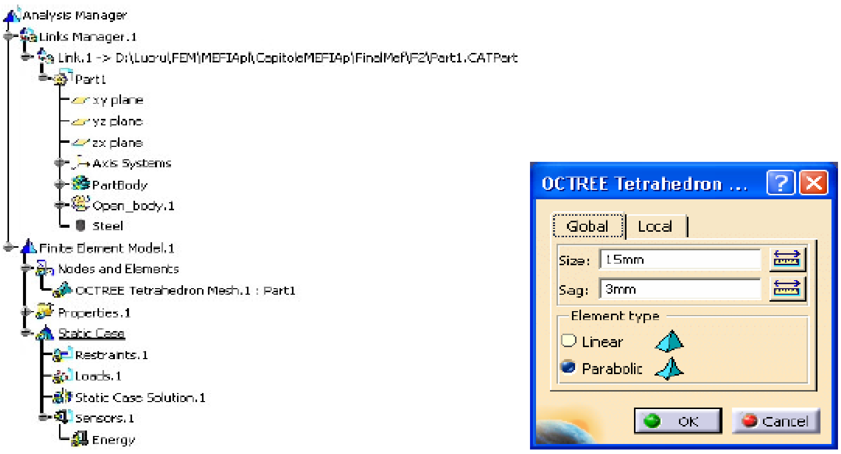

Figure 3. Activation of the menu from specifications tree area

c) Constrains modeling;

The constraints imposed to the model are defined by the cancellation of the 6 possible degrees of freedom of the spring bearing surface: **(Clamp) Clamp Name: Clamp.1, Supports: 1 Face** selecting of a spring bearing surface, **OK** (Figure 4).

Figure 4. *Selecting of a spring bearing surface*

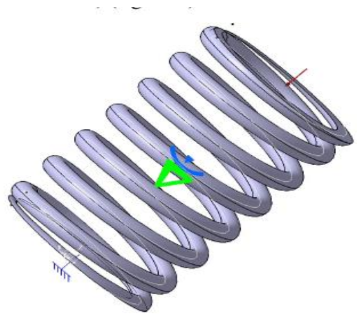

Figure 5. *Loading the spring model*

d) Tests modeling

Loading the model is materialized through an axial force of 50 N, distributed on the bearing surface of the spring (surface without constraints): **(Distributed Force), Distributed Force Supports: 1 Face** selecting of the spring bearing surface without constraints; **Force vector X** 0N, **Y** 0N, **Z** -50N, **OK** (sign "-" corresponds in this case, to the direction of the axial force that produces spring compression) (Figure 5).

Verification of the model

In the verification stage, is obtained information about the correctness of the created model **(Model Checker), OK**; the green light is on and accompanied by a message confirming the correctness of the model (Figure 6).

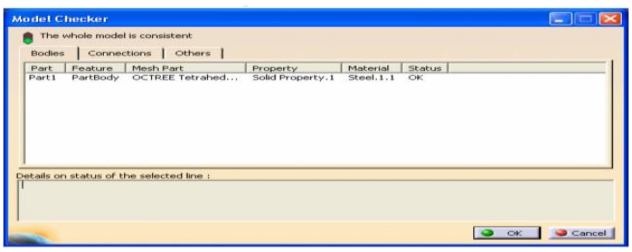

Figure 6. Verification of the model

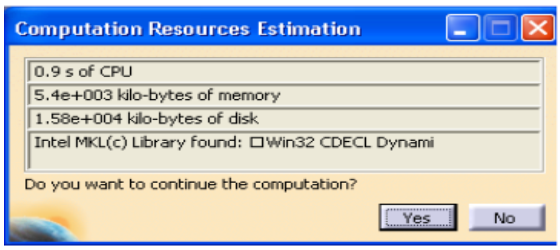

Figure 7. Resolving the model

Resolving the model

The resolving the model is achieved automatically by the soft: (**Compute**) _ **Compute _All**; **OK _ Computation Resources Estimation, Yes**; **Computation Status** ... (Figure 7).

The results postprocessing

The deformed status of the model is visualized by activating the command (**Deformation**) (Figure 8); changing of the scale factor is achieved by activating the icon (**Deformation Scale Factor**). The animated status is viewed by (**Animate**).

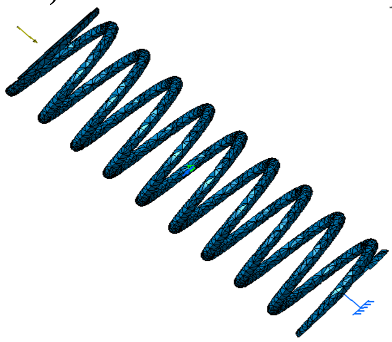

Figure 8. The deformed status of the model

The displacement field is viewed by command (**Displacement**) (Figure 9). and the *Von Mises* equivalent tensions by (**Stress Von Mises**) (Figure 10).

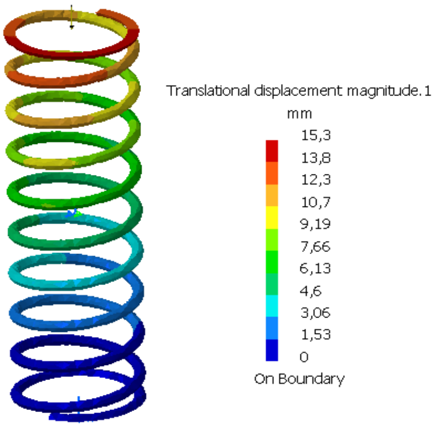

Figure 9. Displacement field

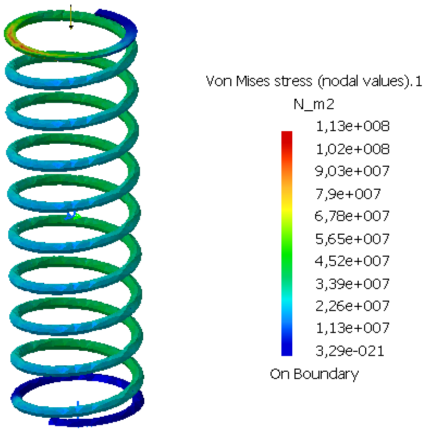

Figure 10. Von Mises equivalent tensions

CONCLUSIONS

From the finite element analysis of cylindrical compression spring results that the maximum equivalent tensions are found on the inside area of the coils, which confirms the specialized studies.
Numerically, the maximum of Von Mises equivalent tension (121 MPa) is less than the allowable torsion strength at τat = 660.8 MPa, which confirms the spring resistance to stress. In terms of deformation, the finite element analysis is useful in determination of the elastic characteristic of the spring.

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A SOLAR PASIVE AND ACTIVE DRYER FOR BIOLOGICAL MATERIALS

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Abstract: In this work an original solution of a mobile, periodically operating, ecological, universal dryer for biological materials, which completes the drying process of drying, using only solar energy, is shown. Preparation of the drying agent is carried out on flat plate collectors of solar energy located laterally on the dryer, during transportation, but when the dryer is in the working position the flat plate collectors of solar energy are opened and launched. One characteristic is that both sides of the collector can be raised or degraded by height; another is that the collector together with the entablature of the side car can swing around a vertical axis. It is driven by PV modules placed on the roof of the dryer. In this paper the results of an executed experiment, regarding the work of flat plate collectors and the dryer as a whole are given. Using the experimental results obtained we can define an analytic formulation for the drying curve and drying rate curve.
Key words*:* solar dryer, PV panel, drying curves

INTRODUCTION

Dryers using solar energy can be solar radiation ones, whose characteristic is direct exposure of the material being dried to solar radiation and solar using corresponding collectors of solar energy for the preparation of drying agents. They can have additional energy sources with natural or directed circulation of the drying agent, ventilator drive with electric energy or energy from PV modules and differently constructed drying chambers. The characteristic of solar dryers is the use of solar energy for the preparation of drying agents. Differing from some solutions of drying in the Sun in these dryers the product does not get dirty, it is protected from insects, dew and rainfall and it enables better preservation of materials determining the nutritious and biological value of the products and the quality of the material. Solar dryers enable a significantly shorter drying time, higher productivity and lower product price as a cheep energy source is used.

JUSTIFICATION FOR THE SOLUTION

The facts [1][2]:

- the intensity of solar radiation in our area is the highest in late spring, the summer and early autumn that is exactly the time
- when agricultural cultures are taken care of,
- different materials are dried, fruit and vegetables, aromatic plants and spices,
- the interest for dried biological material has grown both in our country and in the world,
- these cultures grow far from urban areas where it is hard to deliver relatively expensive liquid or solid fuel,
- energy saving and indirect drying methods are required,
- most materials must be dried immediately after picking in order to preserve quality,
- the requirement for clean technologies and quality dried products is more expressed,
- the only and highest item when using solar dryers is the investment value and costs of constructing the dryer,

- from the economic and ecologic aspect the dried product obtained by drying in a solar dryer is more competitive in relation to the product obtained by drying in dryers using classical fuels as energy sources,

indicate the need and justification for the solution of a mobile, chamber, ecological, universal dryer for drying biological materials.

CHARACTERISTICS OF THE ADOPTED SOLUTION CONCEPT

The adopted and defined solution concept enables the most favorable reception of solar energy, better quality of the dried material and energy saving.
The basic characteristics of the dryer are [1],[2) :

- it is of a chamber type with a periodical working regime,
- all dryer components are devices that are fixed on an one axle trailer and represent a compact mobile whole,
- the dryer solution enables operation at any location,
- the complete dryer is transported to the operation point and transformation from transport to working mode is fast and easy,
- the material in the drying process is stationary on pans placed vertically along the drying chamber,
- the drying agent is pure air heated in flat collectors of solar energy whose position and slope are changeable,
- the collectors of solar energy for heating air, preparation of the drying agent are placed on the side of the dryer and are knuckle joined to the construction frame of the drying chamber so that they can rotate around the horizontal axis and be placed in a vertical position during transport,
- the drying agent flows around and through layers of the material during the drying process,
- movement of the drying agent is natural or compulsory and enabled with ventilators,
- two accumulator batteries built in the rear of the trailer are used for charging the electromotor used to drive the ventilator and they are recharged using an electric energy regulator from PV panels,
- modular design system,
- possibility of regulating the drying process regime by recycling the drying agent,
- the most favorable reception of solar energy,
- softer drying regime,
- small exploitation costs,
- universality, different materials are dried,
- ecological, does not pollute the environment,
- enables a standing time of the material during the drying process.

The dryer is intended for farms that have an arable land of about 0.5 ha under medicinal herbs, aromatic plants or spice cultures.
The construction of the walls, the roof, the floor and the door prevents loss of heat from the dryer, Fig. 1. The walls consist of three parts: the outside is made of aluminum sheet 1 mm thickness (1), the inside is made of wood 21 mm thickness (3) and the air gap is in-between (2). This gap also allows the usage of already used drying agent from the chamber exhaust (7) for regulation of the drying agent temperature during the drying process. For that purpose a shutter with a flap (4) is installed at the entrance into the drying chamber and it is manually controlled on the prototype. It enables mixing of the air from the wall insulation space of the drying chamber with heated air from the collector in different ratios, maintaining the required temperature regime and humidity of the drying agent at the entrance into the drying chamber. The shutter on the chamber exhaust (8) on the roof gives additional control of the drying agent characteristics and it is manually controlled, too. The centrifugal ventilator (6) has three working speeds.
The wall above the solar collector (9) is a reflective surface and it increases the effect of solar radiation on the solar collector. The roof, the floor and the door have similar construction with the air gap. Plates for placing the drying material (5) are placed with alternately facing openings for circulation, which enables optimal circulation of the drying agent around the plates.

The rod (10), perpendicularly mounted on the frame of the solar collector, is used for optimal positioning of the dryer and the solar collector. The optimal position is obtained by lifting or lowering the collector jack (11) or trailer jacks and by turning the whole dryer on the trailer. The mesh of concentric circles and lines in the base of the rod gives good orientation in positioning.

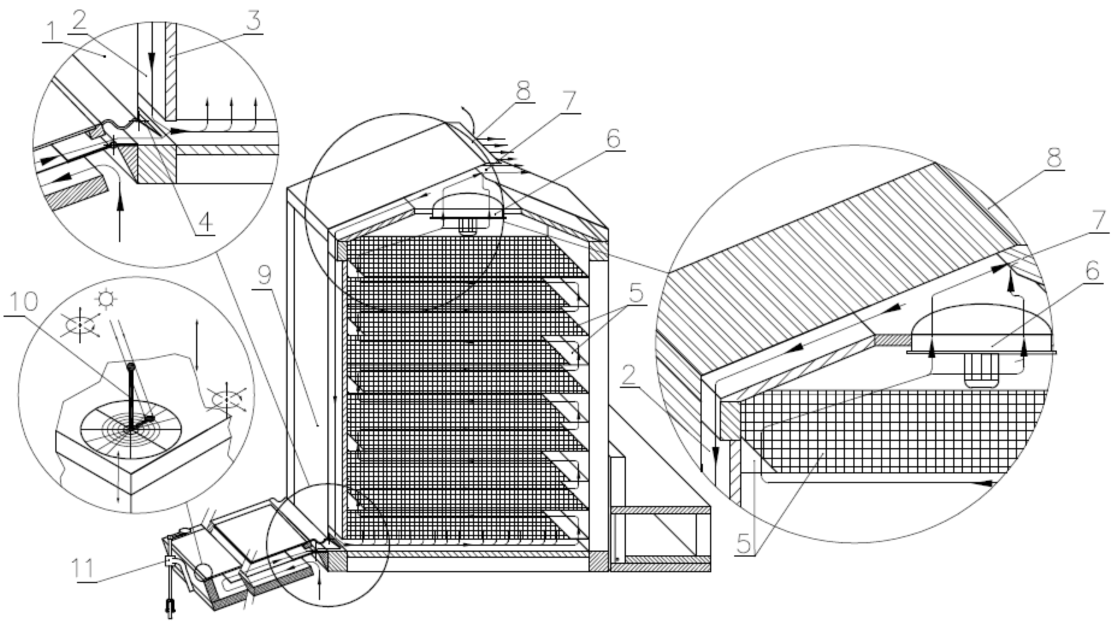

Figure 1. Cross section of the dryer chamber with walls enabling recirculation of the drying agent and regulation of the drying agent temperature

Description and characteristics of a dryer module prototype

- On Fig. 2 a prototype of a module of a mobile, universal, ecological, chamber dryer for drying biological materials using solar energy is given [2].The basic dryer element is a drying chamber with a rectangular surface area with pans distributed upwards for placing material in a dense immobile layer. A hydraulic jack is built in the middle of the trailer. It is used to lift or lower the chamber with the solar energy collectors (dryer in the narrower sense) to the height that corresponds to the optimal angle of the working position of the solar energy collector for a given location and conditions. The front wheel can be used to turn the trailer in the most favorable position in relation to the spreading angle of solar radiation in dependence on the time of day and given location that is controlled by a pole built-in the frame of the solar energy collector. The solar energy collector used for heating air is installed on the side of the dryer and knuckle-joined to the construction frame of the drying chamber so that it can rotate around the horizontal axis and by turning place into a vertical plane. This turning enables lifting and fixation of the solar energy collector into a vertical position during transport and also lowering to a corresponding angle, below horizontal. A photovoltaic panel installed on the sloped roof surface is used to provide electrical energy for driving the ventilator electromotor for moving of the drying agent. Its slope can be changed according to requirements. An accumulator battery with a corresponding regulator is built-in the rear part of the trailer. The structure of boundary surfaces (walls and roof) is: wooden plating on the inside, a layer of air and then Al sheets on the outside. A system with a flap is installed at the entrance of the drying chamber that enables mixing of air from the wall insulation space of the drying chamber and heated air from the collector maintaining the required temperature regime of the drying agent at the entrance to the drying chamber. The basic technical characteristics of the dryer module are: dimensions of the mobile part, trailer 1300 x 2650 mm,
- dimensions of the drying chamber 800 x 1000 x 1200 mm,
- absorber dimensions 805 x 1180 mm,

- dimensions and useful pan dimensions 800 x 1000 mm; 760 x 920 mm,
- power and surface of the PV module, N= 75 W, F = 0.66 m^2,
- centrifugal ventilator with three working speeds,
- maximal and minimal height of the lower frame of the drying chamber in the working position 600 and 960 mm.

Figure 2. Prototype of a module of a mobile universal solar dryer

EXPERIMENTAL RESULTS AND KINETICS OF THE DRYING PROCESS

Experiments drying spin age leaves, selected for their characteristic parameters (exceptionally high starting moisture, moisture content from 9 kg_{wm}/kg_{adm} and high ratio between the fresh and dried material – 100/8) and easy availability during the whole year, were conducted. The unit surface load of the pan surface with fresh material was 1.5 kg. Investigations were performed on September 08 and 09 2005,[3],[4]. During the experiment the following parameters were measured: temperature of the environment and the drying agent at the entrance to the drying chamber, temperature of the material, flow speeds of the drying agent and mass of the material samples on representative pans. For drawing the drying curve values of absolute moisture of the material in each point (instant measurement). Mass of the absolutely dry material was defined by drying a corresponding sample in a laboratory dryer using a standard method.
The corresponding drying curves are given in Figs. 3 and 4 for the following conditions: $t_{da_{mI}} = 46{,}5^o C$. $t_{e_{mI}} = 31{,}3^o C$, $\varphi_{emI} = 42{,}3\%$ and $t_{da_{mII}} = 38{,}778^o C$, $t_{e_{mII}} = 28{,}8^o C$, $\varphi_{emII} = 46{,}3\%$., The drying rate is defined by the expression $N = -\frac{du}{d\tau}$ that means that it can be defined as the first derivative of the function $u = f(\tau)$ or graphical differentiation of the drying curve. Based on the drying curves presented in Figs. 3 and 4, corresponding fitted curves, the corresponding analytical expression was obtained for the drying curve (for mean values of absolute material moisture) of the form:

$$u = a + b \cdot e^{-05(\frac{\tau - c}{d})^2} \tag{1}$$

where a=6.0714276, b=3.0876823, c= 10.530993, d= 2.4667399, residue r^2=0.99608194, and differentiation gave the corresponding analytical expression for the drying rate:

$$-\frac{du}{d\tau} = \frac{b}{d^2}(\tau - c) \cdot e^{-05(\frac{\tau - c}{d})^2} \tag{2}$$

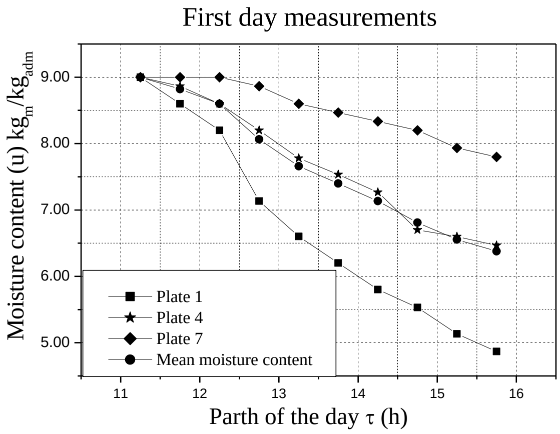

Figure 3. Drying curves

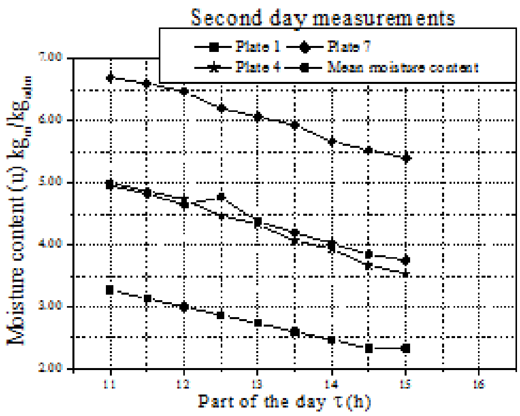

Figure 4. Drying curves

A conclusion can be made on the operating quality of the solar energy collector based on experimental results of the investigation of the solar energy collector and dryer as a whole that means the attained values of the temperature of the drying agent at the exit from the solar energy collector and realized temperature differences (difference between the temperature of the drying agent at the entrance and exit of the solar energy collector). Oscillations in temperature values are obvious in the diagrams and they are the consequence of the time of day and also the occurrence of cloudy periods during the experiment. Having in mind the realized temperature values at the exit from the solar energy collector and corresponding temperature differences and values of regime process temperatures of biological materials (first medicinal, aromatic herbs and spices and then fruit and vegetables) one can conclude that the solar energy collector satisfied completely. Investigations of the solar energy collector showed satisfactory results regardless of not so good weather conditions and temperature differences even up to
20 ^{o}C were realized. Analysis of drying curves on representative pans 1, 4 and 7 give a picture of the unevenness of the drying process regarding the drying chamber height that is a disadvantage of all chamber dryers. Due to specific experimental conditions changing of pan positions during the drying process was not possible, even though this is usually done in practice. One should note that a significant moisture reduction of the material occurred during the night (see kinetic diagrams) that is partly the consequence of the construction and structure of boundary surfaces of the drying chamber. Analysis of the drying rate curves gives the best picture of the moisture separation rate. Analysis of the material's drying curves enables obtaining of a picture of the moisture separation intensity from a moist material. Definition of the drying time and dryer capacity per separated amount of moisture, moisture flow is possible.
However, having in mind that the energy source is free, the value obtained would not be relevant for comparison with values obtained for existing dryer types for artificial drying of biological materials. Application of solar energy in drying processes is not just exchange of classical fuel with solar energy, but also provision of a better quality product in a more economical way.

CONCLUSIONS

In the last few years the world has started to understand that the ecological crisis is more serious than the energy one. As the main threat to environmental protection stems from activities connected with energy solution of the energy problem would at the same time become significant from the ecological viewpoint. Thus, renewable and clean energy sources have come up front. The rapid development of technical knowledge and technologies with prior understanding of physical laws and also continual growth of energy needs and the fact that energy sources are limited have contributed to the application of solar energy. Research results on this project are a new solution of a solar, mobile, universal, ecological, chamber dryer that satisfies the basic three requirements in the drying process: maximal process intensity, good quality of the dried material and minimal energy consumption. Its characteristics are based on a construction solution: operation at any location (mobile solution), insignificant costs in the exploitation period, execution of the drying process, universality, possible drying of different products as soon as they are picked, the most favorable reception of solar radiation (the angle and illusory path of the Sun are followed), better quality of the material from the viewpoint of nutritious and biological values, a better economic effect as a cheap energy source is used.

NOMENCLATURE

a, b, c, d- constants, F - surface, N – drying rate, power, r -factor coleration $\boldsymbol{t}$ - temperature of the drying agent and material, PV - photo panel, u - absolute moisture, moisture content, I – first day, II – second day.

Subscripts

da - drying agent, $adda$ - absolutely dry drying agent, adm - absolutely dry material,
m - mean value, e- environment,

Greek letters

φ - relative air moisture, τ - time,

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A DESIGN OF MICROPROCESSOR-BASED CONTROLLER FOR SMALL AUTOMATION

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Abstract: This paper presents a method for synthesis of firmware for microprocessor-based controller for small automation. The microprocessor embedded system for small automation was implemented by microcontroller C8051F120. An algorithmic firmware structure of based on a fast method by fusion of state diagrams on Moore's automata and sequential graph algorithmic diagrams. The relation between Moore's automata states and algorithm realization is described. The connection of states and sequential program steps are presented by a chart diagrams and interim variables. The synchronization between states is made by timer interrupt service routine of microcontroller. The algorithm is converted to assembler program for the microcontroller. The ability of synthesized firmware for filling-capping machine control is analyzed.
Key words: microprocessor, firmware, embedded systems, controller, small automation.

INTRODUCTION

Control algorithms of discrete systems typically have cyclic structures. Process control of complex systems are characterized by multiple internal states and certain numbers of conditions causing changes in the status of the control system. Therefore, these systems could be modeled and analyzed by finite automates. It is evident that algorithms operation of microprocessor firmware is the single programming model, and can be designed on the basis of the finite automata. This approach allows to obtain algorithms optimal structure, practically free from logical errors as pre-built model based on the theory of finite automata allows to analyze carefully detailed operation of the system state by state. For that reason is easy to detect errors as early as the design phase of firmware. Best suited for algorithmic construction of firmware is the finite automate of Moore. For-mal presentation of this machine is done by graph of transitions. The graph of transitions by using the nodes displayed the status of the machine, and by directed arcs – transitions between states [2]. An example of what kind machine is shown in Fig.1. This finite state machine has 4 states: A, B, C and D. The initial state is A, and the final state is D. In general operation of the machine Moore comes down to that in every state generate a specific output signal. If it occurs an appropriate input (X1, ..., X8) transition to an-other final state is performed. In real microprocessor sys-tem any condition characterized by a set of performance features is the output state of the machine. The input signals of microprocessor system are logical conditions of internal state variables. Every microprocessor system in general is a synchronous machine.

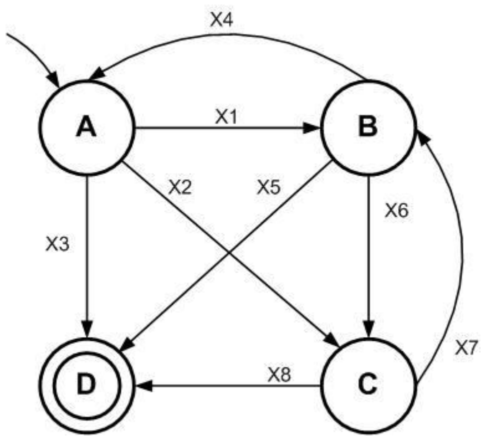

Figure 1. Graph of finite automate

Frequency synchronization of mass eight bit microcontrollers is dozens of megahertz [4]. To build the firmware algorithm using the synchronous approach and the period of synchronization can be formed by any of the built-in timers of microcontroller. If a graph scheme of desired behavior is presented it is possible to move to the algorithmic scheme. In Fig. 2 is shown one way of transformation into an algorithmic circuit for the graph model of Fig. 1.

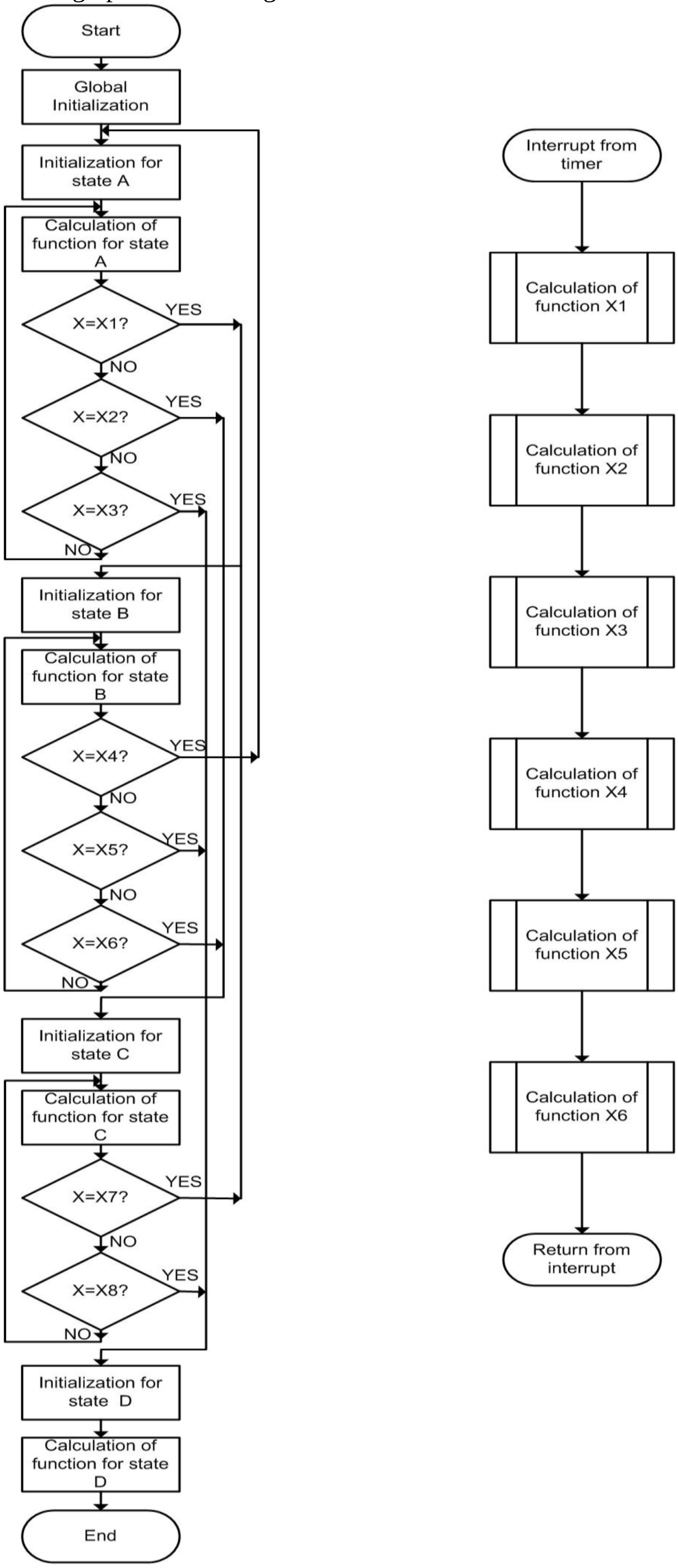

Figure 2. Algorithm chart

After initialization of the microprocessor system goes initial state A. The scheme of each cycle represents the finite states including operator initialization state operator function of the state in the loop body and checks the input signals of the machine to exit the loop. If the input signals are inactive, the cycle continues i.e. machine stores the current state, if the signals are active transition is performed. The goal of this paper is to present and analyze a fast design method for firmware of microprocessor-based system for small automation. The presented transfer method is base of fusion of state diagrams on Moore's automata and sequential algorithmic diagrams. The proposed method is tested for control of machine for small automation. The connection of states and sequential program steps are presented by a chart diagram and interim variables.

HARDWARE DESIGN

The design of a microprocessor-based system for automation starts with analysis of controlled object. As object for our synthesis is chosen a small filling-capping machine (Fig. 3). The machine has four inputs sensors (I0 - level sensor, I1 - bottle stop sensor, I2 - stop piston sensor, I3 - cap plunger limit switch) and four outputs activator (O0 - stop bottle piston, O1 - bottle filling piston, O2 - cap plunger piston, O3 - conveyer).

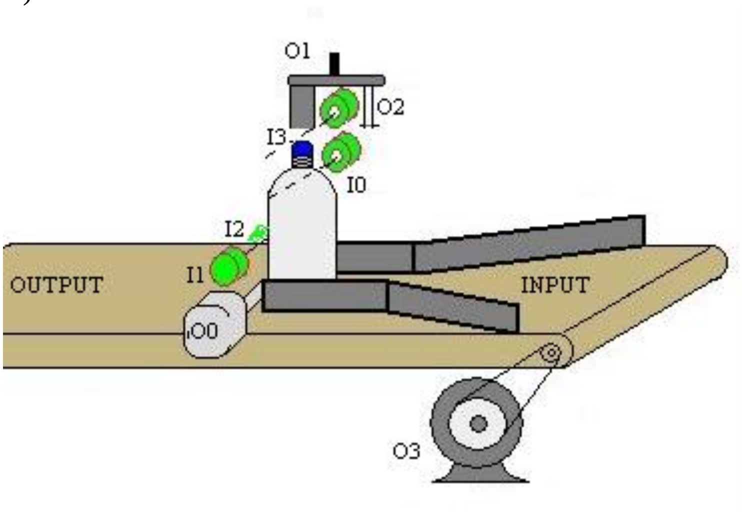

Figure 3. Filling-capping machine [1]

Hardware synthesis is base on eight bit microcontroller C8051F120 [3]. The selected controller support widespread Intel MCS-51 instruction set [6] and can use free development software [5]. The C8051F120 provides the following standard features: 100 MIPS, 64 I/O Lines, 5 Timers, SPI, I^2C, 2 UARTS, Watchdog Timer, Real-Time Clock, 8 Channel (12-bit) A/D, 2 Channel (12-bit) D/A, On-Chip Temp Sensor, on-chip oscillator, 128K Byte In-System Programmable FLASH, 256 Bytes RAM, 8K Bytes XRAM 2K bytes of Flash and 128 bytes of RAM. The basic form of proposed controller has embedded four discrete inputs and four discrete outputs and expanded connector with route all signals of microcontroller. The schematic diagram of proposed microprocessor-based controller is shown in Fig. 4. All discrete inputs are for 12V AC/DC operation voltage and they are photo-couplers isolated from the microcontroller. All discrete outputs are galvanically isolated by relays (K1, K2, K3 and K4). The inputs and outputs can expand by presented diagram connection. The power subsystem of the proposed controller is realized by two cascaded step-down switching regulator LM2576 and LM2937. The first regulator IC2 provides 12V DC for periphery interfaces and the second regulator IC3 provides 3.3V DC for the microcontroller. The R1, R2 and C3 group is standard for the processor and produces the signal for the initial resetting after the switch on of the power supply. A 24 MHz quartz resonator Z1 has been selected. The value of the resonator Z1 is not critical for designed system and can be change. In this case interrupt time interval will be change too.

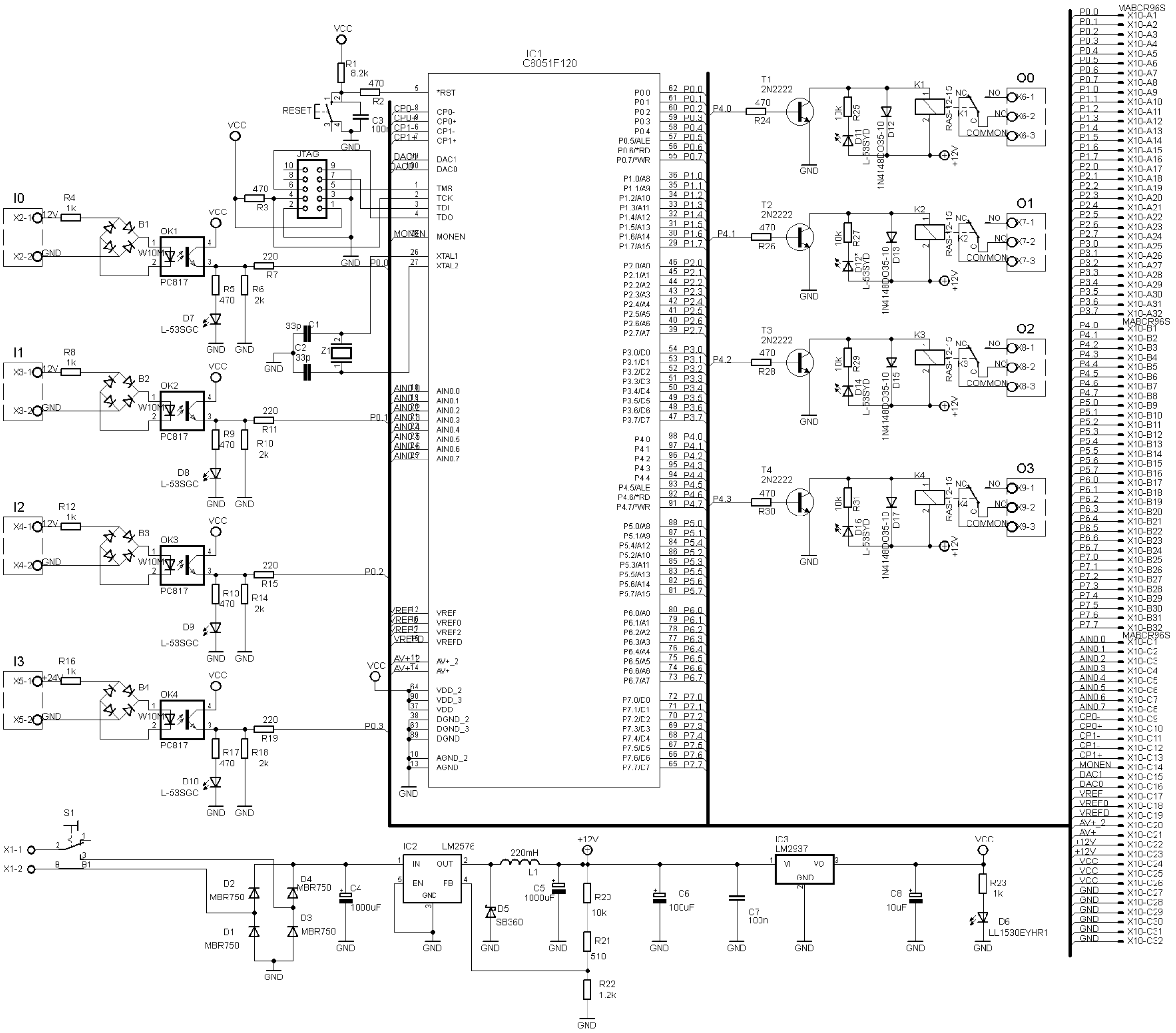

Figure 4. Schematic diagram of the microprocessor system

SOFTWARE DESIGN

The system has five states. ST1 is initial state, ST2 is barrier close state, ST3 is filling state, ST4 is cap putting stage and ST5 is cap closing stage. I1 is signal from sensor for bottle presence, I2 is signal from sensor for close bar-rier, I0 is signal from high level sensor, I3 is signal from sensor for cap presence, µ1 e time delay input. The state diagram of the proposed system is shown in Fig. 5.

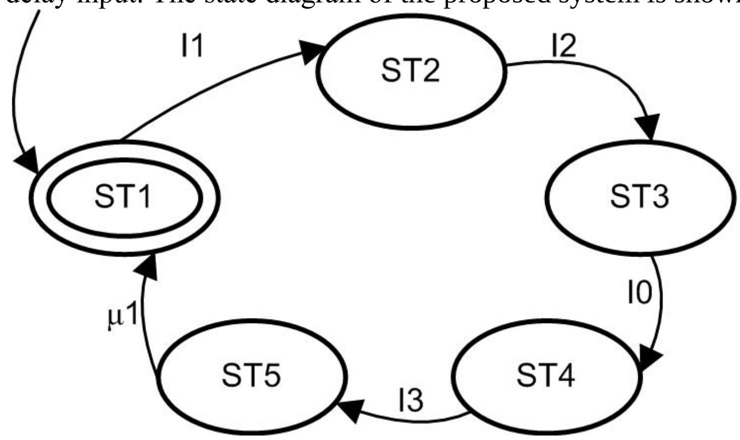

Figure 5. State diagram of the proposed system

Every finite state can be described by this equation:

$$STATE_i = \left(STATE_i + \sum_{j=1}^{n} (C_{j,i}.STATE_j) \right) . \prod_{k=1}^{m} (\overline{C_{i,k}.STATE_i}) \quad (1)$$

, where
n are numbers of transitions to state ***i***;
m are numbers of transitions from state ***j***;
$C_{j,i}$ is logical condition for transition (T) from state ***j*** to state ***i***;
$C_{i,k}$ is logical condition for transition (T) from state ***j*** to state ***k***.
Using (1) the Bool's equations for transition and states can be written in matrix forms:

$$\begin{cases} T1 = \mathrm{Re}\,set \\ T2 = ST1.I1 \\ T3 = ST2.I2 \\ T4 = ST3.I0 \\ T5 = ST4.I3 \\ T6 = ST5.\mu1 \end{cases} \quad (2)$$

$$\begin{cases} ST1 = (ST1 \vee T1 \vee T6) \wedge \overline{T2} \\ ST2 = (ST \vee T2) \wedge \overline{T3} \\ ST3 = (ST3 \vee T3) \wedge \overline{T4} \\ ST4 = (ST4 \vee T4) \wedge \overline{T5} \\ ST5 = (ST5 \vee T5) \wedge \overline{T6} \end{cases} \quad (3)$$

These equations (2) and (3) can be use to program firmware for microprocessor system. This is call classical methods for state diagrams converter to firmware logic equations.
In Fig. 6 and Fig. 7 are shown proposed methods for conversion of state diagrams to graph algorithm charts for firmware for microprocessor-based controller for small automation. In main algorithm diagram, microcontroller makes global initialization as enable interrupt via timer 3 and then goes to state 1. If condition X1 is true algorithm move to state 2 and etc.

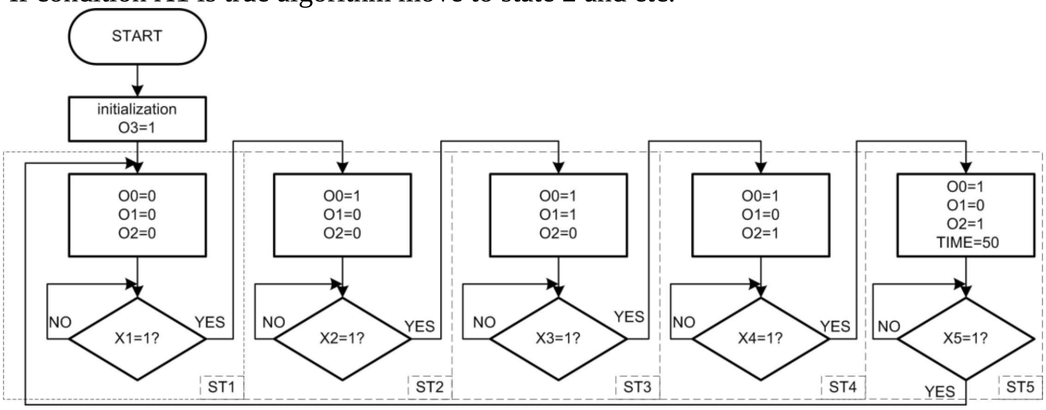

Figure 6. Main graph algorithm chart

Interrupt service routine are running every 50ms and check the inputs and time of delay. In initialization timer 3 interrrupts are enable and timer reload value is 65536 minus 50000 divide to three. The inputs are checked two times to eliminate input signals debounces. The firmware is vital for the designed system. Firmware of the proposed microprocessor-based controller is written in assembly language. The part of code for interrrupt routine is:

```
TMR3_ISR:   anl    TMR3CN,#not(Tmr3if) ; reset the timer 3 interrupt flag
            jnb    I1S,Cl_PRF      ; I1S=1?
            jb     I1F,St_Per      ; I1F=1?
            setb   I1F             ; set I1F=1
            sjmp   X2cal
```

```
St_X1:  setb    X1      ; set X1 =1
Cl_I1F: clr     I1F     ; clear I1F
```

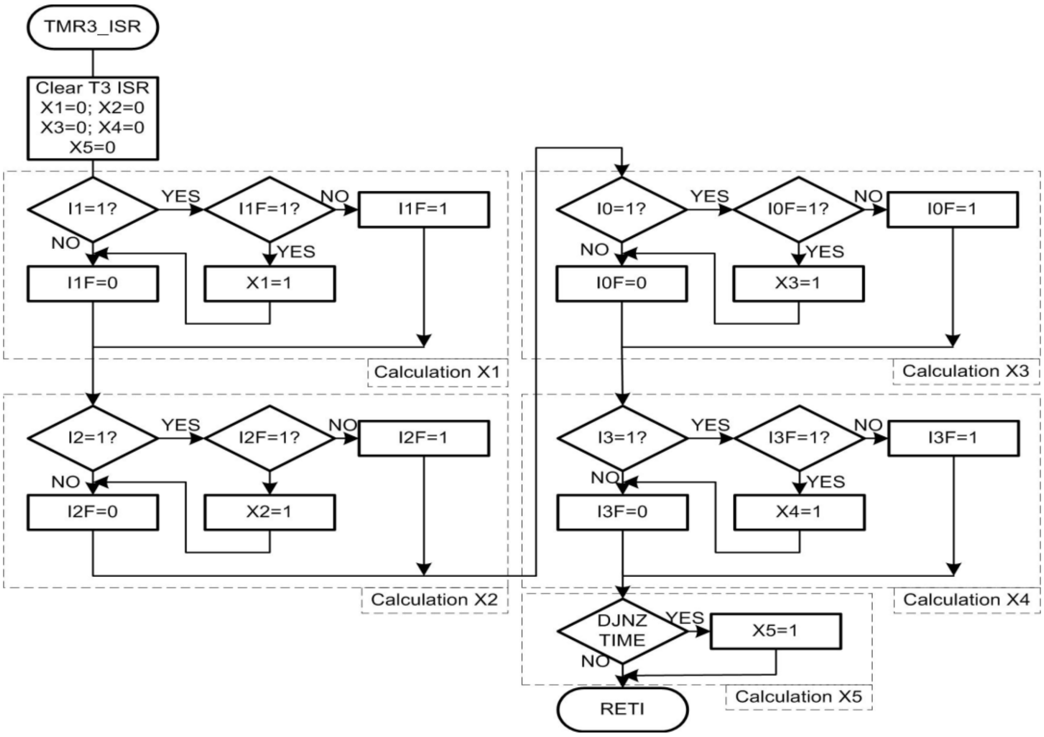

Figure 7. Interrupt graph algorithm chart

For purposes of analysis were carried implementations based on classical state diagram method and novel proposed graph algorithm charts method. The classical method use 17 auxiliary variables more than proposed method. Use of additional hidden variables in classical method lead to difficult to track bugs and states of the system. The controller has low price below 60 EUR and high reliability because it is built on the quality microcontroller C8051.

CONCLUSION

The present authors microprocessor-based system is low priced and ensure implementation of various discrete control algorithms through predefined macros. Operating results of the device are very good so far, no defects and failures. The proposed algorithm synthesis allows fast preprogramming of new func-tions and low cost automation realization. The proposed novel method for firmware design can be use with analog input sygnals by external expanded connector. The stages of algorithm are clear and can easy traced for bugs. This proposed original design can be use for other projects of small automation in food industries.

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Session 6.

Basic operations, machinery and processes

THE ROLLING INDUSTRY: APPROACHES AND TENDENCIES IN THE QUALITY ASSURANCE

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Abstract: Our approaches the issue of quality assurance of the rolling mills rolls, from the viewpoint of the quality of materials, which feature can cause duration and safety in exploitation. The experimented durability research, as well as the optimization of the manufacturing technology, allows the conclusion of direct results for the rolls. The beneficiaries of these results are the unit in which the rolls are manufactured, as well as the unit that exploits them. The technological manufacturing process of the rolling mills rolls, as well as the quality of material used in manufacturing them, can have a different influence upon the quality and the safety in the exploitation.
Key words: rolling rolls, quality assurance, manufacturing, safety in exploitation, materials

INTRODUCTION: METHODS, APPROACHES AND TENDENCIES

The technological manufacturing process of the rolling mills rolls, as well as the quality of material used in manufacturing them, can have a different influence upon the quality and the safety in the exploitation. Our proposal approaches the issue of quality assurance of the rolling mills rolls, from the viewpoint of the quality of materials, which feature can cause duration and safety in exploitation.
In these sense, our researches propose, on aside, to analyze the durability in industrial exploitation of the iron cast rolling mills rolls (Figure 1) – analysis materialized from prism of the laboratory experiment (Figure 2), and on another side, the optimization of manufacturing technology of the cast rolls, especially those from cast–iron – using electronic calculus technique as the modeling phenomenon (Figure 3) and mathematical interpretation of the technological processes.

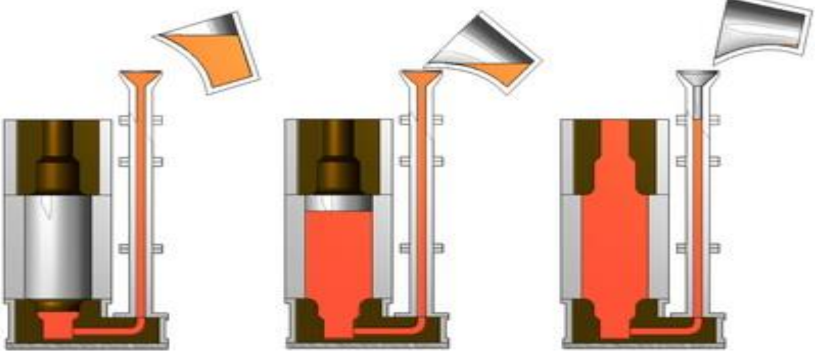

Figure 1. Casting process of the rolling mills rolls

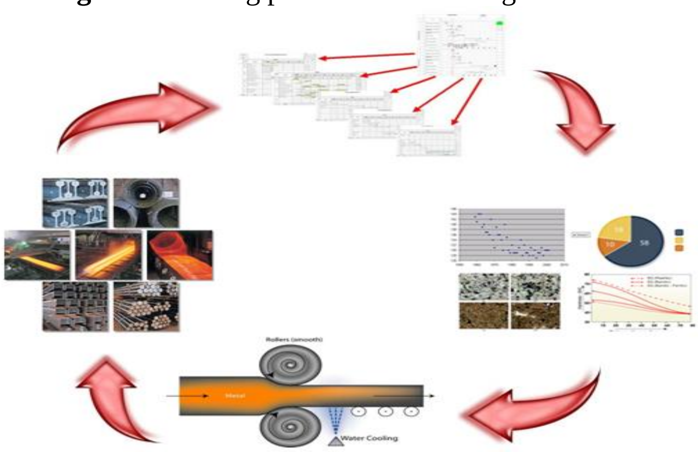

Figure 2. Quality assurance through the laboratory experiment

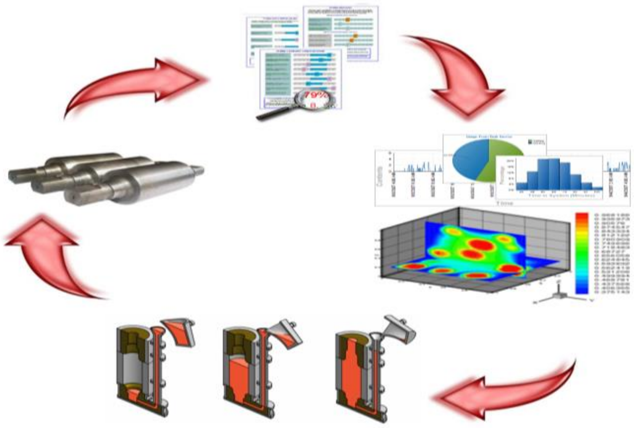

Figure 3. Quality assurance through the modeling phenomenon

The quality assurance research fields can be defined through the general research area, through the different experiments effectuated in the laboratories, and, also, through the modern calculation programs, optimization technologies and the better capitalization of the manufacturing data.

QUALITY OF ROLLS ASSURED BY THE LABORATORY EXPERIMENTS

The researches of durability in the exploitation of cast from cast–iron rolls, constitute a scientifically novelty, and experimentally define an important chapter from the thermal fatigue of the organs of machines in the movement of rotation, in variable temperature mediums. Hot rolling mills rolls work the in in the variable compound solicitations, due to lamination process and which repeated to regular intervals of time.

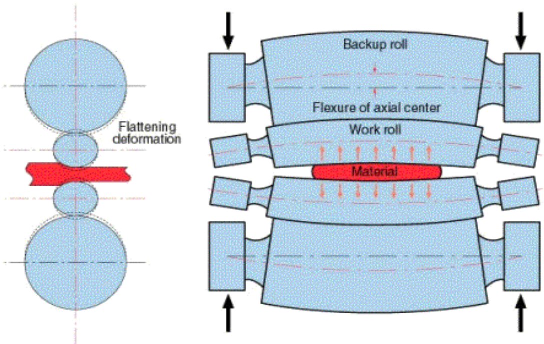

Figure 4. Hot rolling mills rolls work the in the variable compound solicitations

All these phenomena, which are more or less emphases depending on the type and typical of rolling mills, are not taking into consideration in the classic calculus of rolls. If the study of the rolls resistance is extended upon their durability, we must consider the whole complex of tensions with mechano–thermal influences. The research on durability in exploitation of hot rolling mills rolls assures relevant conditions for the appropriation of the research methods of the thermal regimes that are submitted the rolls or other organs of machines, that works in constant (symmetrical) or variables (asymmetrical) thermal solicitation conditions.

The recommendations for the increase of the duration of exploitation and remove of the damages through the accidental rupture of rolls from the stands of lamination, the attenuation of rolls thermal fatigue, the avoiding of thermal shock and their rational exploitation are actuality issues that must be continuously researched. In this trend is situated the research of the thermal fatigue phenomena, materialized in technical reports, whose beneficiary is the unit in which the rolls are exploited, as well as through scientific papers, that can develop the framework of scientific research. These researches results lead to direct conclusions about the cast–iron rolls, and permit their comparison with date about steel rolls, area studied thoroughly researched of specialists.

The work is of practical immediate utility, inscribing itself in the context of technical capitalization of the manufacturing technologies and of exploitation of cast–iron rolling mill rolls, for which exists an attentive preoccupation both from foundry sectors, as well as from lamination sectors, having as determinate aim the quality assurance and increase the durability in exploitation.

QUALITY OF ROLLS ASSURED BY THE MODELLING OF MANUFACTURING DATA

Starting from the principle of modeling process, used as necessary basic instrument, both in phase of conception, as well as in the industrial technologies analysis, is determined the optimum regimes of the cast rolls, from the view from chemical composition, as one as the most important parameters of disturbance of the manufacturing process.

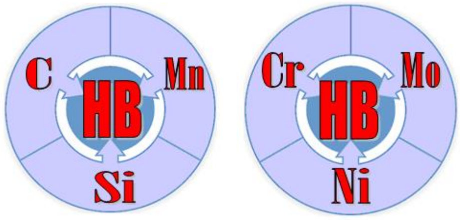

Figure 5. The influence of the basic and the alloyed elements upon the Brinell hardness, in mathematical perspective

The enunciation of some mathematically modeling results, described through a number of multi–component equations determined for the spaces with 3 and 4 dimensions, as well as the generation of some regression surfaces, of some curves of levels, of the volumes of variation, of the lines of outlines of the volumes of variation of surfaces and the areas of variation of these, can be represented and interpreted by technologists and can be considerate diagrams of correlation between the analyzed variables. From this point of view the research is inscribes in context of scientific capitalization of the process and the industrial technologies optimizations, on the way of the analysis and the mathematical experiment.

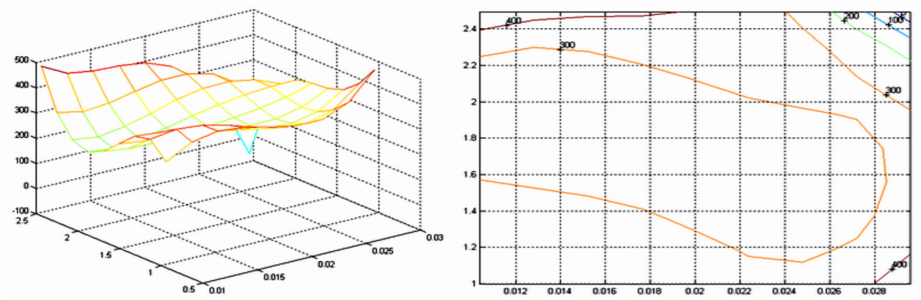

Figure 6. The regression hyperplanes and the representations variation areas of the cast–irons chemical composition

The character of the metallurgical processes optimization is influenced by the complex peculiarities of these, which take place into a great number of variables (parameters) that operates independently or cumulate.

For this reason, to analyze the metallurgical processes is used, mainly, the statistical fundamental methods that permit to draw conclusions, from the observed values, about the repartition of the frequencies of various parameters, about their interaction, about verification validity of certain premises, and about the research of the dependencies among different parameters. However, the statistical methods of the metallurgical process analyses do not solve a series of aspects regarding the mode of establish the decisions for the management of the process. Thereof, parallel with the statistical methods it was developed optimization methods.

The optimization of any technological process has, as a base, a mathematical model. The search for the best solution, for the truth, requests either to find, on the way of a study, definitive truths, or of relative valid truths, valid only in certain conditions, and which, in relation with the definitive truths, include implications and errors.

CONCLUSIONS

The aim of the propose research is to answer to as many questions possible regarding the quality of rolls. In this sense, durability in exploitation is extremely current, both for immediate practice, and for the scientific research attributed to the cast–iron. Also, the realization of optimum chemical compositions of the cast–iron can constitute a technical efficient way to assure the exploitation

properties, the material from which the rolling mills rolls are manufactured having an important role in this sense.
The research on durability in exploitation of hot rolling mills rolls assures relevant conditions for the appropriation of the research methods of the thermal regimes that are submitted the rolls or other organs of machines, that works in constant (symmetrical) or variables (asymmetrical) thermal solicitation conditions. Also, it can be emphasized the thermal shock, phenomenon that constitutes a permanent danger, which leads to rupture, specific to rolling mills rolls.
On another hand, the realization of an optimal chemical composition can constitute a technical efficient mode to assure the exploitation properties, the material from which the rolling mills rolls are manufactured having an important role in this sense. From this point of view is applied the mathematical modeling, witch is achieved starting from the differentiation on rolls component parts, taking into consideration the industrial data, as well as the national standards regulations, which recommends the hardness, for different chemical compositions.
The optimum solution is determined through some mathematical restrictions to the input values that the mathematical modeling is started. The realization of a mathematical model starting from industrial data, gathered at the rolls hardness measurement, and at the national standards regulations, which recommends the hardness, for different chemical compositions, also determines the degree of originality of the suggested project. The determination of the equations of regression hyperplanes, which describe the mathematical dependency between the chemical composition and the hardness, the determination of the multi–component relations and the realization of the graphic interfaces for the representations variation areas of the cast–irons chemical composition, completes this area of preoccupations within a processing mathematical of modeling and optimization. Through the original aimed elements mentioned above, the suggested research allows the enunciation of new approaches in the area afferent to the theme.

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INERTIAL CONVERTERS OF TORQUE AND PRELIMINARY CALCULATIONS OF THEIR BASIC PARAMETERS

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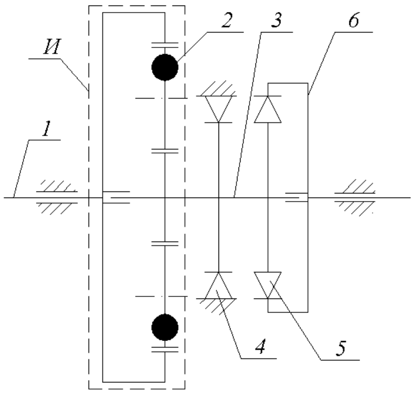
Abstract: In the beginning of this work is given a generalized principle scheme, the principle of operation of mechanical inertial converters of torque as well as some their advantages and disadvantages. The procedure of the determination of the basic design parameters of inertial converter of torque with one of most used impulse mechanisms (epicyclic gear impulse mechanism of Levin) has been shown.
Key words: CVT, one-way clutch, inertial converter of torque, CAD

INTRODUCTION

In many modern machines is needed adjustment of speed of the driven machine depending on the conditions of the working process. Usually is necessary transmission (or gear) ratio (this is the ratio of the input angular velocity to the output angular velocity) of the gear unit between the motor and the driven machine to increase with the increase of the resistance torque. There are discrete and continuous (infinitely) change of the gear ratio, as continuous is better, but more difficult to achieve. Continuously variable transmission, or CVT, provides more useable power, better fuel economy and a smoother driving experience (when is used as a car's transmission) than a traditional automatic transmission.
Inertial converters of torque are self automatic mechanical continuous variable transmissions (CVT) which utilize oscillating torque, engendered by inertia forces. These converters have a number of advantages: compact design, high efficiency, wide range of torque transformation and other benefits. If the parameters of inertial converters of torque are appropriately selected, they could work in three characteristic regimes - as a dynamic clutch (when the load at the output is extremely low), as a transformer of torque (when the load has intermediate values) and in so-called "stop" regime (when the load is very or extremely high and the motor rotates even when output shaft is blocked). The disadvantages that limit the spread of their usage are: relatively low reliability of used in their constructions one-way clutches; high dynamic loads; ripple and high frequency switching on and off.

GENERALIZED PRINCIPLE SCHEME AND PRINCIPLE OF ACTION

Generalized principle scheme of inertial converter of torque comprises impulse mechanism И (mechanical system with two , or more, degrees of freedom which includes elements with eccentric masses 2), three shafts (input shaft 1, intermediate shaft 3 and output shaft 6 with flywheel) and two one-way clutches 4 and 5 working in opposite directions – Figure 1a.



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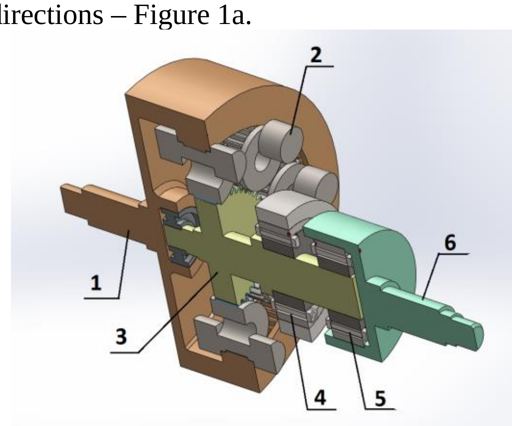

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Figure 1. Generalized principle scheme (a) and CAD-model section view (b) of inertial converter

The clutch 4 leads the negative pulses of torque which come from the impulse mechanism to the immoveable housing, whereas the clutch 5 transmits the positive pulses of torque to the output shaft 6 for its movement. The impulse mechanisms could be different types, but here the Levin's impulse mechanism is chosen (Figure 1b), because of its advantages [2] as: compact design; low dynamical loading to the bearings, the one-way-clutches and the other elements; wide range of transmission ratios; it can realize regime of dynamic clutch, etc. The Levin's impulse mechanism is epicyclic mechanism (Figure 2) with two degree of freedom. The motor drives the ring gear 1. If the ring gear 1 rotates with constant angular velocity it makes all planet gears 2 having unbalanced masses to rotate, as well. The unbalanced masses are mounted firmly on the planet gears as shown on the Figure 2. So the unbalanced planet gears 2 consecutively and repeatedly take positions shown on Figure 2 – a, b, c, d, a, b... and so on. The inertial forces from unbalanced masses create sinusoidal torque which influences on sun gear wheel and connected to it intermediate shaft 3. As shown on Figure 2: at the position a – no influence from inertial torque on the sun gear wheel 3; at the position b – the most influence in clockwise direction from inertial torque on the sun gear wheel 3; at the position c - again no influence from inertial torque on the sun gear wheel 3; position d – the most influence in counterclockwise direction from inertial torque on the sun gear wheel 3 and so on.

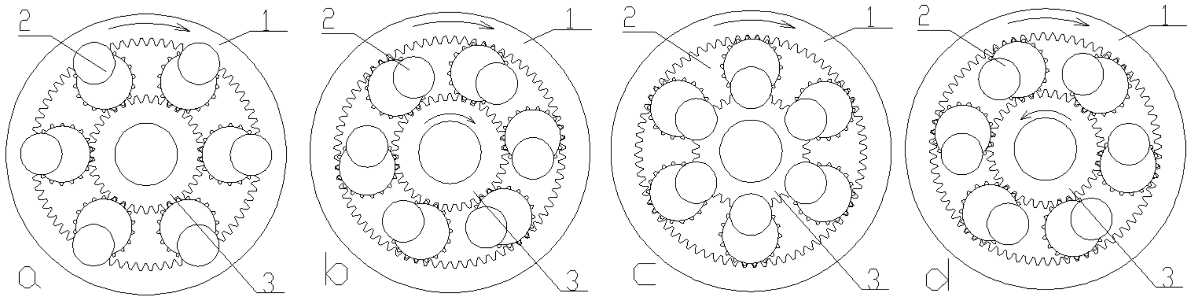


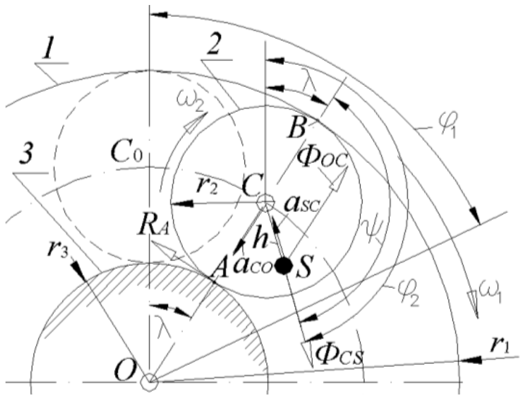
Figure 2. Sequence of the generation of the torque impulses.

The positive half-waves of torque, for example in the clockwise direction, are accepted by the output shaft 6 (Figure 1) through one-way clutch 5. The negative half-waves of torque are stopped by the immoveable housing through one-way clutch 4. The massive flywheel on the output shaft accumulates positive impulses of torque in relatively smooth rotation.

ESTIMATION OF AMPLITUDE OF THE TORQUE INFLUENCING ON THE IMMOVEABLE INTERMEDIATE SHAFT

One of disadvantages of mechanical inertial converters of torque is their difficult dynamics. Despite the simple construction of these drives [3], their motion is described by complicated nonlinear systems of differential equations, which exclude exact methods to solve them. Variable structure of these drives makes the researchers to draw systems of differential equations for sections of the cycle on which they work [1]. One simple approach to estimate possibilities of such drive is to determine the amplitude of the torque which influences on the immovable intermediate shaft.
It could be doing by means of CAE (computed aided engineering) simulation of the motion of a 3D-model of the drive [4]. The CAE simulation results are proved by means of analytical investigation of kinetostatics of planet's gear wheel (Figure 3). Let's ω_1 is the angular velocity of the input ring gear 1; r_1 - internal radius of input ring gear 1; ω_2 - angular velocity of the planet gear wheel 2; r_2 - radius of the planet gear wheel 2; r_3 - radius of the sun gear wheel 3; n - number of the unbalanced planet gear wheels; m - whole mass of each unbalanced planet gear wheel; $h = CS$ - distance between center *S* of mass of one unbalanced planet gear wheel to its axis *C* of rotation and $\omega_3 = 0$. Then it is derived that the amplitude of torque is:

$$M_{R\max} = \frac{m.h.r_3.n}{8}.\left(\frac{2.r_2 + r_3}{r_2 + r_3}\right).\left(\frac{r_1.\omega_1}{r_2}\right)^2$$



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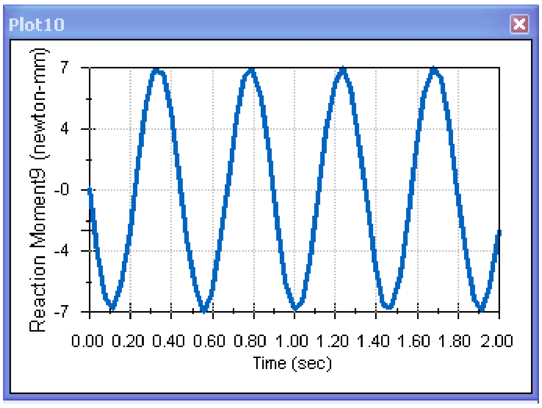

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Figure 3. Kinetostatics of planet's gear wheel (a) and CAE simulation results of the its motion (b).

PRELIMINARY CALCULATIONS OF INPUT PARAMETERS

Before deeply investigation of the dynamics by means of solving systems of differential equations of any inertial converter of torque it should make preliminary calculations [2] of basic parameters. The rest of this article will be presented by means of calculation of practical example of such drive.
The input parameters for such calculations are (see Figure 3 a):

Overall dimension of the gear - radius of ring gear wheel of impulse mechanism: $r_1 = 0{,}05$, m

Rated angular velocity of the motor - input angular velocity of ring wheel $\omega_1 = \dfrac{5200*\pi}{30} = 544{,}5$, rad/s

Maximal resistance torque at the output - $M_C = 20$, Nm

First it should choice the coefficient of cyclic recurrence q of the impulse mechanisms. Epicyclic impulse mechanisms (as is Levin's impulse mechanism) have constant coefficient of cyclic recurrence. The advisable values [2] are between 1 and 1,5.

We choice q = 1,3.

Next it should calculate approximate radius of the planet gears

$$r_2 = \frac{r_1}{1+q+\sqrt[2]{1+q^2}} = \frac{0{,}05}{1+1{,}3+\sqrt[2]{1+1{,}3^2}} = 0{,}01269 \text{ , m}$$

We accept $r_2 = 0{,}0125$, m

Then it should calculate the radius of the sun gear wheel:

$$r_3 = r_1 - 2.r_2 = 0{,}05 - 2.0{,}0125 = 0.25 \text{ , m}$$

Center distance between sun and planet wheels will be:

$$e = OC = r_3 + .r_2 = 0{,}025 + 0{,}0125 = 0.0375 \text{ , m}$$

The advisable values [2] of the distance between center S of mass of one unbalanced planet gear wheel to its axis C of rotation should be:

$$h = CS = 0{,}1.e = 0{,}1.0{,}0375 = 0{,}00375 \text{ , m}$$

Next, it should calculate the coefficients a and b of the impulse mechanisms. They connect linear velocity of the axis of the planet gear wheel with angular velocities of the ring gear wheel 1 and of the sun gear wheel 3 by means of formula:

$$v_C = e.\dot{\lambda} = a.\omega_1 + b.\omega_3$$

For the Levin's impulse epicyclic mechanism these coefficients are calculated as follow [1]:

$$a = r_2 + \frac{r_3}{2} = 0{,}0125 + \frac{0{,}025}{2} = 0{,}025\text{, m} \qquad b = \frac{r_3}{2} = \frac{0{,}025}{2} = 0{,}0125\text{, m}$$

On the basis of the condition for „neighbourhood" of the satelits (planet gear wheels) it should be satisfied the inequality:

$$n \le n_{\max} = \frac{\pi}{\arcsin\left(\frac{r_2}{e}\right)} = \frac{\pi}{\arcsin\left(\frac{0{,}0125}{0{,}0375}\right)} = 9{,}244 \qquad \text{So we choice } n = 8$$

The mass of the each planet gear wheel is calculated on the condition for overcoming of the maximal resistance torque at the output:

$$m = \frac{M_C}{\left[n.e.h.q.(\omega_1)^2.\left[1 - \frac{b}{e}.\left(\frac{b}{e} - q\right)\right]\right]} = 0{,}03488 \text{ , kg}$$

On the basis of approximate calculations or of the 3D model of the planet gear it is possible to determine the mass and moment of inertia J_B taken about axis of rotation of the planet gear (Figure 4).

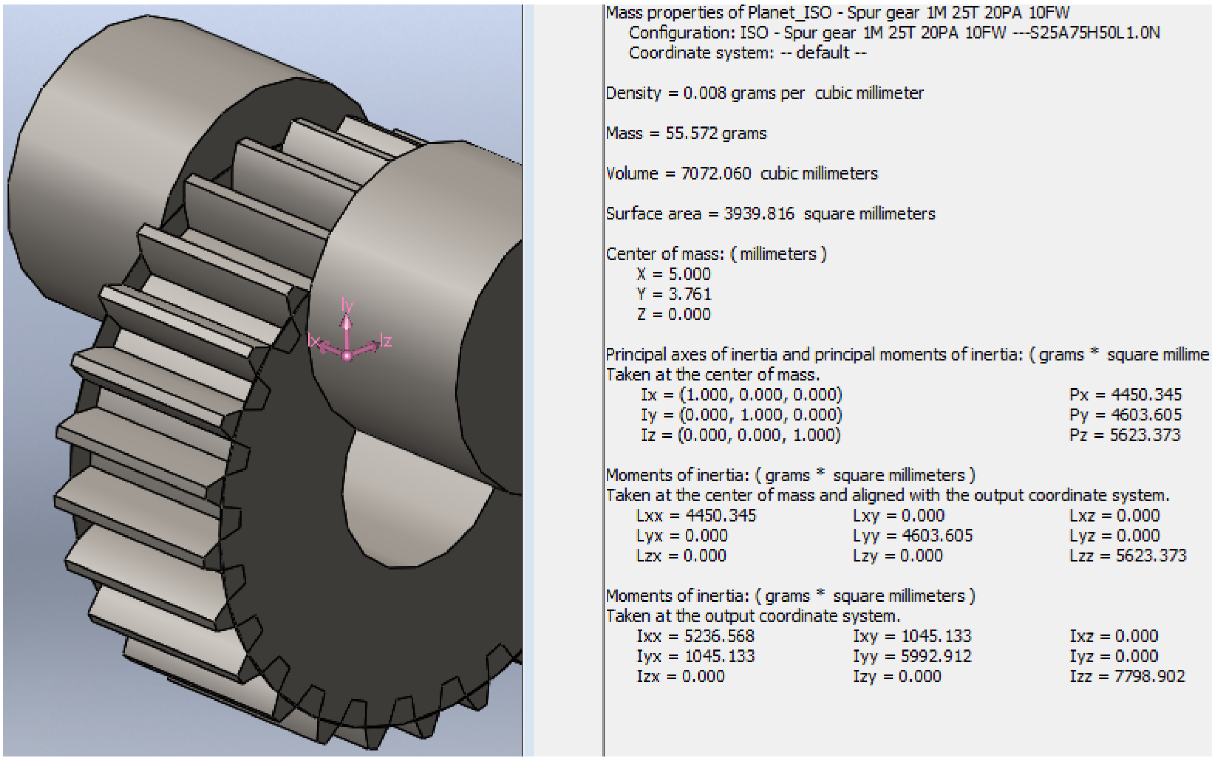

Figure 4. Mass properties of 3D-model of unbalanced planet gear wheel.

From Figure 4 it is shown that:

$$h = CS = 0{,}003761\text{ , m}$$

$m = 0{,}055572$, kg

$J_B = 5{,}236.10^{-6}$, kg.m^2

These three values are needed to calculate the moment of inertia of the intermediate shaft assembly 3 (Figure 1 b).

$$J_3 = 4.n.m.e.h - n.m.b^2 - n.J_B.\left(\frac{b}{e} - q\right)^2 - 2.n.m.b.h.\left(\frac{b}{e} - q\right) = 1{,}826.10^{-4} \text{ , kg.m}^2$$

The moment of inertia J_3 of the intermediate shaft assembly 3 should be less than 1,826.10^{-4} kg.m^2 for that the inertial converter of torque to could work as dynamic clutch at very low loading.

The determined basic parameters in such way are tentative. On their basis one can do the thorough mathematical model analysis and detailed design of that inertial converter of torque.

CONCLUSION

Above, the procedure of the determination of the basic design parameters of inertial converter of torque with one of most used impulse mechanisms (epicyclic gear impulse mechanism of Levin) has shown. The procedure regarding other epicyclic gear impulse mechanisms is the same, but there are differences in formulas of determining the parameters. More information could be found in [1] and [2]. A thorough mathematical analysis and detailed design after determination of the basic parameters are needed.

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AIR TRANSPORT PLAN OF GRINDED STRAW

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Abstract: This paper describes the design solution of technological milling - grinding, transport and production of briquettes from straw. The project is designed and implemented for "Victoria Group" in Zrenjanin. The paper contains a description of technological scheme of process, specification of mechanical and technological equipment, energy needs and measures of safety at work, pictures of machines and equipment and so on.
Key words: briquette, air transport, grinded straw.

INTRODUCTION

"Victoria Group" in Zrenjanin has built a production plant - briquetted biomass. Biomass that is specifically used in this case is a plant residue wheat "straw". Figure 1 shows the technological scheme of production of biomass briquettes from straw. Lower calorific value of straw is about 12 MJ/kg. It can be seen that there are two hammers, one for coarse grinding of straw, and the other for fine grinding of straw and two machines pellet mills for the production of the final product - pellet biomass. On the basis of performed measurements during operation of the plant, was established technical capacity of 2000 kg/h. Given that technical capacity is not achieved, it was performed reconstruction of grinding line and air transport straw. Technological scheme of the reconstructed line is given in Figure 1.

Each project of the production process - the system, has its own peculiarities. Depending on the type of installations and facilities, projects in some of its parts may have some similarities. This applies to general and technical requirements, which must be an integral part of every major technological and mechanical design.

In the framework of this paper is given some basic elements of the project such as: description of technological process, the scheme of technological process, support safety at work, pictures of machines and equipment and so on.

DESCRIPTION OF TECHNOLOGICAL PROCESS

Straw bales throw into box for straw. Belt conveyor put the straw in the hammer for rough grinding. Transport of straw to hammer for fine grinding is performed by pneumatic pipeline. The ground straw is further transported by means of pipelines, the cyclone 1 and 2, wherein the separation is carried out, i.e. extracted the straw from the air. From cyclone 1 and 2, by air stunts - rotary extractor, milled straw goes into the spiral conveyor 1 and 2, and then in the mixer and further it is transported to the briquetting machines, i.e. pellet press 1 and 2. Aspiration system is performed by using a bag filter for dust and fan 2. Pneumatic conveying line is suctorial type and transport is performed using two centrifugal fans 1 and 2. Briquettes are further transported by chain conveyor and elevator, to refrigerator and vibro sieve. After that briquetted mass is transported to a warehouse and in the boiler room for combustion. Technological scheme of the process is given in Figure 1.

As part of this study, it is given a conceptual technology solution of system - plants for the production of briquettes from biomass. Biomass that is specifically used in this case is a plant residue wheat "straw". The project has two hammers, one for the coarse grinding of the straw and the other for the finer grinding and two pellet machines for producing the final product, the pellets of biomass. The solution includes: Description of technological process, scheme of technological process, calculation of pneumatic transport of grinded straw, specification of mechanical and technological equipment.

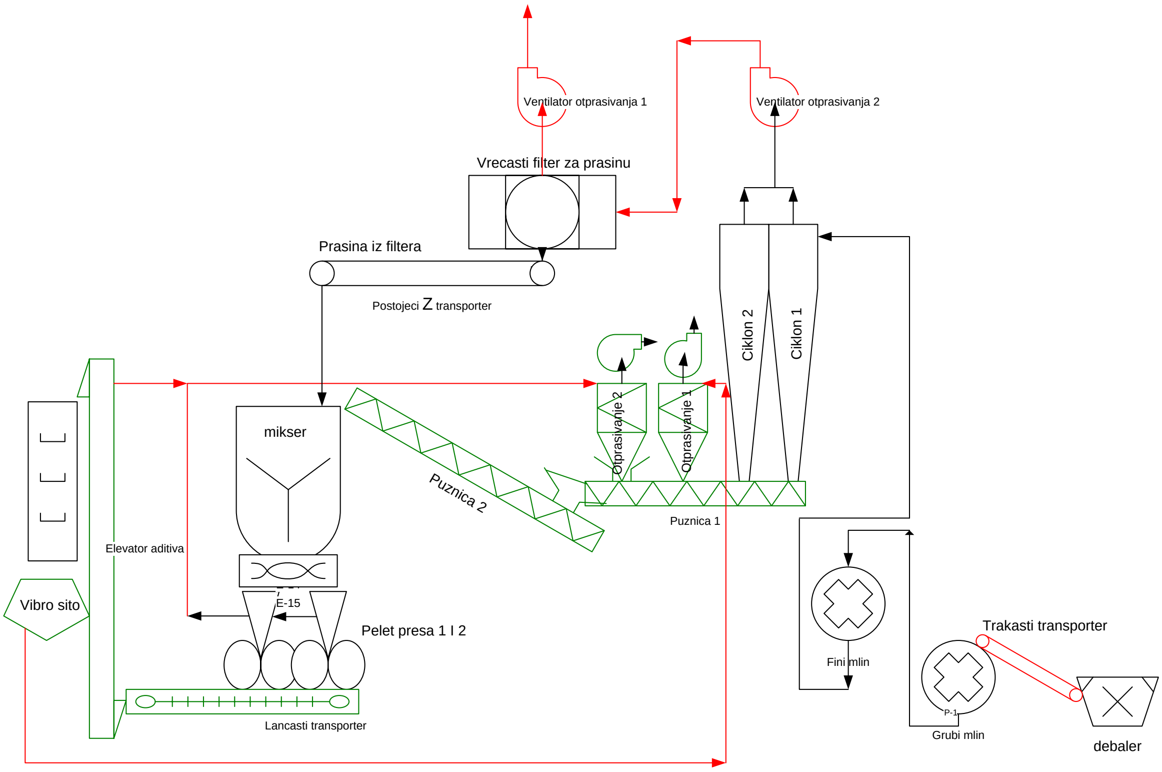

Figure 1. Technological scheme of production of briquettes from straw

Figure 2. Hammer for rough grinding of straw and transport

The total installed power is 423 kW. For operation of the production plant in two shifts which is 16 hours, if the coefficient of coincidence of work is 0,95, the power consumption is 423 x 16 x 0,95 = 6430 kWh. On that basis, the specific energy consumption for the production of pellets is 105,75 kWh/t i.e. 0,105 kWh/kg of pellets.

Figure 3. Hammer for fine grinding of straw and transport

Figure 4. Machines for peletting of grinded straw

MEASURES OF PROTECTION AT WORK

Work organization at protection in facility, first of all, should provide preventive care.

Previous measures of protection

All rotating parts (clips, pulleys, etc.) are protected with protective sheet metal. For the purpose of removal of static electricity, machines and devices connect to each other and earthed.

All flange connections - flange of elevators, pipeline, etc. bridge with the copper tape.

All machinery and equipment must be enclosed and therefore is strictly prohibited opening the cover and other protective elements during work. In the event of an audit or similar action on the machines, it must be ensured that the worker will look after to avoid a sudden release of machines in operation.

Machinery and equipment should be maintained as per the instruction of supplier of equipment. In case of necessity of welding and like this, it will be done only when the machines and devices out of operation with the previously performed preparation.

Employed staff at this facility must fully understand basic rules of safety, preventive measures to prevent fires, as well as handling of fire extinguishers.

Every employee must know the functions of certain machinery and equipment, and in a prominent place must be emphasized ban of using of faulty devices as warn of danger during the operation. Prior to the commissioning in operation of individual lines or machines, staff must warn by sound signal.

CONCLUSION

Plant for crushing - grinding and air transport of straw, capacity 4000 kg/h, built in company "Victoria Group" in Zrenjanin, allows the preparation of chopped straw for briquetting. Briquetting is performed on two machines for pelleting. After that, the pelleted mass is stored in a separate silo cell. The pellets are used for combustion in boilers for steam production. Lower calorific value of the briquettes is 16 to 18 MJ/kg.

Factory "Victoria Starch", in the process of wet processing in the most modern way, will produce syrup and starch from corn. Part of the capacity will be used for the storage of crop residues for the needs of the company "Victoria Group" in which structure "Victoria Starch" operates, and straw will be used for energy production. This method of operation is a good example to close the entire cycle of procurement of materials, processing of raw materials, production, and that it all performed in one facility to cut costs and particular to reduce the consumption of energy to be 2-3 times cheaper.

Company Victoria Logistic buys raw materials for all manufacturing capacities. Annually, it buys about 70 000 tons of straw from barley, wheat and soya which are necessary to produce cheap energy in all manufacturer capacities. To produce steam in a future plant for processing of corn daily consumption based on 300 tons of crop residues.

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ANALYSIS OF OPTIONS AND A SUMMARY MEASURE OF PROTECTION AGAINST ORGANIC DUST EXPLOSION IN MANUFACTURING PLANTS

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Abstract: Explosion of organic dusts can incite great material damages and injuries of workers. Therefore, within this paper is given a series of relevant data, that points out (some) potential possibilities of these occurrences in industrial plants and silos, as well as a sequence of preventive measures for protection.
Organic dust explosions can cause great material damages and injuries of workers. In this paper are presented some useful figures about conditions and sources for dust explosion in silos.
Key words: dust, explosion, industry, protection

INTRODUCTION

Buildings industrial plants, ware houses and various kinds of silos, demands expertness of properties for materials that will be stored, as well as knowledge of other factors. In this case we must take into consideration fire-explosive characteristics of material when we design industrial warehouses [4]. Properties of transported material cause choice of transport way, as well as transport devices, choice of deducting devices and filter material, as well degree of anti-explosive protection.
Transported materials in warehouses and silos may be, according to their properties, sorted into.
a) granular materials (mouse, wheat, barley, granular soy bean and the like).
b) coarse ground: pallet, briquette of mentioned materials and tapioca.
c) flour of mentioned materials, manioc and the like.
With transport, storage and deducting, i.e with work with mentioned materials, are notable the next physical properties:

- porosity,
- looseness,
- stratification,
- capability of sorption and desorption,
- features connected with change of heat and mass (humidity).

The characteristics of the mentioned materials from the aspect of deducting are:

- abrasion,
- hygroscopic,
- stickiness,
- explosiveness.

Each of the mentioned materials has got adequate degree of explosiveness and dustiness. The degree of explosiveness to which belong the above mentioned materials given according to [3]. The mentioned materials are of organic origin, they are inflammable, and on certain conditions in mixture with air become explosive.

CHARACTERISTICS AND EXPLOSION OF ORGANIC DUST

In various technological processes in: agricultural industry, food processing, chemical, pharmaceutical, textile industries and the like, may occur bringing into being explosive concentration of material in powder with air, as well as occurrence of static electricity in irregularly earthed machines and units. Therefore, it is necessary to know fire-explosive characteristics of material that should be taken into consideration, when one design silos and protects environment both within factories and in environment.

Explosions of organic dust in silos of cereals, sugar, flour and the like, can cause great material damages and workers' wounding. In the table 1, are cited statistic data for the place of explosion occurrence.
For every material that builds explosive mixtures with air there is minimal concentration that is fixed experimentally, and it moves between 10-15 g/m^3 and 200-250 g/m^3. Minimal energy can cause explosion, respectively ignition and moves between the limits from (10 to 100) mJ. The necessary quantity of energy for ignition is presented in table 1.

Table 1. Statistical data about the place of explosion occurrences

Place	**Number of explosion**	**Amount in %**
silos	62	21.3
crushers	38	13.1
conveyors (transporters)	32	11.0
cyclones	32	11.0
dry rooms	25	8.6
boilers	18	6.2
mixers	15	5.2
purifiers (filters, strainers)	6	2.1
dosators (adders)	2	0.7

When organic dust and air accomplish certain relation, and then occurs explosion, as well as with gases. Certain energy of ignition is necessary to cause ignition. It depends also on nature of dust, but every kind of explosive dust is danger for explosion. Statistical data about the causes of explosion appearance are cited in table 2.

Table 2. Statistical data of the causes of explosion appearance

Source of ignition	**Number**	**Amount in %**
mechanical spark	86	29.6
slow combustion (burning)	27	9.3
mechanical warming	26	8.9
electrical spark	27	8.3
warm surface	19	6.5
fire	24	8.2
self-ignition (spontaneous combustion)	17	5.8
welding	14	4.8
electrical machines	10	3.4
unknown causes	34	11.7
miscellanea	7	2.4

THE PREVENTIVE MEASURES OF PROTECTION FROM STATIC ELECTRICITY AND EXPLOSION

If we want to protect ourselves from dust explosion, we must eliminate all sources in industrial plants that could cause ignition by sparking or worming. At warehousing silos it is necessary to predict outlets, so called anti-explosive flaps in accordance with the standard VDI 2263 and VDI 3673 and in accordance with literatrure [1, 3, 4, 5]. For series of dusts energy necessary for ignition is very little, so one must prevent appearance of static electricity and electro-static voltage that cause explosions. In table 3, is minimal necessary energy that can cause ignition of dust clouds. Danger of static electricity appears when at one place gathers certain quantity of electricity and when it discharges through spark and that in limits of explosiveness can begin to burn explosive mixtures, steam and dust or explosive materials. Detailed measures and means for protection of static electricity are predicted in literature [3, 6, 7]. Explosiveness is eliminated by building in passive anti-explosive protection, as building in filter sacks with metal armature for discharging static electricity.

Table 3. Necessary energy for ignition

Material that produces dust	Necessary energy for ignition in (mJ)
wheat flour	50
sugar, castor and icing	30
rice	40
wheat	30
rye	27
barley	20
maize	23

At turn-round assemblies of transport machines and devices is necessary to build-in temperature transmitters on appearance of fire and explosion. If it is passable one should build in impellers of ventilators from non-sparking material.
After fixing reduces pressure that would be in power immediately after explosion in silo, one defines necessary size of explosion outlet at silo put in square meter of sheer cross-section. At explosion outlets are built-in inertial or membrane anti-explosive flaps. Because of safe work, anti-explosive flaps must react to super-pressure of 0.1 bar.
According to the standards VDI 2263 and VDI 3637, one defines sizes of explosive outlets at silos and calculation. In the literature [2], is given a diagram for defining of explosive outlet on silos. Reduced pressure is pressure that would appear in silo after explosion. If according to size of outlet is defined also reduced pressure, then during explosion damage will be far less (not so great), a lot of equipment will be saved and so time for repairing will be shorter.

CONCLUSION

Building of industrial plants and warehouses request the knowledge of explosive and fire properties of materials that will be stored.
Explosion of organic dust in industry can cause great material damages and workers injuries. Minimal energy that can cause explosion of mixtures of dust and air is from 10 to 100 mJ. On machines and devices one must prevent occurrence of static electricity that can cause electricity. On silos one should foresee counter explosion - CE flaps.
Reduced pressure is pressure that would be in silo after explosion. If according to size of outlet defined as well reduced pressure, then during explosion damage will be far less, enough of equipment will be preserved and so will shorten time for repair.
In this paper is cited the sequence of data, as:

- statistical data for place of explosion occurrence,
- statistical data for cause of explosion occurrence,
- way of defining for explosion outlets surface, and the like.

The given data can be usefully used by researchers, designers and users for the purpose of defining safety (precautions) measures against fire and explosion.

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EXPERIMENTAL EVALUATION OF EVAPORATION RATES FROM WATER SURFACE OF AN INDOOR SWIMMING POOL

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Abstract: Indoor swimming pool buildings consume a lot of energy annually. The most of the energy consumed is used to heat swimming pool water, and to maintain thermal comfort conditions in the swimming pool hall. Water evaporation from the swimming pool's free water surface can be considered a significant factor to energy efficiency of indoor swimming pool buildings. The properties of air flow over the water surface, and partial pressure difference of water vapour at water surface level and in the air above have the greatest effect on water evaporation rate from the pools suface. In this paper, properties of indoor swimming pool water and pool hall air and evaporation rates measured in a real indoor swimming pool building are presented and compared with data from the literature. A large scattering of results from the literature is found. It is found that most of the correlations either underestimate or overestimate water evaporation rates from indoor swimming pool water surface. Results calculated according to correlations found in literature are compared to the results measured in an indoor swimming pool.
Key words: water surface evaporation rate, indoor swimming pool, measurement

INTRODUCTION

Indoor swimming pool buildings consume a lot of energy for heating and ventilation. Energy in swimming pool halls is used for maintaining thermal comfort conditions in the swimming pool hall and for maintaining the pool water at desired temperature. In indoor swimming pool buildings 45% of energy is used for pool hall ventilation, 33% for heating pool water, heating and ventilation of the rest of the building accounts for around 10%, 9% of energy is used for lighting and equipment and sanitary hot water accounts for 3% of total energy consumption [1]. The highest thermal loads in indoor swimming pool buildings, often originates from water evaporation from the pool water surface [2].

WATER EVAPORATION FROM THE SWIMMING POOL FREE WATER SURFACE

There are many mathematical models representing efforts to describe the physical phenomena of water evaporation from a free water surface [4-14] and most of them are empirical or semi-empirical, heavily relying on measurement results from experiments on either real objects or scaled laboratory installations with controlled parameters. Simultaneous transport of heat, mass and momentum occurring during this process with two phase flow, make it's modelling difficult. In a general case, water evaporation rate from a surface depends on the air flow above the water surface, and the gradient of partial pressures of water vapour at water level and water vapour in the air above the water. Correlations for predicting water evaporation rate from a free water surface to both still and moving air can be found in literature [4-14]. Bowen (1926) provided a general solution for determination of heat transfer by convection and evaporation from a water surface of an element of volume for three different conditions [11]. In order to do this, he first determined a model of vapour diffusion from a unit area. Most of the correlations are based on the Daltons theory, but there are also attempts of creating correlations based on analogy between heat and mass transfer [7, 11], where a ratio between heat loss by conduction to heat loss by evaporation is determined. Many evaporation models are analyzed or reviewed in literature [7-14], but even for detailed numerical simulations [12, 15] it is necessary to first determine the evaporation rate from the water surface and the evaporation rate coefficient.

Heating and ventilation equipment of swimming pool halls usually consists of supply and return ducts spread on several locations throughout the hall, which cause complex air movement in the hall and contributes to forced evaporation. Experimentally obtained correlations for predicting evaporation rates from a water surface of indoor and outdoor swimming pools, as well as ponds, lakes etc. are a function of air velocity above the water surface [7]. Air velocity over the indoor swimming pool water surface is not uniform, but extremely complex, where the intensity and direction of the air velocity vector show large variations over time. This can be seen in results of a CFD simulation of a public swimming pool [12], where air temperature and humidity at the air return intake was measured and compared to the simulation results with acceptable agreement between the two. Most of the simulated air velocities were up to 0.2m/s, but there were also some slightly higher values. In addition, apart from air velocity, the nature of air flow over the water surface in indoor swimming pools has a strong influence on evaporation, which is determined by the influence of Reynolds number and Sherwood number [15].

The first equation of evaporation from free water surface was given by Dalton (1802) [6], when it was found to be proportional to the partial pressure difference of water vapor near the boundary surface p_{sw} and away from the surface p_v :

$$-dE = K\left(p_{sw} - p_v\right) df_{sw} \tag{1}$$

Where df_{sw} is an element of evaporation surface, dE is evaporation rate per unit time, and K is a coefficient affected by properties of air flow over the boundary water surface. Evaporation rate can also be determined according to Lewis as:

$$-dE = K_E\left(x_{sw} - x\right) df_{sw} \tag{2}$$

Here, K_E is the evaporation rate coefficient given in (kg/s m^2), which is again affected by the properties of air flow over the boundary water surface. It is usually given as a linear function of air velocity in a general form:

$$K = A + BV_a \tag{3}$$

Where, V_a is the velocity of air above the free water surface, A and B are correlation constants. Values of this coefficient from literature is given in Table 1.

Table 1. Correlation coefficients found in literature

Author	Correlation coefficients of eq. (3)	Application
McMilan	A=0.0360; B=0.250	Lakes
Chernecky	A=0.05053; B=0.06638	swimming pools
Carrier	A=0.088403; B=0.001296	Solar Pond
Hahne and Kübler	A=0.0850 B=0.0508	Outdoor swimming pools
Rohwer	A=0.0803; B=0.0583	Laboratory model
Smith et. Al.	A=0.0888; B=0.0583	Swimming pool
Smith et. Al.	A=0.0638; B=0.0669	Outdoor swimming pool
Himus and Hinchey	A=0.1538; B=0.06898	General
Lurie and Michailoff	A=0.109; B=0.0859	General

A review and comparison of mathematical models for predicting evaporation rates by Sartori [7], indicated a large scattering of results obtained using investigated literature correlation models. Here, it is also indicated that some of the models neglect the impact of relative humidity of the air, and might be discarded as such. Sartori provided a correlation model, where evaporation is a coefficient of Air velocity to the power of 0.8, and length of the water surface, instead of actual water surface. Shah proposed a model where evaporation rate coefficient equals to 0.00005 [13,14]. Asdrubali at al, determined values of the corelation coefficient for air velocity values of 0.05 m/s, 0.08m/s and 0.17 m/s, equal to 3.4 x 10^{-8} , 4.2x 10^{-8} and 5.2 x 10^{-8} respectfully, based on results from a laboratory indoor swimming pool scale model [5]

Measurement description

Empirical equations strongly depend on the conditions of the experiment i.e. results they are based on. According to Sartori, one empirical evaporation prediction equation is necessary for each class of these conditions [7]. There are differences of height of the point above water level where air velocity is measured, which usually ranges from 0.3-10m, however most of the heights range from 0.5-2m for which the differences in results are not significant and are considered not to affect results [3,5,7,10]. Smith et al performed measurements on an outdoor swimming pool, where water body temperature was kept at 28.9 ºC, which was monitored using thermo couples. Pool water level was monitored using a microtector gauge, whereas wind speed was monitored using a rotating cup anemometer at 0.3m above the pool. Tang and Etzon, compared water evaporation from free water surface and wetted water surface, for which they constructed two identical water "ponds", and found that the evaporation rate of from a free water surface is proportional to the difference in partial pressure of water vapour at water temperature and air above it to the power of 0.82 [4]. Ruiz and Martinez measured relevant parameters of water and air at the border of an outdoor pool, at 0.5m above water level, and water temperature was measured 1m below water surface, but evaporation rate was not measured, instead it was calculated using correlations from the literature which lead to difference in results [8]. Asdrubali created a scale model of an indoor swimming pool, and measured evaporation rates for velocities of 0.05m/s, 0.08m/s, 0.17m/s and relative humidity 0.5, 0.6 and 0.7 [2], but the air flow in the laboratory model could be considered uniform and the air flow originating from a typical duct ventilation system in a pool hall is extremely complex. Smith et al [10] used shallow aluminium floating evaporation pans with diameter of 20cm, to determine short term evaporation from an outdoor swimming pool, but such small pan evaporation surface and the air flow above it are either affected by pan walls, or permit water penetration, thus affecting reliability of the results.

Results presented in this paper were acquired by measuring air flow speeds at 5 points along the pool border, at 0.65m above water level in the direction of the air flow coming from the ventilation ducts. Average air velocities ranged from 0.01m/s to 0.07 m/s at the opposite ends of the pool border, and from 0.15m/s to 0.34 m/s at the middle of the pool border. Water temperature was measured 1cm below water level using a thermo couple probe type K probe. Relative humidity and temperatures were measured 1cm above the water level and 90cm above water level. Evaporation rate was measured each hour using an evaporation pan with a needle, with diameter of 0.8m, which was immersed in the pool water 1.3 meters from the pool border. The diameter of the evaporation pan was chosen so it would be big enough to account for the affect of the complex air flow above the water surface in the pool hall. Evaporated water is measured with a precision of 1g every hour.

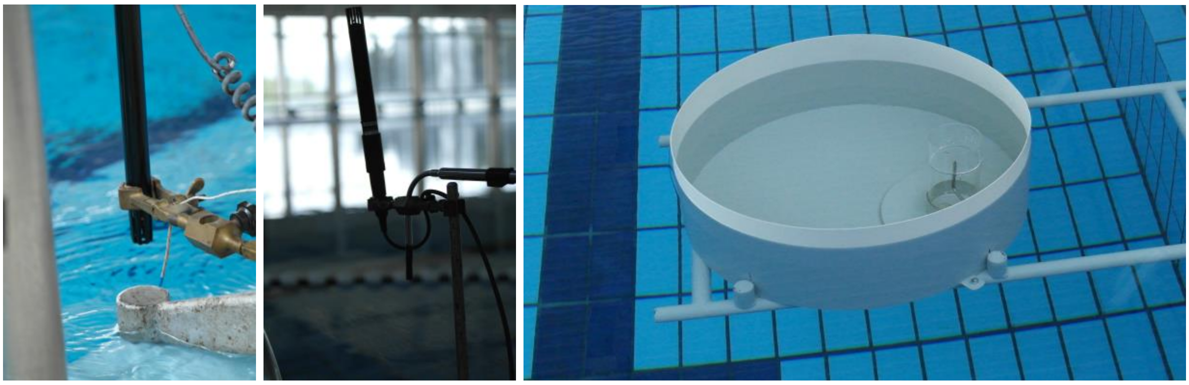

Figure 1. Measurement apparatus

RESULTS AND DISCUSSION

Results are obtained and collected in a the hall of active indoor swimming pools, in the Sport and Recreation Center, Dubocica in Leskovac in the period from May to August. The following apparatus was used (fig. 1.):

1. TESTO 454 with 0420 relative humidity and air temperature probe,
2. Cole Palmer 37950-12 relative humidity sensor with air temperature probe,

3. AIRFLOW TA5 anemometer with thermometer,
4. Thermo couple type K water temperature probe,
5. Evaporation pan with a needle.

Some of the evaporation rate results are discarded, since they were affected by activity of the swimmers causing water penetration into the evaporation pan. Evaporation rate E as function of air velocity Va is given in Fig. 2.
In Fig 3, measured evaporation rates are presented as a function of the difference of partial pressures of saturated water vapour at water surface temperature and partial pressure of water vapour of air above water level (eq. 4), calculated in Pa according to IAPWS Industrial Formulation for the Thermodynamic Properties of Water and Steam.
It can be observed from Fig 2. and Fig. 3. That the evaporation rates mostly rise with the increase of air flow speed above the water surface, and generally increases with the increase of difference of partial pressure of water vapour at water surface temperature and air above water surface.

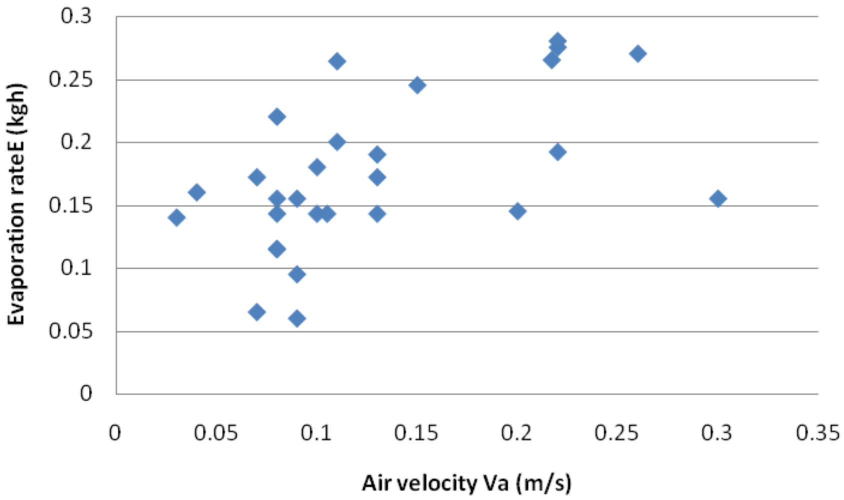

Figure 2. Measured evaporation rates as a function of measured air velocity.

This is kind of relationship is in concordance with the majority of correlations found in literature. The measured results also showed a strong dependence on the air flow velocity. A significant drop of air velocity caused by the swathed off ventilation system, caused a drop of air velocity to near zero values, which led to low values of evaporation rates despite relatively high partial pressure difference gradient. This can be observed in Fig. 3.

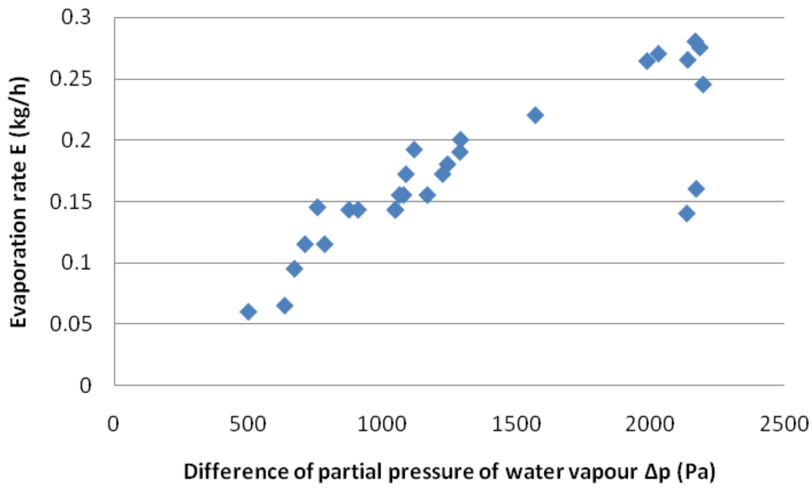

Figure 3. Measured evaporation rates as a function of difference of partial pressures of water vapour ($\Delta p = p_{sw} - p_v$)

Obtained results are compared to the values from literature. Most of the authors provided correlations for predicting evaporation rates based on known relevant air and water parameters. Most of the evaluated results from literature correspond to outdoor swimming pools [3, 5, 8, 10] representing usually higher air flow velocities which originate from wind, and are affected by direct solar radiation. Asdrubali [5] measured evaporation for speeds of 0.05m/s, 0.08 m/s and 0.17m/s, which is a good mach to air velocities found in a real indoor swimming pool hall, and reported evaporation rates in the range from 0.07-0.15 kg/h for relative humidifies between 50% and 70%. His results show a decrease of evaporation rates with increase of relative humidity of ambient air, which is related to the trend of change of the difference of partial pressures of water vapour at water temperature and air above the water level. One evaporation coefficient was determined for each of the tested cases, however a correlation as a general solution of the problem in the tested domain was not reported.

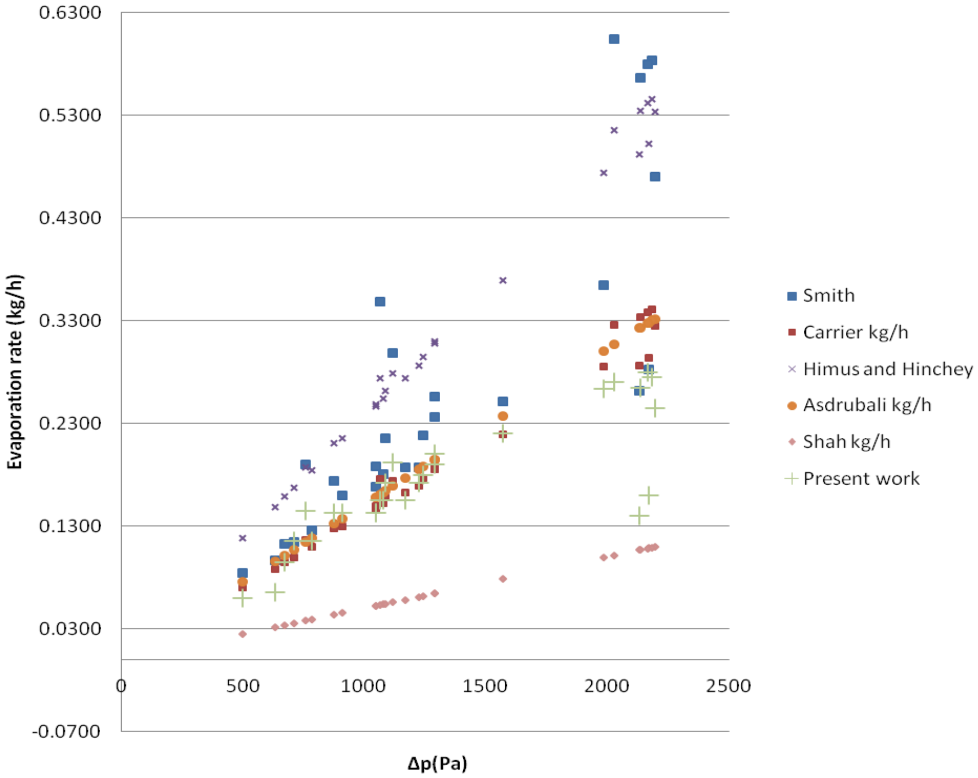

Figure 4. Measured evaporation rates as a function of difference of partial pressures of water vapour (eq.1)

In his research, the temperature difference of water and air was kept constant at 2°C. Although this is a recommended temperature difference found in engineering design handbooks [4], other scenarios could occur in reality as shown in the results in TABLE I. Shah [13,14] provided correlations for predicting evaporation rates of indoor swimming pools, but he used data from literature to fit correlation curves. Therefore, measured data are compared to the values obtained using correlations for calculating evaporation rates found in literature. Results obtained using most typically used correlations from literature are compared with the measured data in Fig. 4.

It can be observed that some of the correlations, such as Smith's and Himus and Hinchey's significantly overestimate the evaporation rate for indoor swimming pools, while Shah's correlation underestimates the Evaporation rate of indoor swimming pools.

CONCLUSION

Water evaporation from the water surface of an indoor swimming pool was measured, as well as relevant parameters for its prediction. Measured results are presented in the paper and compared to the results obtained using correlations for predicting evaporation rates from a water surface from the literature. It was found that most of the equations either overestimate or underestimate the evaporation rates.

A new correlation should be fitted according to the measured data to ensure good prediction of evaporation rates for the purpose of indoor swimming pool building modelling and simulation.

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BIOFUELS: FUTURE BENEFITS AND RISKS

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Abstract: Biomass continues to be investigated as an alternative resource to resolve the demanding consumption of petroleum-based gasoline and diesel fuel. In addition, biomass can be used to provide bio-oil, biogas, and hydrogen as well as electricity. The growing demand for alternative energy sources has contributed to increased biofuel production, but the effects on biodiversity of land-use change to biofuel crops remain unclear. As a result and in order to minimize impacts of biofuel crops on biodiversity, management practices that reduce chemical inputs, increase heterogeneity within fields, and delay harvests within wildlife areas are recommended. There is also the need to address the growing challenge of climate change by closer scrutiny of biofuels to assess whether they can be produced, traded and used sustainably. Criticism of biofuels has centered on the perceived negative impacts on the environment through deforestation, spread of monocultures, loss of biodiversity and possible higher GHG emissions under uncontrolled land-use change. The potential of biofuels to contribute to a shift into more sustainable energy systems has been contested, and scientists had to move away from emotional preferences and question the claimed environmental superiority of biofuels.
Key words: Biomass, biofuel, hydrogen.

INTRODUCTION

The term biofuel is referred to as liquid or gaseous fuels that can be used to supplement the demand for petroleum-based liquid fuels. Furthermore, biomass offers a sustainable source of liquid and gaseous fuels with the further promise of a reduction in the amount of greenhouse gas emissions as well as playing a role as a co-feedstock in the refinery of the future (Reijnders, 2006; Speight, 2008, 2011a, 2011b, 2011c). Furthermore, the widespread availability opportunities of biomass resources may also allow the petroleum-importing counties to enjoy a measure of self-sufficiency in energy production (2011b).
Biofuels, unlike fossil fuels, are a renewable energy source and the raw material (biomass) is are grown all over the world and include: (1) corn and soybeans, mainly in the United States, (2) palm oil in South East Asia, (3) rapeseed mainly in Europe, (4) sugar cane in Brazil, and (5) jatropha in India. In addition, food waste such as cooking oil can also be used as a feedstock to produce biofuels as can waste products such as straw, timber, cattle manure, and sewage (Gabrielle, et al., 2014). Furthermore, biofuels have (correctly or incorrectly) been recognized hailed as the answer to two major issues: (1) moving away from the heavy reliance on petroleum and (2) climate change. However, biofuels may not be the panacea they have been made out to be and are worthy of a thorough analysis of the benefits and risks of using and producing such fuels.

BIOFUELS

There is no doubt that the supply of crude oil is finite and the flow of petroleum to refineries will eventually become unsustainable as supply/demand issues are erode by the depletion of the resource. However, the precipice will not appear suddenly and *out-of-the-blue* (as many observers seem to think). With adequate pre-planning and consideration of the resource availability in terms of real numbers, the peak-oil-production situation can be mitigated by the exploitation of more technically challenging fossil resources and the introduction of technologies for fuels and chemicals production from biomass. Consequently, in addition to the variety of potential energy-production technologies (Speight 2008), there is a renewed interest in the utilization of plant-based matter as a raw material feedstock for energy and chemicals production (Speight, 2008, 2011b). Plants accumulate carbon from the atmosphere via photosynthesis and the widespread utilization of these materials as basic inputs into the generation of power, fuels and chemicals is a viable route to reduce greenhouse gas emissions.

While the use of biomass may not be the ultimate source of energy, the production of fuels and chemicals from renewable plant-based feedstocks utilizing state-of-the-art conversion technologies presents an opportunity to fend off any potential energy crises which arise from the depletion of petroleum resources. However, bioprocessing routes have a number of compelling advantages over conventional petrochemicals production but in the last two decades rapid progress in biotechnology has facilitated the commercial development of plant-based processes with the emergence of the biorefinery concept, which is analogous to conventional petroleum refineries and petrochemical complexes that have evolved over many years to maximize process synergies, energy integration and feedstock utilization (Speight, 2008, 2011).

Plants offer a unique and diverse feedstock for energy and chemicals production. For example, biomass can be gasified to produce synthesis gas, which is a basic source of hydrocarbon fuels and chemical feedstock as well as a source of hydrogen for a future hydrogen economy (Chadeesingh, 2011; Speight, 2013a, 2013b, 2014). In addition, the specific components of plants such as carbohydrates, vegetable oils, plant fiber and complex organic molecules known as primary and secondary metabolites can be utilized to produce a range of valuable monomers, chemical intermediates, pharmaceuticals and materials. Furthermore, a simple, cheap, and common method of obtaining energy from biomass is direct combustion. The heat of combustion can be used, through the use of a steam turbine, to produce electricity (Speight, 2013b).

Thus, almost all crops, whether grown for food, animal feed, fiber or any other purpose, result in some form of organic residues after their primary use has been fulfilled. These organic residues, as well as animal wastes (excrement) can be used for energy production through direct combustion or biochemical conversion. Current worldwide production of crop residues is very large; but an increased scale of use for fuel may have significant environmental impacts, the most serious being those of lost soil fertility and soil erosion.

Benefits

Biofuels have the potential to be a sustainable, low carbon fuel source and at a time when the depletion of petroleum reserves becomes obvious biofuels could be crucial factors in world energy production. Thus, with effective management and global compliance (Nasterlack et al., 2014), the biofuels industry could help to reduce the greenhouse gas emissions from transport, alongside increased fuel efficiency and public transport improvements. However, whether or not biofuels can replace *all* of the crude oil that is currently used for energy and chemicals, it may not be possible to grow sufficient biomass without serious consequences for the environment and people. It has to be recognized that biofuels may only be part of the answer to provide energy after petroleum production has peaked and there will be limits to the amount of biofuel feedstocks that can be grown due to conflict with current land uses – growing food, forests, and human habitation. Food prices could increase significantly as crops once destined for food are sold for fuel instead.

Indeed, various national governments are insisting (even legislating) that petroleum refining companies start to use some biofuels in the fuel they sell. There is widespread support for an alternative to traditional fossil fuels. However, the possible negative impacts of a huge growth in biofuels are beginning to be realized.

In theory, biofuels are *carbon neutral* insofar as the carbon released (as carbon dioxide) when they are burned was taken from the atmosphere by the plants as they grew. However, the energy needed to transport and refine crops usually comes from fossil fuels and the chemical fertilizers and pesticides used in growing the crops require energy and cause nitrous oxide to be released. Potential climate benefits can be lost or limited this way. In addition, agricultural chemicals can make their way into water supplies, contaminating drinking water and killing aquatic life. The availability of water can also be affected if supplies are diverted to irrigate crops leading to the risk of drought in some areas.

As an example, one of the biofuels with the most contentious issues is palm oil – demand for palm oil from both the food and biofuel industries has led to massive expansion of oil palm tree plantations. This, in turn, requires clearing land for use as these plantations and the land cleared is often is often rainforest. Thus, natural habitats are lost and the biodiversity of the Earth, including many endangered flora and fauna will be threatened and eventually lost. The destruction of ecosystems such as rainforests has indirect impacts on people as well. The forests are responsible for regulating water

flow and protecting soils; many people also depend on them for food and medicines. Destroying ecosystems can even lead to outbreaks of disease. These effects are felt most by the poor who are more dependent on the natural environment.
The implosion of new fuels, in this case biofuels, will have implications across many business sectors and in a time when interest in *being green* is high, the race to secure safe, sustainable stocks of biofuels is already in place. In fact, with a focus on the environment and worries about crude oil reserves becoming depleted, governments across the world are understandably getting involved to encourage the growth of the biofuels industry.
In 2007, EU leaders agreed on an integrated climate and energy policy which includes ‘a 10% binding minimum target to be achieved by all Member States for the share of biofuels in overall EU transport petrol and diesel consumption by 2020. At first glance, many would see this as a step forward. However, if not implemented sustainably, it could actually set us back. In the UK, the government claims that the Renewable Transport Fuel Obligation (RTFO) will deliver substantial carbon savings but this assumes that biofuels will (pound for pound) emit less than half the carbon (dioxide) of fossil fuels and this is often not the case at the moment. Until there is a move to a system where only biofuels from sustainable sources are eligible for RTFO certificates, there will be no positive carbon balance. In the US, the strategy is to cut petroleum consumption by 20% by 2017, which is to be achieved (in part) by replacing approximately 15% of the gasoline used in vehicles with renewable fuels or biofuels. This will require the production of biofuels to increase five-fold to meet projected demand.
However, biofuels do present the opportunity of a more environmentally friendly alternative to crude oil, but there is a risk of doing more harm than good if sustainability is not made a priority. If managed properly, biofuels could form part of the solution in the fight against climate change.

Risk Assessment

The quality and composition of a biofuel depends on the source of the biomass/feedstock as well as the types of processing and conversion techniques utilized in its manufacture (Ramroop Singh, 2011). The feedstock composition ultimately decides the yield from the chemical or biochemical conversion processes, which in turn, affects the production economics. There are many plant varieties which are used as biofuel sources - the geography, weather conditions, soil composition and legislation of a location normally dictates what types are grown specifically for biofuel production.
Furthermore, the risks that arise from the production of the raw starting materials for biofuels production can cause serious problems – for example the destruction of rainforests while in some places people may be forced from their land. Furthermore, greenhouse gas savings of some biofuels may even be just as bad as crude oil!
Agricultural feedstocks are critical for decreasing petroleum dependence through sustainable biofuels production. Continued rapid improvements in both biofuel resources and processes are needed if agricultural biofeedstock crops are to significantly address concerns about the depletion of fossil fuel reserves, energy security and greenhouse gas emissions as contributors to climate change (Antizar-Ladislao and Turrion-Gomez, 2008). The current first generation biofeedstock crops represent modification and the use of food-based grains for biofuel production. These will be largely supplanted by second generation crops representing specialized industrial oilseed crops and the utilization of lignocellulosic crops and crop residues (Gressel, 2008). Unless, and until, third generation technologies using algae and bacteria become a reality, plant-based agriculture – with the attendant tradeoffs regarding land use alternatives and the balance of needs for food, feed and fuel production – will remain the leading opportunity for biofuel production.
Briefly, risk in any area is the joint probability of exposure and the consequence of exposure, the conventional risk assessment process describes exposure and its consequence (an adverse effect or harm) in four steps: hazard identification, dose-response, exposure characterization and risk characterization (EPA, 1998). Risk is assessed through a science-based process that integrates with risk management to facilitate informed decision-making.
The long-term success in developing sustainable bioenergy resources is frequently tied to perennial herbaceous and woody plants such as switchgrass (*Panicum virgatum*) and poplar (*Populus*) for ethanol production or jatropha (*Jatropha curcas*) for biodiesel production (Speight, 2011c). The

targeted attributes for an ideal bioenergy crop vary, depending on whether the objective is a dedicated biofeedstock crop or a food and fuel crop. Nevertheless, in those cases where range and forest plants are targeted as dedicated biofeedstock crops there will be a need for domestication in order to improve agronomic performance, uniformity, quality and productivity. These crops will also need to undergo compositional modifications, for instance to better affect the conversion of lignin, cellulose and other cell wall polysaccharides to ethanol or to improve yield and quality of the bio-oils.

Food versus fuel is the dilemma regarding the risk of diverting farmland or crops for liquid biofuels production in detriment of the food supply on a global scale (Speight, 2008; 2011c). There is disagreement about (1) the cause, (2) the impact is, (3) the overall significance of such an issue, and (4) the resolution. Biofuel production has increased in recent years and some foodstock commodities such as corn, sugar cane, and vegetable oil can be used either as food, feed or to make biofuels. For example, vegetable oils have become more attractive recently because of its environmental benefits and the fact that it is made from renewable resources (Demirbaş, 2008). Vegetable oils are a renewable and potentially inexhaustible source of energy with energy content close to diesel fuel. On the other hand, extensive use of vegetable oils may cause other significant problems such as food shortages in many countries (Demirbaş, 2007).

The need to address the growing challenge of climate change has led to closer scrutiny of biofuels to assess whether they can be produced, traded and used sustainably. Criticism of biofuels centered on the perceived negative impacts on the environment through deforestation, spread of monocultures, loss of biodiversity and possible higher GHG emissions under uncontrolled land-use change. Moreover, the food crisis of 2007-08 and the ensuing surge of commodity prices heightened the debate over food versus fuel and the possible consequences of biofuel production on food security. The potential of biofuels to contribute to a shift into more sustainable energy systems became contested, and scientists had to move away from emotional preferences and question the environmental superiority of biofuels.

Biofuel certification schemes, despite their multiplicity, are dominated by a singular form of governance – namely voluntary, private industry-led initiatives targeting sustainability assurances with input from non-industry stakeholders. These schemes are driven as much by market access and trade considerations as by the need to provide sustainability assurances. This may explain why the first schemes and initiatives have focused on those feedstocks and biofuels most involved in south-to-north trade (soybeans, sugarcane and oil palm). This dual role of biofuel certification schemes also explains the tendency to target selected sustainability criteria and not others and hence the absence of a full integration of the three core dimensions (economic, environmental and social) into a coherent framework or strategy.

Rethinking sustainability also requires incorporating full environmental costs in economic cost-benefit assessments and fostering business models that can reconcile sustainability with economic growth and integrate inclusive-development with food security. Also required are policies, regulations and incentives that broaden the biofuel development options to include small-scale locally harnessed renewable energy technologies and systems.

Finally, biofuel sustainability will need to be integrated into major trends that focus on sustainability and climate-smart agriculture in line with the triple objectives of enhanced productivity, strengthened food security and climate change adaptation and mitigation.

CONCLUSIONS

The growing demand for alternative energy sources has contributed to increased biofuel production, but the effects on biodiversity of land-use change to biofuel crops remain unclear (Robertson and Doran, 2013; Dauber and Bolte, 2014). To minimize impacts of biofuel crops on biodiversity, management practices that reduce chemical inputs, increase heterogeneity within fields, and delay harvests until breeding seasons have ceased are recommended.

From the perspective of sustainability, biofuels offer not only advantages but also risks:

Advantages	*Risks*
Contribute to increased energy security	Negative impacts on biodiversity
Help reduce GHG emissions	Replace of natural forest with biofuel crops
Improve air quality in cities	Influence water availability
Spur growth in rural areas	Influence water quality
	Adversely influence GHG emissions due to indirect land-use change

Indeed, balancing the economic benefits with environmental and social impacts is a delicate act. Even when biofuels meet environmental and social sustainability criteria, they need to first pass the economic sustainability (or viability) test. This means ensuring efficiency of production (through high yields and intensive management) and long run profitability, access to productive resources (e.g. land, labor, technology), and reliable output markets. The challenge is to achieve these goals while ensuring economic viability and minimizing potential negative social and/or environmental impacts.

Many of the initiatives on biofuel sustainability at the country or supranational levels come from industrialized economies where biofuel growth has been most dynamic and where there is large scope for bioenergy demand and huge energy substitution possibilities. Sustainability initiatives coming from Europe or North America largely mirror the industrial economies' priorities for biofuels (e.g. energy security supply, protection of agriculture, and increasingly climate-change mitigation).

Finally, the need to address the growing challenge of climate change has led to closer scrutiny of biofuels to assess whether they can be produced, traded and used sustainably. Criticism of biofuels has centered on the perceived negative impacts on the environment through deforestation, spread of monocultures, loss of biodiversity and possible higher GHG emissions under uncontrolled land-use change. The potential of biofuels to contribute to a shift into more sustainable energy systems has been contested, and scientists had to move away from emotional preferences and question the environmental superiority of biofuels.

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CUSTODY TRANSFER METERING AND SAMPLING SOLUTIONS FOR OIL, GAS, PETROL AND CHEMICAL PRODUCTS USING BY BPMN AND HMI APPLICATIONS

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Abstract: The modeling and execution of business process in every industry is usually a complex task. It consists of two phases: the design and the technical realization which are often spread among different roles The essence of measuring the flow of oil and petroleum products in refineries, especially custody transfer metering systems and sampling systems, are based on a prescribed periodic certification to be valuable measures, according to international standards, which include the legal metrology and is applying in the same way in practice in countries all around the world. In this paper, we will present using Business Process Modeling Notation and InTouch HMI 10.0 software package for developing Supervisory Control And Data Acquisition application and modeling of sampling system in oil refineries. Our approach benefits, from building upon a standardized graphical notation and from using flexible software.
Key words: BPMN, SCADA applications, InTouch HMI, custody transfer metering systems, sampling systems, oil, gas, petrol and chemical industry.

INTRODUCTION

The Business Process Modelling Notation (BPMN) is an important standard for the graphical representation of business processes. 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 medicine [1], higher education [2], [3], computer science [4], Oil and Gas industry [5, 6] etc. For that reason, BPMN is the most recognized language for specifying process workflows at the early design steps [4], [7], [8], [9], especially as a starting point for software service design [10].
In our paper, we use Microsoft Office Visio 2007 for creating BPMN diagrams, in process modelling of sampling 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 application. HMI application has been developed entirely in ArchestrA System Platform 2012 software environment. Alarm and event history were stored within standard InTouch SQL database, but historical data logging was done in a custom made Microsoft SQL Database. This software package is a very useful 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. Advantages of the system are its mobility, simple and quick installation, user friendly usage and accessibility. Legislative unique metrology for sampling systems is used all around the world in area of Oil and Gas industry. In our country the sampling system must be performed in accordance with „Law of planning and construction" ("Official Gazette of Republic of Serbia, NO. 47/2003 and 34/2006, „Law on security and health at work in Republic of Serbia" and „Fire protection and prevention Act ".
The remainder of this paper is structured as follows: in the first section we will give overview of the main graphical representation of BPMN concepts using Microsoft Office Visio tool. In the second section we will summarize the main issues of using BPMN, human machine interface (HMI) SCADA

applications and in-line sampler system. Third section presents a example BPMN diagram of business process of sampling system in refineries parallel with SCADA application. The fourth section contains discussion and the most important conclusions of this paper. Finally, in fifth section we will present our future work about this subject.

BPMN GRAPHICAL CONCEPTS

BPMN has emerged as an important open standard graphic notation for drawing and modelling business processes (Figure 1.), [11], [12], [13. 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 2007 is software that enables creating diagrams by the BPMN specification, including set of patterns. That patterns can be imported into Microsoft Visio software. Business process diagram (BPD) is made by importing BPMN graphical tools into Visio workspace. BPMN diagram is synonym for BPD. When the modelling of business process is complete, diagram can be saved in various formats: JPEG, XML drawing, AutoCAD drawing, Web page, Windows Bitmap and other.

A Business Process Model (BPM) 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 subprocess. 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, Sub-Process, and Task (Fig. 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 behaviour Decisions/branching (exclusive-XOR, inclusive-OR, parallel – AND, and complex). BPMN extends the behaviour 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 (Fig. 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 (Fig. 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 (Fig. 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.

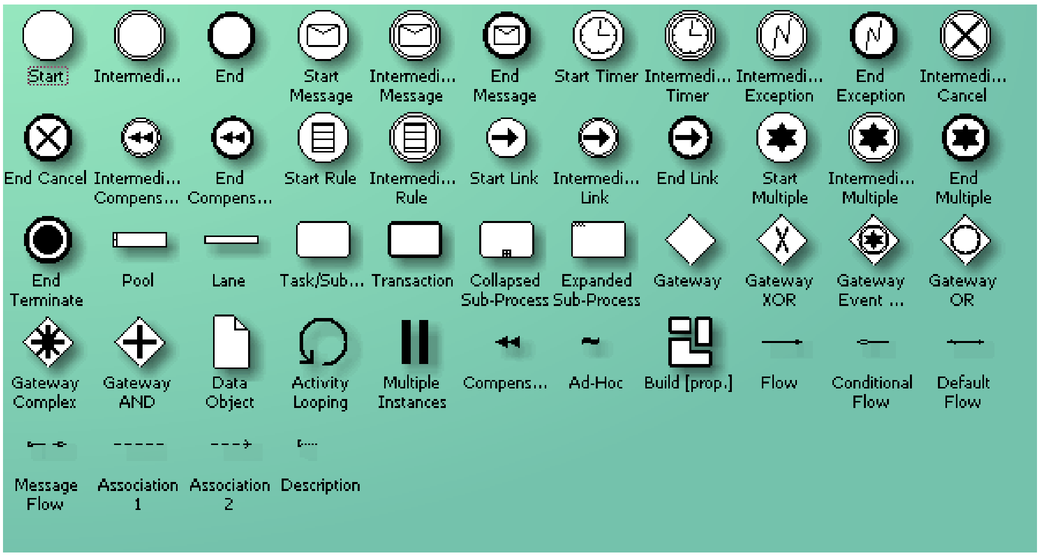

Figure 1. Graphical representation of BPMN concepts using MS 2007 VISIO tool

MATERIALS AND METHODS

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 [14], [15], [16], [17]. 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 [14]. BPMN is therefore contributed to the development of more efficient SCADA applications for sampling systems. SCADA application refers to industrial control systems (ICS): computer systems that monitor and control industrial, infrastructure, or facility-based business processes. 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. In our work we covered three complementary aspects of modelling process. First one, the aspect from process sampling system modeller in refineries must be clear and must follow the appropriate standards, second one, from the aspect of software designers, SCADA application must be clear and exact, and third one, and from the aspect of business users it must be easy for understanding and implementing. Very often in practice there are experts who are doing on-line analysis of the modelling of sampling system. Over the time, they are becoming an integral part of refinery, considering their importance in minimizing ‘Quality Give-Away’ and in refinery optimization. It is important to understand the functioning of these analyzers and their limitations.

In an oil refinery, crude oil is processed and refined into more useful petroleum products. All over the world there is extensive piping running throughout, carrying streams of fluids between large chemical

processing units. These fluids are at different temperatures, pressures, viscosities and so on. The object of crude oil sampling is to determine the quality of the oil at the custody transfer point. Sampler is using for sampling process (Fig. 3.). The amount of the basic sediment and water in the oil, a chemical analysis of the oil and shrinkage should be determined. The purpose of a crude oil sampling system is to withdraw from a pipeline a small representative portion of the product that contains the water, oil, and contaminants in the same proportion as is flowing in the stream. Therefore, it becomes essential to do sampling of these processes, condition these samples and analyze them. Sampling is not just `another' function of measurement; it is the heart and soul of the profit figure. Crude oil sampling is done at strategic locations, which includes offshore platform, marine loading terminal, pipeline or refinery and goes on past the pipeline, into the laboratory, analysis and accounting (Fig.2.). The world companies have to seriously weigh the question of perceived convenience versus accuracy in analysis and the monetary savings. Consequently, many authors are doing researches from different types of sampling, such as: stack gas sampling, solids sampling, sampling difficult processes etc. [18].
HMI application was developed on Wonderware System Platform 4.0 software environment. History and trending was done in Wonderware Historian and reports were designed and implemented in HMI Reports software. System interoperability enables parameterisation of SCADA application, creation of trends, data transfer to other LAN nets, reports creating. All of these things as well as functionality of the system are controlled by host servers. All the access elements are in standard Fast Ethernet LAN network, which makes the system access able even from the Internet.

Figure 2. Flow metering system

Figure 3. In-line sampler for sampling system

CUSTODY TRANSFER METERING AND SAMPLING SOLUTIONS FOR OIL, GAS, PETROL AND CHEMICAL PRODUCTS USING BY BPMN AND HMI APPLICATIONS

Business process of sampling system in refineries is carried out by three independent participants: customer/supplier, refinery and laboratory. The entire business process is taking place in four locations: jetty associated with customer/supplier, measuring place in refinery associated with operator in the field and maintenance workers, control room (CR) associated with operator and responsible person who verifies the entire business process and laboratory associated with specialists who are responsible for product analysis [19]. All participants in the process have to be informed about current situation and have to be prepared for potential critical situations. That is the first benefit we get with BPMN and SCADA application – there is a clear picture of process all over its duration. Using BPMN in our work we managed to create model that can be very useful in term of sinhronization of participants in the process and in term of making communication between them easier. If we look to the BPMN diagram of the entire process (Fig. 4.), we can see the sequence of events in the process and causes that lead to the normal flow and to the unwanted situations.

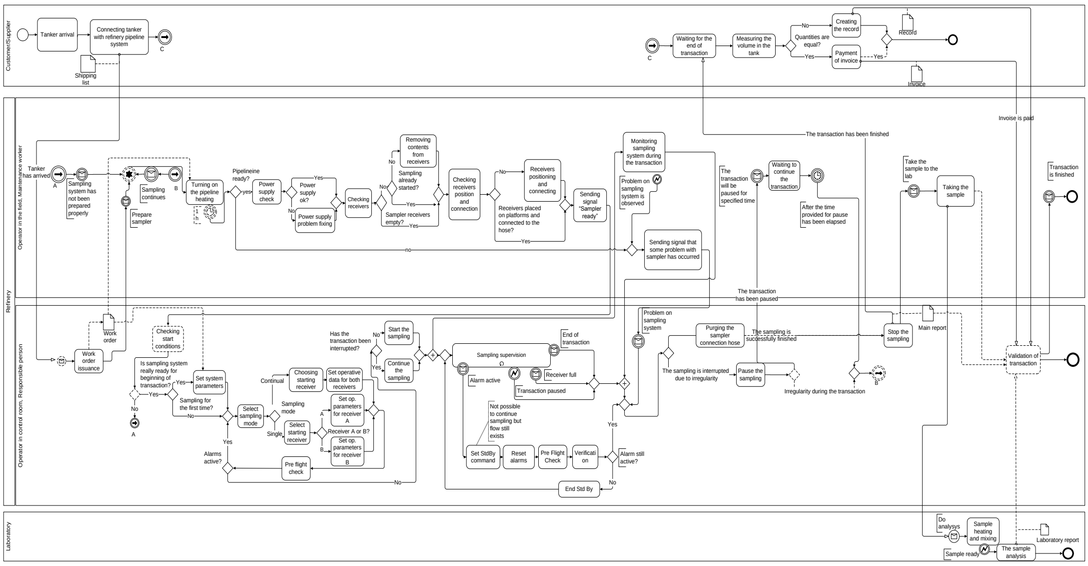

Figure 4. BPMN diagram of business process of sampling system in refineries

All measuring lines are realized and delivered on skids. The main screen created in our work (Fig. 5.) represents HMI for the sampling process. It consists from several functional parts: command section on the upper left side of the screen with following commands: start and stop, pause and resume, reset alarms, emergency stop; additional screens: screen where user can read and set system parameters, screen where he can read and set operational parameters; alarm screen with following alarms: communication error, flow rate out of range, grab factor and performance factor out of range, sampling frequency too high, receivers A or B overweight, starting weight out of range, line overpressure, sampler probe error, sampler probe controller error ; section in the middle of the screen where the operator in CR (Control Room) can check parameters before start and during the operation: level, weight, initial gross weight and sample volume for both receivers; process parameters on the left and right side with all data necessary for the sampling supervision. HMI application has somewhat unique visual style. Many of the standard HMI elements like displays, tables and flashing alarm lights are present in their recognizable shape and form. However, metering skid screens, as well as field instruments and valves have a different visual style. Most of instruments and valves are represented with actual photos (of the instrument model) which are then inserted into regular HMI graphic. Metering skid themselves are designed and represented in HMI in such way to have great visual resemblance to “actual” skid in field, outside of control room.

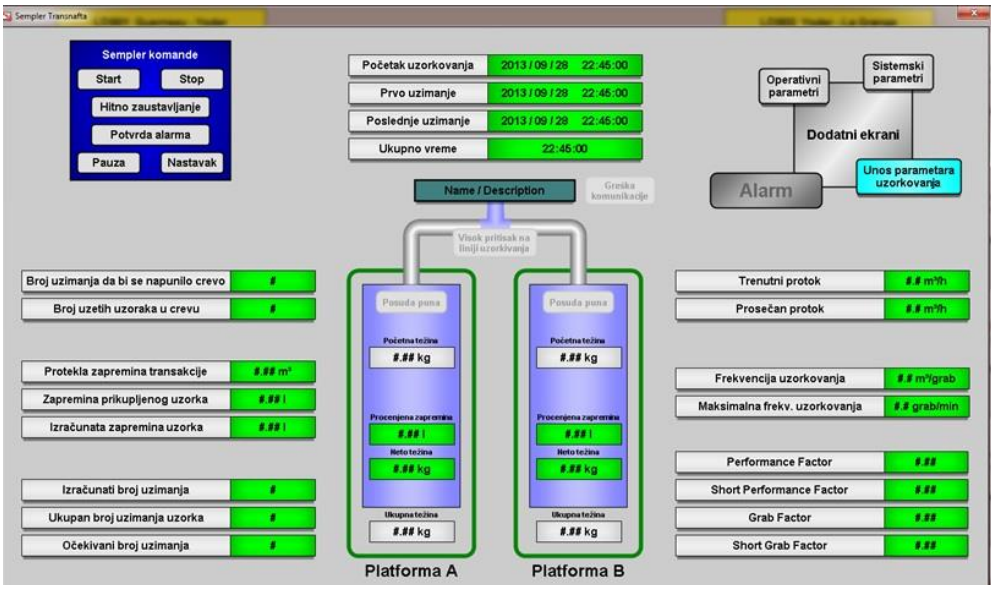

Figure 5. SCADA application for sampling system in refineries – main screen

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.

Our work considers detailed explanation of workflow business process of sampling system according to Fig. 4.

1. Customer/supplyer arrives on a jetty in the refinery. This moment is starting point for the entire process.

2. Tanker is connecting to the existing pipeline system in the refinery. Customer/supplyer informs operater that tanker is connected to the system and sends shipping list with all information about future transaction. The most important data are: fluid type, expected transaction duration and quantity of product, density, percentage of water in the product, date, responsible person, transaction code...

3. In our paper this moment represents starting point for Pool Refinery. Operater fills in the work order and sends it to the operator in the field who will prepare sampling system. The same work order is used for SCADA application inputs.

4. The operator in the field prepares sampling system for the transaction. It is a complex subprocess which consits from: 4.1. Turning on the pipeline heating and waiting one hour. This is done in order to make fluid temperature above pour point.

4.2. Then we can have two situations in our workflow:

4.2.1. If the pipeline is ready, the process will be normally continued.

4.2.2. If the pipeline is not ready, operator in the field will call operater in the CR and tell him that the transaction has to be postponed.

4.3. Power supply and communication check is next task and we can also have two results:

4.3.1. If there is a problem with sampler power supply, then maintenance worker will fix the problem.

4.3.2. If power supply is ok, there will be no action and the process can be continued.

4.4. Now, we came to task “checking receivers’ content” and the process can be continued with:

4.4.1. Removing remaining content from receivers if there is some, or

4.4.2. No action.

4.5. After this in our process, we came to the task “Checking if receivers are well positioned and connected” and two situations:

4.5.1. They are not, so operator in the field must place them on the platforms and connect them to the hose.

4.5.2. They are, so there is no action to be performed.

4.6. Finally, operator in the field sends the information that sampling system is ready for the transaction.

5. The next step in workflow is when the operator in the field informs operater in CR that sampling system is ready, operator in the CR will check all signals on the screen.

6. Two situations are possible in this part of process:

6.1. In one case, if something is not ok, he will inform operator in the field to fix the observed problem, and process will be continued with complex subprocess Sampler preparation (go to Step 5.).

6.2. In other case, process will be continued with next task.

7. The next steep of process is complex subprocess “Setting initial parameters” (Fig. 6 and Fig.7.).

7.1. This process can begin in one from next two ways depending on if this is the first sampling or not:

7.1.1. If this is the first time sampling system has been started, operater will set system parameters (connection hose volume, min and max flow rate, low and high flow rate alarm values, min and max receiver weight on start and grab size). These parameters are the same for all other samplings so operater doesn’t have to set them again. At every moment operator can check system parameters (Fig. 6.) and operational parameters.

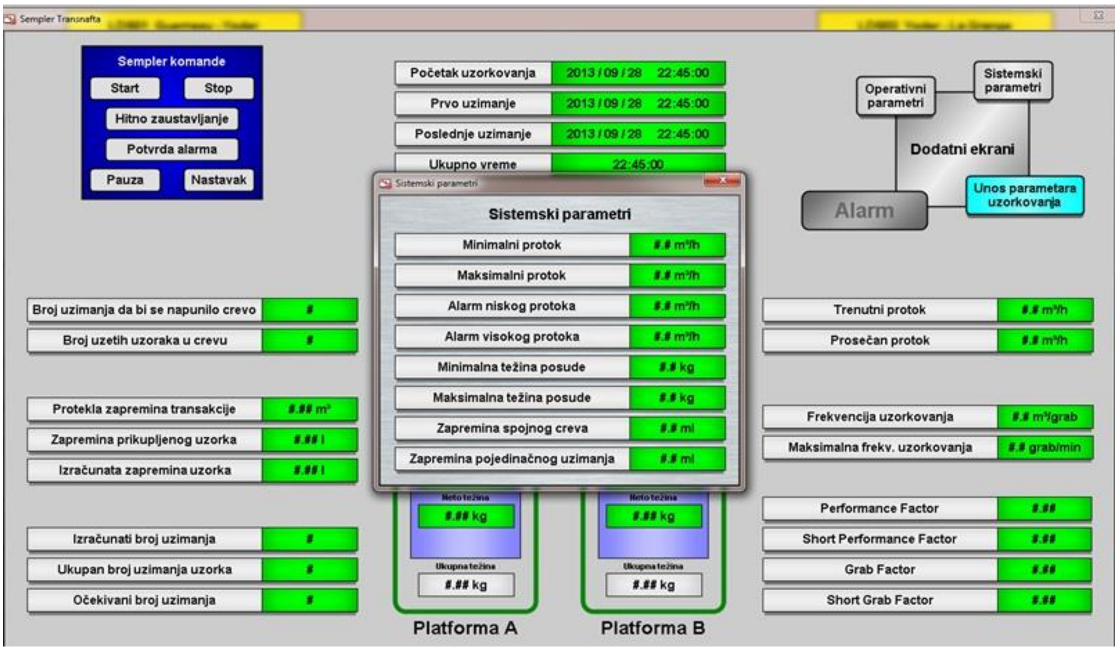

Figure 6. System parameters

7.1.2. If this is not the first sampling, process will be normally continued with next task.
7.2. At this point of process operater in CR will set operational parameters starting with sampling mode selection (Fig. 7.).

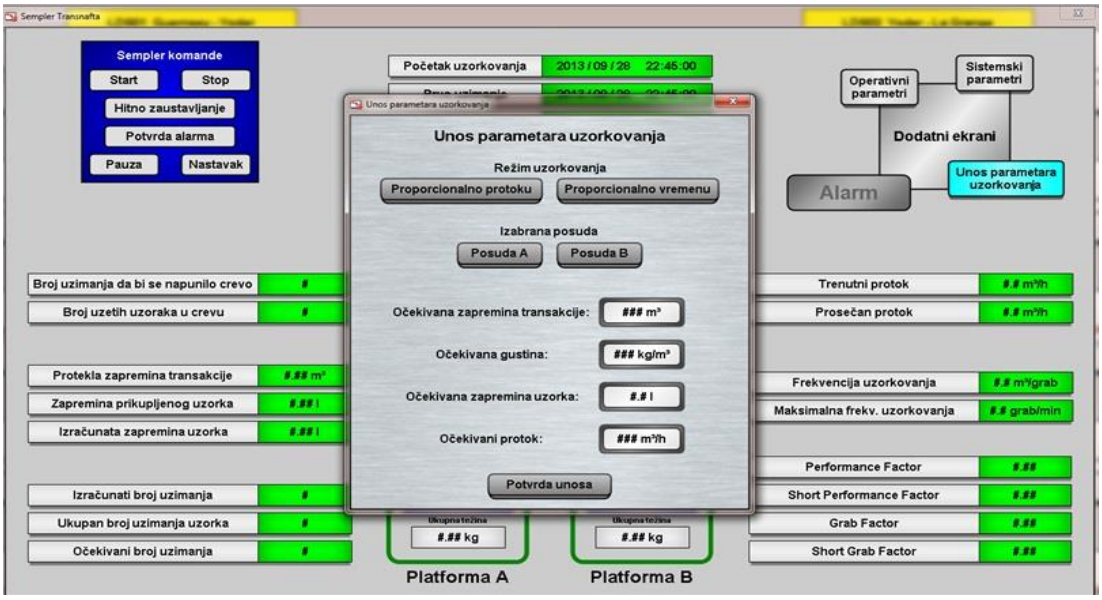

Figure 7. Section for operational parameters input

7.2.1. If he selects continious mode, then he will select starting receiver and after that set operational parameters for both cells (expected transaction volume, expected density, expected volume of one grab, sample volume and expected flow rate.
7.2.2. If he selects single mode, then he will choose receiver and set operational parameters for that cell.
7.3. At the end of this subprocess, operater in CR will check all parameters and see if there is something he has done wrong or not. There are different status messages that will help the operator to check system status and to supervise the process.

7.3.1. He will repeat the whole procedure if there is any of the alarms active (Fig. 8.), or
7.3.2. He can go to the next action.

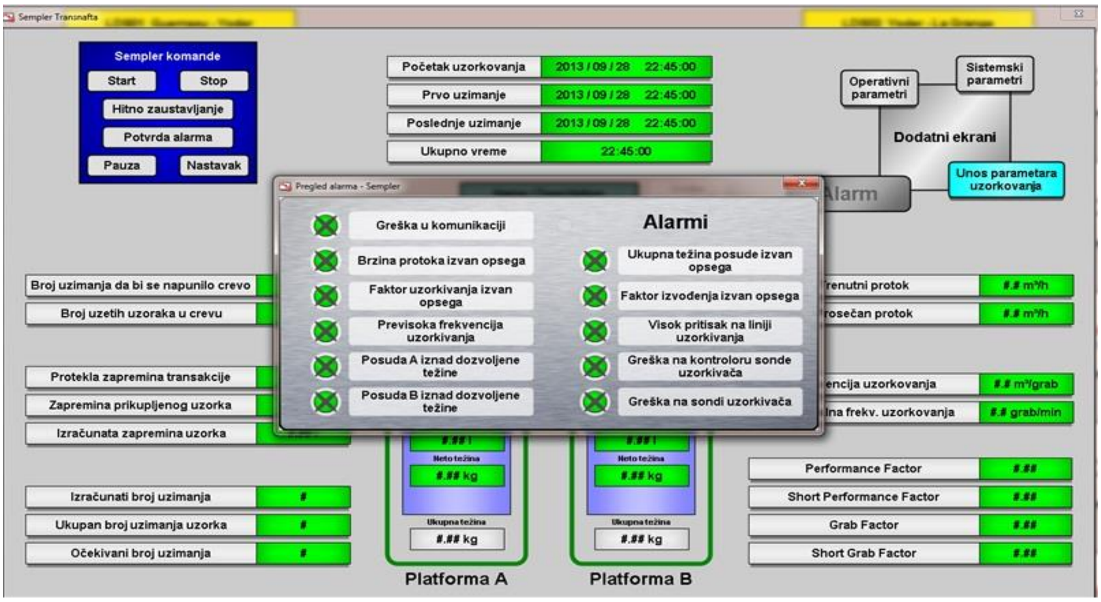

Figure 8. Alarm screen

8. Folowing workflow of the process we have that after setting initial paremetrs, operater in CR can either
8.1. Continue sampling if it has been paused or interrupted due to hardware failure, or
8.2. If it hasn't already been started, start sampling system.
9. Then, we have two parallel subprocesses that will take place simultaneously:
9.1. The first one is Sampling supervision and control:
Activity „Sampling supervision and control" is the repeating one. It has one message intermediate event, in case that the transaction is completed, and has three triggered events, exception in the cases related to the activity „Sampling supervision and control" (if the sampling cell is full, if the transaction is paused, and if some of the alarms for sampling process occured). In this phase of the process there are four variations of activity „Sampling supervision and control ":
9.1.1. Normal flow: If there isn't any problem during this activity, a message will appear that transaction is successfully completed.
9.1.2. Exception flow (Message type): Occurs in case the operator receive a message that the sampling cell is full. In the edge of „Sampling supervision and control" activity a message triggered intermediate event is attached and it leads to the end of this activity.
9.1.3. Exception flow (Error type): Occurs when transaction is paused. In the edge of „Sampling supervision and control" activity, an error triggered intermediate event is attached and it leads to the end of this activity.
9.1.4. Exception flow (Message type): In the case that some of the alarms for sampling process appears, a message type exception flow occurs. In the edge of „Sampling supervision and control" activity a message triggered intermediate event is attached. There are following activities:
9.1.4.1 If any of alarms becomes active, the operator in CR has to follow next procedure. When operator receives information that some of the alarms for sampling process appeared, he sends command „Pause" using corresponding button on the screen – that means, that there is still flow through the pipeline, but it is not possible to continue sampling.
9.1.4.2 When the problem with sampler is removed, operator sends command „Alarm reset".
9.1.4.3 Then operator sends command „Pre Flight Check" and reads results about several key parameters, sach as overall condition, gross cell weight, max sampling frequency and so on.
9.1.4.4 After that step, operator checks if everything is ok.
9.1.4.5 Checking if there is any alarm still active:

9.1.4.5.1 If the problem isn't overcome, the sampling process will be finished (error type end event).
9.1.4.5.2 If there isn't any alarm that is still active, operator will send command „Resume“ and the entire procedure will be repeated.
9.2. The second one is Monitoring sampling system in the field during the transaction:
9.2.1 The normal process flow is that one in which the operator in the field doesn’t observe any problem during the transaction.
9.2.2. If he observe some problem, he will inform operator in CR about it.
10. At this point of process we can have two scenarios:
10.1. If the sampling process is finished successfully, the operator in the CR will send “STOP” command and stop sampling.
10.2. If the sampling has been interrupted due to irregularity, operator will pause the sampling and inform operator in the field about it. After specified time elapsed, process will be continued from the “Sampling system preparation” subprocess 4.
11. Operator in the CR informs operator in the field that transaction is finished and that he can take the sample to the laboratory.
12. The next task is heating and mixing of the sample and when the sample is ready for analysis, the lab determine the quality of crude oil. The report from laboratory will be send to the responsible person.
13. Operator in the CR informs customer/supplier that the transaction is finished successfully and sends him the main report. The copy of that report will be send to the responsible person too.
14. Customer/supplier is waiting for the transaction end, and when he gets the main report, he measures the level in the tank and compares his result with the result in the report.
14.1. If the results don’t match, customer/supplier will create the record about it and then he will send it to the responsible person who will analyse this situation.
14.2. If the results match, customer will pay the invoice according to the main report and sends the receipt to the responsible person.
15. At the end of the overall process the responsible person verificate the transaction according to the lab report, main report and the receipt. Entire process of sampling is finished.

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 [2], [3]. Another representative example is using BPMN in randomized clinical trial which compare various rehabilitative treatments [1]. Additionally, in petroleum industry, BPMN enables better understanding of various production processes [5], [6]. 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 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;
- In our study unique strategy is made before starting process realization. It was done using standardized and simple notation, so it can be easily accepted by further participants;
- 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.
- Business analysts can identify critical points in business processes by using BPD and try to eliminate or improve them.

FUTURE WORK

In this paper, we have presented this unique business process with detailed explanation of all participants, roles and their interactions. The goal was to completely formalize semantic for modelling real life situations in gas and oil industry. 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. Software support represents a great contribution to the business process precision. The future work must be oriented to enrich using BPMN in other industries and real life scenarios.

Acknowledgments

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TANK MANAGEMENT AND CRUDE OIL TRANSPORT SOLUTIONS USING BPMN AND SCADA APPLICATION

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Abstract: The developing industry of business process modelling requires various tools, techniques and methodologies and aggravating factor is expensive equipment. Our approach benefits are parallel modeling and previewing this process with standardized graphical notation BPMN and SCADA application. BPMN is universality graphical standard. Business analysts can identify critical points in business processes by using BPD and try to eliminate or improve them. Our paper is based on very unique and specific real life scenario. Tank management and crude oil transport solution includes tank management, oil transport control and management, some procedures and measurement control and implementation of pump station control. In this paper we will explain a part of this whole process ie. Transaction „Pre- start checking“. The proposed transaction model is studied using of metrological conditions and other acts of Republic of Serbia, which is referring to this area. For that reason, proposed model ensures the accurate, credible and economical crude oil transportation.
Key words: tank management, crude oil transport solutions, BPMN, InTouch HMI, SCADA, oil, gas industry.

INTRODUCTION

The business in the world have dramatically changed in the past few years. In today's global economy, which is influenced by the globalization of the world market expands with one hand, while on the other hand, the closer the competition, many organizations are looking for ways to increase productivity and reduce operating costs. Market requirements are changing rapidly, and with them the need and pressure on the organization to better position themselves in the emerging trends in the global market. If the business organization as a complex dynamic and stochastic system, the application process approach becomes imperative. Over time, the process approach began to develop as an important element of business. Based on the process approach to develop a variety of software solutions, which quickly become widely accepted. In order to survive in the market, organizations need to adjust their system modeling of business processes with relevant international standards. Expansive Web technologies have been caused by the significant collaboration of business partners, suppliers and customers. On that basis, BPMN (Business Process Modeling Notation) allows the business viewed through visually designed standardized business processes and provides the concept of integration of multiple business participants. BPMN has been developed with the aim to provide a notation for defining business processes, easily understandable by all business users, from the business analysts who need to design processes to software engineers who are responsible for implementing the technology with which to execute processes. BPMN as intuitive notation is easy to learn and apply. Thus, BPMN creates a standardized bridge for the gap between the business process design and process implementation. Currently, there are scores of process modeling tools and methodologies. BPMN will be constrained to support only the concepts. of modeling that are applicable to business processes.
Many applications use BPMN in different kind of real life scenarios. For example, in area of computer science [1]. For that reason, BPMN is the most recognized language for specifying process workflows at the early design steps [2, 3], especially as a starting point for software service design [4].
Microsoft Office Visio 2007 is used, in this paper, for creating BPMN diagrams Transaction „ Pre-start checking“. Modeling processes related to tank management and crude oil transport solutions are considered as a crucial issue by many enterprises because they are key to maintain competitiveness. 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 application.

HMI application was developed on Wonderware System Platform 4.0 software environment. HMI application has somewhat unique visual style. Many of the standard HMI elements like displays, tables and flashing alarm lights are present in their recognizable shape and form. Most of instruments and valves are represented with actual photos (of the instrument model) which are then inserted into regular HMI graphic. History and trending was done in Wonderware Historian and reports were designed and implemented in HMI Reports software. System interoperability enables parameterisation of SCADA application, creation of trends, data transfer to other LAN nets, reports creating. This software package is a very useful tool for development SCADA (Supervisory Control And Data Acquisition) applications [5, 6].

SCADA application for Tank management and crude oil transport solution was made according to the main BPMN diagram. InTouch software offers many opportunities – displaying 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 [7, 8]. Also, before starting of a system, it is possible to simulate real life scenarios and improve the BPMN model and application. Advantages of the system are its mobility, simple and quick installation, user friendly usage and accessibility.

Legislative unique metrology for sampling systems is used all around the world in area of Oil and Gas industry. In our country the sampling system must be performed in accordance with „Law of planning and construction“ (“Official Gazette of Republic of Serbia, NO. 47/2003 and 34/2006, „Law on security and health at work in Republic of Serbia“and „Fire protection and prevention Act “.

The remainder of this paper is structured as follows: in the first section we will give overview of the main graphical representation of BPMN concepts using Microsoft Office Visio 2007 tool. In the second section we will summarize the main issues of using BPMN, human machine interface (HMI) and SCADA applications. Third section presents the modelling of Transaction „ Pre- start checking“through BPMN diagrams in parallel with screen displays of SCADA software solution. The fourth section contains discussion and the most important conclusions of this paper. Finally, in fifth section we will present our future work about this subject.

MATERIALS AND METHODS

BPMN graphical concepts

BPMN has emerged as an important open standard graphic notation for drawing and modelling business processes (Figure 1.), [9, 10, 11]. 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 2007 is software that enables creating diagrams by the BPMN specification, including set of patterns. Those patterns can be imported into Microsoft Visio software. Business process diagram (BPD) is made by importing BPMN graphical tools into Visio workspace. BPMN diagram is synonym for BPD. When the modelling of business process is complete, diagram can be saved in various formats: JPEG, XML drawing, AutoCAD drawing, Web page, Windows Bitmap and other.

A Business Process Model (BPM) 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 (Fig. 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, i.e. “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, Sub-Process, and Task (Fig. 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 behaviour Decisions/branching (exclusive-XOR, inclusive-OR, parallel – AND, and complex). BPMN extends the behaviour 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 (Fig. 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 (Fig. 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 (Fig. 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 (Fig. 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.

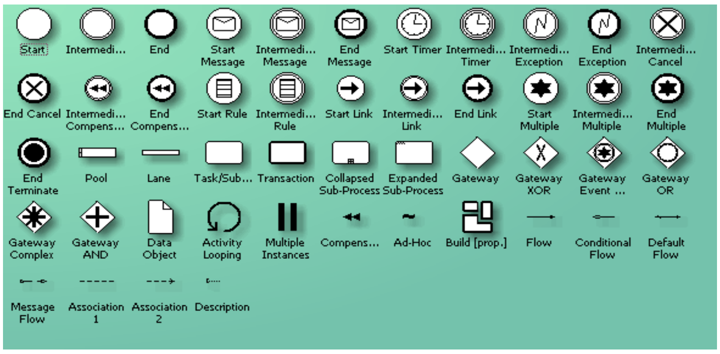

Figure 1. Graphical representation of BPMN concepts using MS 2007 VISIO tool

TANK MANAGEMENT AND CRUDE OIL TRANSPORT SOLUTIONS USING BPMN AND SCADA APPLICATION

Transaction „ *Pre- start checking“*

This complex Transaction „ Pre- start checking“ is important because it ensures the accurate, credible and economical crude oil transportation. It can be canceled and delayed until next day (if there is no available storage space) or it can be finished because of the instrumentation failure or drainage process in the field (operator will wait untill he gets the information that everything is ready). In normal conditions, the operator will finish next 8 subprocesses: logging, network checking, calculating storage capacity, checking instrumentation, water draining, sampler parameterization, alarms/simulation configuration and pump parameterization.

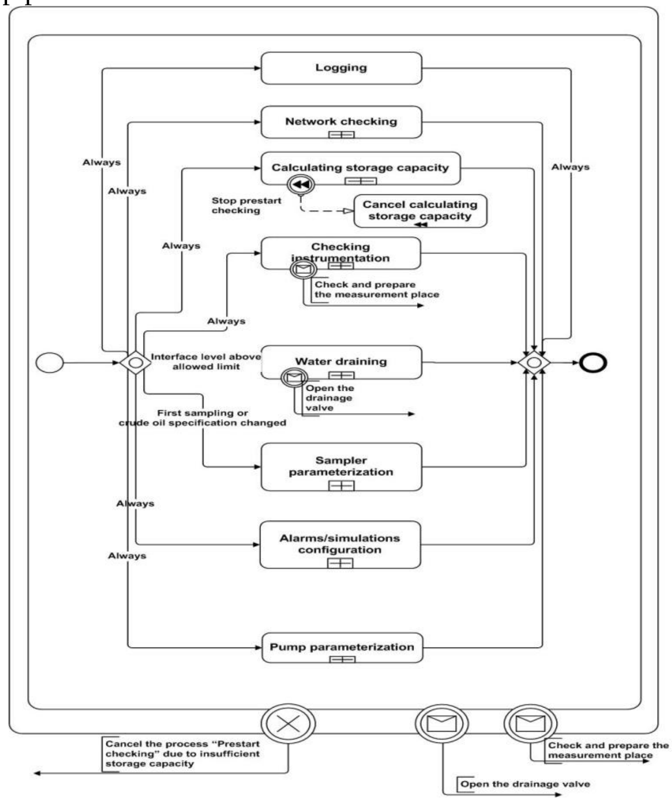

Figure 2. BPMN diagram for Transaction *Pre-start checking*

1. Logging:
2. At the beginning of Transaction „ *Pre- start checking"* , the operator will have to enter his own user name and password in order to have full access in SCADA application (Fig. 3.).

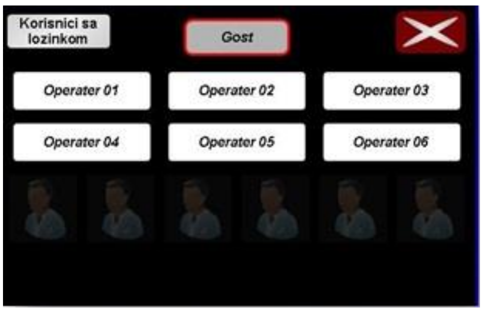

Figure 3. Logging into the SCADA application

3. Network check (Fig. 4.):

2.1. The operator will check network parameters and communication.
If there is no network problem, this process is finished.
2.2. In case there is some communication problem, the operator will check IP adresses and depanding on the result he will:
  1.2.1. Fix the IP address issue, or
  1.2.2. Go to the next step:
2.3. Ethernet cable will be checked and after this:
  1.3.1. Operator will replace ethernet cable, or
  1.3.2. Network checking process is finished.

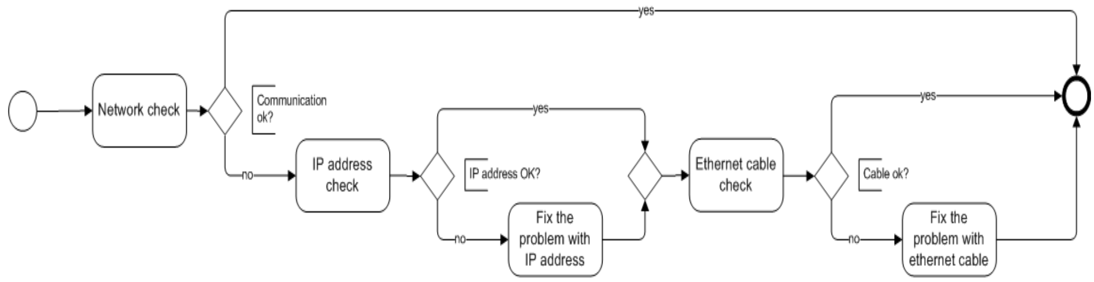

Figure 4. BPMN diagram for “Network checking” subprocess

4. Calculating storage capacity (Fig. 5.):

3.1. The operator will take into acount current fluid volumes in all tanks and calculate available volume in them. This calculation can be the reason to stop the whole prestart check because operator can find out that there is no available tank at the moment. In that case, the transportation will be moved to the next day.

3.2. If there is one or more available tanks, one of them will be choosen for the transport, and then,

3.3. The operator will calculate some of the most important data (volume before and after the transaction, expected density, water content, interface level...).

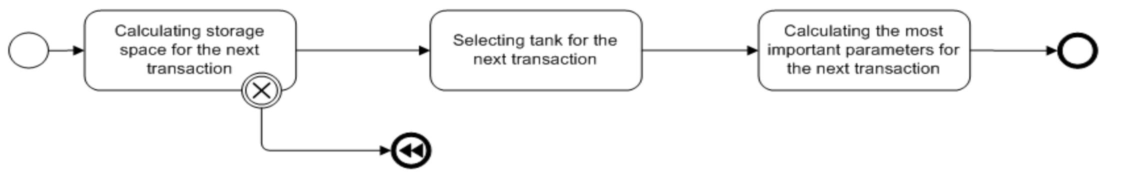

Figure 4. BPMN diagram for “Calculating storage capacity” subprocess

5. Checking instrumentaion (Fig. 5.):

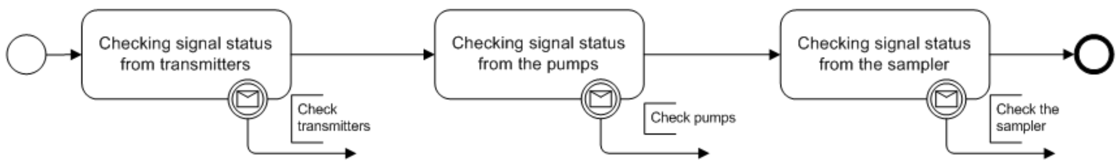

Figure 5. BPMN diagram for “Checking instrumentaion”

There are three subprocesses, and each of them can be finished if the operator notices some irregularity during the checking.

4.1. First check is related to the transmitters - level transmitters, pressure transmitters, temperature transmitters and transmitters for interface level (Fig. 6.).

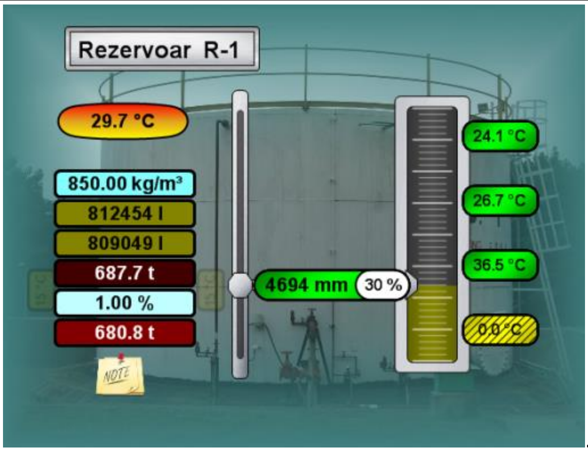

Figure 6. SCADA reprezentation of a tank with its instrumentation

4.2. The second check is related to the signals coming from the pumps (Fig. 7.), and finally,

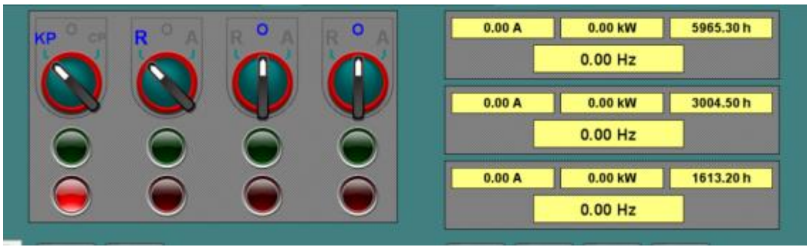

Figure 7. SCADA reprezentation of pump parameters

4.3. The operator will check signals from the sampler.

6. Water draining (Fig. 8.):
5.1. Before the beggining of the transportation, the operator will check if it is necessary to drain water from the selected tank. If a water level is within operating range, the subprocess will be finished, and in case it is above high limit, the operator will
5.2.1. Calculate the time period the water will be drained within it, and,
5.2.2. Inform operator in the field to open drainage valve. After the calculated time, he will check the interface level again.

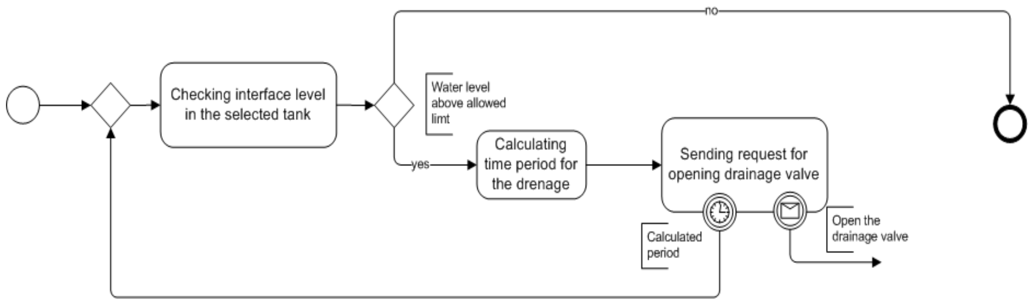

Figure 8. BPMN diagram for “Water draining”

7. Sampler parameterization (Fig. 9.):
This process will be executed in case sampler will be used for the first time or there has been a change of crude oil specification.
6.1. The first action will be calculating system parameters according to the working conditions and crude oil specification.

6.2. The second action is entering these parameters.

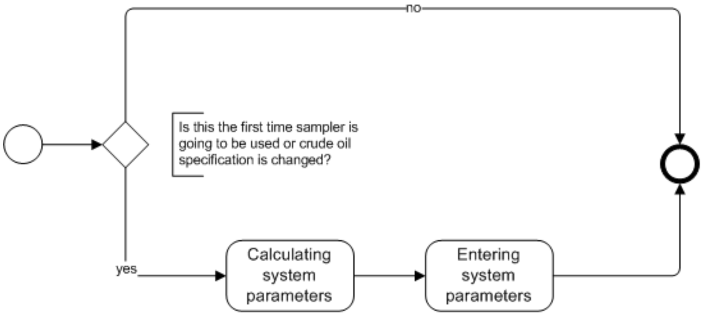

Figure 9. BPMN diagram for “Sampler parameterization”

8. Alarms/simulations configuration (Fig. 10.):

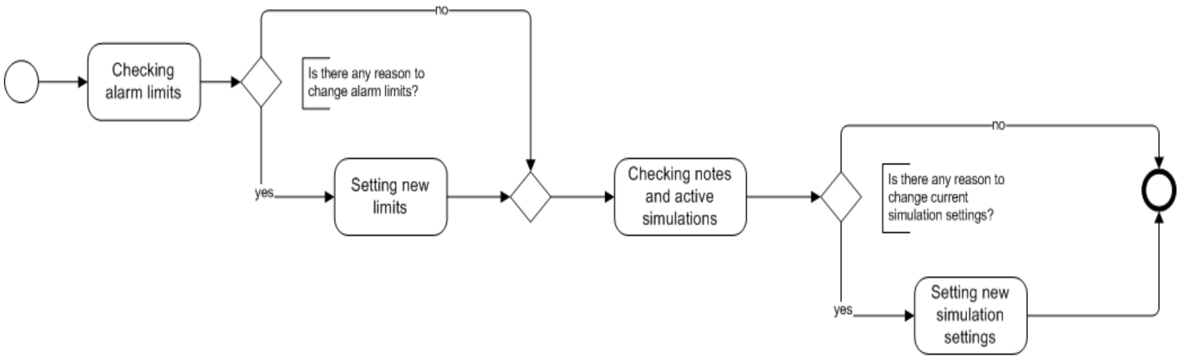

Figure 10. BPMN diagram for “Alarms/simulations configuration”

7.1. There are predefined alarm limits for all transmitters. Operator will check current configuration and set new limits if necessary.
7.2. After that, he will read all notes about instrumentation and, if necessary, change simulation configuration (Fig.11.).

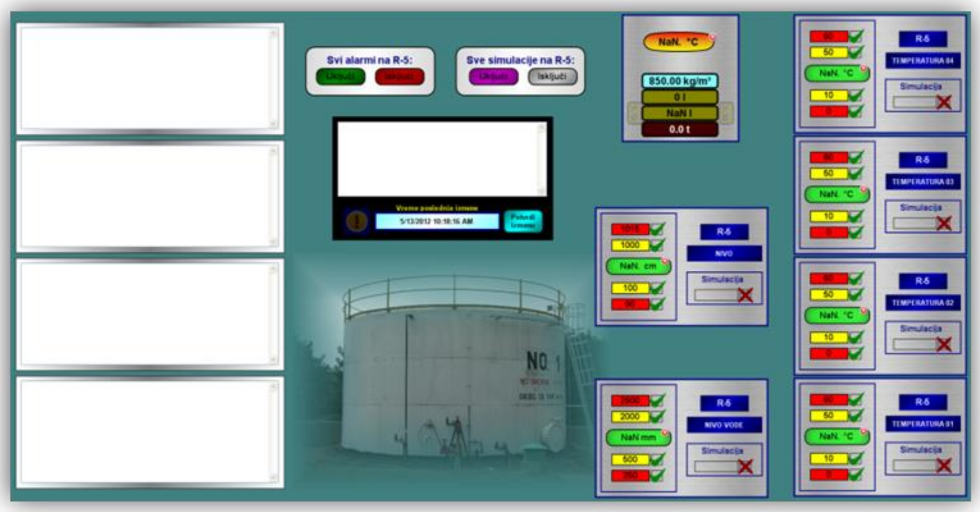

Figure 11. SCADA screen for alarms and simulatio

9. Pump parameterization (Fig. 12.):

8.1. The first action in this subprocess is calculating pump parameters according to work order and selected pump's options.
8.2. After that, the operator will select control mode and depending on the selection:
8.3.1. Send information to the operator in the field about pump parameters (local control), or
8.3.2. Select pump regime (Auto or Manual). If he choose auto regime, the process is finished, but in oposite case, he will set the pump speed.

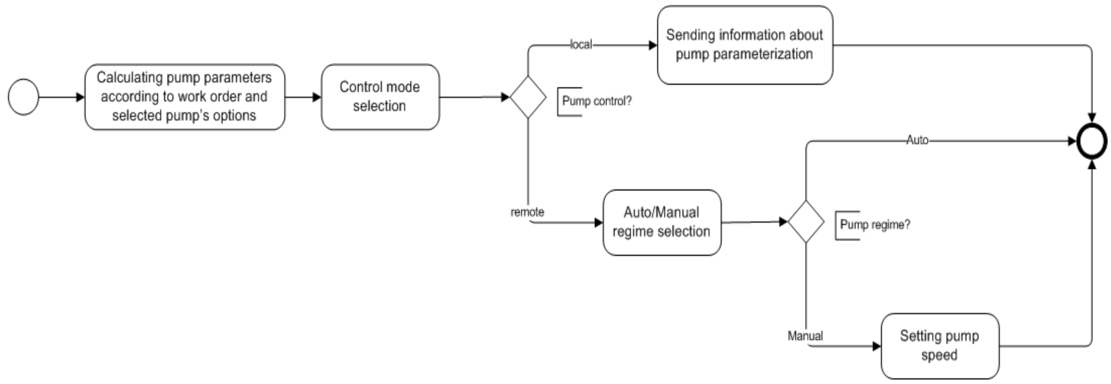

Figure 12. BPMN diagram for "Pump parameterization"

DISCUSION AND CONCLUSION

Our study resulted in following:

- HMI application has somewhat unique visual style. Many of the standard HMI elements like displays, tables and flashing alarm lights are present in their recognizable shape and form;
- InTouch software offers many opportunities – displaying 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;
- 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;
- The proposed transaction model is studied using of metrological conditions and other acts of Republic of Serbia, which is referring to this area;
- The proposed transaction model ensures the accurate, credible and economical crude oil transportation;
- The benefits of modelling by BPMN notation are simplicity, clear visualization and visibility of modelled process;
- Business analysts can identify critical points in business processes by using BPD and try to eliminate or improve them;
- Before starting of a system, it is possible to simulate real life scenarios and improve the BPMN model and SCADA application;
- Advantages of the SCADA application are its mobility, simple and quick installation, user friendly usage and accessibility.

FUTURE WORK

Transaction „ Pre- start checking“ is a very important part of the real life scenarios in the oil and gas industry. The proposed model can be used for simulation in order to prevent errors during process execution before it starts. This is very important because of critical points during the transaction that can threaten the transaction. Software support represents a great contribution to the business process precision. The proposed transaction model ensures the accurate, credible and economical crude oil transportation.

Acknowledgments

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STATE AND ANALISYS OD LPG MARKET IN CHOSEN COUNTRIES OF THE WORLD

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Abstract: Today, alternative fuels find their application more and more as fuel sources. One of most present alternative fuels is liquefied petrol gas (LPG). Using LPG in the world is gaining importance. Consumption of LPG as a fuel source is in constant growth. In accordance, analysis of LPG market is conducted on a global scale. As countries in the world that record the highest consumption of LPG are Korea, Turkey, Russia and Poland. For each of the countries the LPG consumption trend is presented and the trend of the increase of numbers of cars that use LPG as fuel source for the period 2000-2010. It is determined that the demand for LPG as a fuel source for the period of 2000-2010 is increases by 59%.
Keywords: alternative fuels, liquefied petrol gas (LPG), LPG market, motor vehicles that use LPG.

INTRODUCTION

Alternative fuels are a very current topic today, that is gaining more and more importance, mostly for two reasons. The first one is the knowledge that conventional fuels, that are mostly used as a fuels source for passenger and commercial vehicles, fall in the group of non-renewable natural resources, so their replacement must be considered in the near future with another energy source. The second reason is of ecological nature. Due to growing levels of pollutions of our planet and engagement of people's health, plant and animal life, stricter and stricter requirements are set that a car must fulfill regarding pollution, in order to be able to take part in everyday traffic. [1] [4]
From the aspect of the environment the considerable negative influence of the transport is air pollution. Every spent liter of fossil fuel produces, during combustion, approximately 100g carbon monoxide (CO), 20g volatile organic compounds, 30g nitrogen oxide (NOx), 2.5kg carbon dioxide (CO2) and many other harmful and poisonous matter such as lead, sulfur compounds and solid particles. All these compounds, to a certain extent, lead to air pollution, whether by direct effect on health or globally, by causing green house effects.Emissions of CO2 in the world have increased by 45% between 1990 and 2010 and reached a record breaking 33 billion tons. Around 90% of global emissions of CO2 comes from burning fossil fuels. The biggest increase was recorded in countries whose economies developed suddenly, such as China and India, but also in already developed countries. The biggest increase of CO2 emissions was recorded in sector of manufacture and road traffic. In the sector of road traffic the increase of CO2 emissions was recorded in developed countries and countries in development, with the exception of 2008, when the increase of fuel prices and recession caused the decrease of emissions [3]. Recently conducted study about climate changes caused by emission of gases from the economy sector showed that the biggest emitter of green house gasses and air polluting gasses is road traffic [7]. Energy consumption is constantly growing. Prognoses indicate that in the following years, along with the further development of technologies and increase of population, the transport of people and goods will continue to grow. That will require more and more energy, that is, energy consumption will grow. According to some estimates by 2050, the needs for energy will more than double. Transport will use about 50% of the energy, mostly derived from oil [6]. For many years, new types of fuels are being researched. We are looking for a fuel that will be readily available and which will be present for longer period of time, at an affordable price and with favorable ecological properties. The attention is directed to various alternative fuels: LPG, methane (compressed natural gas-CNG), biogas, biodiesel, alcohols (methanol, ethanol), hydrogen, and other. Fulfilling strict legal regulations, that are imposed for motorcycles and vehicles, is only possible by combining automobile and oil industry. [2]

ANALYSIS OF LPG MARKET IN THE WORLD

LPG is the leading alternative fuel of today. Due to its economical, ecological and safety characteristics, LPG is more and more used as an alternative fuel source for motor vehicles. In the eighties, LPG was used because of its lower price in comparison to other fuels sources, and today big ecological advantage of LPG over other fuel sources is obvious. Mass use of LPG, as an ecologically acceptable fuel source, means reduction of harmful gasses, that is, reduction of green house gas effects. The appearance of LPG as an alternative to petrol and diesel is a direct result of "Government politics" for solving energy safety and ecological problems.
Large number of countries have developed LPG markets. Global consumption of LPG as a fuel source for motor vehicles reached 22.9 million tons in 2010, and continues to rapidly grow [8]. Figure 1 shows a growth trend of world consumption of LPG as a fuel source for motor vehicles. In 2010, a consumption of 22.9 million tons was recorded, which is an increase of 22% in comparison to 2005.

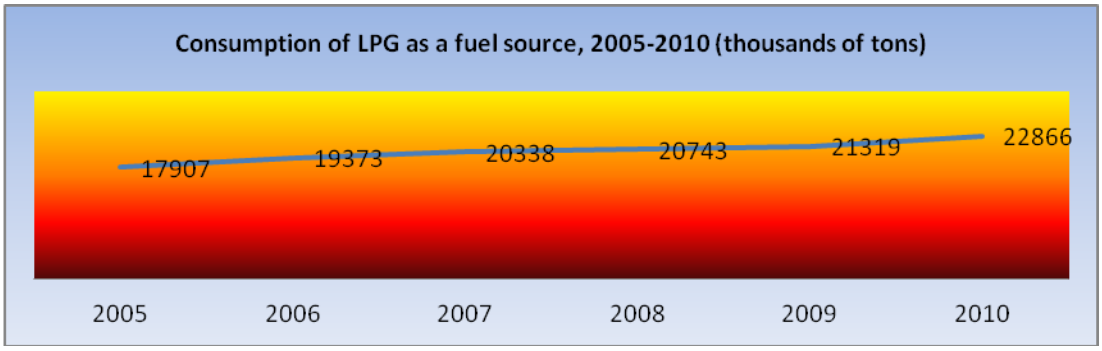

Figure 1. Growth trend of LPG consumption as a fuel source , 2005.-2010. [8]

Demand for LPG as fuel source is increased by 59% between 2000 and 2010 (Figure 2) [8], and the growth comes from already developed and newly developed markets of LPG. Demand still remains highly concentrated in a small number of markets: five biggest counties make 53% of world consumption in 2010, and first ten countries 75%. Four biggest consumers, Korea, Turkey, Russia and Poland record the absolutely highest consumption during ten years, until 2010 (Figure 2). There are more than 17.4 million vehicles that run on gas, all over the world, and over 57.000 locations where LPG can be refueled.

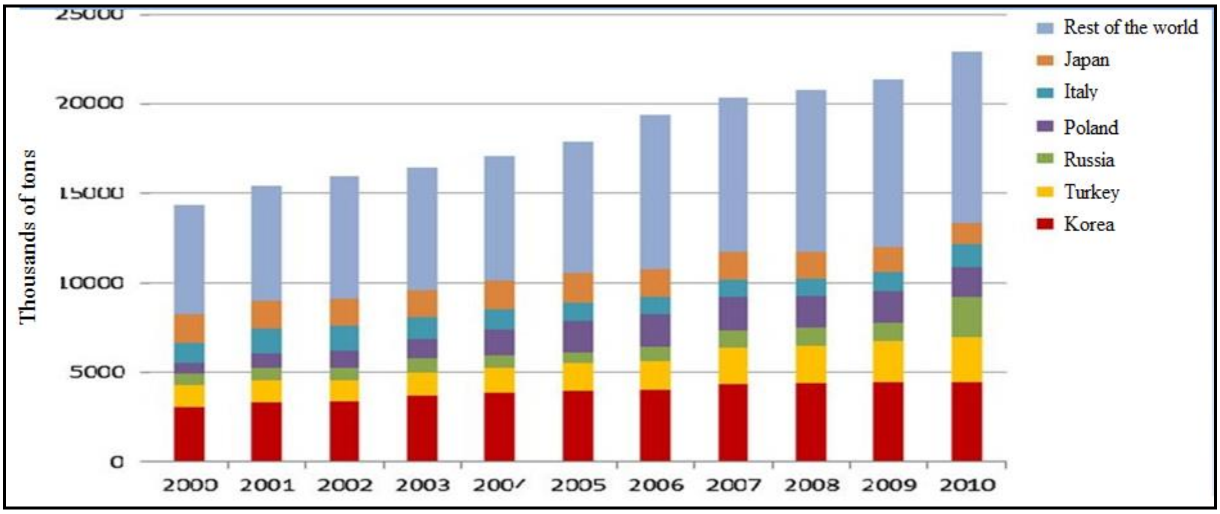

Figure 2. World consumption of LPG as a fuel source by countries in the period of 2000-2010.

Growth trend of car with LPG in the period of 2005-2010 is shown in Figure 3. [8]. In 2010 34% more motor vehicles is recorded, in comparison to 2005.

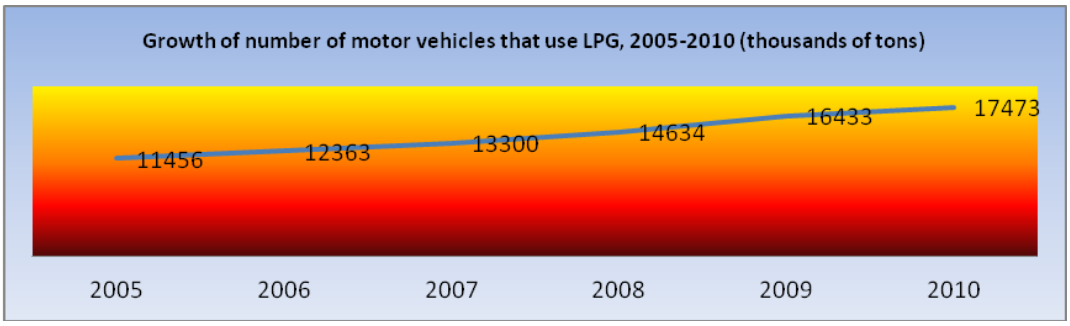

Figure 3. Increase of number of vehicles that use LPG as a fuel source, 2005.-2010.

Consumption of LPG as a fuel source for vehicles make up about 9% of total world consumption of LPG, but this ration varies in different countries. Out of 19 included countries (Algiers, Australia, Canada, China, France, Germany, India, Italy, Japan, Korea, Mexico, Netherlands, Poland, Russia, Thailand, Turkey, United Kingdom, United States), in the report from world LPG association, the biggest portion is in Poland 73%, and smallest one in USA 1% [8]. Table 1 shows countries with largest LPG markets for motor vehicles in 2010.

Table 1. The biggest LPG markets as a fuel source for motor vehicles in 2010. [8]

Countries	Consumption (thousands of tons)	Number of LPG vehicles	Number of LPG refueling stations
Korea	4.450	2.300	1.611
Turkey	2.490	2.394	8.700
Russia	2.300	1.282	2.000
Poland	1.660	2.325	5.900
Italy	1.227	1.700	2.773
Japan	1.202	288	1.900
Australia	1.147	655	3.200
Thailand	922	473	561
China	909	143	310
Mexico	837	535	2.100
Rest of the world	5.723	5.379	28.094
Total:	**22.866**	**17.473**	**57.150**

Car fleet of vehicles that run on LPG is different for each country. In two biggest Asian LPG markets, Japan and Korea, taxi vehicles and light cargo vehicles are responsible for the biggest portion of LPG consumption. In both countries all taxi vehicles run on LPG, as a result of incentive measures and government measures that require the use of alternative fuels in these vehicles. In Europe, private (passenger) cars are main consumers of LPG market. In most countries, vehicles that run on LPG are converted vehicles that used to run on petrol, so now they can use petrol and LPG. In Korea most vehicles have factory installed device for LPG. Currently there is a very small number of heavy cargo vehicles that use LPG, due very expensive conversion of diesel engines. In recent years, busse sna d medium heavy cargo vehicles are being fitted with engines that run on LPG, mostly in USA, Korea and China.

STATE AND ANALYSIS OF LPG MARKET IN CHOSEN COUNTRIES OF THE WORLD

Market for LPG as a fuel source in Korea

Korea is one of the first countries that promotes the use of LPG in vehicles for many years and has the biggest LPG market in the world. LPG demand has grown in the 90's as a response to a strong government support for using LPG in taxi vehicles, other cars and busses. Big tax reliefs were given not users of cars that run on LPG. Ecological limitations of diesel vehicles have also incited the use of LPG. Big increase of LPG consumption started to slow down in 2000, mostly because of sudden change in government politics towards LPG. Despite these changes, LPG consumption reached 4.5 million tons in 2010 (Figure 4) [8]. LPG as a fuel source includes half of total consumption of LPG in Korea, and about 17% of total consumption in road transport. The number of vehicles that run on LPG continued to quickly grow in accordance to the growth in LPG consumption. There were about 2.3 million registered vehicles that ran on LPG at the end of 2010 (Figure 4), that is, 14% of total car fleet in the country. Gas is available in more than 1.600 refueling stations.

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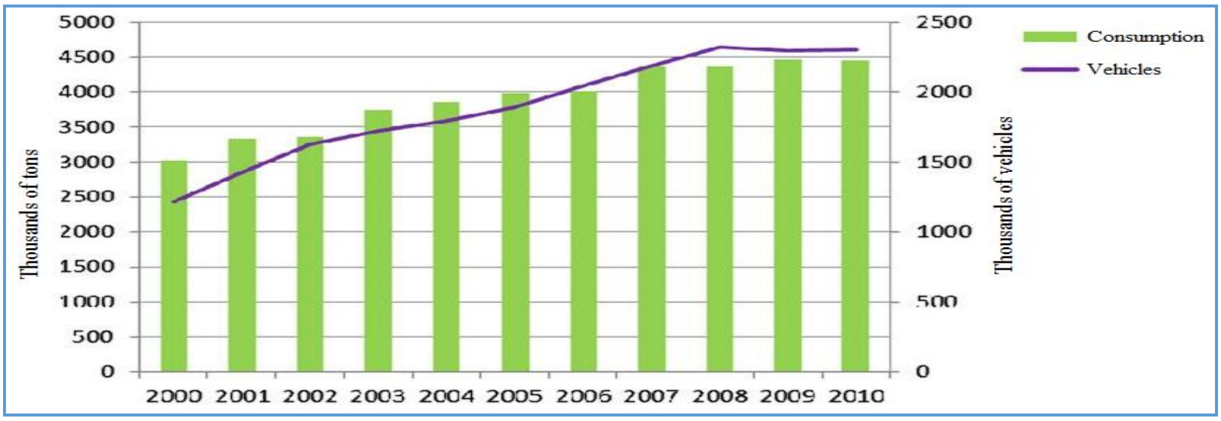

Figure 4. LPG consumption trend as a fuel source and the number of vehicles that use LPG in Korea

Market of LPG as a fuel source in Turkey

As a result of sudden growth since late 1990's, when the ban of vehicles the use LPG was lifted, and especially since 2003, Turkey today has the second largest market of LPG in the world, right after Korea. Consumption was doubled from 2003 to 2010, reaching almost 2.5 million tons (Figure 5) [8]. Demand suddenly grew, especially in 2007. In 2010, the consumption of LPG surpassed the consumption of petrol. The number of vehicles that use LPG is grew, reaching almost 2.4 million vehicles at the end of 2010, or approximately one third of car fleet of the country. The consumption of LPG makes 18% of total car consumption of fuel and two thirds of total consumption of gas in Turkey, of which more than four fifths is imported. Around 40% of private cars are vehicles that run on LPG, and the growth of number of busses that use LPG is expected to grow. In 2012, the number of petrol cars converted to LPG surpassed 300.000.

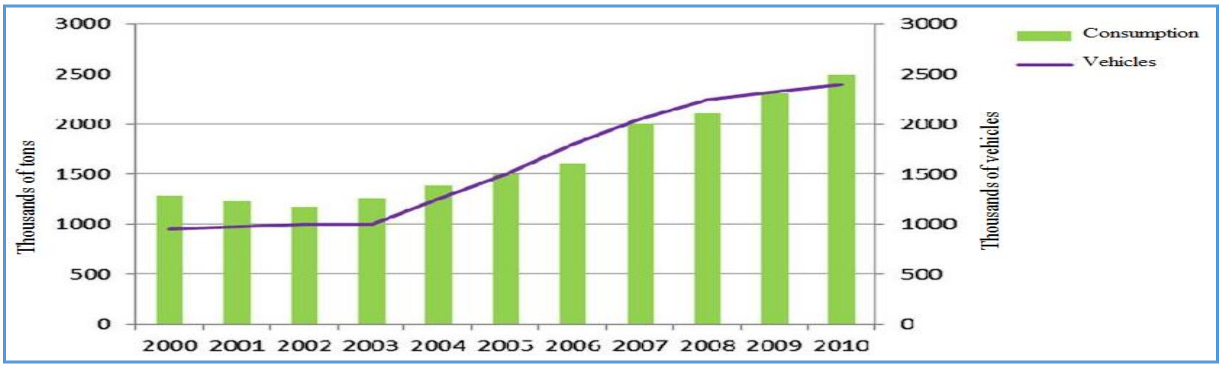

Figure 5. Trend of LPG consumption as a fuel source and the number of vehicles that run LPG in Turkey

The number of converted vehicles from 2006 is about 250.000, annually, and those are mostly private passenger cars and taxi vehicles. The sales of vehicles with factory installed LPG device is also growing, with over ten manufacturers, including Chevrolet, Dacia, Daihatsu, Fiat, Hyundai, Lada, Proton, who now promote cars that run on LPG. Renault and Honda also started the sales of cars that use LPG in Turkey at the beginning of 2012.It is estimated that there is about 7.800 refueling station for LPG, which makes about one third of total number of stations in Turkey.

Market of LPG as a fuel source in Russia

Russia has the third biggest market in the world for LPG. The demand is in constant growth since the mid 2000. In 2010, it jumped to 2.3 million tons (Figure 6) [8]. Based on data from 2010, the LPG consumption makes 5% of total fuel consumption in Russia. At the end of 2010 there was 1.3 million vehicles that used LPG and 2.000 refueling stations where you can buy LPG all over Russia. Around 60% of vehicles that used LPG are later converted and are older than ten years. In Russia, solving problems of air pollution needs to begin in Moscow, because in this city more than 10% of the entire county's car fleet is concentrated. Annual increase of car fleet of Moscow is 150-200 thousand vehicles. If something is not done, Moscow could become one of most polluted cities in the world.

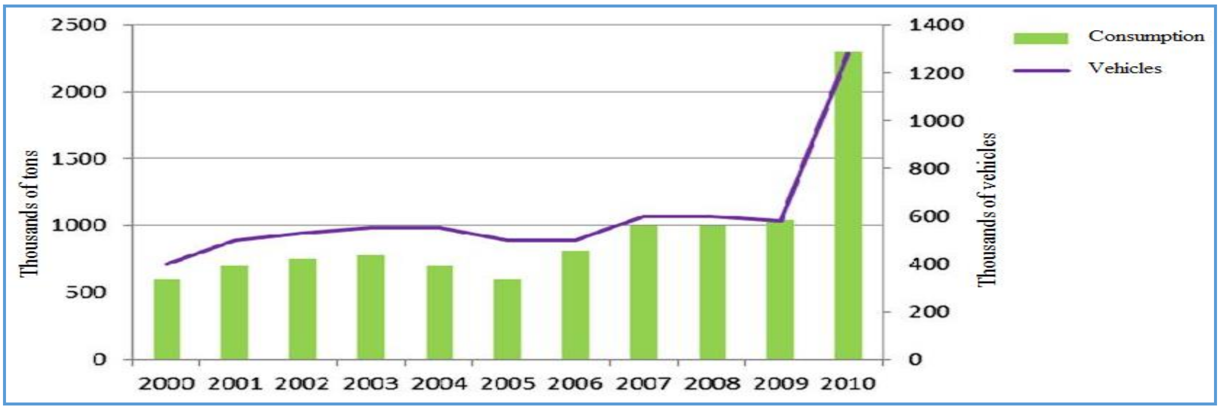

Figure 6. LPG consumption trend as a fuel source and the number of vehicles that use LPG in Russia

Market for LPG as fuel source in Poland

Poland has the fourth largest market of LPG in the world, after Korea, Turkey and Russia, thanks to fast growth of demand during 90's and first half of 2000. Market in Poland is the biggest market of LPG in Europe. This was achieved thanks to the price of LPG in comparison to conventional fuels and low costs of vehicles conversion. Demand dropped slightly in 2007, due to the improvement of fuel consumption economy (old cars are replaced with models that are highly fuel efficient). The number of vehicles that run on LPG has not dropped in the period of 2000-2010. The consumption of LPG almost tripled in the period of 2000-2007, reaching over 1.8 million tons, but in 2009 it dropped to 1.7 million (Figure 7). [8]

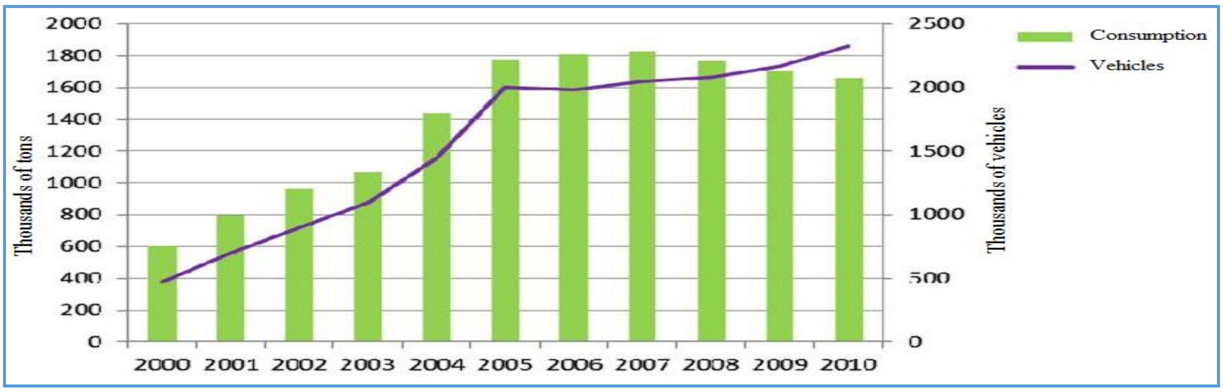

Figure 7. LPG consumption trend as a fuel source and the number of vehicles that use LPG in Poland

LPG as a fuel source for vehicles makes 11.5% of total fuel consumption in Poland, and about third of total LPG consumption. Poland is a big importer of LPG, mostly from Russia. According to number of LPG refueling stations, Poland is in first place in Europe. At the end of 2010, there was around 2.23 million vehicles that run on LPG in use, or 14% of total car fleet of the country. Most light cargo vehicles are converted to LPG for private and commercial purposes. The number of LPG conversions in 2004 grows, due to increase of imported petrol cars, that are cheaper to convert, after Russia entered in European Union. Expenses for conversion are much lower in comparison to western European countries. It is estimated that there is around 5.900 refueling stations where LPG is sold, which is third largest number in the world, after Turkey and Germany.

CONCLUSION

The possibilities of replacement of petrol and diesel with alternative fuel are huge. The choice of best alternatives is not simple. Because of that there is also legal and fiscal regulative, that through the system of taxes and other incentives needs to influence the consumption of alternative fuel. Gaseous alternative fuels, above all LPG, are the best alternative fuel. From the perspective of development, car industry will move to minimal gas emissions. Activities for the protection of life environment, watched from the standpoint of emission of harmful ingredients of exhaust gasses, are seen in the intense development of engines with mandatory constant reduction of exhaust emission and fuel consumption [5]. With the increase of number of motor vehicles and with intensifying of road traffic the influence of exhaust gasses is increased on the environment. There is over 17.4 million vehicles that run on gas, in use all over the world and over 57 000 locations where LPG can be bought. Growth trend of the number of vehicles that use LPG is constantly growing in all countries of the world. Mass use of LPG, as an ecologically acceptable fuel, includes a considerable reduction of harmful gas emissions, that is, reduction of green house gasses. The creation, distribution and incentives for using LPG as an alternative to petrol and diesel are directly connected and depend of “Government politics” for solving energy safety and ecological problems in their countries. In the end, we can conclude that today, large number of countries have very developed LPG markets. Countries with most developed markets include Korea, Turkey, Russia, Poland, Italy and other countries that increase, improve and expand the development trend of this market.

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THE EXTENDED FINITE ELEMENT METHOD IN FATIGUE LIFE PREDICTIONS OF OIL WELL WELDED PIPES MADE OF API J55 STEEL

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Abstract: This paper presents an application of the extended finite element method (XFEM) in the modeling and analysis of simultaneous cracks propagations in a seam casing pipe made of API J55 steel by high-frequency (HF) contact welding. The geometry used in simulations is pipe with axial crack subjected to constant amplitude cyclic loads. Short theoretical background information is provided on the XFEM, as well as the demonstration of the method used for verification of computed stress intensity factors (SIFs). The obtained numerical results prove the efficiency of XFEM in the simulation of the axial cracks propagations in tube geometry. Some guidelines for improving the XFEM use in fatigue life predictions are also given.
Key words: XFEM, seam casing pipes, axial surface crack, fatigue crack growth, fatigue life prediction

INTRODUCTION

Pipelines are the most economical and safest way for oil and gas transport. However, majority of failures of welded steel pipelines occur due to insufficient resistance to crack initiation and growth, poor quality of welded joints and reduced capacity due to corrosion damage. Low-alloy steels are nowadays widely used for pipelines due to optimal combination of mechanical properties and weld ability, but their application for oil and gas pipelines is still related to failures.
The reliability of the oil rigs system is very important for the continued exploitation and for environmental protection as well. Therefore, the standards and recommendations for assessing the effects of cracks on the integrity of welded pipes were developed. However, welded casing pipes can also have an axial surface crack on the inner and/or outer surface, and be subjected to different loads, including external and internal pressure and axial loads (e.g. due to structure weight).
In order to keep pipeline safe and reliable in operation, its fatigue life is of utmost importance. The essential part in fatigue life prediction is to estimate precisely the maximum allowed pressure, as well as to evaluate fracture mechanics parameters, like stress intensity factor and J integral. So far, there are no detailed 3D finite element analyses of wide spectrum of outer surface cracks.
This paper presents an application of the extended finite element method (XFEM) in the modeling and analysis of simultaneous cracks propagations in a seam casing pipe made of API J55 steel by high-frequency (HF) contact welding.
The geometry used in simulations is pipe with axial crack subjected to constant amplitude cyclic load.

Crack growth under cyclic loading

Crack growth under cyclic loading of machine parts and construction has a crucial influence on their lifetime. Therefore, of practical importance is to determine the relationship between the present stress state at the crack tip, which is at variable load determined by the stress intensity factor range *ΔK*, and the crack growth rate *da/dN*.
The crack growth to its critical size primarily depends on external loads and crack growth rate. Paris equation for metals and alloys, establishes the relationship between fatigue crack growth *da/dN* and stress intensity factor range ΔK, using the coefficient C_p and the exponent m_p:

$$\frac{\mathrm{d}a}{\mathrm{d}N} = C_p (\Delta K)^{m_p} = C_p \left(1{,}12 \cdot \Delta\sigma \cdot \sqrt{\pi \cdot a}\right)^{m_p}$$

Resistance to crack growth of API J55

Pressured welded pipes can be very sensitive to cracks and their stable or unstable growth. Therefore, it is important to identify reliable criteria for assessing the remaining lifetime of pressured pipes with cracks in base material and weld. In order to understand better the crack initiation and crack growth in casing pipes exposed to high pressures, high temperatures and chemically aggressive work environment in oil rigs, the material behavior control parameters at the crack tip and the fracture resistance should be expressed quantitatively.

Tests of the modified CT specimens were carried out at room temperature on a machine SCHENCK-TREBEL RM 100. Modified CT specimen thickness is d = 6.98 mm (equal to the pipe wall thickness) [12]. Indirectly, through the critical J values J_{Ic}, the critical values of stress intensity factor K_{Ic}, are determined, i.e., calculated using the expression (1) and are given in Table 1:

$$K_{Ic} = \sqrt{\frac{J_{Ic} \cdot E}{1 - \nu^2}} \tag{1}$$

Using the expression:

$$K_{Ic} = 1{,}12 \cdot \sigma_c \cdot \sqrt{\pi \cdot a_c} \tag{2}$$

and taking into account the values of stress, $\sigma = \sigma_c$, (where σ_c is fracture stress) approximate values of critical crack length (a_c) for base material (BM), heat affected zone (HAZ) and weld metal (WM) were calculated.

Table 1. The values of K_{Ic} - pipe from service

Specimen	Temperature [°C]	J_{Ic} [kN/m]	K_{Ic} [MPa m$^{1/2}$]	a_c [mm]
BM-NR-E	20	35.8	91.4	14.4
HAZ-NW-E		48.5	106.4	19.6
WM-NW-E		45.7	103.3	18.5

Based on the obtained values of K_{Ic} for the base metal, HAZ and weld, the basic material (BM) has the lowest resistance to crack initiation and propagation.

XFEM in fatigue life prediction

The extended finite element method was developed to ease difficulties in solving problems with localized features that are not efficiently resolved by mesh refinement. One of the initial applications was the modeling of fractures in a material. A key advantage of XFEM is that in such problems the finite element mesh does not need to be updated to track the crack path. Morfeo/Crack for Abaqus relies on the implementation of the extended finite element (XFEM) method available in Abaqus. Morfeo/Crack for Abaqus is capable of performing crack propagation simulations in complex geometries. It calls Abaqus at each propagation step and between each step, then reads the Abaqus solution, recovers a richer, improved XFEM solution in a small area surrounding the crack and computes the SIFs. SIF values at crack tip determine the appropriate crack growth increment for crack. This procedure was performed 100 times in order to simulate incremental crack growth.

Fatigue life predictions of pipes with axial surface crack

The main technical characteristics of the oil rigs from where the observed pipe is are as follows:

- Layer pressure (Kp-31): maximum=10.01 [MPa], minimum=7.89 [MPa].
- layer temperature: T=65 [ºC],
- number of strokes of pump rod: n_{PR}=9.6 [min^{-1}]

The geometry used in simulations is pipe with axial surface crack in the base metal (BM), Figure 1. The pipe is made of API J55. On the outer surface of the pipe there is an initial axial surface crack with dimensions: a=3,5 mm and 2c=200 mm.

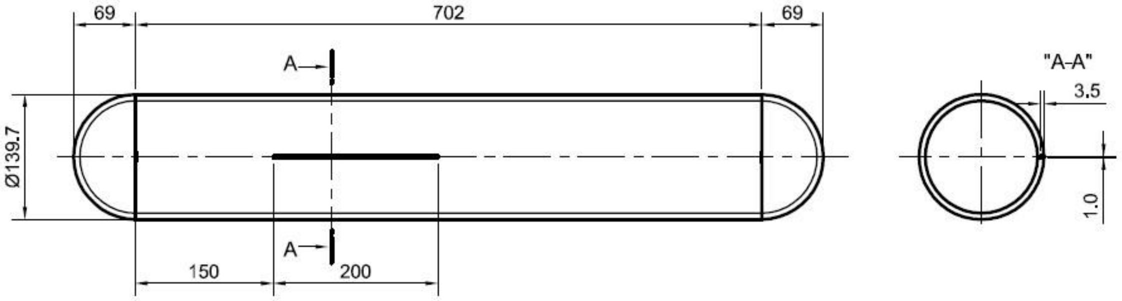

Figure 1. Pipe (pressured vessel) with an axial surface crack on the outer surface

The initial crack length used in the analysis was 200 mm, and it was 3, 5 mm deep. The growing crack was incremented at steps of 0.2 mm. Figure 2 shows crack at beginning (1st step- crack opening), figure 3, after 7th step of propagation when the crack grows through the wall, while Figure 4 shows the crack at the end of XFEM simulation (step number 100). The final crack length at the end of simulation was 219.8 mm.

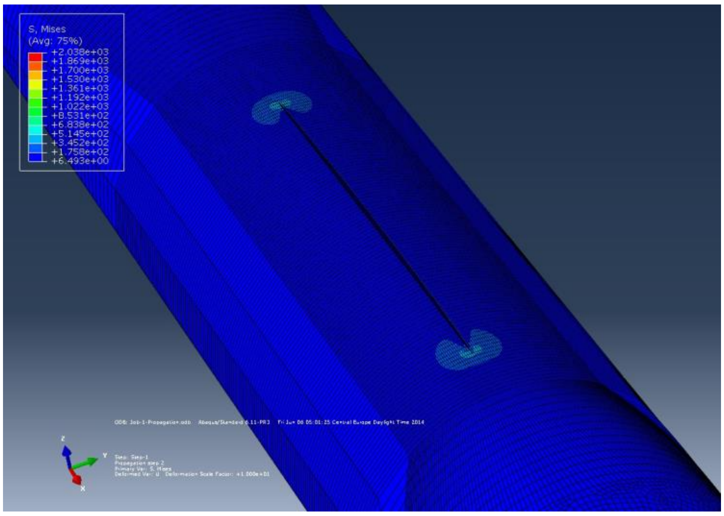

Figure 2. Step 1 - crack opening and Von Mises stresses at crack tips

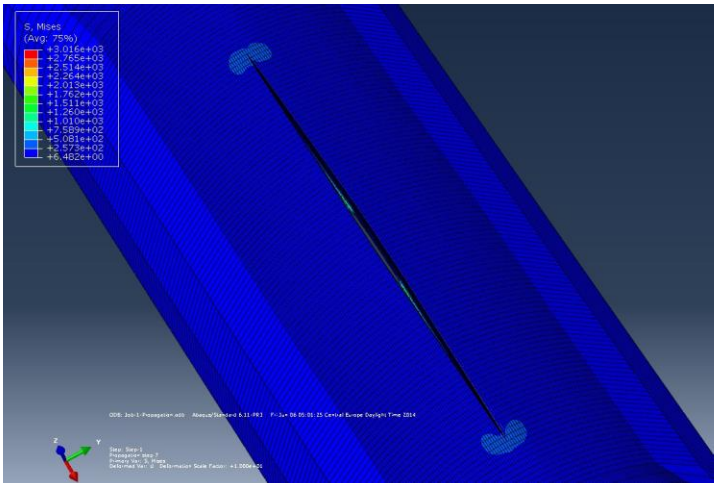

Figure 3. Von Mises stresses at 7th step – crack became through-wall

A finite element model of the pipe was created using the Abaqus software. Mesh was refined around the initial crack, and a uniform template of elements was used.

The prediction of crack growth rate and residual strength of pipe demands accurate calculation of stress intensity factors (SIFs). Morfeo/Crack for Abaqus calls Abaqus at each propagation step and between each step, then reads the Abaqus solution, recovers a richer, improved XFEM solution in a small area surrounding the crack and computes the SIFs.

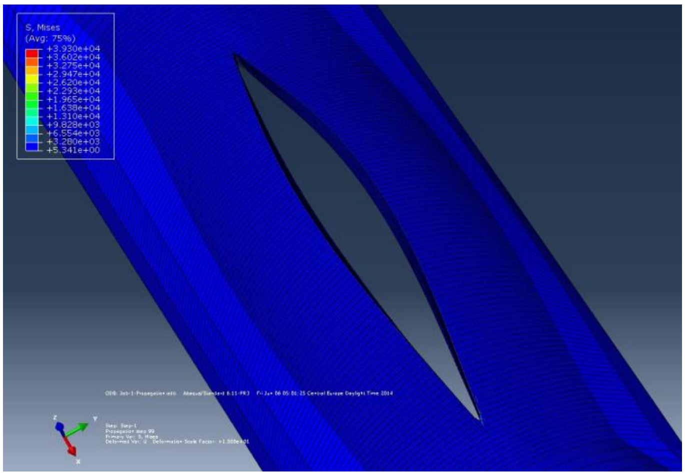

Figure 4. Final crack length at 100th step (219, 8 mm) and Von Mises stresses

SIF values at the crack tip determine the appropriate crack growth increment for the crack. This procedure was performed 100 times in order to simulate incremental crack growth. Some of the values obtained in Abaqus for every crack growth step are shown in Table 1. SIF values at the crack tip are shown in the last four columns. Those are equivalent SIF – Keq, and respectively SIFs for modes I, II and III, K_I, K_{II}, and K_{III}. Obviously, value K_I is more influential in crack growth then K_{II}, and $K_{III.}$ Thus, it will be reasonable for further consideration to use stress intensity factor K_I, or even better Keq, in fatigue crack growth prediction rates.

Table 2. Some of the values obtained in Abaqus for every crack growth step

Curvilinear abscissa along the crack front	x (front point coordinate)	y	z	K_{eq}	K_I	K_{II}	K_{III}
0	50.7745	8.77E-05	69.4784	860.175	837.413	1.55444	1.65058
0.349	50.7745	8.72E-05	69.1294	859.6	837.004	1.468	1.74059
0.698	50.7745	8.68E-05	68.7804	859.072	836.648	1.38001	1.83133
1.047	50.7745	8.64E-05	68.4314	858.595	836.348	1.29048	1.92288
1.396	50.7745	8.59E-05	68.0824	858.175	836.113	1.19942	2.01528
1.745	50.7745	8.55E-05	67.7334	857.82	835.95	1.10692	2.1085
2.094	50.7745	8.51E-05	67.3844	857.54	835.868	1.01306	2.20247

The obtained relationship between equivalent stress intensity factor K_{ekv} and crack length *a*, Figure 5, shows tendency of increasing K_{ekv} with increased crack length *a*, while the crack was reached up to 210 mm. The largest increase in value K_{ekv} , as expected, was before the seventh step, when crack penetrates the pipe wall. In working conditions leaking starts here and the pipe is already failed. However, the pipe is still in use for simulation.

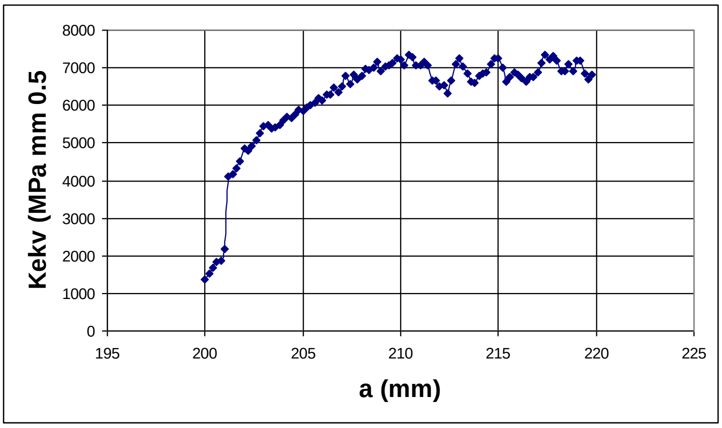

Figure 5. Obtained relationship between equivalent stress intensity factor K_{ekv} and crack length *a*

The chart in Figure 6 shows the obtained relationship between steps and cycles number logN.
After the seventh step, when the crack penetrates the pipe wall, the number of cycles becomes significantly lower and remains at about the same values until the final step, when the crack length is 219.8 mm.

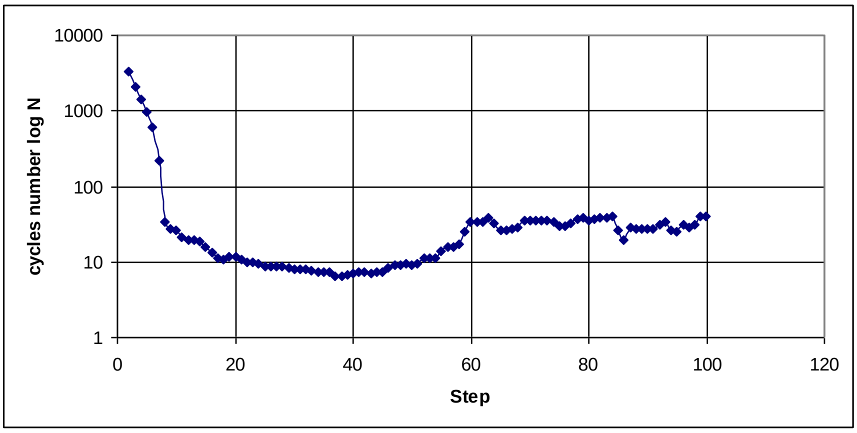

Figure 6. Obtained relationship between steps and cycles number logN

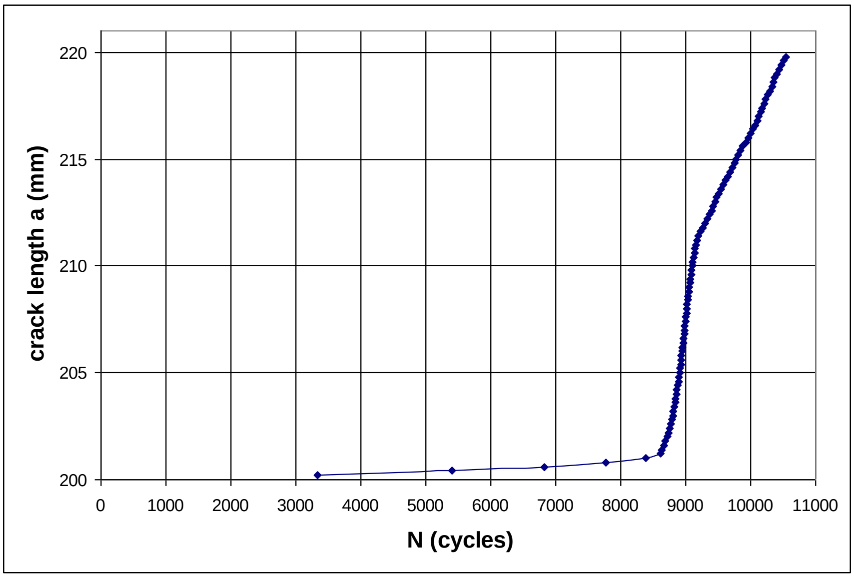

Figure 7. Obtained relationship between crack length *a* and number of cycles N

The chart in the Figure 7 shows the obtained relationship between the crack length *a* [mm] and the number of cycles N. Obviously, after the seventh step, in which the crack becomes through-wall crack, while the further cracks growth requires a very small number of cycles.
The obtained stress intensity factor histories can be used to predict fatigue crack growth rates by using them as input data for AFGROW of NASGRO software.

CONCLUSION

Fatigue life predictions of welded seam casing pipes with axial surface crack on the outer surface of pipes, made of API J55 steel, was performed in this paper using XFEM**.**
Based on the critical value of stress intensity factor K_{Ic} for the base metal, HAZ and weld metal, the critical crack lengths were calculated. The results indicate that the basic material has the lowest resistance to crack initiation and propagation, and according to that, the analysis of crack propagation in basic material was performed.
The obtained numerical results prove the efficiency of XFEM in the simulation of the axial cracks propagations in tube geometry.
Majority of failures of welded steel pipelines occurs due to insufficient resistance to crack initiation and growth. However, during its life cycle, welded casing pipes are exposed to corrosion effects, augmented with high pressure and high temperature environment. Having in mind the predicted severe exploitation conditions, significantly lower remaining fatigue life of welded casing pipes is expected.

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Session 8.

Computer technologies and engineering education

CAD SOFTWARE IN THE FIXTURE DESIGN

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Abstract: In article is presented a method for developing a library for strap clamps used in construction of the cutting processing devices. It is a method of high productivity, especially when the mechanisms are used so often because is no longer necessary to perform the design and modelling the mechanism every time when it has various dimensions. For developing this methodology is used Autodesk Inventor and Excel Microsoft Office software.
Key words: Computer Aided Design, strap clamps, library

INTRODUCTION

In actual conditions, the market success can be ensured only by the market launch of new products in a short time with high quality and with low cost. This can be ensured by the use of the new techniques for constructive design, technology and manufacturing that use the computer systems to solve technical problems, such as CAD, CAM, CAE technologies.
It is also known that in the technological system, the jigs and fixtures are the basic components that define the main technical and economic coordinates of the obtained product: cost and quality. For these reasons, it is understood that it is necessary to use the modern CAD technologies for jigs and fixtures design and manufacturing.
In this paper it is presented a method of performing a database of strap clamp mechanisms, making it easier both, work of the fixtures designer and the designer of manufacturing technologies.
The strap clamps mechanisms, in their construction, include one, two or more clamps, which have the role of transmit, amplify and / or change direction or sense of the clamping forces developed by various types of mechanisms: screw, eccentric, pneumatic, hydraulic, etc.

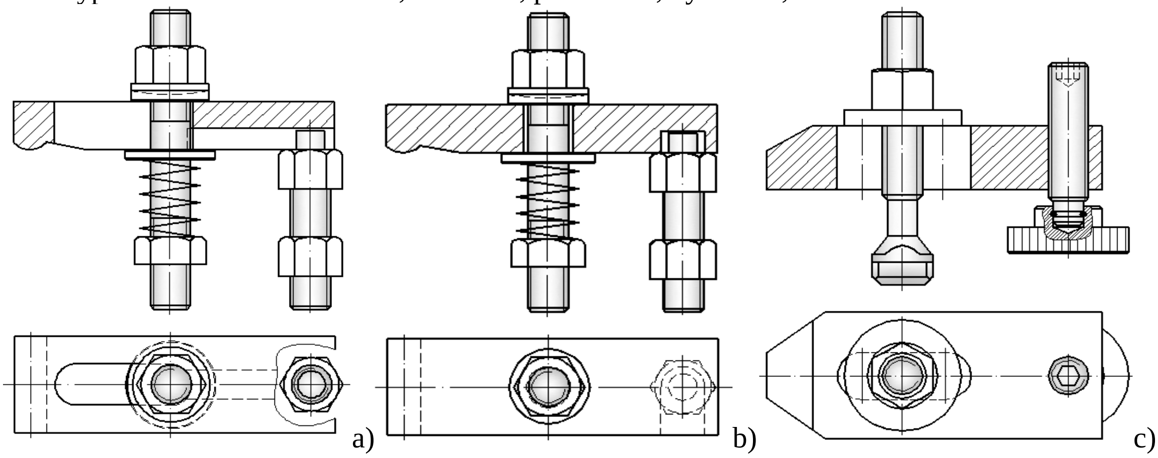


Figure 1. Types of the strap clamp mechanisms

Several types of mechanisms with a clamp is shown in Figure 1. The mechanism from Figure 1a is moved through translational over the workpiece to the left, so it is called translatory strap clamp and that of Figure 1b through rotation about the axis of the screw and is called rotational strap clamp. The mechanism of Figure 1c is a translatory strap clamp mechanism that used the support screw for support element.

A METHODOLOGY TO ACHIEVE A DATABASE WITH STRAP CLAMP MECHANISMS

The databases represent useful tools for increasing the productivity, by creating and using families of pieces. Different types of families of pieces can be formed for instance: screws, screws, washers, nuts, bearings, etc. Generally, their shape and dimension are presented in tables of standards and normative.

In order to develop database, we need the following soft packages:
- Autodesk Inventor Professional, with this software will realize the parametric model of the strap clamp;
- Microsoft Office Excel, with this software the tables shall be carried out having the dimensional characteristics of constructive variations of the mechanism.

We will make use of the library terminology in order to designate piece collections drawing their dimensions from the tables of values.

Making the parametric model of the strap clamp

To illustrate the method, it will be used the strap clamp mechanism shown in Figure 1. The first step consists in parametric modeling in Autodesk Inventor of each piece of the mechanism.
The piece is developed beginning with a sketch, on this basis of which a first 3D feature will be generated. In the first stage, the constructive shape of the piece is of interest, the dimensions being in the second place as they can be modified at any time.
The strap clamp mechanism consists of 5 pieces that were parametric modeled in Autodesk Inventor using the specific commands [3], each piece having its own particularities. Parts necessary for assembly mechanism are: clamp, bolt for T-slots, a support screw, a hexagonal nut and a washer (fig. 2 ... 6).

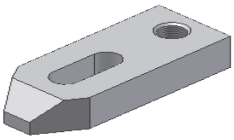


Figure 2. Clamp

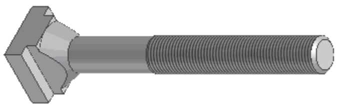


Figure 3. Bolt for T-slots

Figure 4. Support screw

Figure 5. Hexagon nut

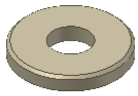


Figure 6. Washer

After modeling all the pieces making up the mechanism, their assembly follows.
Between the components, there are no links. What follows is the addition of 3D constrains, the assembly begins to take shape. During the assembly, the degrees of freedom are checked, which can be eliminated up to completely constraining the assembly.
3D constrains represent relative lining and positioning techniques of two pieces. Inventor has 4 types of constrains: mate (superposition), Angle (fixes a relative angle), tangential (tangential angle) and insert (inserts).
To assemble the clamping mechanism need the following 3D constraints: mate, flush and angle. The result of applying these constrains shown in Figure 7.

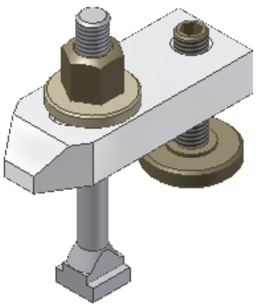


Figure 7. The 3D model of the clamping mechanism

Creating link with Excel Microsoft Office

In order to develop a library for all pieces with in assembly it is necessary to create in an Excel file a table containing all dimensions of the pieces. This can be achieved by making a link between the case containing the assembly parameters and the sheet containing the Excel table. The table consists of a number of columns corresponding to the number of parameters from which a dimensional variant can be chosen for the assembly (table 1).

Table 1. Parameters of the assembly in Excel sheet

Force	lungb	grosb	latb	bcb	ecb	eb	diams	lat_s	inal_s	lats	lungs	lung_f_s	d1t	desc_ch	di_saiba	gr_saiba	lung_tija_t	d_in
kN	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
14	80	15	30	12	15	30	10	9,7	6	15	80	50	10	16	28	4	39	6
20	100	20	40	14	21	40	12	11,7	7	18	100	65	12	20	35	5	49	6
38	125	25	50	18	26	45	16	17,7	10	28	125	85	16	24	45	6	55	8
60	160	30	60	22	30	60	20	19,7	14	32	160	110	20	30	50	6	69	10

The number of lines equals the number of dimensional variations established for the assembly. Within the stage of shaping the assembly pieces, a link is made with Excel page, and these parameters are used in the stage of dimensional constraint of drafts and of editing the characteristics obtained following the application of shaping tools for the pieces making up the assembly.

The software identifies the parameters, and the assembly obtained has the shape and the dimensions corresponding to the dimensional variation selected in Excel file.

In the Excel file will be achieved another table with four columns: in the first column is parameter name, in the second column are the mechanism dimensions, in the third column are the units of measure of the parameters, and the last column, the description of the parameters. Table 2 is directly linked to the mechanism modelled in Autodesk Inventor.

Table 2. Mechanism dimensions

Parameter	Value	U.M.	Description
lungb	160,0	mm	Clamp length
grosb	30,0	mm	Clamp thickness
latb	60,0	mm	Clamp width
bcb	22,0	mm	Width head clamp
ecb	30,0	mm	Length head clamp
eb	60,0	mm	Length hole
diams	20,0	mm	Bolt for T-slot diameter
lat_s	19,7	mm	Width T - slot
inal_s	14,0	mm	Height foot support screw
lats	32,0	mm	Width support screw
lungs	160,0	mm	Length bolt for T-slot
lung_f_s	110,0	mm	Length thread bolt
d1t	20,0	mm	Support screw diameter
desc_ch	30,0	mm	Spanner dimension
di_saiba	50,0	mm	Washer exterior diameter
gr_saiba	6,0	mm	Washer width
lung_tija_t	69,0	mm	Length support screw
d_in	10,0	mm	Torx dimension

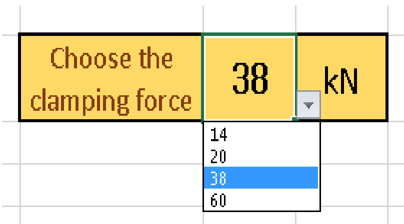


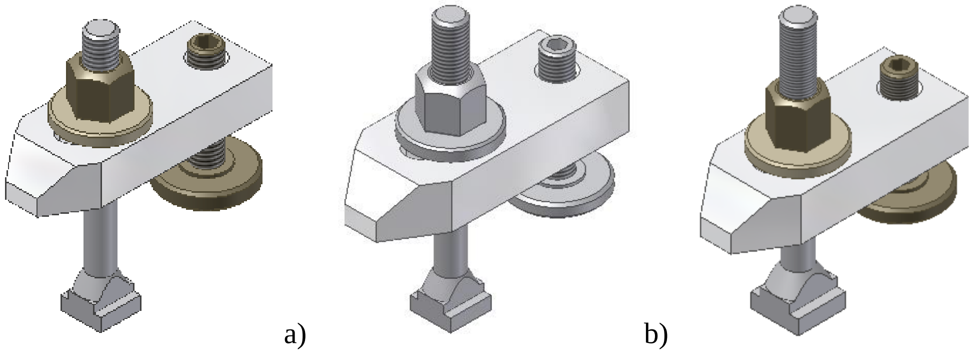
Figure 8. Cell to data validation

Choosing the dimensional variations is facilitated by using the LOOK UP function in Excel (figure 6), which enables to choose a dimensional variation of the strap clamp mechanism from a drop list where the values of nominal clamping forces are presented.

After developing the library, this can be used easily by any person, by a simple access of the Excel file and by modifying the clamping force depending on the required force for the desired mechanism.

CONCLUSIONS

Developing a library for any piece or mechanism is a method of high productivity, especially when they are used so often. This is because it is no longer necessary to perform the design and the shaping of a piece every time when it has various dimensions. Both the dimensions in Excel file and the pieces shaped by the Inventor can be modified at any time. The assembly, when modifications are identified, will adapt accordingly with them. Also, new lines of values can be added in case they have not been achieved by the initial library.
It can be successfully used by anyone because it takes the modification of only one value in order to choose another mechanism. In the same time, it does not need a large storage space as it develops only one assembly.



a) b) c)

Figure 9. Strap clamp mechanisms that develop clamping forces of 14 kN, 20 kN and 38 kN

The result obtained after these steps is shown in Figure 9. Figure 9 presents three mechanisms that develop clamping forces of 14 kN, 20 kN and 38 kN.

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USE OF COMPUTER ANIMATION IN COMPUTER ERGONOMICS

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Abstract: The long-term performance of a computer is one of the serious risk factors for the onset and development of various pathological conditions and diseases, whose weight ranges from relatively benign to extremely serious. They arise as a result of long-term static loading of the spine, non-physiological position and repetitive motion in the wrist. The aim of this paper is that, based on research conducted during the project TEMPUS 158781_2009 show applied knowledge in the subject computer animation. This paper presents some of the ways of implementing the knowledge of computer ergonomics in 2D animation. To create animation was used Adobe Flash.
Key words: computer ergonomics, education, computer animation

INTRODUCTION

In contemporary world, the use of computers is growing almost exponentially. Computers are used in business, education and for fun and communication. Computer use is especially popular in people who every day spend more and more time searching the Internet, making movies and music, participating in social networks, discussion groups, etc. On the other hand, people unfortunately play less sports and go rarely to recreation in nature, all of which mainly results in improper body posture, obesity, eyesight problems, unsociability, alienation and other. If a person is also professionally oriented to working on computers, the risk of the aforementioned health problems is significantly increased [1].
In the project that is conducted in our School, TEMPUS 15871_2009, our students were finished education of computer ergonomic. They are well known with preventive measures and advantages of their application. Also they are are familiar with the injuries that can result from improper use of the computer, namely improper postures while working on the computer.
Several hours working on computers every day causes a range of health problems, starting from minor ones to potentially fatal ones. As well as injuries that according [2] can be classified into three groups:

- injuries due to repeated straining (paresthesia of the hand, injuries of tendons and muscle connections, tendinitis, tenosynovitis; a detailed description of the symptoms can be found in [9]
- disorders of upper extremities function (reduced movability and pains in upper extremities)
- problems with spine (pains in spine, back, neck, myofascial syndrome; a detailed description of the symptoms can be found in [2])

A more detailed description of the diseases that occur as consequences of working on computers can be found in [3-5]. According to these sources, persons who spend more of 30 hours per week working on computers have increased risk of the occurrence of some of the aforementioned health problems.
There is a wide range of measures that can be undertaken with the aim of reducing the risks of diseases occurrence connected with long hours of working on computers.
More over, there is an array of ergonomic products on the market, products adapted for human body (keyboards, mouses, chairs) which application can significantly reduce the adverse effects of working on computers.
We are going to single out only some of the mentioned measures that can help proper body positioning, and a more detailed list and the description of measures can be found in [3].
One of the most wonted measures are:

- proper seating at the table,
- the monitor should be at a distance of 60 - 110 cm from the eyes,
- after an hour of working with the computer make a break of 10 -15minutes,
- provide quality monitors and monitor the protection of reflections and flashes of light.

Education in the field of computer ergonomics can help us to avoid above mentioned health problems.

With classical education we influence on the awareness of the students as we have demonstrated and shown through the research [1].
Due to the good results obtained with education we continue with our research that has spread in the form of constant influence education. In order to give even more effort in computer ergonomy education we are currently working on a computer animation, which we plan to set up as screen savers on the computers in our computer labs. The animations should remind our administrative worker on the correct posture.
The aim of this paper is to show student implemented knowledge of computer ergonomic in subject computer animation, and how good symbiosis of knowledge and use of modern technologies in the use thereof.

RELATED WORK

The use of computer animation can be found in many different areas. So, Brigitte Vigs Henningsen, in their work explore the possibilities of animation as a method of learning to develop childrens and your peoples skills and competencies [6].
In graduate thesis [7] we can find a lot of the possibilities of applying flash animation in teaching Renewable Energy Resources. Were we can see use of computer animation in application of solar energy, wind energy, and so on.
Paper [8] presents the results of training students in computer ergonomics and these are the measures proposed application of this knowledge, and as one of the effective measures were applications through animation.
In the work [9] we can find use of computer animation in teaching technical and computer education.

COMPUTER ANIMATION

The root of the word animation should be sought in the Latin verb *animare,* meaning breathe life into being. By applying the principles of traditional animation as anticipation, "flatten and drag" operation that overlaps, exaggeration and "finalizing" scene, which comes to life and reveal the charm [10].
With animation on stage can be introduced the concept of time. Match time is better recognized by observing changes in the everyday world: the sunlight that passes through the clouds, a heart that beats, a clock ticking, the human body that play in rhythm, steady rhythm machines, rivers flowing to the sea, slowly fingering the stars in the sky. Statements about past times may be imposed on the basis of a comparison of what the user sees with what he remembers: grizzled hair, furrowed brow, an empty glass or an empty house [10]. Time may make the world go around user or crowded, beautiful or depressing, light or dark, old or new.
Computer animation comprises 2D and 3D modeling and animation of objects in some type of video material. In 2D animation mean moving images that match the frames. Impression of moving images is obtained if the images are exchanged at a certain speed, which is 24 frames per second, so the human eye accepts it as a continuous movement. Animation is achieved by drawing as needed frames for a change to give a smooth movement [11]. In 3D animation defines the geometric body in space, the environment, the point where the light propagates, material properties, and various other things to get to the end through one of the algorithms obtain the final image [12].

Adobe Flash Professional

Adobe Flash Professional is the successor of a software product known as FutureSplash Animator, a vector graphics and vector animations program released in May 1996. FutureSplash Animator was developed by FutureWave Software, a small software company whose first product, SmartSketch, was a vector-based drawing program for pen-based computers. With the implosion of the pen-oriented operated systems, it was ported to Microsoft Windows as well as Apple Inc.'s Mac OS. In 1995, the company decided to add animation capabilities to their product and to create a vector-based animation platform for World Wide Web; hence FutureSplash Animator was created. (At that time, the only way to deploy such animations on the web was through the use of Java platform.) The FutureSplash animation technology was used on several notable websites such asMSN, The Simpsons website and Disney Daily Blast of The Walt Disney Company.

Term ergonomics in workplace

Ergonomics studies the working conditions, as well as customization of man these conditions and ways and methods for adapting working conditions to man. As a scientific discipline encompasses all aspects of human activity during the development and use of the elements of the work process: machine tools, work environment, and the work of his organization, taking into account the biological, psychological and social factors of man in the process. Ergonomics is the science whose mission is to work more comfortable and safer, is widely used in all areas, for improving and maintaining efficiency, productivity, health and safety in carrying out their tasks. Takes into account the ergonomics and the man:

- its possibilities;
- its capacity, and
- boundaries within which an application can set a man.

The main goal of ergonomics is a reduction in the number of workers affected by a group of diseases that are called common musculoskeletal disorder (MKP), which represents the most common diseases related to work. The main ergonomic risk factors are:

1 Repetition of a movement many times;
2 Continuous or uninterrupted execution of the movement;
3 Uncomfortable position, static posture, vibration;
4 Prolonged sitting;
5 Using a large force of parts or the whole body in the frame work activities;
6 Perform work activities that require a great stretch of the body or body parts;
7 Manual tasks (lifting, lowering, pushing, carrying) and working with difficult cases;
8 Manipulation loads below knee height or above shoulder height;
9 Manipulation dimensionally large objects; 10 unnatural position of the joints and contact load.

The main ergonomic risk factors are:

- Change in the design and organization of work;
- Change in the way of organizing and implementing work activities;
- Rest and physical exercise;
- Training of employees to work in an ergonomically correct way.

The most common musculo - skeletal disorders that are related to ergonomic risk are:

- Carpal Tunnel Syndrome;
- De Quervain's disease - tenosynovitis;
- Golf and tennis elbow;
- Vibration anchor hands and arms;
- Pain in the lower back;
- Sidra rotatorske cuffs;
- Tendinitis;
- Tension neck syndrome;
- Trigger finger.

The measures that must be taken into account in the prevention of the musculo-skeletal disorders are the following:

- Avoid too frequent repetition of activities that require twisting, twisting, bending and other unnatural postures of the body and hands;
- Changing the position of the body during the day, a combination of sitting and standing;
- Avoiding repetition east movement a number of times, the combination of different jobs;
- posture when lifting and transferring cargo to ask for help if you guys are making difficult or dimensionally large;
- Making a short break to allow rest and relax your body.

EXAMPLES OF COMPUTER ANIMATION

Flash animation is used for application development rich content, user interface and Web applications. This program allows designers and developers to integrate video, text, audio, and graphics into content that gives excellent results in the areas of interactive marketing, presentations, e-learning, and user interface for the application. Students, of our School, with this program learn through exploring the environment, the basic tools for work, setting the scene, creating animated icons and placing instances of the scene, working with the time zone scenes and symbols, and creating animation motion of objects change shape or footage frame-by-frame . By mastering these methods to work with Flash program, students are trained to make video material, 2D animation, which will be applied in a particular area. For example, students of this generation were supposed to do an animation on the topic of ergonomics computer with which they learned about in class the other cases the program TEMPUS 15871_2009.

On the subject computer animation students are supposed to shape their knowledge of ergonomics in a 2D multimedia animation using program Adobe Flash. Through this proekat students have realized the importance of how we want to emphasize topics, how important is the time that is given to show animations and information transfer through movement. Some of the responses on this subject are shown in Fig.1 and Fig. 2. Figure 1 shows how an image can be used for the animation. Every part of the body that need to be corrected in the position must be specially prepared by the picture that could be animated.

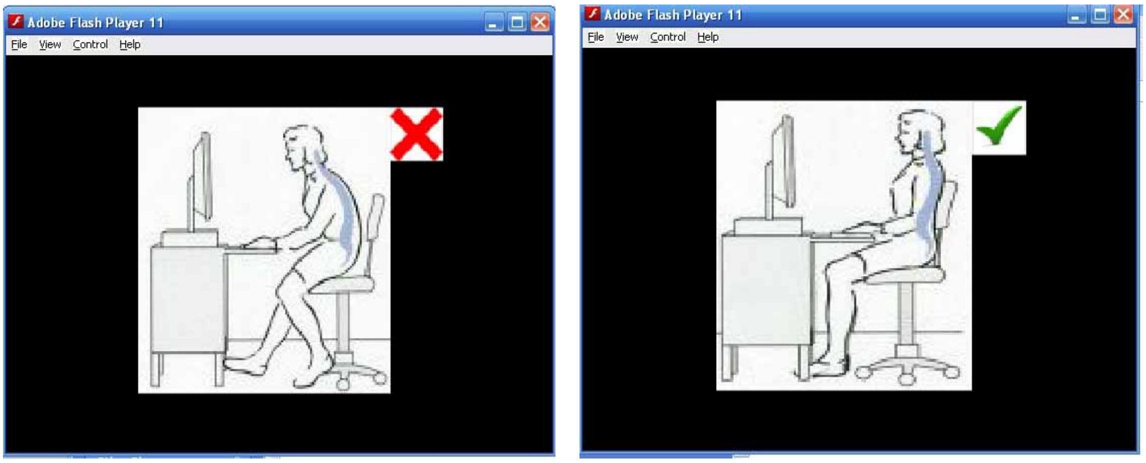

Figure 1. Use of the image in the animation

To display the correct posture while working can be symbolically show the body parts and put them in the correct position as shown in Figure 2.

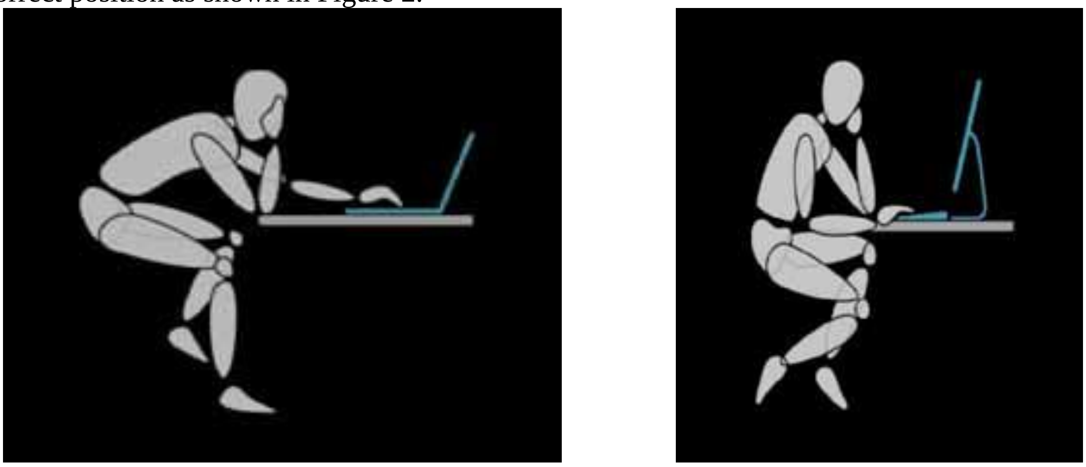

Figure 2. Symbolized by the position of the body

These examples will be further utilized in the project at the Technical College of proper posture at the computer. During this project on every computer in the laboratory classrooms will be installed screen saver of animation made with a certain timing to keep track of user activity in certain periods warn him to posture as a mandatory break required during operation in order to influence the risk reduction the occurrence of adverse events during long-term operation of a computer.

CONCLUSION

The focus of the work is given to computer animation, the modern mode on the Computer Animation. There is a need to educate students in this field as the demand designers and animators who can work with these programs is very high. We are witnessing the implementation of this knowledge in all areas of work and relaxation. The success of our students need only ideas for ways of implementing these ideas have been educated through modern education and new technologies that are infused into study programs in Higher Education Technical School of Professional Studies in Novi Sad.
The paper lists the most common health problems that can occur during the long-term irregular work on the computer. In the paper are presented the basic ways to prepare animations using image processing and the development of models and scenes.
The idea is to make a further elaboration of the computer animation to be used as a screen saver, and to remembered us to the injuries that can result from improper use of the computer, namely improper postures while working on the computer.
Of course, we are faced with problems that dictate the hardware requirements necessary to complete the work in these programs as well as constant new releases and update the above programs.

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COMPARATIVE FEATURES OF AUTOCAD AND INVENTOR SOFTWARES WITH EARLIER VERSIONS

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Abstract: In this work we are showing new features of AutoCad and Inventor software. We have compared previous versions with newer in order to see if there is need to upgrade the software for users that are using older versions. It is imperative to know areas of the development of these softwares in order to understand what you can do with newer versions and where space for improvement lies.
Key words: computer-aided design (CAD), new versions of AutoCAD, new versions of Inventor

INTRODUCTION

AutoCAD is a computer-aided design (CAD) program used for 2-D and 3-D design and drafting. AutoCAD is developed and marketed by Autodesk Inc. and was one of the initial CAD programs that could be executed on personal computers.
AutoCAD was initially derived from a program called Interact, which was written in a proprietary language. The first release of the software used only primitive entities such as polygons, circles, lines, arcs and text to construct complex objects. Later, it came to support custom objects through a C++ application programming interface. The modern version of the software includes a full set of tools for solid modeling and 3-D. AutoCAD also support numerous application program interfaces for automation and customization.
DWG (drawing) is the native file format for AutoCAD and a basic standard for CAD data interoperability. The software has also provided support for design Web format (DWF), a format developed by Autodesk for publishing CAD data.
Autodesk releases new versions of AutoCAD every year. Part of this strategy is to introduce improvements that focus on a particular category of features. This latest version, AutoCAD 2014, includes new and improved features that are related to the command input and GIS.
The command line has been beefed up to be more interactive and intuitive. It offers an autocorrect feature and can display suggestions, much like the way some popular web browsers work.
The ability to make objects appear transparent has also been improved.
Autodesk has discovered that the number of users making use of point cloud scanning is on the upswing, so with this version, we can see some new features that will allow as to make smoother use of real-world references with point clouds, with controls similar to those in other referenced files. A new adjunct program called ReCap is available to help as import point cloud data into AutoCAD. [1,2]

NEW FEATURES OF AUTOCAD 2014 COMPARED TO EARLIER VERSIONS

AutoCAD 2011

AutoCAD 2011 has refined its interface by adding some new elements like animated tool tips and a new Web-based help system. A new Welcome screen offers short videos to help as learn basic functions. Dig a little deeper and we canl find that some new features have been added to simplify our work so we don't have to keep track of so many details. Here are some of the new features:

- Advanced surface modeling with procedural and NURBS surface tools give you a new level of control in 3D modeling.
- Streamlined materials and rendering tools make it easier to produce presentation-quality renderings from diagrammatic sketches to photo-real presentations.
- Powerful new hatch pattern interface greatly simplifies fill patterns.
- Expanded transparency control adds transparency to any pattern or object.
- Multifunction grips give you expanded control over 2D and 3D objects.

- New selection features enable you to isolate and select similar objects quickly and easily.

AutoCAD 2012

AutoCAD 2012 offers a wide range of new features, including expanded arrays, a way to store and open drawings online (AutoCAD WS), faster creation of groups, a new interface to access drawing content (the Content Explorer), and many small additions to improve your efficiency in both 2D and 3D drawings.

AutoCAD 2013

AutoCAD 2013 offers a range of new features, including an updated command line; a way to store, open, and even edit drawings online (AutoCAD 360); expanded features for 2D documentation and layout of 3D drawings; a preview of choices you make in the Properties palette; and many small additions to improve your efficiency in both 2D and 3D drawings. Autodesk also offers a new feature, Autodesk Cloud, for online storage.

AutoCAD 2014

AutoCAD 2014 has a long list of new features, many of which are aimed at making our work easier and faster. Some features like AutoCAD® WS and Autodesk Exchange are web tools that help as share our work, keep up with the latest on AutoCAD, and discuss issues we may be having. Here are some of the new feature:

- Improved online help and collaboration tools
- A redesigned command line with Autocorrect and Autocomplete capabilities
- File tabs that allow quick navigation between open files
- Full-screen previews of files through the file tabs
- A layer merge option in the Layer Manager
- Improved Xref management options to switch from attached to overlay Xrefs
- Aerial and map backgrounds with the geographic location tools
- Improved point cloud support
- Improved executable file security

Table 1 shows comparative features of AutoCAD softwares.

Table 1. Comparative features of AutoCAD softwares [3]

FEATURES	***AutoCAD 2014***	***AutoCAD 2013***	***AutoCAD 2012***	***AutoCAD 2011***
USER INTERACTION				
Multi-functional grips	√	√	√	√
Hide and isolate objects	√	√	√	√
Create and select similar objects	√	√	√	√
Delete duplicate objects	√	√	√	
Content explorer	√	√	√	
Associative arrays	√	√	√	
Clickable command line options	√	√		
Property edit preview	√	√		

Viewport change preview	√	√		
Intelligent command line	√			
File tabs	√			
DESIGN				
Solid, surface, and mesh modeling	√	√	√	√
Autodesk materials library	√	√	√	√
Editable UCS icon	√	√	√	
In-canvas viewport controls	√	√	√	
Surface curve extraction	√	√		
Context-sensitive press-pull	√	√		
Import sketchup files (SKP)	√			
Autodesk ReCap point cloud tool	√			
DOCUMENTATION				
Geometry measurement tools	√	√	√	√
Parametric constraints	√	√	√	√
Object and layer transparency	√	√	√	√
Base and projected views	√	√	√	
Blend curves	√	√	√	
Copy array	√	√	√	
Section and detail views	√	√		
Strike-thru text	√	√		
Text align	√			
CONNECTIVITY				
DGN 8 import/export/underlay	√	√	√	√
PDF publish/underlay	√	√	√	√
FBX import/export	√	√	√	√
DWG convert	√	√	√	
IGES, CATIA, Rhino, pro/engineer, and step import	√	√	√	
Inventor file import	√	√		
Autodesk 360 connectivity	√	√		
Design feed	√			
Share on Facebook	√			

Geolocation coordinate system and live maps	√			
CUSTOMIZATION				
Action recorder	√	√	√	√
CUIx file format	√	√	√	√
Online license transfer	√	√	√	√
Migration reset	√	√	√	
Multiple plot file search paths	√	√	√	
Customization and support file sync	√	√		
Exchange app manager	√			
Featured apps ribbon tab	√			
Secure load	√			

AUTODESK INVENTOR SOFTWARE

Autodesk Inventor is a 3D mechanical solid modeling design software developed by Autodesk to create 3D digital prototypes. It is used for 3D mechanical design, design communication, tooling creation and product simulation. This software enables users to produce accurate 3D models to aid in designing, visualizing and simulating products before they are built.

This software incorporates integrated motion simulation and assembly stress analysis, whereby users are given options to input driving loads, dynamic components, friction loads and further run the dynamic simulation to test how the product will function in a real-world scenario. These simulation tools enable users designing cars or automotive parts, for example, to optimize the strength and weight of a product, identify high-stress areas, identify and reduce unwanted vibrations, and even size motors to reduce their overall energy consumption.

Autodesk Inventor's finite element analysis feature allows users to validate the component design through testing part performance under loads. The optimization technology and parametric studies permit users to design parameters within assembly stress areas and compare the design options. Then, the 3D model is updated based on these optimized parameters.

Autodesk Inventor also uses special file formats for parts, assemblies and drawing views. The files are imported or exported in a DWG (drawing) format. However, the 2D and 3D data interchange and review format that Autodesk Inventor uses most frequently is design web format (DWF). [4]

New features of Inventor 2014 compared to earlier versions

Table 2 shows comparative features of Inventor softwares.

Table 2. Copmarative features of Inventor softwares – What is new [5]

Official name	Version	Code name	Date of release	What's New
Inventor	2011	Neon	March 26, 2010	Dynamic Input, Direct Manipulation, Assemble tool, Visualization, iCopy, iLogic

Inventor	2012	Brunel	March 22, 2011	Provides easier ways to interact with 3D mechanical design data; new opportunities for sharing, accepting and updating CAD data regardless of source and complexity; and high-impact performance and productivity improvements for both users and IT departments
Inventor	2013	Goodyear	March 27, 2012	Equation curves
Inventor	2014	Franklin	March 27, 2013	Express mode, Connection, Symmetrical constraint, Slot geometry, Enhanced rectangle geometry, Thin wall FEA, Frame FEA, Assembly relationship folder Mouseover grounded constraint visibility, Model & assembly simplification, Joint constraints.

CONCLUSION

Modern design and engineering design in mechanical engineering, construction industry, architecture, traffic, electrical engineering and other is a complex task, which is today mainly supported by methods of computer technologies. Computer methods and technologies of the CAD/CAE (computer aided design/computer aided engineering) type have contributed to an essentially new approach to the process of designing and engineering designing in recent years. Knowing the theory of design should be an element of the general professional knowledge of each engineer of technical disciplines.
Considering the fact that mechanical engineering belongs to the group of progressive sciences and that it is one of the pillars of technological development, that it permanently changes and improves, it seems necessary for engineers themselves to keep being intensively educated and to improve their knowledge and skills. There is an obvious need to revise education for engineers as a response to changes in society. Engineers dream to have everything they need for their work: a series of practical and theoretical data in electronic from, no need to use books, manuals, tables, etc. By using modern software this objective of engineers and technicians can certainly be attained. [6,7]

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APPLICATION OF 3D PRINTING IN INDUSTRIAL MODELING

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Abstract: Since the 1980s, 3d printing or additive manufacturing technologies have been used primarily as a tool to aid the product design process. Additive manufacturing was a rapid and low - cost way to fabricate plastic prototypes of design concepts, visual aids, or fixtures for traditional manufacturing machines. As the quality of available materials improves, however, additive manufacturing is increasingly used to make parts or products that will actually be used in production. This paper describes basic characteristics of 3d printing, core technologies and possible advantages and barriers for using it in industrial modeling.
Key words: 3d printing, additive manufacturing, rapid prototyping

INTRODUCTION

As the multibillion dollar additive manufacturing (AM) industry continues to evolve, a growing number of companies have adopted 3D printing to produce finished goods. The 3D printing market has been experiencing double-digit growth in recent years. When compared with traditional manufacturing, however, AM production volumes are diminutive, and the technology remains far from gaining mass adoption, especially in direct – part production [2]. Many companies are still struggling to determine how to adopt AM technologies, even in cases where 3D printing could deliver clear benefits (e.g., small production quantities, expensive tooling, and geometric complexity). It is not surprising that executives are having difficulty; the technology has many second - order effects on business operations and economics.

The 3D printing technology made its way to the technological world in 1986, but was not fully noticed until 1990. It was not that popular outside the world of engineering, architecture and manufacturing.

Speaking of historically important moments, in March 1983, Chuck Hull, now cofounder, executive vice president, and chief technology officer of "3D Systems" company, created a small teacup by shooting a laser into a vat of UV - curable photopolymer. Dr. Hull built the first successfully produced 3D - printed object. In 1986 Charles Hull founded a company named "3D Systems" and developed the first commercial 3D Printing machine, called Stereolithography Apparatus. He named the technique as Stereolithography and obtained a patent. Today, according to Hull, "3D Systems has revolutionized the way companies design, present, prototype, and manufacture new products, empowering leagues of artists, hobbyists, and consumers to create previously impossible designs."

3D printing or additive manufacturing is any of various processes for making a three-dimensional object of almost any shape from a 3D model or other electronic data source primarily through additive processes in which successive layers of material are laid down under computer control. It can also be said that a 3D printer is a type of industrial robot. 3D printing is also known as desktop fabrication, because it can form any material that can be obtained as a powder. For creating an object, a digital 3D-model is needed that can be obtained by scanning a set of 3D images, or drawing using computer-assisted design or CAD software. Today thousands of models are available for download for free. The digital 3D-model is usually saved in STL format and then sent to the printer. The process of "printing" a three-dimensional object layer-by-layer with equipment is similar with ink-jet printers.

3D PRINTER

On a 3D printer the object is printed by three dimensions. A 3D model is built up layer by layer. Therefore the whole process is called rapid prototyping, or 3D printing.

A common process of rapid prototyping is to apply a fine powder (plaster, bioplastic, polyurethane, polyester, epoxy, metal, etc.) in such 3D inkjet printers. Printer prints out the layer of powder on a bed and forms a fixed object. The design is defined by a CAD file.

Fused deposition modeling (FDM) is another method in which molten polymer is sprayed on a support layer and the model is built layer by layer.
Another way is to use liquids, such as photopolymer, by the same inkjet-type head which is also printed each layer by layer.
Following, an ultraviolet light is used to activate the print head so that the liquid layer becomes a solid layer. This process is also well-known as stereolithography.
A number of trends are contributing to the adoption of 3D printing capabilities. First, compressed product life cycles and competitive pressure are forcing users to reduce new product time - to - market and innovation timelines. 3D printing can create geometries that sometimes are not possible with traditional manufacturing methods and can do so without increased costs. Thirdly, the push for companies across the board to reduce waste and energy consumption makes 3D printing an attractive option. In fact, many 3D printers allow users to recycle material after each use, cutting both waste and cost. Finally, a recent Engineering.com survey reveals that 66 % of engineers do not use professional 3D printers and 3D printing technologies, revealing a huge untapped market.
Many different materials can be used for 3D printing, such as ABS plastic, PLA, polyamide (nylon), glass filled polyamide, stereolithography materials (epoxy resins), silver, titanium, steel, wax, photopolymers and polycarbonate.

Methods and technologies

Not all 3D printers use the same technology to realize their objects. All of them are additive, differing mainly in the way layers are build to create the final object. Some methods use melting or softening material to produce the layers. Selective laser sintering (SLS) and fused deposition modeling (FDM) are the most common technologies using this way of printing. Another method of printing is to lay liquid materials that are cured with different technologies. The most common technology using this method is called stereolithography (SLA).
Selective laser sintering (SLS) - This technology uses a high power laser to fuse small particles of plastic, metal, ceramic or glass powders into a mass that has the desired three dimensional shape. The laser selectively fuses the powdered material by scanning the cross-sections (or layers) generated by the 3D modeling program on the surface of a powder bed. After each cross-section is scanned, the powder bed is lowered by one layer thickness. Then a new layer of material is applied on top and the process is repeated until the object is completed. All untouched powder remains as it is and becomes a support structure for the object. Therefore there is no need for any support structure which is an advantage over SLS and SLA. All unused powder can be used for the next printing. SLS was developed and patented by Dr. Carl Deckard at the University of Texas in the mid-1980s, under sponsorship of DARPA.
Fused deposition modeling (FDM) - The FDM technology works using a plastic filament or metal wire which is unwound from a coil and supplies material to an extrusion nozzle which can turn the flow on and off. The nozzle is heated to melt the material and can be moved in both horizontal and vertical directions by a numerically controlled mechanism, directly controlled by a computer-aided manufacturing (CAM) software package. The object is produced by extruding melted material to form layers as the material hardens immediately after extrusion from the nozzle. FDM was invented by Scott Crump in the late 80's. After patenting this technology he started the company Stratasys in 1988. The software that comes with this technology automatically generates support structures if required. The machine dispenses two materials, one for the model and one form a disposable support structure.
Stereolithography (SLA) - The main technology in which photopolymerization is used to produce a solid part from a liquid is SLA. This technology employs a vat of liquid ultraviolet curable photopolymer resin and an ultraviolet laser to build the object's layers one at a time. For each layer, the laser beam traces a cross-section of the part pattern on the surface of the liquid resin. Exposure to the ultraviolet laser light cures and solidifies the pattern traced on the resin and joins it to the layer below. After the pattern has been traced, the SLA's elevator platform descends by a distance equal to the thickness of a single layer, typically 0.05 mm to 0.15 mm (0.002″ to 0.006″). Then, a resin-filled blade sweeps across the cross section of the part, re-coating it with fresh material. On this new liquid surface, the subsequent layer pattern is traced, joining the previous layer. The complete three

dimensional object is formed by this project. Stereolithography requires the use of supporting structures which serve to attach the part to the elevator platform.

3D PRINTING IN INDUSTRY

In the last couple of years the term 3D printing has become more known and the technology has reached a broader public. Still most people haven't even heard of the term, while the technology has been in use for decades. Especially manufacturers have long used these printers in their design process to create prototypes for traditional manufacturing and research purposes. Using 3D printers for these purposes is called rapid prototyping [6].

Fast 3D printers can be had for tens of thousands of dollars and end up saving the companies many times that amount of money in the prototyping process. For example, Nike uses 3D printers to create multi-colored prototypes of shoes. They used to spend thousands of dollars on a prototype and wait weeks for it. Now, the cost is only in the hundreds of dollars, and changes can be made instantly on the computer and the prototype reprinted on the same day.

Besides rapid prototyping, 3D printing is also used for rapid manufacturing. Rapid manufacturing is a new method of manufacturing where companies are using 3D printers for short run custom manufacturing. In this way of manufacturing the printed objects are not prototypes but the actual end user product. Here you can expect more availability of personally customized products.

As the use of additive manufacturing to create production parts continues to increase, some observers predict that eventually, the result will be another industrial revolution, as global manufacturing networks will be profoundly disrupted, replaced by a new regime of localized, just - in - time 3D - printed manufacturing [6].

Today, the most compelling perceived benefits are the abilities to increase geometric complexity and reduce time to market, closely followed by reduced tooling and assembly costs [2].

According to [4], a list of 10 major impacts the 3D printing ecosystem will have on businesses, consumers, and the global economy can be summed up as following:

1. Massive environmental impacts

Traditional manufacturing is often wasteful and dirty. In many ways, 3D printing lessens that waste and the carbon footprint manufacturing has on the Earth.

- Fewer wasted materials: Only the raw materials needed to create the object are used. Using biodegradable PLA plastic filament in fused deposition modeling is an example.
- Possibility of longer life spans: Product parts can be replaced with 3D printing, so the entire product doesn't have to be thrown away and replaced each time it malfunctions.
- Less transport: Products often travel across many continents to get to their final destination. With 3D printing, the production and assembly can be local. Raw materials are the only things that will ship, and they take up less space.
- Fewer unsold products: If a company makes a product, the ones that are discontinued or not sold often end up piling up in landfills. 3D printing can improve this because companies can make them as needed.

It should be mentioned that research shows 3D printers themselves have inefficiencies that make them less environmentally friendly. An inkjet 3D printer wastes 40 to 45 percent of its ink. And if a printer isn't turned off or unplugged, it uses an excessive amount of electricity. As the printers become more accessible, manufacturers will need to figure out how to improve these issues.

2. Creating a new art medium

3D printers are being used to create new types of modern art. The printers can also recreate pieces that aren't accessible to everyone around the world, which helps museums. For instance, the Van Gogh museum in Amsterdam has teamed with Fujifilm to recreate 3D replicas of several Van Gogh paintings.

3. Innovation in education

3D printers along with 3D scanners can change how students see innovation and manufacturing, and help train engineers, architects, and.

4. 3D printing in zero-gravity

Printing parts, tools, and other gadgets for astronauts while they're in space with the goal to make space missions more self-sufficient.

5. Revolutionizing mass manufacturing
Mass production is the biggest challenge in 3D printing, but with the adoption of large-scale printers and rapidly evolving technology to produce parts faster, the printers will completely disrupt traditional manufacturing in many industries:
Food: Anything that exists in liquid or powder form can be 3D printed.
Military: The machinery for the military is often customized and replacements must be made quickly. A 3D gun has already been printed, so it's only a matter of time before the technology catches on in this industry.
Electronics: The size, shape, and materials used to make electronics make this industry a natural candidate for 3D printing.
Toys: Home 3D printers and open source design will change the way children create and play.
Automotive: This industry is already utilizing the technology—Ford reportedly uses 3D printing to test parts. High-end and smaller auto companies will benefit first, though 3D printing could improve the efficiency of making replacement parts for any company.
6. Changing medicine and healthcare
Bioprinting is one of the fastest-growing areas of 3D printing. The technology uses inkjet-style printers to make living tissue.
7. Transforming the home
People can print custom jewelry, household goods, toys, and tools to whatever size, shape, or color they want. They will also be able to print make replacement parts right at home, rather than ordering them and waiting for them to be shipped.
8. Reaching disconnected markets worldwide
Developing countries are often completely disconnected from global supply chains for even the most basic products, but 3D printing has the ability to help them in terms of for example manufacturing clothing or prosthetic limbs for medical care.
9. Impacts on the global economy
The 3D printing industry will have far-reaching effects on the global economy. McKinsey Global Institute recently released a report that said 3D printing will cause major disruptions in the global economy by 2025. The analysis firm predicts it will bring about new product development cycles as the systems become cheaper. More companies will adopt the technology and product creation will focus on client feedback and customer-centered design. The industry is also reducing the cost of entry into markets, allowing very niche businesses to pop up everywhere.

By reweaving the literature, three major challenges that the 3-D printing industry needs to overcome in order for adoption rates to improve have been detected:

- Organizational readiness: There's a high barrier of entry for a manufacturing company to get its operations and team in order. A lot of technical expertise around 3-D printing needs to be gained before a manufacturing operation can implement 3-D printing into its process.
- Technology: The majority of the design of 3-D printed objects is done by hand today. As you can imagine, this is not a very efficient approach for a manufacturer with millions of parts in its inventory. Until a streamlined and robust solution to automate this process becomes readily available, this major bottleneck will continue to play out.
- Awareness - Labor force experience: Mainstream awareness of 3-D printing is very new, and consequently, there's very little formal education around the subject. The total expertise pool needed to get an entire economy on board with 3-D printing simply isn't available today.

It is also important to mention ethical issues of 3d printing. Additive manufacturing technology enables a larger segment of the population to create copies and derivatives of rights - protected objects. One of the unresolved issues around additive manufacturing technologies is its potential to disrupt the intellectual property (IP) laws that protect physical objects against counterfeiting and other forms of IP theft. Consumer - level availability of 3D printing technologies could increase the likelihood that small businesses and individuals could infringe upon one another's IP rights on a large scale [6].
There are also a few other limitations which should be addressed. One promising aspect of 3D printing is that it may have a positive effect on our environmental impact, since it allows us to cut down the supply chain by printing objects as they are needed; similarly, it is less wasteful of raw materials than

subtractive manufacturing [5,7]. Nevertheless, long-term environmental impacts have not been studied, and must be considered. Similarly, many 3D printers are limited in the size of objects they can print, as well as what materials they can use; while 3D printing has expanded from plastics to certain kinds of metalworking and biological materials, there are still many other materials we cannot currently work with [1].

CONCLUSION

As 3D printing ' s costs shift further in line with traditional manufacturing, a greater number of industries and product segments would become subject to the " democratization of innovation " that digital manufacturing promises. Multinational corporations could face the unenviable prospect of competing against countless start - ups that need only a computer, design expertise, and the ability to finance small production runs. Numerous printing service bureaus — the modern - day equivalent of a small machine shop — continue to sprout up across the United States and offer their customers ample manufacturing capacity with almost no upfront capital costs. The pace of innovation could accelerate as start - ups pursue a more rapid, iterative, and market - driven product development strategy. All of these factors could reshape industries by putting greater pressure on large incumbents to deliver customized solutions and respond to a speedier innovation cycle [3].

Even if companies are not currently prepared to integrate 3D printing into their operations, it is essential to address the hurdles to integrating AM into business operations. To promote adoption, executives must foster top - to -bottom and cross – organization collaboration — from sponsorship at the executive level to a team of proactive frontline product designers, procurement category managers, and quality specialists. Even more broadly, it will eventually require a larger ecosystem beyond just the corporate world to create a capable workforce. The coming years will bring new opportunities and challenges; savvy executives who prepare their companies by taking a series of initial steps to raise awareness and build the necessary organizational capabilities will be well positioned to benefit from this breakthrough technology.

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REVERSE ENGINEERING AND CAD INSPECTION OF KNEE IMPLANT USING THE NOOMEO OPTINUM 3D SCANNER

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Abstract: The paper presents an application of the Reverse Engineering (RE) technology using a 3D Scanner to read the shape of the knee implant manufactured via Rapid Prototyping (RP) technology and generate the geometry in a computer file that can be analysed by Computer Aided Inspection (CAI) software - GOM Inspect V8.
Keywords: Reverse Engineering, 3D Scanner, knee implant, Rapid Prototyping, CAD Inspection

INTRODUCTION

Orthopaedic implants have always maintained close relationships with engineering disciplines, mostly relying on production engineering. Computer-aided technologies are being increasingly used for the solution of many problems associated with biomedical engineering. A significant number of these have proven to be especially useful in orthopedics. During the last decade, efforts have been concentrated towards advancement in modelling and manufacture of orthopaedic replacements by introducing modern computer equipment and state-of-the-art materials and machining technologies. Amongst the modern engineering technologies which have found broad application in this area, the most widely used are 3-Dimensional (3D) digitization, Computer Aided Design (CAD), Reverse Engineering (RE), Computer Aided Engineering (CAE), Computer Aided Manufacturing (CAM), Rapid Prototyping (RP), Computer Aided Inspection (CAI), etc. The development and implementation of such technologies and systems have paved the way towards significant advancement of conventional modelling, manufacture and inspection of orthopedic replacements, [1,2].
Non-contact optical three-dimensional measuring, scanning and digitising are increasingly present in quality assurance systems. Simple scanning procedures, high density of data acquired in a single scan, and the possibility of integrated Reverse Engineering and inspection, are all advantages of optical scanning compared to conventional measuring methods. Due to the three-dimensional acquisition of measuring data, an optical scanner is often considered to be an alternative possibility for coordinate measuring machines. However, the accuracy of the measured data acquired by optical scanning is still far below the level achieved by high-level coordinate measuring machines, [3, and 4].
This paper examines the possibilities of using a non-contact 3D scanner Noomeo Optinum for inspection of knee implant model manufactured by Rapid Prototyping technology.

THE DESCRIPTION OF THE 3D SCANNER

The Noomeo Optinum 3D Scanner, Fig. 1, is a portable scanner that connects to the acquisition system via USB 2.0 with autonomy offered by the battery included in the configuration. This non-contact scanner was acquired by "Eftimie Murgu" University of Resita, and it is intended to be used for 3D digitization purpose in Centre for Numerical Simulation and Digital/Rapid Prototyping (http://www.csnp.roedu.ro/index_eng.htm).
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 1024 x 768 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 cm^3 ÷ 1 m^3, 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 auto position is calculated, which eliminates the need for markers and the light flow provides additional information for taking geometry as a cloud of points.
Technical characteristics of the scanner are: accuracy ± 100 mm, spatial resolution 300 mm, the acquisition distance 400 mm, A4 FOV (field of view), 150 mm DOF (depth of field). The scanner system does not require preparation of items scanned, their installation in a reference system or reference markers, [5]. The scanner comes with dedicated NumiSoft software, which conducts the whole process of acquisition and 3D model reconstruction of the cloud of points.

Figure 1. The Noomeo Optinum 3D Scanner

THE REVERSE ENGINEERING OF THE KNEE IMPLANT SLS MODEL

According with [6]: "Engineering is the process of designing, manufacturing, assembling, and maintaining products and systems. The process of duplicating an existing part, subassembly or product, without drawings, documentation, or a computer model is known as Reverse Engineering. Reverse Engineering is also defined as the process of obtaining a geometric CAD model from 3-D points acquired by scanning/digitizing existing parts/products."
The knee implant model, Fig. 2, were manufactured on the Formiga P100 machine in the laboratory "3D Impuls" at the Faculty of Mechanical Engineering and Construction in Kraljevo, Serbia (http://www.3dimpuls.com/en). The development of the model on this machine was based on the technology of Selective Laser Sintering (SLS). The material used in the job was Fine Polyamide powder PA 2200 provided by the machine vendor. From a 3D scanning point of view, the difficulty of this part is given by its thin thickness and the complex surfaces.

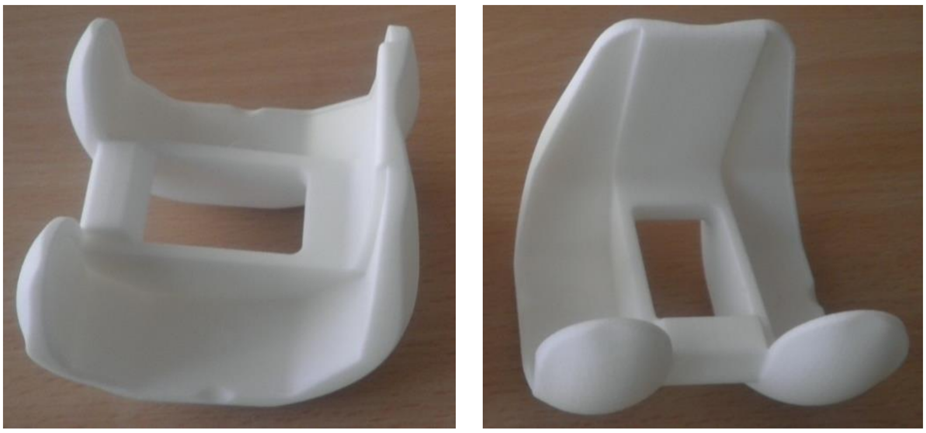

Figure 2. The SLS knee implant geometry

This investigation presents analysis of the application of 3D digitization system of more general purposes in the field of orthopaedic prosthetics. The basis of this experiment is a method of CAD inspection that includes checking up geometric and dimensional deviations on the bases of CAD and 3D digitization model. Namely, a digitized representation of a physical model is checked for deviations against the nominal geometry defined by the CAD reference model.
The investigation methodology is presented in Fig. 3.

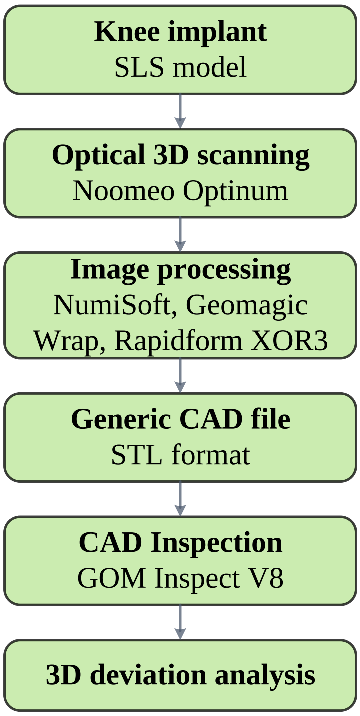

Figure 3. Investigation methodology workflow

The Reverse Engineering process consists of:

- **Scanning phase:** Generating the point cloud of the knee implant by non-contact 3D Scanner Noomeo Optinum and Numisoft software.
- **Point processing phase**: this phase involves importing the point cloud data Geomagic Wrap software, reducing the noise in the data collected and reducing the number of points; the output of the point processing phase is a clean, merged, point cloud data set in the most convenient representation;
- **Generate geometric model:** the goal of this phase is to generate CAD model from previous representation; mesh model processing and transfer into neutral CAD format in Rapidform XOR3 software, the generation of CAD models from point data is probably the most complex activity within Reverse Engineering because complex surface fitting algorithms are required to generate surfaces that accurately represent the three-dimensional information described within the point cloud data sets;

Scanning phase
In the first phase of the research the selected sample of the knee implant was scanned by the optical 3D scanner OptiNum and saved in ASCII format using NumiSoft software.
NumiSoft software include the driver communicating with the hardware and algorithms for point cloud processing: alignment of 3D cloud of points, automatic 3D model reconstruction, cleaning capabilities of the points, sharp edges refining, optimization point, export cloud points and XYZ ASCII format, compared with STL-CAD geometry at points level, strategy alignment type for the geometry and/or texture, [5].

Fig. 4 shows the Point Clouds scanned with Optinum scanner and edited in NumiSoft software.

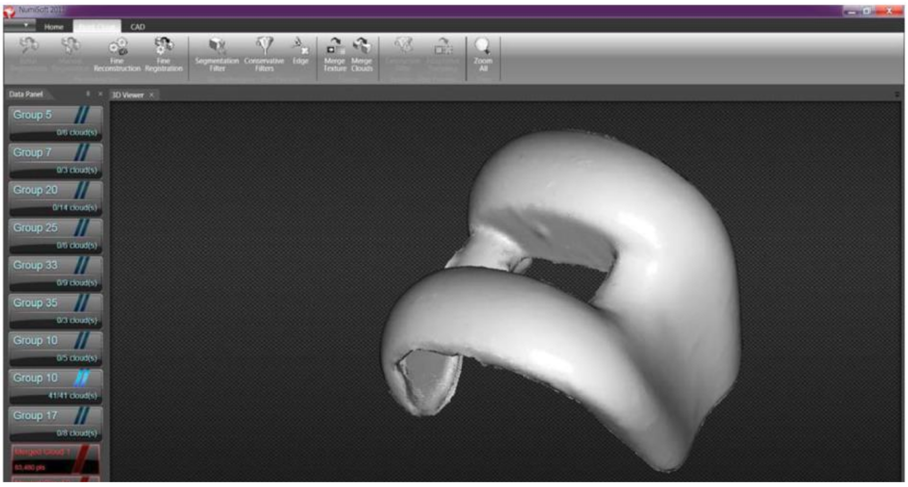

Figure 4. Point Clouds scanned with Noomeo Optinum scanner

Point processing phase

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, [7].

Fig. 5 shows the implant mesh model created in Geomagic Wrap software.

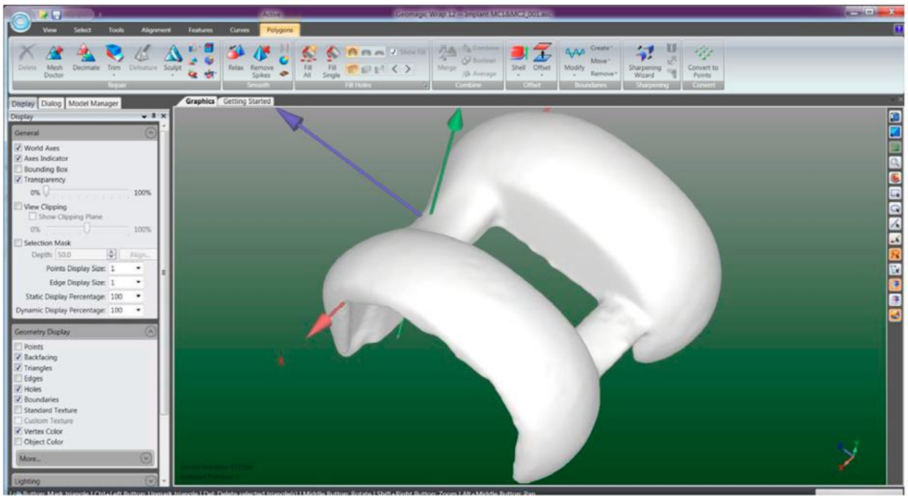

Figure 5. Knee implant mesh model created in Geomagic Wrap software

Generate geometric model

Rapidform XOR3 software (nowadays Geomagic Design X) is a "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 XOR3 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, [8].

The steps to generate geometric model in Rapidform XOR3 software are [5], Fig. 6:

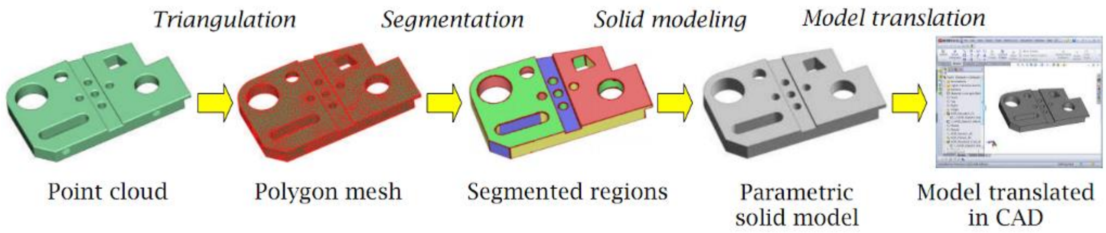

Figure 6. The steps to generate geometric model in Rapidform XOR3 software

The Rapidform XOR3 software can operate in the followings workflows [9]:

- **Scan-to-Mesh** - for archiving, animation, measurement, 3D printing and other polygon-based applications, Rapidform XOR3 includes a full suite of mesh processing tools. With the Mesh Build-up Wizard™, it is possible to go through the entire scan alignment merging and mesh optimization processes. Steps: Mesh Optimization, Mesh Modelling, Export.
- **Scan-to-Surfaces** - Rapidform XOR3 also supports NURBS surface fitting, which is useful for creating an identical copy of scan data that does not need editing. Steps: Mesh Optimization, NURBS Surfacing, Export.
- **Scan-to-CAD** - to make a CAD model suitable for manufacturing, Rapidform XOR3 employs a straightforward workflow that parallels today's well-known solid modelling processes. Instead of modelling from scratch, Rapidform XOR's feature wizards and other automated tools help to build the features directly from 3D scan data. Steps: Mesh Optimization, Solid Modelling, Export.

Fig. 7 shows the knee implant geometry recreated in RapidForm XOR3 software.

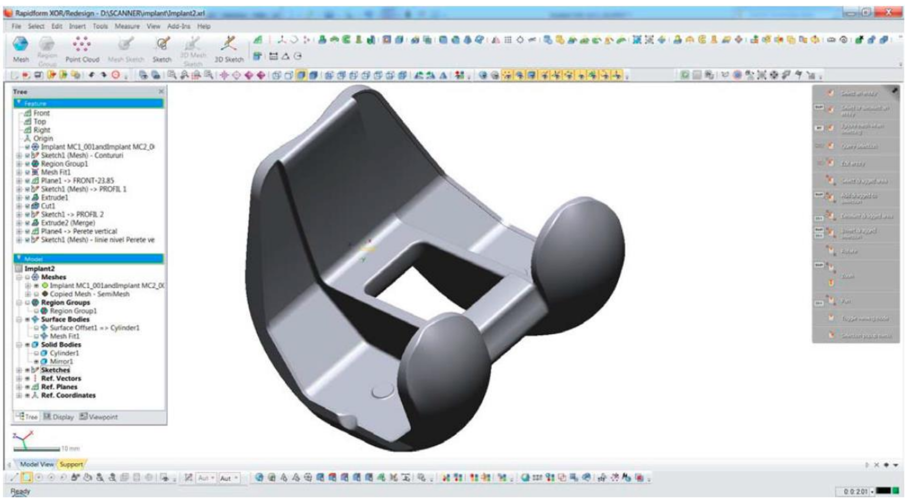

Figure 7. Knee implant geometry recreated in Rapidform XOR3 software

CAD INSPECTION OF KNEE IMPLANT DIGITIZED GEOMETRY

3D digitization represents a measurement method which can utilize various working principles. Basic indicators of quality of 3D digitization are accuracy and precision. Accuracy represents the degree of closeness of measurements of a quantity to that quantity's true value, while the precision (also known as reproducibility or repeatability) is the degree to which repeated measurements under unchanged conditions show the same results, [2].

Measurements and analyses of deviations were performed using GOM Inspect V8 software.

GOM Inspect software is a "free" application for inspection and processing of the 3D polygonal mesh, analysis of dimensional data sets of cloud-point type. Capabilities of the application: import of CAD models (IGES, STEP, etc.) and points cloud scanned data (STL, ASCII), alignment (automatic, 3-2-1, best-fit), mesh processing (mesh generation, filling holes, mesh refinement, extraction curve, export STL, ASCII), CAD comparisons (surfaces, section, points), CAD primitives generation (lines, planes, circles, cylinders, cones, etc.), 3D and 2D analysis inspection tools (dimensions, angles, diameters), report (tables, images, PDF) and export data, [10].

Application program GOM Inspection V8 allows the subsequent analysis of the accuracy of the measured performance of the element with respect to the nominal model. The possibility of analyzing the whole item - described thousands or even millions of points - it gives a complete picture of the accuracy of its execution. In addition, optical measurement coordinate system gives the possibility to use different systems of measurement to match the CAD model: the geometric elements, best-fit or RPS (Reference Point System).

Fig. 8 shows phases of combining nominal model of the 3D CAD with measure knee implant.

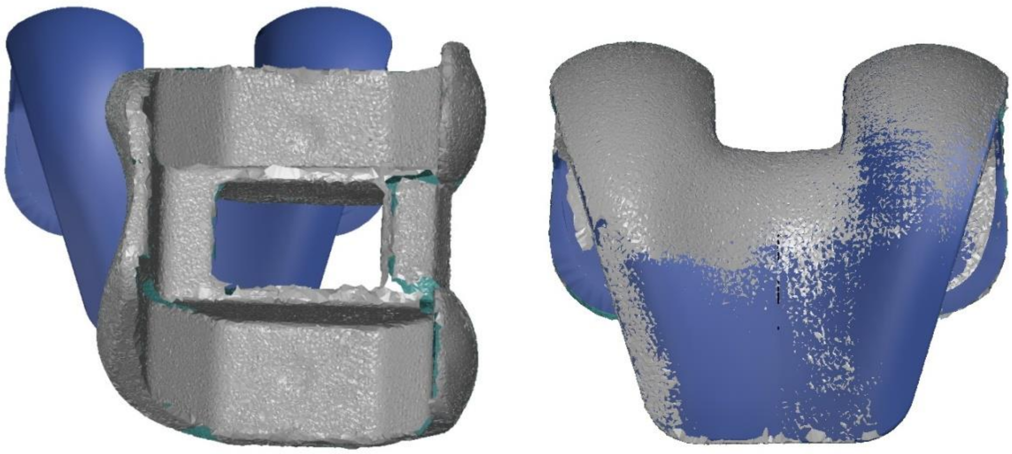

Figure 8. Combining nominal model of the 3D CAD with measure knee implant

Performed investigation procedure, as already shown in Fig. 3, involved 3D deviation analysis which included two different kinds of results. Fig. 9 presents the result in a form of map of regions, where the different colours indicate respective deviations. From the histogram in Fig. 9, it is clear that the majority of deviations are in positive direction, ranging from –0.5 to 1 mm, and with the most concentrated deviations around 0.25 mm.

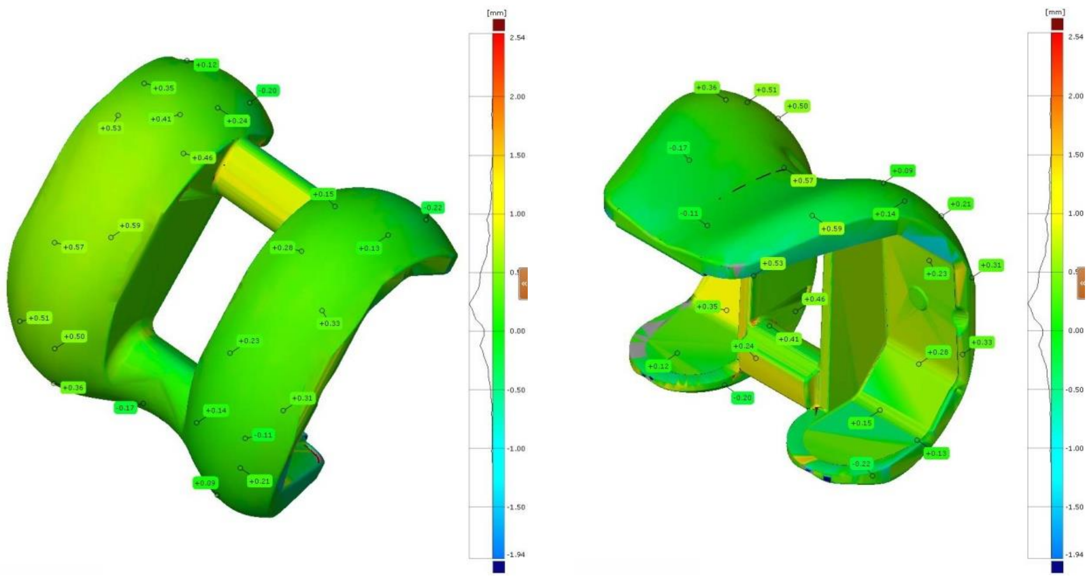

Figure 9. Resulting deviations in a map of regions form

Another type of 3D results is presented in Fig. 10, where the coloured regions present deviation areas within 0 ÷ 75 %, 75 ÷ 100 % and over 100 % of defined tolerance, in both directions – positive and negative. The mentioned regions are represented on the accompanying scale by the terms Pass, Warn and Fall, respectively. This type of result includes numerical values of areas in mm^2 from the analysed CAD model. Fig. 10 shows results obtained for four different tolerance levels: 0.25 mm, 0.5 mm, 0.75 mm and 0.9 mm.

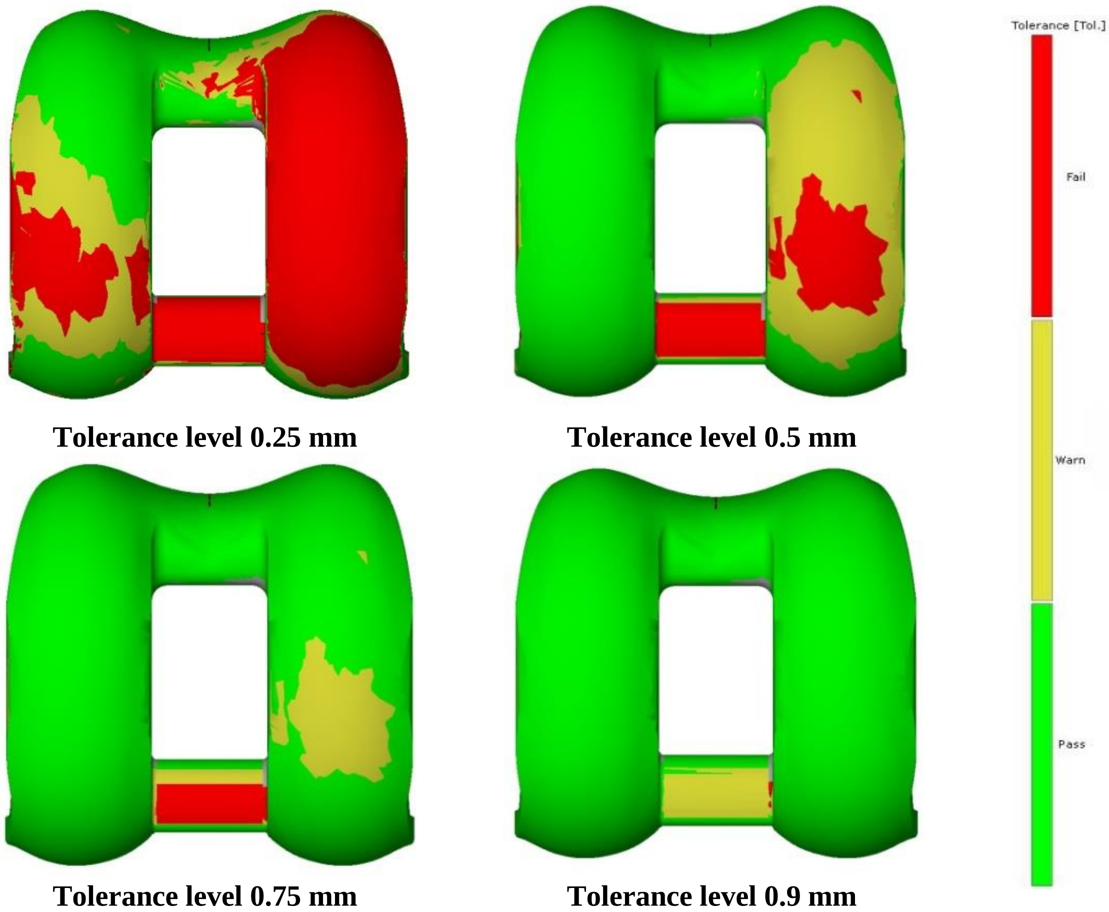

Figure 10. Resulting deviations in a form of areas classified according to level of tolerance

CONCLUSION

The Reverse Engineering technology was used to recreate the knee implant SLS model geometry using the Noomeo Optinum 3D Scanner and RE software's: NumiSoft, Geomagic Wrap and Rapidform XOR3. Some general considerations about the RE process and commercial software that is able to generate geometric models from scan data are presented, with an accent on the Rapidform XOR3 software.

Obtained results of an accuracy analysis of high-end 3D digitization system of more general purposes (Noomeo Optinum) confirm previous findings and indicate the effective application of this system in the field of orthopaedic prosthetics. The accuracy of obtained measurement results via GOM Inspect V8 software confirms that the application of this system contributes to the quality of orthopaedic implants in terms of geometry. In the result's analysis some obvious limitations should be considered. These primarily include difficulties in models' orientation and fitting as well as the problem of differences in algorithms of STL file format generation.

Future research will be aimed at overcoming identified obstacles and problems as well as at the confirmation of assumptions related to dependency of the analysed system accuracy of the model's geometry and position.

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Session 9.

Biotechnology

PARAMETERS OF DIE HOLES ON BIOMASS PELLET PRESS

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Abstract: This paper describes the technological process of pressing ground biomass and analyses different forms and dimensions of holes in dies on pellet presses depending on the type of raw material for extrusion. Dies can be flat and ring-like, and holes in them tapered (conical), square, cylindrical and oval. Dimensions of die holes along the channel can be constant or variable. The hole at the channel entrance can be expanded in order to avoid any accumulation of the material at the entrance to the channel, i.e. to reduce the resistance of the material during compression. The ratio of diameter to length of the press channel determines the degree of compression of the material. Also, expanded output area of the channel is intended to reduce the resistance of compression of the material. Shapes and sizes of channels on the surface of rollers depend on the type and condition of the raw material for extrusion. It was noted that certain types of plant materials compress differently and therefore require different construction characteristics for pressing.
Key words: biomass, energy pellet, pellet press, construction characteristics of dies and rollers

INTRODUCTION

Pelleting process was developed more than forty years ago in the field of safe storage of animal feed and concentrate. In English language, the word "pellet" means a sphere, a small ball or a roller. Thus, the process of pelleting means compression or molding of ground bulky material into a suitable shape, which has a considerably smaller volume compared to the starting material (raw material or feed). After potential drying, grinding and conditioning of raw material, the process of pelleting is performed on the pellet press. Technology of production of pellets is derived from the industrial production of animal feed (Gluvakov and Brkić, 2014) Adjusting the technology of pelleting of ground raw material for the production of energy pellets with an adequate shape, size and moisture content, it is possible to produce a homogeneous biofuel from wood waste or agricultural biomass. Equipment for the production of energy pellets is also derived from the equipment for industrial production of animal feed, i.e. from presses for animal feed, whose parameters are optimized and which are made of a material of adequate strength.
The most important working part of the biomass pellet press is the die with pressing rollers. There are two types of dies: a ring die and a flat die. In the ring die press, the raw material is put from above, it is inserted into the central part of the ring die, it falls down over the rollers onto the die and the rollers press the raw material sideways (laterally) through the holes in the die. The raw material comes out compressed from the die holes by the process of extrusion. The die can be mounted vertically or horizontally (Obenberger I. and Thek G. 2009). In the flat die press, the raw material falls from above, over the rollers, onto the die, it is pressed by the rollers through the holes in the die through which it is extruded. In this case, the die is mounted horizontally.
Therefore, in the process of pressing the raw material, the most important components of the press are die, rollers and knife for cutting the pellets. The raw material enters the compression area and should be evenly distributed across the holes of the die (Fig. 1). A "carpet" (thin layer) is formed on the die from the raw material by rotating rollers or dies. Pressing rollers rotate over the "carpet" and form a compressed, dense layer of the raw material. Excessive rolling of the rollers generates strong pressure, which leads to clogging of the holes in the die. For this reason, rollers need to have adequate peripheral speed of rotation. An endless thread of raw material comes out of the die, which is cut by knife to the desired length. Knives can be stationary or movable, depending on whether the die rotates or not. This is how pellets are made.

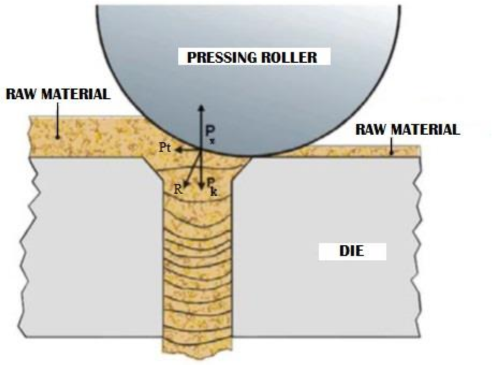


Figure 1. Graphical display of extrusion of raw material through the die channel of the pellet press (Alakangas et al, 2002)

The aim of this paper is to analyse the shape and dimensions of tools for pressing biomass depending on the type, structure, size of grinds and moisture content of biomass, in order to define the required constant parameters for the efficient production of energy pellets.

SPECIFICATION OF THE DIE

Important characteristic values in the production of pellets are compression ratio, the number of holes in the die and hence the use of the open inner area of the die (regardless of the circumstances, i.e. accessibility). Compression ratio is the relation between the length of the channel (die hole) for pressing the material and cross-section of the drilled hole, i.e. diameter of the die hole, as the characteristic value, Fig. 2 (CR = l/d). Compression ratio also depends on the type of the raw material for pressing, in order to generate appropriate friction in the press channel.

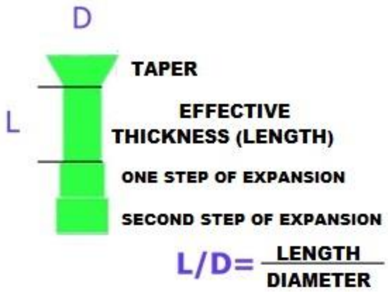


Figure 2. Longitudinal section of a relieved die hole
D - diameter, L - length, compression ratio L/D = length/diameter of the hole

Therefore, compression ratio depends on the characteristic dimensions of die holes and the type of raw material, thereby to produce a good quality (hard) pellets and achieve the desired effect (productivity) of the press. In order to have a strong relation between the section of drilled holes and the desired section of pellets, compression ratio may only be varied (changed) along the press channel length (i.e. die thickness). Raw material with low binding (adhesion) properties requires longer press channels and vice versa, raw material with high binding properties requires shorter press channels. Temperature of the raw material in the press channel rises with the increase in length of the press channel, thereby increasing the hardness of pellets.
As a rule, dies are designed exactly for each type of raw material and cannot be used for any other type. Thus, pressing parameters for a certain type of raw material are: die thickness; press channel length; number, form and section of a hole; width of the path the pressing rollers traverse; number of pressing rollers, section, width and outer surface of rollers; form (shape) of pressing rollers (cylindrical or tapered) in the flat-die press, type of channel on the surface of rollers (perforated, linear, etc.).

Number of pressing rollers can be two, three or four. Number of die holes, and thus the use, disposal of constantly open areas of holes affects the performance (productivity) of the press. Precondition for good and high quality pelletizing is continuous (constant) feed of homogeneous raw material into the press, sufficiently ground, with constant moisture content which for certain types of presses and specifically woody feedstock is between 8 and 13%. When pressing agricultural biomass, moisture content in the raw material can be slightly higher, 10 to 15%.

TYPES OF TOOLS FOR PRESSING BIOMASS

Ring die presses

CPM biomass pellet press (Fig. 3) at "Eko pelet" plant in Bački Petrovac (Gluvakov, 2011) is a stable structure, consisting of a bin, screw conveyor-extractor, conditioner, feeder and working tool of the die. Weight of the press is about 3 t, and of the die about 150 kg. After the ground material has entered the bin of the pellet press, it is necessary to steam (dampen) it using the conditioner in order to obtain a more compact pellet. The die is ring-like with two pressing rollers. Die dimensions are 500 x 100 x 70 mm. The ring die rotates and rollers that force the feedstock through die holes are static. There are 9 rows of holes 6, 7 or 8 mm in diameter. The total number of holes is 1200. Operating temperature of the ring die is about 130°C. Press performance is 400 kg/h of energy pellets from straw. The shape of the hole (opening) in the die is as follows: inner tapered hole Ø 8, 9, 10 mm, and a depth of 3 mm, central cylindrical part where pellets are formed: Ø 6, 7, or 8 mm and a length of 28 mm, outer cylindrical part for the relief of pressure on the pellet (expansion) Ø 6,5; 7,5 and 8,5 mm and a length of 39 mm. Total length of the hole is 70 mm. Fig. 4 shows longitudinal section of a die hole.

Figure 3. CPM ring-die press

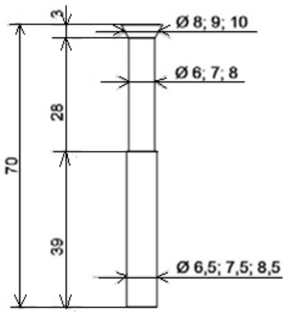


Figure 4. Longitudinal section of "Eko Pelet" ring-die hole

Ground material enters through the tapered hole in the ring die (Fig. 4) extruded by rollers. The feed is compressed in the taper. Further compression is performed in the narrow part of the die hole (diameter 6, 7, 8 mm), depending on the required hole diameter. After this hole, the mass enters a wider section of the hole (Ø 6.5, 7.5, 8.5 mm), where it expands, the pressure in the mass is relieved and the pellet exits the hole more easily. This type of the hole is responsible for the production of straw pellets (Brkić et al., 2009a).

Fig. 5 shows construction parameters of a hole in the ring die of the company "General Dies" from Italy (www.generaldies.com).

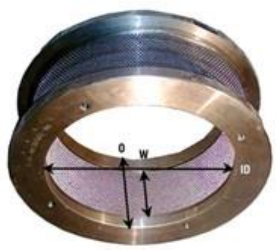


Figure 5. "General Dies" ring die
ID - inner diameter, W - working width, O - overall width

Fig. 6 shows longitudinal sections of ring-die holes when pelleting biomass (cylindrical, tapered, square, oval and rounded inlet or outlet area of the hole), Mayang, 2012 Inlet or outlet area of the hole generally expands in order to reduce the resistance as the feed exits the die channel.

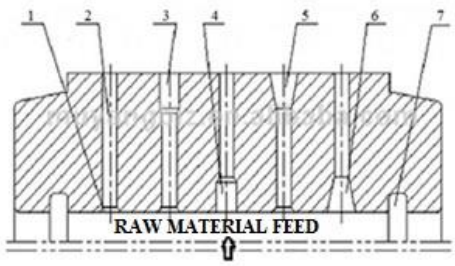
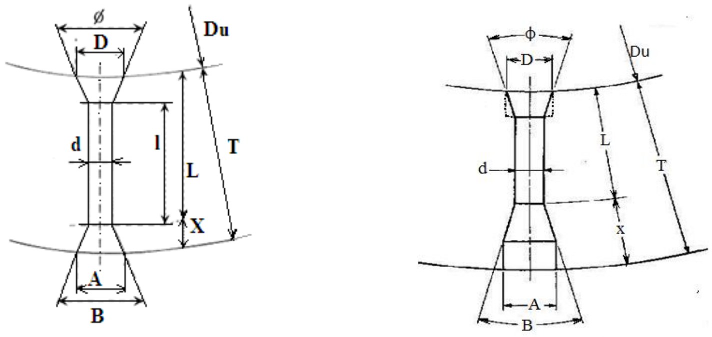


Figure 6. Different shapes and dimensions of ring die holes "Mayang"
(1-tapered inlet, 2-straight hole, 3- expanded hole outlet, 4-compression-type of expanded hole, 5- tapered hole outlet, 6- tapered hole inlet, 7-groove)

Fig. 7 shows construction parameters of ring die hole according to the Lithuanian company JSC "Radviliskis machine factory" from Radviliškis, in cooperation with the Italian company Factori S.A.S., from Merate (http://factorylt.en.busytrade.com/contact_us.html). As can be seen below, exit channel may be tapered (a) or tapered which changes into cylindrical shape (b), so as to prevent the pellets scatter in the taper due to the expansion.



a) b)

Figure 7. Construction parameters of die hole "Radviliskis machine factory"
(d - pellet diameter, L - effective length, Du - inside diameter of the ring die D - inlet diameter, Ø - inlet angle, T - total thickness of the die, l - length of friction, X - counterbore depth, B - counterbore angle, A - counterbore diameter, compression ratio - D^2/d^2, friction ratio - l/d^2)

Fig. 8 shows a comparative display of sections of die hole of the German company "Magel Maschinenhandel GmbH" from Neuss. http://www.pelletprocess.de/?page_id=20

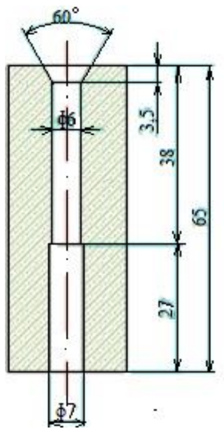


Figure 8. Comparative display of sections of die hole of the German company "Magel Maschinenhandel GmbH" from Neuss

In Figure 8, length of the press channel is greater by 10 mm, compared to the length of the press channel in Figure 4, which corresponds to the compression of lighter materials.

Flat die presses

Pelleting lighter raw materials has advantage to a certain degree, provided flat die is used (Amandus Kahl, 2009). All types of raw materials, with low bulk density (grass, straw, dried beet pulp, municipal waste, wood residues, etc.) with bulk density lower than 0.3 t/m^3, are mainly pelleted with a flat die. The main reasons for this conclusion are: large area in the pelleting part of the press enables each roller to pellet feed instantly; high power transmission (raw material with 0.14 t/m^3 should be "pressed" with a few times greater force, factor, x 4, or 5 to obtain a pellet of 0.65 t/m^3); raw materials with high bulk density, greater than 0.5 t/m^3 are mainly pelleted with a ring die (fodder, food industry waste, etc.) since the material should only be put in the so-called "form", i.e. shape, which requires little us eof power; in ring die pelleting, the first roller performs pre-compression of the raw material for the second roller, meaning that the first roller is not at full load. The second roller pellets the feed (but for it, the second roller would constantly work futilely). For this reason, presses for animal feed have three-rollers.

Wood is a fibrous material with low bulk density, which means that it is a suitable raw material for pelleting on a flat die. In flat die presses, raw material is fed by gravity. Low speed of rollers of 2.5 m/s ensures good quality of the final product. A thin layer of the raw material in the pelleting area allows for greater throughput. Gap between the rollers and the die is adjustable (which is performed with the hydraulic head which carries the rollers), and so that way it is possible to control the quality of the extruded pellets. Lifetime of this die is longer. Fig. 9 shows a press with a flat die and rollers of the German company Amandus Kahl (www.akahl.de).

Fig. 10 shows shapes of flat die holes, cylindrical and tapered (www.generaldies.com).

Figure 9. Press with flat die and rollers, (www.akahl.de)

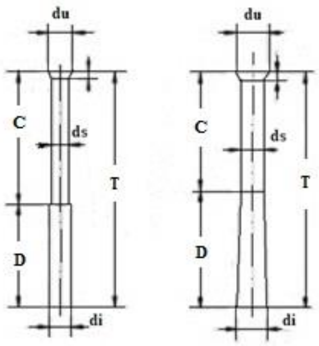
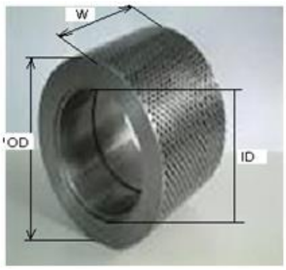


Figure 10. Shapes of flat die holes, cylindrical and tapered (www.generaldies.com)
(D – depth, C – compression, T – thickness, du – inlet diamaeter, ds – compression hole diameter, di – outlet diameter)

In order to relieve the value of resistance force at the outlet of the die channel, usually the diameter of the hole is increased, or a tapered hole is made in which the diameter gradually increases thereby reducing the resistance force.

Pressing rollers

Fig. 11 shows pressing rollers with different shapes of channels on the surface of the roller from the Italian company General Dies (www.generaldies.com), and Fig. 12 shows shapes and sizes of channels on rollers.
Shapes and sizes of channels on the surface of the roller depend on the type and condition of the raw material for pressing. Roughly ground material requires a more pronounced relieved surface of the roller for the purpose of partial grinding of the raw material, as a beneficial side effect.



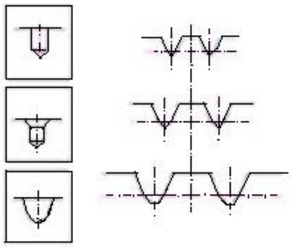


Figure 11. Pressing rollers **Figure 12.** Shapes and sizes of channels on rollers
(W = width, OD = outside diameter, ID = inside diameter)

CONCLUSION

Based on the analysis of construction characteristics of equipment for biomass pelleting, it was found that:

- Shapes of die holes can be cylindrical, square, tapered and oval,
- Dimensions of holes along the channel can be constant and variable,
- The hole at the entrance to the channel may be expanded in order to reduce the resistance of the material during compression,
- The length of the channel determines the degree of compression of the material,
- Expansion of the channel outlet is intended to reduce the resistance of pressing the material.
- Pressing rollers have different configuration of the surface, depending on the type of the feed, coarser materials require a more pronounced configuration
- It was found that certain types of plant material compress differently, and therefore require corresponding construction pressing parameters.

- Sawdust is more easily compressed than wood, a fibrous material, which is well self-binding, whereas agricultural biomass is more difficult to compress as it is non-uniform, with less fiber, and increased moisture content.
- Too dry biomass is also hard to press, thus the raw material needs to be pre-conditioned (dampened).

ACKNOWLEDGEMENTS

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MAIN CHARACTERISTICS OF BIOMASS PRODUCTION FROM CEREAL STRAW

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Abstract: Biomass is one of the more significant source of renewable energy. In Serbia, the biomass is mainly used in the traditional way, in the form of energy for heating, cooking and water heating. In addition to these modes of use, biomass can be used in cogeneration plants for the production of electricity and heat energy, then as a raw material for the production of biofuels. The paper presents the potential of biomass in Vojvodina, the basic characteristics of biomass, as well as data about pelleting of biomass.
Key words: biomass, agriculture, pelleting

INTRODUCTION

Given that the issue of work related to the production of biomass mainly on examples of the production plant of the composition of the Victoria Group, in the introduction will be presented a brief history of the company. Victoria Group is one of the largest processors, exporters and employers in the region, it is a business concern of the ten member companies which are employing 1800 workers, and ten member companies there are from Subotica in the north to Bosilegrad in southern Serbia. Victoria Starch, Zrenjanin is a new member of the Victoria Group whose main activity will be the production of starch and starch derivatives. It is located at the old sugar factory Zrenjanin, which covers an area slightly smaller than 29 ha. New production plants are designed on capacity of processing of 900 t/day of corn, which will enable the processing of approximately 300 000 tons of corn annually, and production of corn starch and fructose syrup as the main products. In the process of refining corn byproducts are formed, corn germ, bran, gluten and cornstip who are mainly used in the production of animal feed. In the phase of designing and subsequent construction of the factory will apply the latest trends from the starch industry, which will enable the obtaining of the products that will meet all the requirements of the EU. This is important because it is planned that around 70% of production will be placed on the EU market.
Biomass is one of the more significant source of renewable energy. In Serbia, the biomass is mainly used in the traditional way, in the form of energy for heating, cooking and water heating. In addition to these modes of use, biomass can be used in cogeneration plants for the production of electricity and heat energy, then as a raw material for the production of biofuels. Also, a very important source of biomass in Serbia (especially in Vojvodina) is the plant biomass in agriculture. When it comes to biomass in agriculture, then, first of all, refers to of crop residues from plant, fruit and grape production. It is estimated that each year in Serbia produce the total amount of 12,5 million tons of biomass, of which in Vojvodina 9 million tons (72%).
Agricultural biomass is the remains of annual crops such as: straw, corn stalks, cobs, stalks, husks, seeds. For Serbia would be particularly interesting, use of residues and refuses from agriculture in order to obtain energy, heat and electrical energy, plus if it is known that is 58% of the territory under arable land.

Pelleting of biomass

In the year 2003 in Europe, there were more than 115 plants of pellets, and today that number is much higher. The largest number of factories located in Germany, Sweden and Russia, while the market is closed with big ports and transport over long distances (China, Canada, America). It is important to mention Denmark as one of the representatives of the countries that use green energy.

In most countries, the use of pellets for obtaining energy is largely a matter of cost and policy of environmental protection. The largest Swedish pellet producers are Bioenergy and Norrland AB. These companies have increased their capacity to 140 000 tones of pellets per year.
This amount replaces 60 000 m^3 of fuel oil. In the factory there are 5 presses, two mill-dryer and a huge storage space to store bags full of pellets. 65% of the product is submitted to users with high needs, such as district heating plants, located near Stockholm.
Probably the largest pellet factory in the world is "Koge", located in Denmark, southern of Copenhagen. This plant produces 130 000 tons of straw pellets and 180 000 tons of wood pellets per year and plans to increase capacity. A large part of the straw pellets are transported to a nearby port and applies to a large thermal power plant Amager, which previously worked in the coal. The factory has two production lines, one for the straw, with a capacity of 17 t/h and one for wood pellets, with a capacity of 30 t/h. Twelve presses work 6000-7000 hour per year and total produce 310 000 tones of pellets per year. In Serbia currently there is no developed market in agro pellets, but the production of wood pellets in a slow expansion.

Basic characteristics of the pellets

With the process of pelleting, volume of the biomass is reduced by 10 to 12 times. The density of the pellets is from 800 to 1200 kg/m^3 and bulk density of 400 to 700 kg/m^3. Lower calorific value of the pellets is from 14 to 17 MJ/kg. For high quality pelleting of biomass optimum content of moisture in the plant material should be 12 to 18%. At lower and higher content of moisture form of pellets is not persistent. Dimensions of pellets are: diameter is up to 20 mm, length is up to 70 mm. Production of presses requires great expertise and fit-out of mechanical industry, because working conditions, high pressures and temperatures, conditions use of special type of materials, high-precision in the production of cylinders, pistons and tools of press and high-quality thermal treatment.
Also, a problem is professional maintenance at the facility, because the moving parts of press are quickly consume. The temperature of pressed vegetable material should reach a value of 80 to 90°C. Therefore, it is need for pressing to provide the pressure 150-350 bar and more. Based on the results of techno-economic analysis of production of pellets can be concluded that the invested investment funds in the construction of place for pelleting can be relatively quick return (from three to five years depending on the size of the structure i.e. performance of equipment).

Combustion of pellets

The two main properties that affect on the choice of using and combustion of pellets, are: the reduction of content of moisture (product stability in terms of content of moisture), i.e. an increase of heat capacity and increase bulk density. In addition, the benefits of pelleting are reflected in the reduction of costs of transport (giving the fact of their size and bulk density, pellets can easily be packed in bags, foil, etc.), in storage, giving the fact that it is much easier and more efficient to store pellets from baled straw for example (requires a smaller stock at the same amount, it is easier to preserve the quality of pellets than baled straw, which is very important, and affects at the final application), and also the advantage on the side of the pellets is in the handling and utilization at all. Pelleting of straw contributes to reducing the moisture from 15-20% to less than 10%, and an increase of bulk density from 130 to 600 kg/m^3. In Table 1 we can see the comparative values for the raw materials and pellets.

Table 1. Comparative indicators for pellets and raw materials

Type of biomass	Bulk density (kg/m^3)	Moisture (%)	Lower heat power (MJ/kg)	Ashes (%)	Energy value (GJ/m^3)
Shredded straw	50	10-20	14,5	5	0,7
Straw bales	130	10-18	14,5	5	1,9
Straw pellets	**600**	**<10**	**15**	**5**	**9**
Woody refuses	250	10-50	11-17	0,5	4,3
Sawdust	200	20-50	12-17	0,5	3,4
Woody pellets	650	<10	17,5	0,5	11,4
Coal	850	10-15	24	12	20,4

Of course, in addition to the advantages of pellets, as well as the reduction of humidity, there are also disadvantages that may influence at the selection of this type of fuel, which are primarily additional costs for the complete equipment for the production of pellets, thus the area for the plant, as well as costs for production of pellets, primarily the costs of electrical energy.

Costs that occur during the production of pellets from straw reflected in:

- the quantity of required energy to obtain a finished product, and then the amount of energy that can be extracted from that product,
- funds for the construction of complete plant (technical and technological equipment, transport and other infrastructure),
- means for packaging, transport and storage (trucks and warehouses).

In Table 2, we can see the quantity of used energy by each process in the processing of wood or straw.

Table 2. Consumption of electrical energy for the production of 1 ton of pellets

Consumption of energy (kWh/t)	Sawdust	Woody refuses	Straw
Separation and shredding	10-20	10-40	10-30
Drying	0-400	0-400	0
Conditioning	0-10	0-10	0-10
Grinding	30-60	30-60	30-60
Cooling	5	5	5
Additional equipment	10-20	10-20	10-20
TOTAL	55-515	55-535	55-125

The potential of biomass (straw) in Vojvodina

The potential of biomass (straw) on the territory of Vojvodina is shown in Table 3, based on harvested area in the period from 2005 to 2010 for the crops that were identified as most important for the project of pelleting. Data are taken from the official site of the Republican institute of statistics.

The potential of straw on the territory in Vojvodina for each of the considered cereal based on the average values for the period from 2005 to 2010 is given in the Table 3. It can be seen that in the territory of Vojvodina available approximately 5,5 million tons of straw.

Table 3. The availability of straw in Vojvodina

Cereal	Tons of straw per hectare	Thousands of hectares in Vojvodina	Thousands available tons of straw
Corn	5,77	671	3871
Wheat	4,04	272	1098
Soya	2,63	138	362
Barley	3,55	44	156
TOTAL	**16**	**1125**	**5487**

If we assume that the available quantities from Table 3, only one-third can be used for energy purposes, i.e. for production of pellets because it is estimated that one-third of the genus will plow and one-third will used for breeding, the available quantity for production of pellets is 1,83 million tons of straw. If we assume, that of one-third for energy purposes, part is used in the industry of cards, and some simply remains in the fields, a rough estimate shows that from this one-third, approximately one million tons of straw can be realistically collected and used for production of pellets.

CONCLUSION

From an environmental standpoint the advantages of biomass are:

- biomass contains insignificant amounts of sulfur so the products of combustion have almost no sulfur - dioxide (which is the inevitable product of the combustion of fossil fuels),
- no emission of hydrocarbons, as incomplete products of combustion.

For these reasons, biomass, along with other renewable sources of energy (wind, water, solar energy), is gaining in importance as a resource for obtaining "clean energy".

Very important source of biomass in Serbia (especially in Vojvodina) is the plant biomass in agriculture. When it comes to biomass in agriculture, then, first of all, refers to of crop residues from plant, fruit and grape production. It is estimated that each year in Serbia produce the total amount of 12,5 million tons of biomass, of which in Vojvodina 9 million tons (72%).
With the process of pelleting, volume of the biomass is reduced by 10 to 12 times. The density of the pellets is from 800 to 1200 kg/m^3 and bulk density of 400 to 700 kg/m^3. Lower calorific value of the pellets is from 14 to 17 MJ/kg. For high quality pelleting of biomass optimum content of moisture in the plant material should be 12 to 18%. At lower and higher content of moisture form of pellets is not persistent.

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PRESENTATION OF DECLARATION QUALITY OF BIOMASS ENERGY PELLETS

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Abstract: This paper describes the classification, specification and quality assurance of solid biofuels, indicators of quality, declaration of quality of biomass energy pellets. The purpose of this classification is to allow the possibility of the raw materials specifications on the basis of origin with, as much as possible, necessary details. Quality assurance should enable manufacturers and suppliers of solid biofuels to design a security system of fuel quality to ensure the business. Solid biofuels must be described in the declarations of quality that the supplier shall provide to the end user. Indicators of the quality of pellets can be classified by the chemical-thermal and physical-mechanical properties. Chemical-thermal properties are determined by the content of certain chemical elements in the pellets, ash content, moisture content and energy value of the pellet, and the physical-mechanical properties are defined by the geometrical parameters of pellets, pellet density, abrasion and pressure resistance. Declaration of pellets quality should at least include: supplier (person or company that provides contact information); specification reference of technical quality assurance; origin and source; form of trade; specification of properties, ie. normative and informative properties, chemical treatment if biomass is chemically treated; signature, name, date and place.
Key words: biomass, classification, quality, declaration, energy pellets

INTRODUCTION

European Committee for Standardization, CEN under committee TC335 published 27 technical specifications (preliminary standards) for solid fuels during 2003-2006. Now, these technical specifications are amended and adopted as European Standards (EN), 2010. When the EN standards become applicable, national standards must be withdrawn or adjusted to the EN standards (Gluvakov et al., 2012). The two most important technical specifications regard the classification and specification (EN 14961) and quality assurance for solid biofuels (EN 15234). Both of these standards will be published as multiple standards. The first part, the general requirements of EN 14961-1 include all solid fuels and are targeted to all consumer groups, although it is likely to be used mainly in the industry. EN 14961-2 and EN 14961-6 are so-called standards for products not intended for industrial use, which means fuel intended for use in homes and small commercial buildings and public sectors.
The general part of EN 14961 covers all types of biomass pellets. These pellets can be produced from various biomass raw materials. This section also includes the classification of fossil fuels, which is based on their origin and source. Production chain fuel undoubtedly can be traced along the entire chain. According to EN 14961-1, solid biofuels are divided into four sub-categories: woody biomass, plant biomass, fruit biomass, and blends and mixtures of biomass.
At the international level, there are national and European norms and quality standards, which are trying to set rules for growing and diverse range of biofuels types. Classification, specification and quality assurance of solid biofuels are intended to increase the use of biofuels so that consumer and seller can uniformly define the quality of biofuels based on biomass origin "packages" to sell and to provide adequate confidence that the specific requirements for quality are met (Alakangas, 2004). Classification, specification and quality assurance of solid biofuels are intended to increase the use of biofuels so that consumer and seller can uniformly define the quality of biofuels based on biomass origin "packages" to sell and to provide adequate confidence that the specific requirements for quality are fullfilled (Alakangas, 2004).
Solid biofuels must be described in the declarations of quality that supplier should provide for the ultimate consumer or retailer. The pellets must be described in the declaration of quality which should contain at least following parameters: supplier, reference specifications of technical quality assurance, origin and source, a form of trade, normative properties, chemical treatment if biomass is chemically treated (Gluvakov, 2012).

The aim of this paper is to present the required quality parameters, defined by standard, that declaration for biomass energy pellets should contain, in order to provide quality assurance of the final product, and therefore make succesfull trading between the manufacturer or supplier and the end user.

CLASSIFICATION, SPECIFICATION AND QUALITY ASSURANCE OF SOLID BIOFUELS

The classification of solid fuels is based on their origin. Biofuels are divided into the following sub-categories in the classification: wood biomass, herbaceous biomass, fruit (fertile) biomass and blends or mixtures (Prvulovic et al., 2012). The most important characteristics are final, normative, and should be given in the product specification (Gluvakov, 2012). These characteristics vary in different forms, but the most important characteristics for all biofuels are: moisture content, size of pieces / dimensions (sp or D / L) and ash content (A). For example, the average moisture content of the fuel is given as a value after the simbol M (for example M20) which means that the average moisture content of the fuel should be ≤ 20% (in wood, moisture content is relative to the dry base). Some features, for example, the net calorific value and density are given informativelly.
With solid fuels eg. pellets (Figure 1), it is important to define: the shape, size, origin (wood not chemically treated, wood without bark), moisture content, shape, mechanical strength, the percentage of fine material (percentage of fine sifted on the sieve with openings ≥ 3.15 mm, not to exceed 1-2% in production), the density of the pieces, ash content, additives, sulfur content, net calorific value, etc.

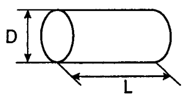

Figure 1. Pellet (L - length, D - diameter)

Determination of physical properties and other parameters of quality assurance are written in technical specification of fuel safety quality. The aim of this is to guarantee the quality of biofuels through the entire production chain from the beginning to the sale of biofuel and to provide adequate confidence that specific quality requirements are fullfilled. Manufacturing requirements must be met with quality assurance and quality control. Principle in defining the quality assurance of solid biofuels is to provide an opportunity of tracing the origin at the request of customers products.
Methodology should provide producers and suppliers of solid biofuels to design the security system of fuel quality to ensure business: to make possibility of tracking, to control requirements that affect the quality of the product, to enable final consumer to have confidence in the quality of the product.
The methodology consists of the following steps: documenting the steps in the production chain, defining the specifications for each product, identifying and documenting critical control points for compliance with the product specification (critical control points are points within or between processes that can achieve relative properties and places that provide potential for possible interventions to improve quality), selection of appropriate measures that give consumers confidence that specifications fullfilled, identifying and documenting the criteria and methods to ensure adequate control of critical control points, testing of production processes and making necessary adjustments for work in alignment with quality requirements, implementing and documenting routines for separate handling the products of unknown origin.
Solid biofuels must be described in the declarations of quality that the supplier should provide for the ultimate consumer or retailer. Declaration of quality should include at least: the supplier (a person or company that provides contact information), specification reference of technical quality assurance, origin and source, a form of trade, normative properties, chemical treatment if the biomass is chemically treated.

INDICATORS OF PELLETS QUALITY

Indicators of the pellets quality can be classified by the chemical-thermal and physical-mechanical properties. Chemical-thermal properties (Figure 2) are determined by the content of certain chemical elements in the pellets, ash content, moisture content and energy value of pellets (Prvulovic et al.,

2014). Physical- mechanical properties (Figure 3) are defined by the geometric parameters of pellets, pellet density, abrasion and pressure resistance (Urbanovicova, 2011).
Chemical-thermal indicators of pellets quality are determined by the quality of pressing material. It is possible to reduce the moisture to enhance the quality, but the other parameters are determined by the material (chemical elements in the biomass, ash content, energy value ...). Physical-mechanical parameters are also influenced by the properties of pressing material (strength of material), but these indicators can be affected by the use of an appropriate technology. The most important physical-mechanical quality indicators, that can be positively affected, is the use of appropriate technology, ie. their density and abrasion. The minimum value of these two indicators of quality is determinated by the above mentioned norms.

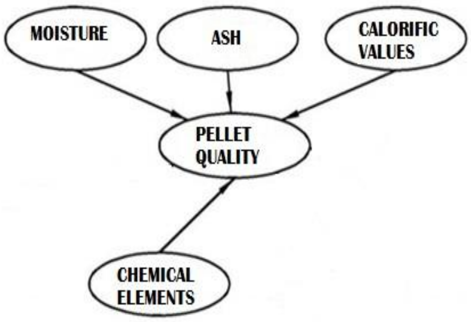

Figure 2. Chemical-thermal indicators of pellets quality

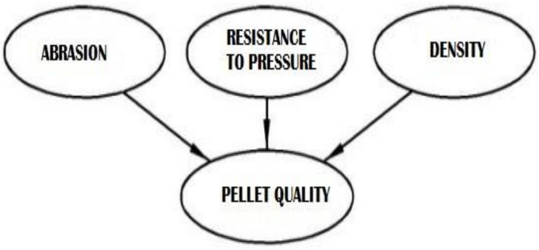

Figure 3. Physical-mechanical indicators of pellets quality

QUALITY DECLARATIONS FOR ENERGY PELLETS

Declaration of quality for solid biofuels (pellets) must exist between the supplier and the end user. The quantity must be defined in the contract of delivery. In the declaration, the quality must be specified in accordance with the relevant standard, which is defined in the contract between the supplier and the end user. Declaration of pellets quality should at least include: supplier (person or company that provides contact information); specifications reference of technical quality assurance; origin and source; form of trade; specification of properties, i.e. normative and informative properties, chemical treatment if the biomass is chemically treated; signature, name, date and place. Supplier should keep the contract made with the end user for at least one year after delivery.
Table 1 shows the product declaration for energy pellets based on the new European standard EN 14961. Classification in standard EN 14961-1 is flexible and therefore the producer or the consumer can choose the classification that best fits the product or the required fuel quality. This so-called "free classification" does not bind the different characteristics to each other. The advantage of this classification is that the producer and consumer may agree on the characteristics in each individual case.

Table 1. Product declaration for energy pellets based on the new European Standard EN 14961.

PRODUCT DECLARATION

Supplier: Solid biofuels
Street
City
Country

Traded form: Pellets
Origin and source: Chemically untreated residues
Country/countries (locations) of origin: Any location or country
Chemically treated material: No

Normative propertise according to EN 14961-1		
Diameter, D and Length, L	D06 6 ± 1; 3,15 ≤ L ≤ 40	[mm]
Moisture, M	M10 ≤ 10	[w-% on receiving]
Ash, A	A	[w-% dryness]
Mechanical durability, DU	DU 96.5 ≥ 96,5	[w-% on receiving]
Fines, F	F1.0 ≤ 1,0	[w-% on fabric gate]
Additives	1% (starch)	[w-%]
Bulk density, BD	BD600 ≥ 600	[kg/m³]
Net calorific value, Q	Q16.5 ≥ 16,5	[MJ/kg on receiving]
Informative propertise according to EN 14961-1		
Nitrogen, N	N0.5 ≤ 0,5	[w-% dryness]
Sulphur, S	S0.05 ≤ 0,05	[w-% dryness]
Chlorine, Cl	Cl0.03 ≤ 0,03	[w-% dryness]
Ash melting temperature, DT	DT1200 ≥ 1200	[°C]

Date:
Name and position of sinatory:
Signature:

Example of declarations for the quality of wood pellet (Table 2) is shown at the 2nd World Congress on biomass, which was held in Rome in 2004 (Alakangas, 2004). It relates to the implementation of quality standards in Finland. Finland has "not yet" made its standard of quality, it still uses the Swedish standard.

Table 2. Declaration of quality for wood pellets

User: One family home

	DECLARATION OF QUALITY PELLET	
Norm	Supplier	"Processed solid biofuel" P.O. Box 1603 Fl-40101 Jyvaskyla, Finland tel. +358-400-542 454 Fax. +358-14-672 598 Contact person: Ms Eija Alakangas Number of contracts: SB1345678
	Source	Chemically untreated wood without bark (1.2.1.1.)
	Country	Finland
	Sales form	Wood pellet
	Delivered quantity	4.000 kg
Technical Information	Characteristics (properties) of pellets:	
	Particle size (mm)	D08 D ≤ 8 mm ± 0,5 mm, and l ≤ 4 x diameter (tag „O”), Max. 20 % the pellet may have a length 7,5 x diameter (tag „X”)
	Moisture content (% mass) received sample	M10
	Ash (% mass)	A0,7
	Mechanical durability	DU97.5 ≥ 97,5 % mass, after testing the pellet
	The mass of fine particles < 3 mm (% mass), after production at factory gate	F1.0
	Net calorific value of the supplied sample (kWh/MJ)	4,7 kWh/MJ
	Bulk density, kg/m^3 exposed	≥ 650 kg/m^3 exposed

Signature of authorized person — Place and date

____

(Eija Alakangas) — Rome, May 10, 2004.

The company "Brites" has five years experience in production and delivery of energy pellets. It is the largest supplier of UK and Ireland. It has successfully accredited ENplus standard. Table 3 contains the declaration of the pellets produced in company "Brites" in England, which were exhibited at the Energy Fair in London at beginning of March 2012.

The technological process for the preparation of pellets is not at all easy to define, because many elements influence the selection of procedures. Key factors are: the type of raw material, moisture (input and output), granulation 2 - 8 mm, temperature (input and output), drying and cooling, a tool that should unite the above mentioned factors, etc. These procedures are described in detail in the master work of Gluvakov Zorica (2012).

Table 3. Declaration of pellets produced in "Brites" (standard EN plus A1)

Dimensions	Diameter 6 mm Length 3,15 ≤ L ≤ 40 mm
Bulk density	≥ 600 kg/m³
Calorific value	16,5 ≤ Q ≤ 19 MJ/kg (cca 4.800 kWh/t)
Moisture	≤ 10 %
Fines	≤ 1 %
Mechanical durability	≥ 97,5 %
Ash	≤ 0,7 %
The softening temperature of ash	1200 °C
Chlorine	≤ 0,02 %
Sulphur	≤ 0,05 %
Nitrogen	≤ 0,03 %
Additives	≤ 0, 02 % dry basis (natural)
Tree bark	no

CONCLUSIONS

The declaration on the quality of pellets as a solid fuel quality must be specified in accordance with the relevant standard, which is defined in the contract between the supplier and the end user. Quality declaration for pellets should at least include: supplier (person or company that provides contact information); specification references of technical quality assurance; origin and source; form of trade; specificaton of properties, i.e. normative and informative properties, chemical treatment if the biomass is chemically treated; signature, name, date and place. Supplier should keep the contract made with the end user for at least one year after delivery.
At the international level, there are national and European norms and quality standards, which are trying to set rules for growing and diverse range of biofuels types. Classification, specification and quality assurance of solid biofuels are intended to increase the use of biofuels so that consumer and seller can uniformly define the quality of biofuels based on biomass origin "packages" to sell and to provide adequate confidence that the specific requirements for quality are fullfilled. The quantity must be defined in the contract of delivery.

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APPLYING THE BDD ELECTRODE IN THE PROCESS OF REMOVING PHARMACEUTICALS BY ELECTROCHEMICAL OXIDATION

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Abstract: Pharmaceuticals and their metabolites are inevitably emitted into the waters. The adverse environmental and human health effects of pharmaceutical residues in water could take place under a very low concentration range; from several µg/l to ng/l. These are challenges to the global water industries as there are no enough efficient processes for removing these pollutants. An efficient technology is thus sought to treat these pollutants in water and wastewater. Research involving electrochemical oxidation of emerging contaminants using BDD electrode is relatively new and more relevant information is still needed to obtain the desired result. The present work reports experimental results of the electrochemical oxidation of Ibuprofen (Ibu) solutions using boron-doped synthetic diamond (BDD) electrode. Electrochemical characterization of Ibu in a solution of 0,05 M Na_2SO_4 using cyclic voltammetry (CV) and the results of Ibuelectro oxidation using BDD electrode with current density of 30 mA /cm^2 during 6 hours were shown. By using UV-VIS spectrophotometry and determination of Chemical Oxygen Demand (COD) decrease of the initial Ibu concentration has been shown, from 375 mg/l to 70 mg/l or 81,4% and decrease of COD value from 960 mg O_2/l to 210 mg O_2/l or about 78%, with a specific charge of 36 A h/l.
Key words: BDD electrode, ibuprofen, electrochemical oxidation

INTRODUCTION

The main source of water resources contamination with pharmaceutical products (PPs) are humans and animals treated with different medicaments. In the case of human consumption, it depends on the location of consumers such as private households, hospitals, schools or retirement facilities. Their main route of entry to the aquatic environment is through excretion and wastewater cycle. Nevertheless, expired PPs are also often discarded and may find their way to the environment via landfill leachate and/or wastewater effluent [1]. It has been found out in a survey conducted in South Eastern England that 63.2% of the people disposes unwanted or expired pharmaceuticals in the household waste, 21.8% returns them to pharmacists and 11.5% empties them into the sink or toilet. A small percentage takes them to municipal waste sites that have special waste facilities [2]. Consequently, there are efforts to mitigate this problem by the proper disposal of unused pharmaceuticals. In Europe, drug take-back programs for expired pharmaceuticals are established [3]. This means that it is necessary for the member states of the European Union (EU) to make sure that appropriate collection systems are available for unused or expired pharmaceuticals [4].
Pharmaceuticals taken up by humans or animals are generally absorbed and are subjected to biodegradation/metabolism inside the body. This process alters the chemical structure of the active molecules, which often results in a change in the physicochemical and pharmaceutical properties. Incomplete metabolism in the body and subsequent excretion may lower or enhance water solubility [5]. The pharmaceuticals and their bioactive metabolites thus continually enter the aquatic environment as excretion via urine or feces into raw sewage, either treated or untreated [6]. A study conducted by Castiglioni et al. [7] about the removal of pharmaceuticals in six sewage treatment plants in Italy demonstrated a low overall removal rate of mostly below 40%. As such, wastewater treatment plants do not offer a viable barrier against pharmaceuticals.
Pharmaceuticals present in the environment can also come from hospital sources. A study about the presence of selected human pharmaceutical wastes in hospital effluents was conducted by Thomas et al. [8]. It was found that analgesics and beta-blockers were detected in high concentrations with paracetamol having the highest maximum concentration from all selected pharmaceuticals with values ranging from 178 µg/l up to 1300 µg/l. Alternatively, the source of veterinary pharmaceuticals found

in the environment can be due to direct and indirect releases. Direct release to the environment is usually through application in aquaculture. On the other hand, indirect release can also occur through the administration of pharmaceuticals to animals being treated, commonly via run-off and leaching of animal excretion [9].

Ibuprofen (Ibu) or 2-(4-isobutyl phenyl) propionic acid, is the first of the non-steroidal anti-inflammatory drugs (NSAID) derived from propionic acid which is sold in many countries. It is important to emphasize that in 2005 this drug took 17th place on the list of the most commonly prescribed medications in the United States [10] or 2300 t/year. Studies were also performed in countries such as Germany, Spain, Switzerland, France, Italy, Sweden, Canada and Denmark, where the quantifications for Ibu in wastewater effluents varied from 60 to 3400 ng/l [11]. In numerous studies, the analysis of concentrations of pharmaceuticals found in surface waters, detected were concentrations of ibuprofen from 0.05 to 0.28 mg/l [12]. Considering all these facts, it is vital to develop a process with significant potential to remove pharmaceuticals residue.

WWTP effluents have been considered as an important source of micro pollutants for aquatic environments; therefore advanced treatment technologies such as ozonation [13] and activated carbon filtration [14] as well as a combination of ozone and hydrogen peroxide [15] are required to reduce the emission of micro pollutants via WWTPs effluents.

The wide application of boron-doped synthetic diamond (BDD) electrodes extends to more specific areas, for instance, the electrochemical oxidation or reduction of emerging contaminants such as pharmaceuticals, which also received more attention in recent years because of their growing presence in the environment. Moreover, there are also research studies aimed at comparing the performance of BDD electrodes with Pt electrodes for the electrochemical oxidation of pharmaceuticals. The oxidation of ibuprofen yielded better results in favor of the BDD anode in comparison with Ti/Pt/PbO_2electrode [16]. Also the results showed that the substrate was destroyed faster on a Pt anode but complete mineralization was only achieved on the BDD anode in all media. This is because intermediates such as carboxylic acids are completely converted into CO_2 with the BDD while they remain stable in solution using Pt electrode [17].

Several research studies are available in the literature, mostly on the electrochemical oxidation of individual pharmaceuticals such as sulfamethoxazole and acetaminophen on BDD electrodes. Li et al. [18] investigated the oxidation of sulfamethoxazole, an antibiotic, at a BDD anode using sodium sulfate (Na_2SO_4) as background electrolyte. Mineralization with high current efficiency was achieved with not known toxic by-product formation as a result of partial oxidation.

Research involving electrochemical oxidation of emerging contaminants using BDD electrode is relatively new and more relevant information is still needed to obtain the desired result. This paper presents experimental results of the electrochemical oxidation of Ibu solutions using BDD electrode.

MATERIAL AND METHODS

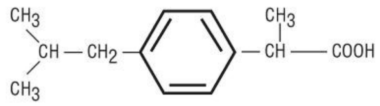
The pharmaceutical certified product Ibu was of analytical grade (99.6 %) and provided by the Pharmaceutical Laboratory Galenikaa.d., Beograd, Serbia. Stock solution of ibuprofen, concentration of 0.375 g/l was prepared in 0.05 M Na_2SO_4. The solution Na_2SO_4 was made by using Na_2SO_4 salt *p.a.* quality provided by Centrohem, Stara Pazova, and demineralized water.

Cyclic voltammetry (CV) experiments were carried out in the custom designed three–electrode system which consisted of a standard calomel reference electrode (SCE) ($Hg|Hg_2Cl_2$ in 3.5 M KCl, E = + 0.250 V *vs*. NHE at 25 °C), coiled platinum wire as a counter electrode and a highly BDD working electrode at the cell bottom with a surface of 0.8 cm^2 bounded by a chemically resistant rubber o–ring. Cyclic voltammetry experiments were performed by potentiostat – galvanostat Gamry G300 control.

Electrochemical experiments were conducted at room temperature (22–25 ◦C) in a 250ml cell, using batch mode. BDD (20cm^2) electrode were used as anode, and stainless steel foils, with an identical area to the anodes, were used as cathodes. All anodic oxidation assays were performed under galvanostatic conditions, with imposed current densities of 30$mAcm^{-2}$, which is characterized in previous works as the optimum current density for the Ibu oxidation on BDD [16], for a volume of 100 ml of solution. A potenciostat/galvanostat , model PAR EGG, was used as the power supply.

The basic solution of Ibu in 0.05 M Na_2SO_4 had characteristics according to Table 1.

Table 1

Ibuprofen	c, mg/l	pH	COD, mg O_2/l
	375	6	960 ± 35

The change in the concentration of Ibu was monitored by UV-Vis spectrophotometer (Shimadzu UV 1800) at a wavelength of 264 nm and calibration curves. Chemical Oxygen Demand (COD) determinations were made following the titrimetric method, according to standard methods [19].

RESULTS AND DISCUSSION

Electrochemical characterization

Cyclic voltamogram of Ibu solution containing 0,05 M Na_2SO_4 with BDD electrods are shown in fig. 1. At the potential higher than 0,75 V vs. Hg/Hg_2Cl_2,the current density increase with addingIbu. The increased current density may result from the direct electro oxidation of Ibu at BDD electrode. When the potential exceeds 1.3 V, the anodic currents increased largely with potential, which may be result of electro oxidation of Ibu plus the evolution of oxygen. With the evolution of oxygen, the active species such as hydroxyl radicals, H_2O_2, or O_3 can be produced, which lead to the indirect oxidation of Ibu.

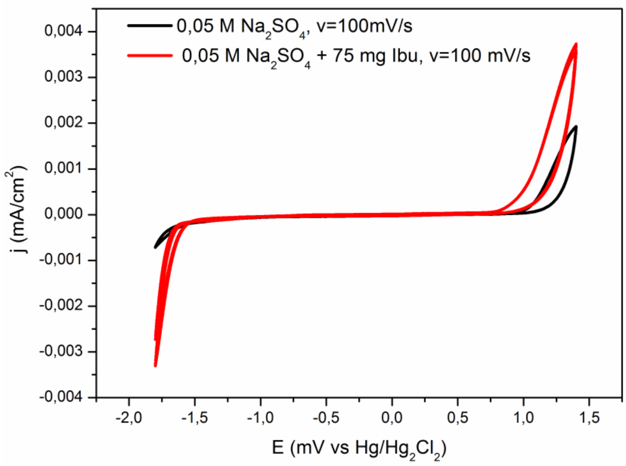


Figure 1. Cyclic voltammograms of Ibuprofen (1,83mM/l) in 0,05 M Na_2SO_4 solution at BDD electrode

Effect of electro oxidation of Ibu at BDD electrode

Electro oxidation of Ibu, initial concentration of 375 mg/l, is performed on BDD electrode. The change in the concentration of Ibu was monitored by UV-Vis spectrophotometer after 1, 3 and 6 hours of electro oxidation. According to the spectrophotometric results, Figure 2, Ibu solution has two peaks (264 and 272 nm). Based on the literature data [20] for the determination of Ibu, the peak at 264 nm was selected. The concentration of Ibu present in each sample was calculated by determining the value of absorbance for each sample at the peak of 264 nm and by using the calibration curve. Figure 2 showsdecrease in absorbance values for peak typical for Ibu (264 nm). Based on the calibration curve, Figure 3, Ibu concentrations were determined after 1, 3, and 6 hours of electro oxidation.

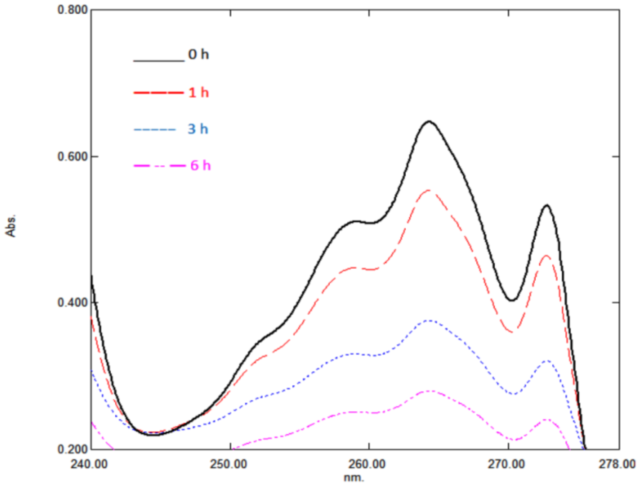


Figure 2. Electro oxidation of Ibu at BDD electrode at various reaction times: UV–Vis spectra of reaction of Ibu solution (initial Ibu concentration 375 mg/l; 0,05 M Na_2SO_4 electrolyte)

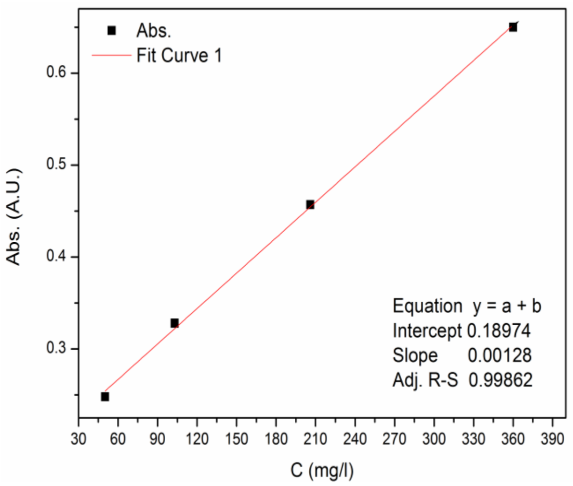


Figure 3. Calibration curve of Ibuprofen in 0,05 M Na_2SO_4 at 264 nm

It was observed extremely decreasing in initial Ibu concentration over the time of 1, 3 and 6 hours from 375 mg/l to 288, 147, i 70 mg/l, respectively. The highest percentage of Ibu removal was 81,4%, after 6 hours of electro oxidation, Figure 4. These results suggested that the intermediates were produced at the initial reaction time, which were degraded with the extension of reaction process.

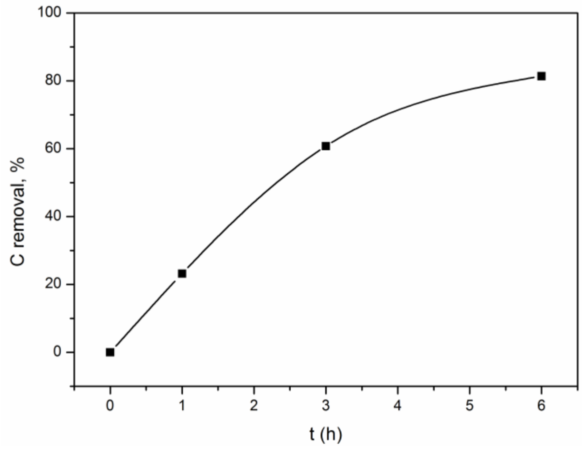


Figure 4. Decrease in the concentration of Ibu in solution after different times of electro oxidation at BDD electrode

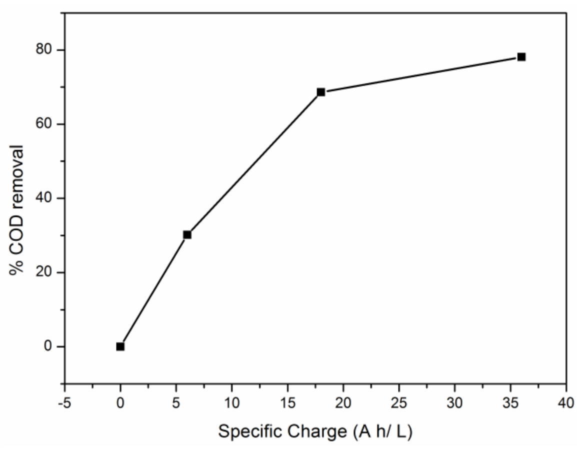


Figure 5. Variation of COD removal as a function of the specific charge passed during electrolysis of Ibu performed with BDD electrode

The possibility of Ibu removal by electro oxidation was additionally confirmed by determining the value of COD in the Ibu solution after 1, 3 and 6 h, in relation to specific charge, Figure 5. The obtained results showed a COD reduction of 78% compared to the solution with the initial concentration of Ibu, after 6 h of electro oxidation on BDD electrode.

No remarkable degradation of Ibu was achieved at anodic potential below 1.2 V, for which H_2O electrolysis nearly cannot occur, which indicated that the contribution of direct oxidation is not significant. The other possible mechanism responsible for the Ibu degradation is indirect oxidation mediated by several oxidants produced from the oxidation of water. Reactive oxidants such as •OH, O_3, H_2O_2, and $•O_2^-$ can be considered as candidate oxidants [21]. The most common oxidation is the •OH radicals formed by the one-electron oxidation of water. Additionally, other reactive oxidants can also be responsible for the Ibu degradation.

CONCLUSION

The aim of this study was to examine the possibilities of Ibu removal from aqueous solution in the reaction of electro oxidation on BDD electrode. The effective removal of Ibufrom aqueous solutionsusing BDD anode has been shown. Regarding the Abs (264 nm),for the current densities of 30 mV/cm^{2}Iburemoval from aqua solution can be possible up to 81%. The possibility of Ibu removal by electrochemical degradation wasalso confirmed by the results of COD which have demonstrated the removal of 78%compared to the initial value.

Acknowledgements
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Session 10.

Reengineering and project management

OUTSORCING IN REALIZATION OF HIGH-RISE CONSTRUCTION PROJECTS

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Abstract: The paper elaborates the possibilities of outsourcing and justification for the realization of high-rise constructions, considering the characteristics of such projects and common practice. The proposed are the criteria and algorithm for deciding of contractor whether to transfer part of the works on the agreed realisation of the project to the companies and trades specialized for these types of works.
Key words: outsourcing, civil engineering projects, criteria of decision making, cost effectiveness, safety

INTRODUCTION

The entire civil engineering sector is extremely sensitive to the globalized and dynamic environment and effects of these environments require constant adaptation to new conditions of construction companies, [9]. The absence of changes in accordance with the new conditions and delay of these adjustments usually means regression and sometimes failure of the enterprises engaged in construction works.
In construction industry it is always necessary, especially in times of crisis, such as the one in the last years in the region, to find a method of performing the works with the lower costs, within the shortest possible terms, with less risk and with satisfactory quality and safety of employees. Planning of lower costs is usually a prerequisite for getting a job in the tender. Lower costs can be achieved in several manners, and one of the most famous manners in most of the activities, including the civil engineering practice, is the outsourcing of the activities which are performed occasionally and in limited quantity. In addition to outsourcing of activities regarding the maintenance of the certain work equipment and certain analysis to the contractor, it is common, as a form of outsourcing, a division of the parts of agreed work on project realisation between the sub-contractors or associates that are specializes only for certain type of work.
Decision in respect of which activities and in which events will be outsourced to the contractors is mainly left to the discretion of management and is usually subject to the practice, rather than to transparent analysis justification. Empirical research has shown that the most complicated task of the managers is to actually notice a problem in business that already exists, [7]. Problematic is that the program of undergraduate education of engineers generally provides the technical knowledge and this is not in accordance with the requirements of the most positions in civil engineering practice.

GENERAL CHARACTERISTICS OF OUTSOURCING

The business philosophy of outsourcing from the perspective of a company that entrusts the activities to the outsourced contractors is the following:
• concentration on core business
• costs reduction
• the availability of well-known part of the service at market prices
• quality improvement
• higher transparency in costs and services
• increased availability of the facilities
• avoiding the risk of employment and efficiency beyond the core business
• the availability of modern techniques of maintenance without personal investments.
According to available sources, many companies could not in productive and qualitative manner perform some simple and especially more complex activities based on their own capacity. Performance of some tasks by their own personnel and based on their own resources caused increase

of the costs. In addition, at the beginning the problem with the quality of the newly established outsourcing companies occurred.

For example outsourcing company takes too many clients and is not able to perform tasks on time and with quality. In these beginnings, the companies and institutions relied on external cooperation, taking into account the following, [11]:

- Associates or companies are selected based on the recommendations.
- The company is unable to employ adequate professional and reliable person.
- If the company employs a quality person, that person is not able to track all changes outside the enterprise.
- The company actually does not have sufficient capacity.

From the above stated, it can be concluded that the use of outsourcing, in general has certain advantages, such as, [11]:

- Risk management because the external partner guarantees the quantity, quality and deadlines for the certain tasks.
- Cost reduction due to engagement of a contractor on the basis of market competition.
- Overall efficiency because the external associate as a professional applies all new methods, more educated and willing personnel and means of work.
- External associate has a need for continuous employees' development.

In addition to the listed advantages, in wider terms the key factors that have led to a growing trend of outsourcing are as follows, [12]:

- lack of skilled labour in some parts of the business process
- the availability of cheaper labour
- capability and the ability to concentrate on other critical business processes.

REALISATION OF THE HIGH-RISE PROJECTS

Specifics of civil engineering production

Civil engineering as a project-oriented activity is characterized by the uniqueness of the product (every construction is in some way a prototype), discontinuity of production and the temporary place of the work (the site - the construction site) and the organization of the works. In addition, construction sites are often dislocated (can be rather distant from the headquarters of the company), sometimes rather isolated. Civil engineering production is specific for its static product i.e. structure and movement of labour and machines. Unsteady conditions include the exposure of the work processes to the weather conditions (seasonal nature of some types of works), and various other local activities (market, exchange rate, traffic conditions, etc.). Such production is more complicated than the stationary, and the temporary organization whereby each organization is specified for certain project, is the answer to seasonal, spatial market and production instabilities, [9].

Work processes in the construction industry are complex with a high representation of manually-craftsman's work and low levels of standardization. They are performed with numerous, various resources (materials, workers, machines, tools and other equipment), with the participation of a large number of companies (more subcontractors for different groups of works by various manufacturers and suppliers of materials, etc.). Activities related to the implementation of civil engineering projects can be physically difficult and dangerous, and based on the bylaws (regulations) many are listed within the positions with special conditions of work for which the application of specific safety rules is prescribed.

High-rise construction (works on residential, commercial and other buildings) in particular is characterized by a significantly higher proportion of manual work performed than the machine performed work, a large number of different types of works i.e. technological processes (one work process always involves workers of one occupation) and operations. In addition, in relation to low-rise constructions (road building, hydro-technical works), in average, there is rather smaller amount of individual works. In the construction industry, the most common cause of severe injuries are workers accidental falls and injuries by falling objects on the workers (which results in 50 percent or more injuries, [7]), and it is clear that certainly more risk of such injuries exists in high-rise construction.

Possibilities of savings through the work of specialized contractors

Training with multiple repetitions of certain actions can reduce the required time and materials for their performance and increase the quality. There is no serial production on construction sites and it is not possible to achieve a level of organization of workers as in the industrial plants, however in some cases when the performance of work is takt time organized (eg. In high-rise buildings with approximately equal levels or with the series of the same buildings) significant savings can be achieved. Rather old German data (W. Triebel Die Tarktarbeit im Rahmen der der Rationalisierung Wohnungsbauten, 1952), which are cites by the recent scientific literature, for housing construction show that eightfold repetition of work operations cut costs by 17% and twenty repetitions reduce costs for 20%. The more complicated are the operations, by training the workers the greater time saving can be achieved (in simple operations complete training of workers is achieved after 8 - 12 repetitions and in respect of more complex operations 30 - 45 repetitions are necessary), [3], [4]. Monitoring of an experienced group of workers has shown that they managed to reach normative time established by the manufacturer after making of 200 m^2 when first using one of modern shell systems, and after twice as large surface of formwork it took them 12 - 15% fewer hour per $1m^2$s. During the next use of the same shell on the new building, the normative of the manufacturer was reached after installation of 100 m^2 of formwork, [1].
Specialized companies and entrepreneurs should definitely be able to provide greater continuity in performing of activities. General rule is that with experienced and well-trained and skilled workers they have all the necessary, appropriate work equipment (usually a special machinery, tools and instruments), as well as protective equipment for the work that they perform. All this enables them to perform activates for less proportional costs comparing to the contractors which perform such activities only occasionally.

The need for outsourcing in the implementation of projects of high-rise construction

On the necessity and possibility of outsourcing in the construction industry indicates the existing fragmentation of this industry. During the past 20 years some of the large construction companies from the socialist period disappeared and large number of small companies was established (in Croatia, more than 97% of small companies were established and less than 0.5% of large companies were established, [5]). Reduction of once large construction companies led to closing of the departments and types of activities that were not the core activites or were evaluated by the management as insufficiently profitable. Taking the said into consideration, the specialization of individual businesses and trades to perform only some specific work has become even more necessary in the construction operative.
One contractor is almost never able to independently perform all necessary works on more complex projects, such as those related to the construction of different buildings. Typically, when a new building is being constructed one large construction company performs most or all of the major construction work (primarily: clay, concrete, steel bending, carpentry, masonry, roofing, isolating), and for most final and installation works (if required, including mechanical works) it contracts the specialized (sub)contractors as its partners (separately for each type of work). In addition to work on the building, it is often to outsource the preliminary and site preparation activities, as well as production and transportation of materials. Subject to the principal contractor (his own available recourses), the particular project (requirements, amount of work) and sub-contract with the investor (which defines obligations undertaken by the contractor, how it will be charged, etc.) it is possible to outsource other various tasks, as indicated in Table 1 below.
Sometimes the contracting companies joining (the joint venture) in order to form a consortium of contractors of various forms of specialization (eg. one part in order to perform low-rise construction works and the second part for high-rise construction works and the third part for engineering works) in order to jointly apply for a tender and the subsequent realization of large projects, [3], however such consortium in addition needs subcontractors.
They are examples of companies with limited own resources, which are used to operate in a manner that most or even all of the contracted work with the charging the commission are conceded to other contractors, however this is considered as negative phenomena. Since the year 2008, such activity is

limited by the *Act on Architectural and Engineering Activities in Physical Planning and Construction*, which prescribes the obligation of obtaining the consent of the Ministry of Physical Planning and Construction for the construction of certain groups of buildings (which are divided by the price to 7 groups, from "A" to "G") and for works (the group "H" and "I"), which is issued to the contractors for period of five years according to the number and professional training of their employees (only employees employed for indefinite period and in full-time are considered), [10].

Table 1. Most common types of work outsourced during implementation of the high-rise project

Production and transportation of materials	Construction-craft works	Installation works	Hazardous works	Other works
- preparation and transportation of concrete (and asphalt) - production and transportation, and assembly of the elements - processing of reinforcement, (making assemblies, according to the plans)	- land works (excavation and transportation) - funding (especially, such as eg., pilots) - works with spec. formwork - assembling conctructions elements - insulation (most common HI) - masonry (plastering, floor , screed) - roofing work (spec. covers) - **All final - craft works** (floor works and ceramist, locksmith, tinsmith, special facades and other works)	- installation of sewers and plumbing installations (basic and fine installation) - assembly of installations of electricity (basic and fine installation) - installation of heating, elevators, etc. (mechanical works)	- demolition (blasting, or with special machines) - works at height (with climbing equipment)	- maintenance of machinery (owned and leased) - maintenance of formwork systems in lease - recycling of materials - an external transpor. - various analysis (soil, materials, etc..) - designing - meals of field workers - various cleaning - IT works, etc.

DECIDING ON OUTSOURCING OF THE PART OF THE PROJECT ACTIVITIES

Specialized contractors for certain types of work should be contacted in regard to price and terms in the moment of drafting an offers, and investor should be informed regarding the selected subcontractors. The cost of subcontractors is increased by the manipulative cost by which the contractor that engages these subcontractors covers portion of its indirect costs on the project (for bidding, preliminary-final works, site management, etc.).
Engaging specialized subcontractors for individual services with acceptable financial terms (price, payment method) is often in practice as a result of established, old business relationships, as well as personal acquaintances. The decision on the selection of subcontractors can be a matter of confidence and management that decides in this respect, and sometimes there are external influences (eg. by investors or political influence). However in order to select such service, rarely is such selection subject to adequate justification analysis which can be rather helpful. It contributes also to a better decision-making and it can even affect the company's business strategy changes, and there are no justified reason not to perform such analysis.
The criteria that should be considered when deciding on outsourcing of the individual types (group) of work during implementation of project are:
- Profitability (lower costs),
- Promptness of execution of works (based on the agreed terms).
- The safety of employees (for works that need special training due to danger),
- The quality of work,
- Reliability (lower risk of plan implementation),
- The possibility of supervision (a large number of participants makes difficult control)
- Contractual obligations and business relationships (with other contractors - eg. in the event of regular exchange of outsourced activities in contracted projects).

The reaching of these criteria should be examined also by other contractors (potential subcontractors) and independently, and they should be numerically or descriptively (qualitatively) evaluated and mutually compare all possibilities. Considering that there are multiple criteria which cannot always be

expressed through monetary value for comparison of offers of potential subcontractors (for the same work) the multi-criteria analysis should be prepared, Analityc Hierarchy Process (AHP) is recommended, [6].
In order to accomplish the profitability of certain investment in technology (in equipment and personnel) it is necessary to provide a sufficient amount of implementation of these works to. On Fig. 1. demonstrated is the finding the amount of work required to conduct the business with profit and minimum quantity of work in order to establish its own, independent production i.e. the minimum amount up to which it is more efficient to outsource the works to other contractors.
Still point of profitability (cost effectiveness) of own production, i.e. individual performance of works (indicated in Fig. 1) is calculated in accordance with following, known expression:
PP [measure unit] = Fix.Costs$_{OWN}$ [Eur] / (Sale.Price [Eur/m.unit] - Prop.Costs$_{OWN}$ [Eur/ m.unit]) (1)

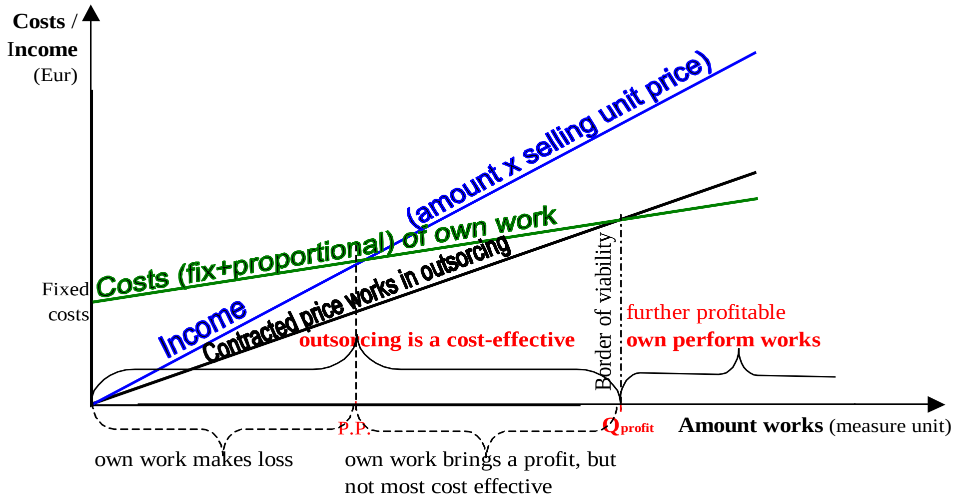

Figure 1. Graphical analysis of cost effectiveness of outsourcing and independent execution of works

If one reviews only criteria of profitability, then outsourcing is justified by the quantity of work:
Q_{profit} [measure unit] = Fix.Costs$_{OWN}$ [Eur] / (Price$_{OUTS}$ [Eur/m.unit] – Prop.Costs$_{OWN}$ [Eur/m.unit]) (2)

Equation (2) analytically determines economic justification for outsourcing of certain works depending on their amount on one project (if it is large and dislocated) or on annual or multi-annual amount of all such works in the company. In this analysis it is assumed that the price of works in outsourcing has accrued a profit, therefore it is expected that its performance with our own resources can be cost efficient if sufficient quantity of such works is provided. Cost-benefit analysis shown in Fig. 1 is simplified, due to the fact that the growth of costs and price per measurement unit of work is always the same (linear), however in reality the unit costs and price are usually decreases with increase of volume of contracts (due to the better organization of workers, the lower proportion of fixed costs per unit volume etc).
The complete decision making process on outsourcing of certain works to other, specialized companies or trades or independent implementation is shown in Fig.2. Reaching the final decision in some cases, depending on its importance, can be finalized by analysis of cost-effectiveness, and sometimes it makes sense to prepare a multi-criteria analysis of the two alternatives (outsourcing of certain works or independent implementation) according to above provided criteria. It should determine the wight of each selected criteria for comparisons for which Saatyev procedure (usage of its scale) is recommended, [6]. Budget part of the procedure can be significantly facilitate and accelerated by the appropriate computer programs.
After reaching the decision, it is necessary to monitor its implementation and effects, which may also indicate the need for its amendments. Eg. during the realization of a long-term project if the problems arise in respect of achieving the planned parameters is can be additionally decided on granting any part of work to other contractors (subcontractors) or contrary, if the contractors do not work as contracted, in some cases, it is possible to proceed on its own performance of works. Such experience will definitely influence the decision on realisation of the work on the other, future projects.

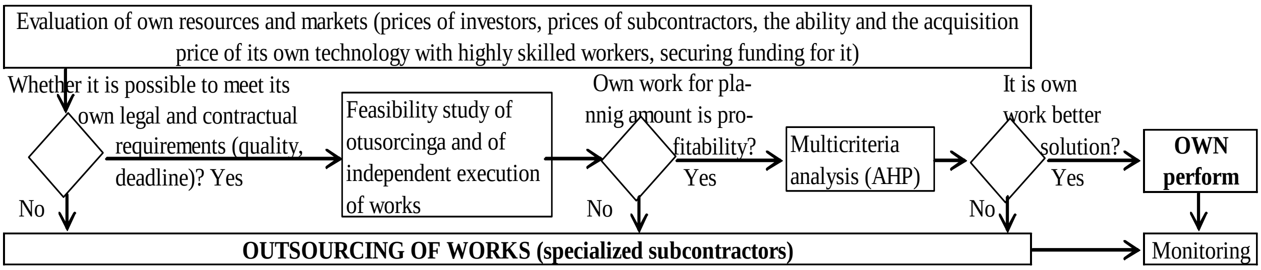

Figure 2. The algorithm of deciding making in respect of outsourcing or independent works

CONCLUSION

Conditions that determine the business of construction companies differ considerably from project to project, each has its own peculiarities and therefore the implementation of each should be considered separately within the cost and time planning before work begins.

The general objectives for the realization of construction projects are to minimize cost, schedule and risk with ensuring greater quality and safety of the employees. The outsourcing can contribute to all of these objectives, if this is indeed the best solution. Therefore, the decision on whether to use outsourcing should not be reached based solely on previous practice in business but it should be analysed.

Decision making on outsource of certain works during the realisation of the project to contractors should be approached on the basis of analysis of their own capabilities (available resources), market conditions, each project and the totality of all projects in the implementation of (contractual) as well as plan for realisation in the next few years (according to the strategic plan of the company). More of these criteria are taken into consideration and according to the listed and not too demanding procedure, efficient and transparent decision on the independent performance of certain works or outsourcing these works and the selection of subcontractors, can be reached.

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RISK MANAGEMENT OF SHAFT BEARING FOR RAILWAY TRANSPORT

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Abstract This paper represents application of remote surveillance by temperature control of bearing axle assemblies (locomotive and coach) in movement, as means of risk reduction of sudden accidents.
The temperature of axle assemblies is a very important parametre based on which one can estimate the state of axle itself. A special advantage of this no contact method is that the complete measurement and surveillance is done in real time and without breaks in production process or in transportation. The need for such surveillance and measurement is multiple. From economic aspect, this way prolongs the exploitation time of bearing axle assemblies and enables gradual replacement first of those axles which are in the running exploitation heating above the expected temperature and there is no need to replace all of them at one time because their guaranteed duration is over. In broader sense, this system lowers the possibility of accident on cargo coaches which would be caused by overheating of axle bearing. Shortly, this system serves the timely discovery and alarm for the malfunction of axles as parts of bearing assemblies.
Key words: Axles, temperature, remote surveillance, risk

INTRODUCTION

Risk management consists of collection of control methods and techniques which are used to reduce the possibility of unwanted damaging events and consequences which would increase the possibility to achieve planned results [1,2].
By risk of breakage of machines, devices or their parts, we presumably think of risk of damage or destruction of the aforementioned by accident or lack of attention in the section. By risk of breakage it is not meant the risk of damaging or destruction of all sorts of tools which are used for material processing, compression fittings, parts of machine which are indirectly used for breaking and chopping ,etc.[3,4]

Specificity of risk of breaking can be seen by its following achievement:

- errors in construction, material and production
- indirect action of electricity: short circuit, atmosphere or some other overvoltage, electric arc, etc.
- decomposition due to centrifugal force,
- shortage of water in steam boilers and apparatus with steam, except in cases followed by an explosion,
- frost, ice or snow pressure, or indirect movement of ice
- overpressure and suction pressures (implosion), failure of device for protection and regulation or automatic management which the machine is equipped with,
- clumsiness, negligence or nespretnost, nemar ili willful misconduct of an employee or another person,
- fall of insured object, stroke or intrusion of foreign bodies into insured object,
- inadequate maintenance

MATERIAL AND METHOD

Practical realization of measuring system for axle temperature

Conception of the measure system is based on contactless measurement of absolute temperature bearing cap axle assembly of truck on the move (3km/h to 40km/h) in conditions of high ambient temperature changes (–40°C do +70°C), large electromagnetic interference, vibration, dust by the rails and weather conditions (sun, rain, snow). Bearing temperature is measured by non-contact infrared (IR) detector located within the measuring point near the railroad tracks [5,6]. Detection system bearing temperature must provide a reliable measurement of absolute bearing temperatures ranging from 40ºC to 125º C with a measurement accuracy ±2ºC. One of the main requirements is that the entire system can operate continuously and independently without a worker . System is set to several different locations (Figure No. 1).

In addition to the tracks, the measuring opto-electronic devices for measuring temperature and the required sensors to control the overall measurement process are set. At the unloading station, it is typical to install an alarm system which has a function to display the temperature of all bearings of a given driver and to alert the high temperature of an axle (from given temperature limit), if such a case arose.

Complete tracking of measurement process and logging of all measurement results is monitored by a computer which is spatially located at the center of a remote control [5,7,8,9].

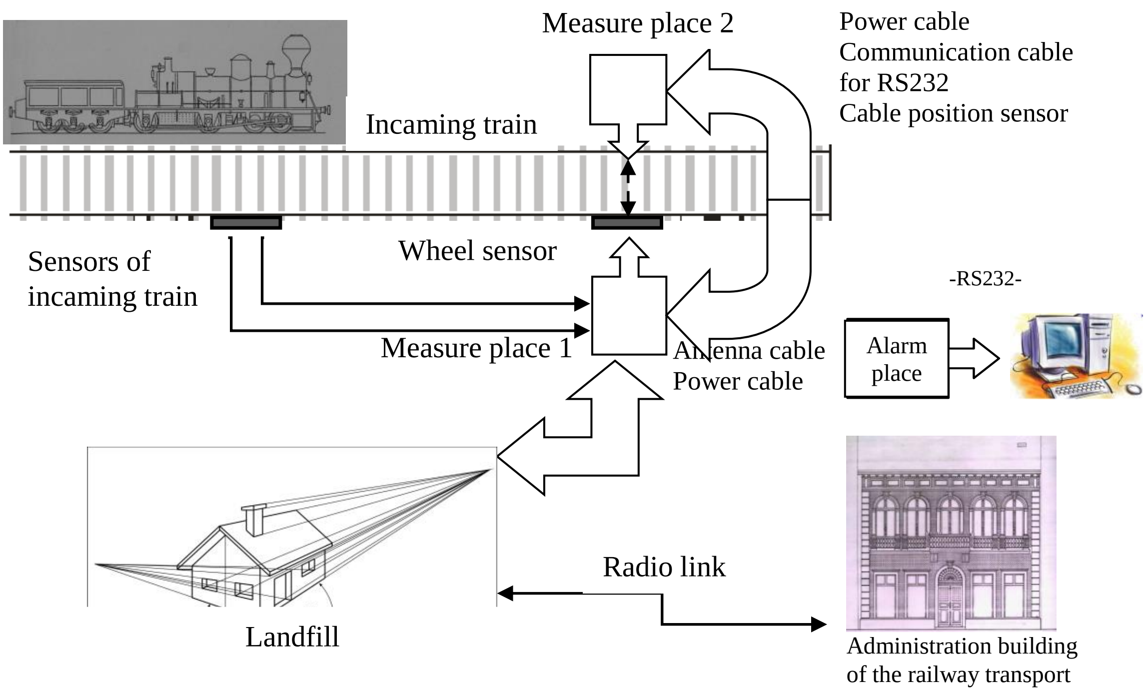

Figure 1. Spatial distribution of the measurement system

In Figure No. 2 a basic block diagram of the entire measuring system was given. The measuring device is a part of the whole measuring system that is installed next to the tracks at the measuring point at which the measurement is performed only and represents the synthesis of complex optical, mechanical, electronic-measuring, sensing, data processing and telecommunication circuits [5, 10].

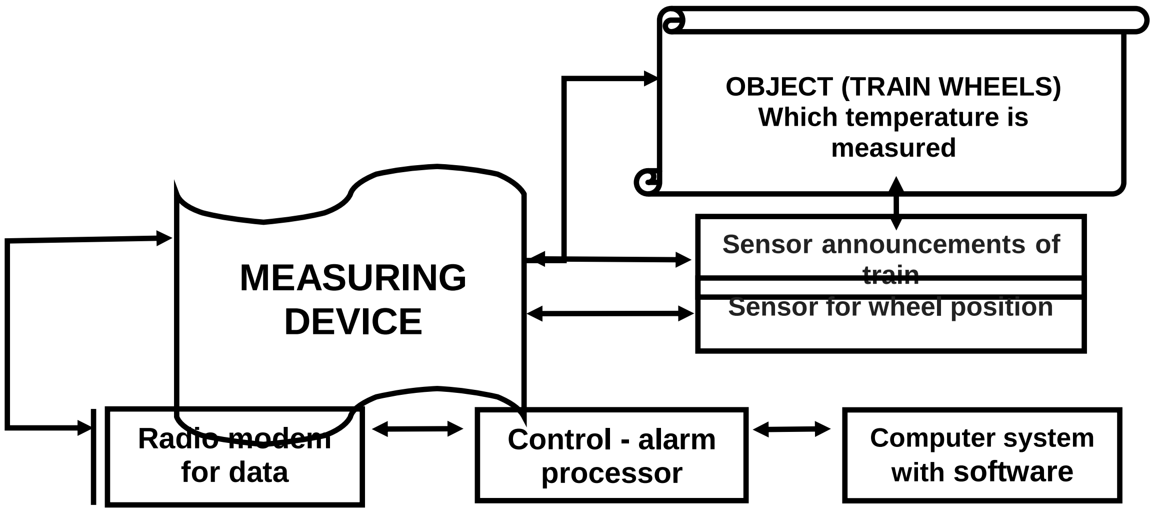

Figure 2. Basic block diagram of the whole system

The main parts of the measuring system

Main parts of the system are given in the block scheme in Figure No. 2.
The object of measurements are covers the housing shaft bearings of truck whose temperature is measured.
The measuring devices are placed on the measuring site on both sides of the tracks and are used for measuring, calculating, recording and sending all necessary data. The measuring device, basically, uses infrared sensors.
Sensors for the train announcement are installed at a distance of 100m from the measuring point and are used for notification and check-out of train (for the measuring system to have enough time to prepare for the measurement - at least 5 seconds or more) in order to detect the direction of movement of the train.
Sensors for setting the position of the point of the wheel are the magnetic type connected to a mechanical unit. They are used to define the position of a point of the wheel in space measurement zone and the time interval in which it measures the temperature, i.e. the time they are obtained by measuring the signal from the infrared sensor is taken as a measure of the desired temperature.
Radio - modems are installed and in measuring and control and alarm station and are used for wireless data transmission from measuring the alarm place and vice versa.
Control - alarm processor device is placed in the alarm-control station and is used for analysis of ambient temperatures bearing current train, and treatment in order to activate the alarm (sound and light units) and further forwarding to the computer. During the passage of a train through the point is done measuring bearing temperatures axle sets of truck. Immediately after passing of the train, measured values are processed and sent to the radio link (via radio modem). Upon receiving the data, the alarm-control place, the check for overheating bearings is conducted, and then the data is sent to the personal computer. This device has the ability to alarm if there is preheated bearing axle assembly. Alarm-control position consists of a display, keyboard, microprocessor cards with communication multiplexer, radio modems, signaling Ledioda, sirens and heat power.
Alarm-control position has the following functions:

1. Receiving data from the measuring point.
2. Sending data to personal computer.
3. Audible and luminous alarm if there is superheated axle.
4. The display temperature of all bearings axle assemblies.
5. The display temperature of overheated axles.
6. Adjusting the threshold values of temperature.

Computer system with software is used for displaying and archiving of measured results and it is connected to the alarm-control by wired connection. Its main function is displaying temperature axle freight wagons bearing the graphics in the form of rectangular pulses (Figure No. 3) and storage of data files in the appropriate format. Data of temperatures arrive via the serial port of a microcontroller with alarm stations to personal computers [5,10]. Creating user interface is done so that the user can numerically and visually (graphic) monitor the ongoing process of measurement (Figure No.3).

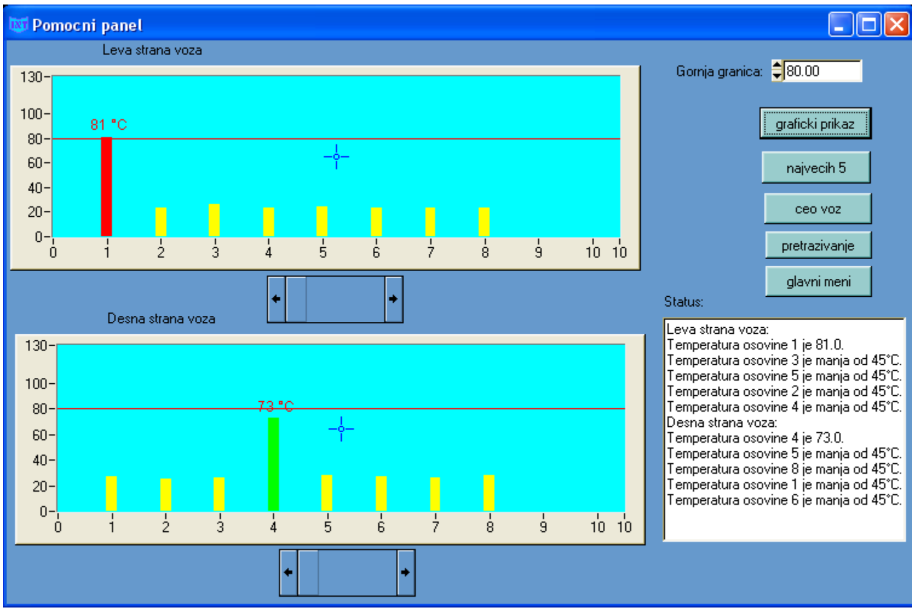

Figure 3. Appearance of user interface on the computer

RESULTS AND DISCUSSION

After the installation and commissioning of the complete measuring system, it is necessary to make the final test in real conditions of exploitation and at different train speeds. On each side of a truck a heat object with a temperature regulator is placed. Positioning of heating objects is performed at the very covers the axle bearings which achieves absolutely faithful simulation of individual overheated axles during the tests. As a secondary standard for checking the temperature of heating plate to be used handheld IC tester Meterman IR610 (the range is from -20 ° C to + 260 ° C, the field of view of 100 mm at a distance of 1m or 10: 1) and the thermal camera [10].
As the heat emitting object a circular heated plate (top) are used in the declared measure and the extent and dimensions that are correlated with the dimensions of covers axle bearings.
Using thermal imaging cameras, one can clearly see the expected inhomogeneous temperature distribution on the surface of the bearing cap and the heating objects. Also it can monitor the temperature of heating of the moving objects and the measuring point. It should be emphasized that this system measures only the heating of bearing cap and heating of rim point, the brake levers are eliminated.

Device for measuring the temperature of shaft bearingsof railway vehicles in motion

A device for measuring bearing temperatures axle sets of rolling stock (locomotives and wagons) on the move is used for the timely detection and alarm malfunctioning parts of the running gear, which can lead to damage during movement (the appearance of the wheels, bearings overheat usually indicates bearing damage, which resulted in the failures during the movement).
Measuring unit consists of:

The outer part of the device (measuring point) installed in front of the first entry points to the station, which is used for the direct measurement of bearing temperature, calculating, recording and sending all necessary data
Alarm-control stations, installed in office of the Signalman, which register the measured values bearing temperatures in the train,
Personal computers (Computational place with software), which is used for processing and archiving of all results of measurements of heating of shaft bearing vehicles.
Alarm-control position has the following functions:
- Receive data from a measuring point
- Sending data to a PC
- Point the display temperature all bearings axle assemblies.
- Point the display temperature of overheated axles
- Acoustic and luminous alarm if there is superheated axle
- Setting the threshold values of temperature

CONCLUSION

Bearing in mind the global trends related to rationalization of the number of perpetrators, increased reliability (especially from the perspective of small transport speed and shorter sections), this system brings significant benefits and improvements to the transport of goods and passengers as well as the production process itself in parts of the industry that depend directly upon of railroad transportation.
By installing these systems, the railways achieve multiple positive and legitimate economic effects:

- Reducing costs by replacing still usable axles .
- Reducing the immobilization of truck.
- Increase the reliability of the mandatory inspection rounds.
- Increase the reliability of the transport due to reducing the risk of disasters.

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IMPLEMENTATION METHODS FDM FOR DECISION-MAKING IN DESIGN

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Abstract: In this paper, an example is given use Function Deployment Method (FDM) for decision making in dimensioning the selected parameters in process development on example of adoption particular element undercarriage system for track type tractor. The model translates customer needs into technical specifications. And the method is based on the technique of Quality Function Deployment (QFD), using Analytic Hierarchy Process (AHP) and Linear programming optimization (LP). Based on optimized parameters, authors were performed selecting elements of the undercarriage system for track type tractor. The model can also be used for assessing the availability of optimal undercarriage parts at markets or it can be used for formatting of a family of parts that better meet the needs of users in terms of various constraints.
Key words: function deployment method, design

INTRODUCTION

Due to market competition manufacturers must be oriented towards in meeting customer requirements of their products. It is significantly, even when making of the product concept to research and get the right information about what is expected from product or service for this product. The requirements tend to be unrealistic and difficult to achieve. Therefore, it is important to communicate with customers and clarify with user all doubts regarding to the requests.
In case when it is needed to explore the information in practice is used matrix-based technic for quality function deployment (QFD). The QFD is basically method that links the requirements of the function design, development, production technology, engineering and serviceability. [1, 2]
In essence of the QFD method at first is collecting and grouping the whole requires which defining customer needs in terms of priority requests (user needs), second is an process of planning to satisfy the demands and classification of attributes (eg. Activity), at last it is to optimizing the collection and classification of attributes (eg. Feature).
For improving the process of product design engineers can use analytical model, called function deployment model (FDM). [1]

MATERIAL AND METHODS

The FDM is a similar method to QFD. The difference FDM from QFD is in the application of analytical techniques called analytical hierarchy process (AHP) to prioritize request, use the functional-oriented approach and the application of optimization methods. It possesses possibility for application of optimization methods such as inventive problem solving (TRIZ) and other.
The matrix approach is most generally used in an engineering design due to its simple essence, effectiveness and productivity. The simplest technique matrix-based approach for decision-making is Pugh's method. For more details it is necessary to include more variables and design process. The QFD is a widely used method for this. It is serial process of problem solving which is focuses on the product quality and providing detailed technical information for design development. However, do not manifest cost, tools, technology and other engineering aspects.
To improve the QFD, many methods have been developed, for instance, some of them are: CFD, TRIZ, Tagaguchi methods, Optimization of parameters price-design, Tolerant Design, etc. In some cases, when the requirements are very subjective and immeasurable, it can be used Fuzzy technique for decoding on design parameters. Frequently used approach for design development is Axiomatic Design by Suh. [5,6,7,8,9]

Flowchart of the FDM (Figure 1), can be used in the conceptual phase of design. The model consists of three parts: the house of quality, function design, and resource optimization design.

The first part covers the characteristic requirements CR_i, characteristic functions FC_j, relationships matrix M, correlation matric P, vector of relative importance of customer request W, and relative importance of the characteristics function represented in matrix V.[1,3,4]

The importance of the weights requires of customer is determined using AHP method given in expression (1):

$$A \cdot W = \lambda_{\max} \cdot W \tag{1}$$

where are: A – matrix for comparison between pairs CR_i; Cr_i – the number of customer requests, $j = 1,...,l$; FC_j – the number of function characteristics, $j = 1,...,m$; $\lambda_{\max}$ - maximum eigenvalue; W_i, w_i – the matrix of relative importance CR_i, $i = 1,...,l$; wherein: $0 < w_i < 1$, $\sum_{i=1}^{l} w_i = 1$.

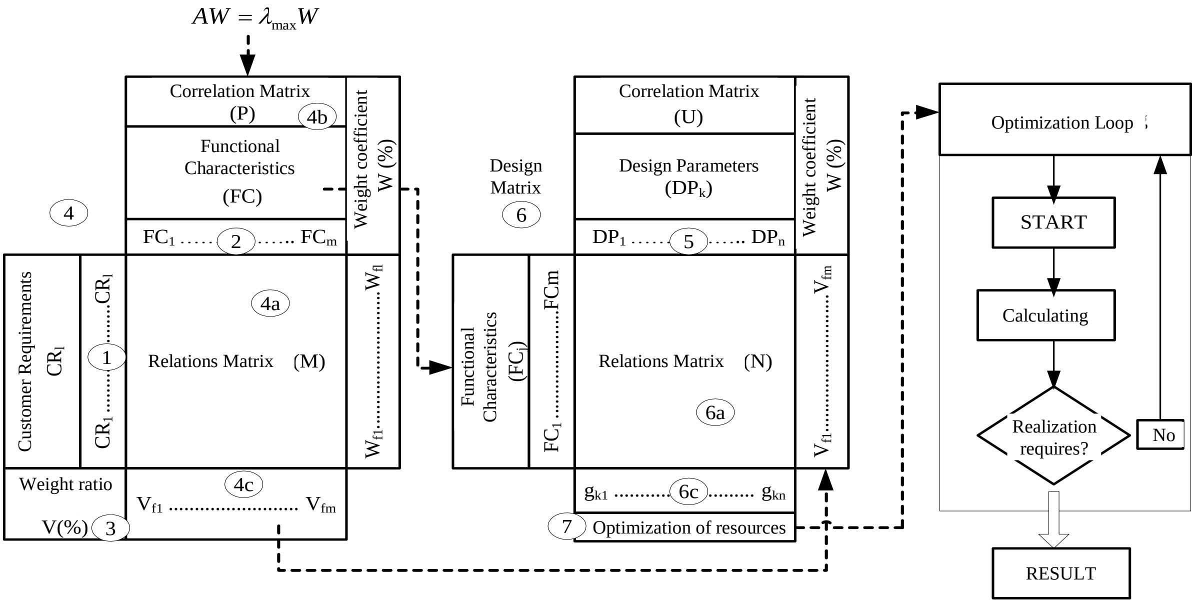

Figure 1. Flowchart of FDM [1]

The Matrix V of relative importance of functional characteristics was given in equation (2):

$$V = \frac{RW}{\left\| RW \right\|_1} \tag{2}$$

where are: V – matrix of relative importance, v_j – element of matrix V for FC_j (wherein: $0 < v_j < 1$, $\sum_{j=1}^{m} v_j = 1$), R – normalization matrix. The elements of the matrix R is computed by the equation (3):

$$R_{ij} = \frac{\sum_{k=1}^{n} m_{ik} p_{kj}}{\sum_{j=1}^{n} \sum_{k=1}^{n} \left| m_{ij} p_{jk} \right|} = \frac{\left(M\, P^T\right)_{ij}}{\sum_{j=1}^{n} \left| \left(M\, P^T\right)_{ij} \right|} \tag{3}$$

where are: m_{ij} – elements of matrix M, and M – is matrix of relations between CR_i i FC_j, P – is correlation matrix between FC_j, p_{jk} – elements of matrix P, a p_{kj} – elements of matrix P^T.

The second part (Figure 1) is used for designing of the function. It includes features of function FC_j and parameters of design DP_k, the matrix of relations N (matrix of relationships between FC_j and DP_k), correlation matrix U (between elements of DP_k), and G the relative importance of the weight factor for design parameter given in expression (4):

$$G = \frac{TV}{\|TV\|_1} \tag{4}$$

where are: G, g_k – matrix of relative importance of the DP_k; T - dot product between FC_j and DP_k, $0 < g_k < 1, \sum_{k=1}^{n} g_k = 1$. Matrix product of T i V is divides the maximum column sum of this product.

Dot product T is similar to R in equation (3), which is used for normalization, while its corresponding form can described by equation (5).

$$T_k = \frac{\sum_{j=1}^{n} n_{ik} u_{kj}}{\sum_{j=1}^{n}\sum_{k=1}^{n} |n_{ij} u_{jk}|} = \frac{\left(NU^T\right)_{jk}}{\sum_{k=1}^{n} \left|\left(NU^T\right)_{jk}\right|}. \tag{5}$$

The third part of the model is the optimization of the design, which is located on the lower right part of the workflow diagram (Figure 1). It is used to determine the optimal value of each parameter design in the form of linear programming (LP) problems or other chosen method for optimization. This part of the optimization consists of three elements: the objective function, constraints and variables is formulated as follows: maximize the total satisfaction of the expressed requirements *($x_1, x_2, \ldots, x_k$)* in the overall budget constraint structure *(B)*, and within the scope of limited to *min.* and *max.* DP_k values.
For target, it can be set the determination of the design parameters in order to increase the total satisfaction of requirements in terms of available technological resources of production.
Finding the optimum value for each parameter within a feasible solution is equivalent to the set goal, and can be expressed as:

Maximise: $$S = \sum_{i=1}^{l} g_k \cdot x_k \tag{6}$$

where are: S – total satisfaction of requests, g_k index values from equation (4), x_k - coefficient DP_k parameters of design attributes, a $k=1,\ldots,n$. Limitations of the design are given in equation (7):

$$\sum_{k=1}^{n} c_k x_k = c_1 \cdot x_1 + c_2 \cdot x_2 + \ldots + c_n \cdot x_n \le B \tag{7}$$

where are: c_k – cost effects of a unit of resource for each DP_k, $k=1,\ldots,n$ in a limited range of minimum and maximum design variables expressed in terms of coefficients, i.e. normalized values shown in the expression (8), and B – is a total budget for the criteria fulfilment.

$$x_k^{(U)} \ge x_k \ge x_k^{(L)}, k = 1,\ldots, N$$
$$x_k^{(L)} = 1 \tag{8}$$

$$x_k^{(U)} = \begin{cases} \dfrac{l_k^{(U)}}{l_k^{(L)}}, & \text{- the case where the higher the better} \\ \dfrac{l_k^{(L)}}{l_k^{(U)}}, & \text{- case when it is smaller the better} \end{cases} \tag{9}$$

$$l_k = x_k \cdot l_k^{(L)}, k = 1,..., N \,. \tag{10}$$

In equation (9), l_k - the optimal value of design parameter, respectively, $l_{k(U)}, l_{k(L)}$ - lower and upper limit of l_k, and $k=1,...,n$. [1, 2, 3]

Example of application FDM in case study

Procedure for application of this method consists of several steps and can be explained by the example of optimizing the choice for dimensions of undercarriage mechanism of track type tractor. Selection of undercarriage mechanism is based in this sample is based on the requests to operation conditions and power drive.

For tractor with crawler undercarriage mechanism is looking the properties that are considered to be machine should possess in order to perform work cycles. The task is to develop a machine that is sufficiently reliable, easily manageable and mobile in different environments. It was said the request was obtained in the form of user queries, and these requests do not have to be fully technically correct. Their correction is achieved through the joint dialogue suppliers and users, as well as exploring the technical characteristics of the available machines on the market.

User requirements in relation to movement and undercarriage mechanism of the tractor is expressed through five individual requirements: 1) one pair of track, 2) movement and / or off-road so transport between work exclusively done with other means of transport, 3) good stability and traction while moving in slope, 4) easy and safe maintenance, and 5) standard caterpillar chain.

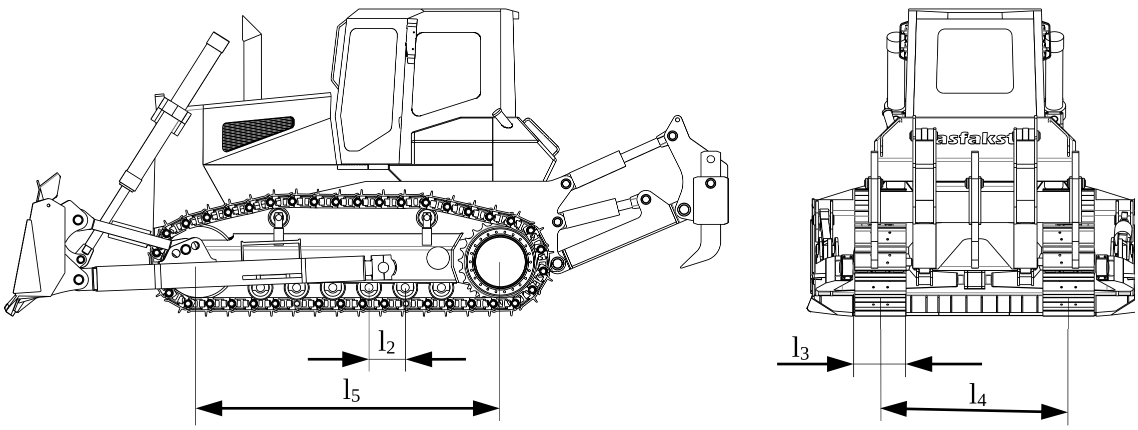

Figure 2. Track type tractor and selected parameters for case study of application of FDM:
l_1- mass of the machine, l_2 – distance between track rollers, l_3 – shoe width,
l_4 - track gauge distance, l_5 – distance between sprocket and idler (length of track on ground)

In the next step, using AHP method is determined matrix *A* for comparing user’s requirements (1) and *CR* relative importance of each set of requirements.

Level of importance for the request is determined in a subsequent step through the approximate method and it represents with vector W of the relative importance.

After this step, all of mentioned above requirements are transformed into function characteristics through the functionally oriented process. It is given five functional characteristics from side of designer to given example of the selecting undercarriage system for track type tractor. It is following characteristics: compacting, shoving, levelling, disposal of soil and ripping.

Then it is formed:

- Matrix of relationships between *CR* and *FC*. The ratio can be given a value of 1, 3, and 9, so that is the ratio respectively as weak, medium and strong, while a value of 0 represents the non-existent relationship between *CR* and *FC*.
- Matrix of correlations between FC_j. The correlation may be given the designation 1, 3 and 9 so as to represent the correlation; weak, medium and strong, respectively, while mark 0 represent no correlation.
- The importance weight of each *FC* with equation (2) and normalisation *Rij* with using equation (3).

Table 1. Ratings pairs in comparing [1]

ID	Verbal judgment	Level of importance
1.	Extremely important	9
2.	Very strong important	7
3.	Very important	5
4.	Medium important	3
5.	Equally important	1
6.	Mean values	2,4,6,8
7.	Inverse comparison	Reciprocal values

Special step makes model building the house of quality. This model will be adding two matrices which represent the relationships between customer requirements and functional characteristics of *M* and correlation between functional characteristics *P*. After defining these two matrices is determined by their products and the relative importance of each functional characteristics *V* expressed in (2).
In a further step, according to information from specialized manufacturers, the choice of the undercarriage system adopted the following important parameters: l_1 - mass of the machine, l_2 - distance between track rollers, l_3 - shoe width, l_4 - track gauge distance, l_5 - distance between sprocket and idler (length of track on ground) and limitations of this dimensions are given in expression (12).
After the evaluation and use of the described mathematical procedure to obtain the matrix: Matrix *M* - the relationship between customer requirements and functional characteristics, *P* - the correlation between the functional characteristics, *R* - product matrix and vector *V* marks obtained in this case.

$$M = \begin{pmatrix} 3 & 9 & 1 & 3 & 9 \\ 0 & 3 & 0 & 0 & 3 \\ 1 & 9 & 3 & 9 & 9 \\ 3 & 1 & 1 & 1 & 1 \\ 9 & 3 & 1 & 3 & 3 \end{pmatrix}, P = \begin{pmatrix} 9 & 3 & 3 & 3 & 1 \\ 3 & 9 & 3 & 3 & 9 \\ 3 & 3 & 9 & 0 & 0 \\ 3 & 3 & 0 & 9 & 3 \\ 1 & 9 & 0 & 3 & 9 \end{pmatrix}, R = \begin{pmatrix} 0.13 & 0.32 & 0.08 & 0.16 & 0.3 \\ 0.08 & 0.37 & 0.06 & 0.12 & 0.37 \\ 0.12 & 0.30 & 0.09 & 0.2 & 0.28 \\ 0.27 & 0.24 & 0.15 & 0.17 & 0.17 \\ 0.28 & 0.24 & 0.12 & 0.19 & 0.19 \end{pmatrix}$$

$$V = \begin{pmatrix} 0.18 & 0.16 & 0.17 & 0.24 & 0.25 \end{pmatrix}^T$$

In the next step of determining the relative importance of each parameter *G* (4), through the relationship matrix functional characteristics of the design parameters, the matrix *N*, the correlation matrix of the parameter in the design, and the product matrix *T* with the determination of the relative importance of the design parameters.

$$N = \begin{bmatrix} 9 & 0 & 1 & 9 & 3 \\ 0 & 1 & 0 & 1 & 1 \\ 9 & 0 & 9 & 9 & 1 \\ 3 & 9 & 9 & 1 & 3 \\ 3 & 0 & 3 & 1 & 3 \end{bmatrix}, U = \begin{bmatrix} 9 & 0 & 9 & 3 & 9 \\ 0 & 9 & 1 & 3 & 0 \\ 9 & 1 & 9 & 0 & 1 \\ 3 & 3 & 0 & 9 & 3 \\ 9 & 0 & 1 & 3 & 9 \end{bmatrix}, T = \begin{bmatrix} 0.28 & 0.05 & 0.18 & 0.23 & 0.26 \\ 0.23 & 0.23 & 0.04 & 0.28 & 0.23 \\ 0.31 & 0.06 & 0.26 & 0.18 & 0.2 \\ 029 & 0.2 & 0.25 & 0.11 & 0.14 \\ 0.36 & 0.03 & 0.24 & 0.12 & 0.26 \end{bmatrix}$$

$$G = \begin{pmatrix} 0.21 & .021 & 0.2 & 0.19 & 0.2 \end{pmatrix}^T$$

The last step is carried out optimization of the proposed design parameters according to equation (11), with the limit determined from the available size of the suppliers catalogue (12).

Maximize:

$$S(x) = 0.21x_1 + 0.21x_2 + 0.2x_3 + 0.19x_4 + 0.2x_5 \tag{11}$$

$$8000 \le l_1 \le 65000 \text{ kg},\ 460 \le l_2 \le 1000 \text{ mm},\ 400 \le l_3 \le 1800 \text{ mm},\ 1600 \le l_4 \le 6000 \text{ mm};$$
$$1600 \le l_5 \le 9000 \text{ mm};\ 1 \le x_1 \le 8.12;\ 1 \le x_2 \le 2.2;\ 1 \le x_3 \le 4.5;\ 0.3 \le x_4 \le 1;\ 1 \le x_5 \le 5.6 \tag{12}$$

In this example, is not considered the impact on the budget choice, but it can be introduced through his determination and application of the expression (7). For optimizing was used functions Maximize from software "Mathematica 5.0 Wolfram Research" with limitations specified by equations 7, 8 i 9.

RESULTS AND DISCUSSION

After the computations of equations (11) with constraints given by (12) and the translation of the results obtained in (1) are obtained optimal parameter values for the set limits. The obtained values of parameters x_i are as follows: $x_1=8.1;\ x_2=2.2;\ x_3=4.5;\ x_4=1;\ x_5=5.6$**,** after replacing values with use of the expression (10), it gets:

l_1*=64800kg,* l_2*=1012mm,* l_3*=1800mm,* l_4*=1600mm,* l_5*=8960mm.*

On the basis of these values are selected from [10] first available closer to the dimension in tables for undercarriage system for track type tractor. Adopted values are: B10 – designation of undercarriage system – Inteltractor for maximal mass tractor l_1*= 65000 kg;* l_2*= 480 mm;* l_3*= 1800 mm;* l_4*= 3500 mm;* l_5*= 8500 mm.*

CONCLUSION

An example illustrates the impact of these methods on the selection for components of the undercarriage system. Results depend on the user's expectations of proper selection criteria, understanding the features of a machine, and final approval must be accessible by using standard sizes to avoid costly and unnecessary development of new parts and components.
FDM may help to the development of new products in detail which sets the market requirements, customer and user. The proposed model extends the conventional QFD model, and provides a framework for designer to feel the expectations according to the requirements. Design goals, using FDM can be defined to search for a compromise between the requirements and available resources.
This model enables decision-making with more criteria's and suitable for optimization in any mathematical software which in itself has integrated some of the classical optimization methods.

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APPLICATION OF NONLINEAR MATHEMATICAL METHOD WITH LIMIT GRADIENT FOR SOLVING PRACTICAL ENGINEERING PROBLEMS

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Abstract. The application of nonlinear programing with limiting method of gradient to resolving the problems in the engineering sciences, consist of determination of the functions extreme meanwhere the unity of variables must satisfied the system of the limits. The resolving of these assigments is approximately. Therefore the need of creating computer program appeared, which is presented and it is examined on a numerical example.

INTRODUCTION

The solving of nonlinear programing tasks determs the functions ending extreme about which the values of the variables ploted in do not have to satisfy the limiting system. The accomplishment of tasks by itrations is made.
For this task type solution proceeding is (1) where:

$$x_j^{k+1} = x_j^k + h \cdot \left[\frac{\partial F(x^k)}{\partial x_j} + \sum_{i=1}^{m} T_i(x^k) \cdot \frac{\partial g_i(x^k)}{\partial x_j} \right] \quad , \tag{1}$$

for k=1, 2, ...
for j=1, 2, 3, ...

where: x - variable ploted in the function's ending, g - function's limiting, k - ordinal number of variables, j - number of variables, i - number of limitings.

- If the i - limiting is satisfied than (2) if it doesn't than follows (3).

$$T_i(x^k) = 0 \quad , \tag{2}$$

$$T_i(x^k) = t \quad . \tag{3}$$

These expressions a faster solution convergency are making.

RESULTS AND DISCUSSION

The application of this method of mathematical solutions at practical problems through a numeric example can be presented most successfully. A classical example (according 2) is presented. The same by software "OPTIMA", created by the authors.
Function ending is (4),

$$(\max)F(x) = x_2 \quad , \tag{4}$$

The limiting are (5),

$$g_1(x) = x_1^2 + x_2^2 + x_3^2 - 1 = 0$$
$$g_2(x) = 2 \cdot x_2 - x_1 - 1 \le 0 \qquad , \tag{5}$$
$$x_1 \ge 0, \quad x_2 \ge 0, \quad x_3 \ge 0$$

The partial derivations for both are (6):

$$\frac{\partial F}{\partial x_1} = 0, \quad \frac{\partial F}{\partial x_2} = 0, \quad \frac{\partial F}{\partial x_3} = 0$$
$$\frac{\partial g_1}{\partial x_1} = 2 \cdot x_1, \quad \frac{\partial g_1}{\partial x_2} = 2 \cdot x_2, \quad \frac{\partial g_1}{\partial x_3} = 2 \cdot x_3 \qquad , \tag{6}$$
$$\frac{\partial g_2}{\partial x_1} = -1, \quad \frac{\partial g_2}{\partial x_2} = 2, \quad \frac{\partial g_2}{\partial x_3} = 0$$

Determing the initial solution: $x_1=0$, $x_2=1$, $x_3=0$ makes possible to calculate the next point coordinates. Depending by the results obtained in previous iteration the function steps "h" and "t" are appropriated. The results from iterative treatment are given in Table 1.

Table 1. The results from iterative treatment

Iter.	$F(x^k)$	$g_1(x^k)$	$g_2(x^k)$	x_1	x_2	x_3	h^k	t^k
0	1.000	0.000	1.000	0.00	1.00	0	0.500	-1.00
1	0.500	-0.500	-0.250	0.50	0.50	0	0.100	1.00
2	0.700	-0.150	-0.200	0.60	0.70	0	0.050	0.50
3	0.785	0.013	-0.060	0.63	0.79	0	0.050	-0.50
4	0.796	-0.009	-0.007	0.60	0.80	0	0.005	0.25
5	0.802	-0.004	-0.005	0.60	0.80	0		
Solv.	0.8	0	0	0.6	0.80	0		

SOFTWARE

The numeric example by corresponding software is solved. Equation (4) is seting into order 111, equations (5) and (6) into 106 an 107 and the system of equations (8) into orders 112-120.
The software enables three ways for its starting:

a) all start solutions are zero,
b) solutions are manual selected,
c) solutions are selected by CPU.

Combining all three solutions leeds to the final solution. It is best to take the zero option when the area of solutions unity is unknown. After less than 20 iterations in few seconds the accurate or aproximal solution can be found dependly of which accuracy is need. In continuation the software listing worked out on VISUAL BASIC or BASIC is given.

```
1 DIM G(50,50),X(50,50),F(50),T(50),DFDX(50),DGDX(50,50)
2 CLS:KEY OFF
4 LOCATE 20,24:INPUT "So kolku nepoznati e funkcijata: ";J
5 CLS
6 LOCATE 20,25:INPUT "So kolku granici e funkcijata: ";I
7 K=1
8 CLS
11 ? "1. Pocetnite resenija da se nuli                "
12 ? "2. Pocetnite resenija sakate sami da gi postavite  "
13 ? "3. Pocetnite resenija sakate da gi odredi programot"
```

```
16 INPUT "Odberete edna od gornite moznosti (1, 2 ili 3): ";T$
18 IF T$="1" THEN GOTO 84
19 IF T$="2" THEN GOTO 90
20 IF T$="3" THEN GOTO 98
21 IF T$<>"1" OR T$<>"2" OR T$<>"3" THEN GOTO 7
24 GOSUB 106
25 GOSUB 111
26 GOSUB 49
27 GOSUB 75
28 FOR B=1 TO J
29 S=0
30 FOR C=1 TO I
31 IF G(C,K)<=0 THEN T(C)=0 ELSE T(C)=T
32 S=S+T(C)*DGDX(C,B)
33 NEXT C
34 X(B,K+1)=X(B,K)+H*(DFDX(B)+S)
35 IF X(B,K+1)<0 THEN GOTO 45
36 NEXT B
37 K=K+1
38 GOSUB 106
39 FOR N=1 TO I
40 IF ABS(G(N,K))>ABS(G(N,K-1)) THEN GOTO 43
41 NEXT N
42 GOTO 24
43 K=K-1
44 IF INKEY$="$" GOTO 7
45 GOTO 28
46 END
49 CLS
50 ? " Iteracija: ";K
51 ? "-----------------"
52 ?
53 ? " Vrednosti za nepoznatite golemini"
54 ? "------------------------------------"
55 FOR N=1 TO J
56 ? "X";N;"=";X(N,K)
57 NEXT N
58 ?
59 ? " Vrednosti za granicite"
60 ? "------------------------"
61 FOR N=1 TO I
62 ? "G";N;"=";G(N,K)
63 NEXT N
64 ?
65 ? "Vrednost na funkcijata"
66 ? "-----------------------"
67 ? "F="F(K)
68 ? :? :?
69 ? "Ako ste dobile priblizno tocno resenie pustetego programot"
70 ? "od pocetok no koristetegi veke dobienite priblizni"
71 ? "rezultati."Za prekin pritisnete go znakot - $"
72 RETURN
75 FOR N=1 TO I
76 IF G(N,K)>0 THEN GOTO 80
77 NEXT N
```

```
78 Z=1
79 GOTO 81
80 Z=-1
81 RETURN
84 FOR N=1 TO J
85 X(N,K)=0
86 NEXT N
87 GOTO 24
90 CLS
91 FOR N=1 TO J
92 ? TAB(30);"X"N"=";
93 INPUT X(N,K)
94 NEXT N
95 GOTO 24
98 CLS
99 INPUT "So kolku cifri da bidat pocetnite resenija: ";W
100 FOR N=1 TO J
101 X(N,K)=RND*10^W
102 NEXT N
103 GOTO 24
106 G(1,K)=X(1,K)^2+X(2,K)^2+X(3,K)^2-1
107 G(2,K)=2*X(2,K)-X(1,K)-1
108 RETURN
111 F(K)=X(2,K)
112 DFDX(1)=0
113 DFDX(2)=1
114 DFDX(3)=0
115 DGDX(1,1)=2*X(1,K)
116 DGDX(1,2)=2*X(2,K)
117 DGDX(1,3)=2*X(3,K)
118 DGDX(2,1)=-1
119 DGDX(2,2)=2
120 DGDX(2,3)=0
121 RETURN
```

Table 2. Subprograms

Limiting subprogram	**Subprogram of function nding partial derivations and limitings**
106 G(1,K)=X(1,K)^2+X(2,K)^2+X(3,K)^2-1 107 G(2,K)=2*X(2,K)-X(1,K)-1	111 F(K)=X(2,K) 112 DFDX(1)=0 113 DFDX(2)=1 114 DFDX(3)=0 115 DGDX(1,1)=2*X(1,K) 116 DGDX(1,2)=2*X(2,K) 117 DGDX(1,3)=2*X(3,K) 118 DGDX(2,1)=-1 119 DGDX(2,2)=2 120 DGDX(2,3)=0

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DECISIONS ABOUT THE CHOICE OF SUPPLIERS WITH AHP METHOD

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Abstract:. In today's competitive business environment, it is impossible to produce a quality product with a reasonable price without corresponding suppliers. The supplier selection process involves the evaluation of various alternative suppliers based on multiple attributes. This is a multicriteria decision problem that is caused by a variety of material and immaterial factors. Selection of suppliers is an important process for the efficient management of the company. In this work it will be used Analytic Hierarchy Process (AHP) for the selection of optimal suppliers who best meet the established criteria. It is shown a concrete example of the suppliers choice of equipment for the Laboratory transport technics and logistics at the Faculty of Mechanical Engineering Niš.
Key words: decision making, AHP method

INTRODUCTION

The planning decisions that is adopted by management is the result of strategy of substantial planning business. This is the primary stage of the management process. The planning is an activity which is carried out strategically by formulating the goals, and it is coordinated with an important factors of the business system: style of management, control methods etc. The results of planning process are the final goal of the brought planning decision. In many companies the process of decision-making involves a lot of time and effort in collecting and analyzing information. Organizations that use modern methods for decision support can gain and sustain a competitive advantage in managing the global business relationships that are rapidly changing technology by many influences. The decision-making is itself a complex set of actions, and the responsibility for the decisions is usually subject to a strict verification and defense. In this sense, today is intensively working on standards for monitoring and evaluation of the parameters that determine the main strategic issues, as well as other forms of decision-making. An important part of these demands, it is possibility to satisfy the mathematical and computer tools, software packages and programming systems, which are collectively referred to as an decision support systems.
The issue of choosing the most appropriate suppliers for cooperation is essential to the success of the company and it is emphasized as one of the most important processes in the business. In today's competitive business environment, it is impossible to produce a quality product with a reasonable price without the corresponding suppliers [1]. In most industries the cost of raw materials and component parts constitutes the main cost of a product, such that in some cases it can account for up to 70% [2]. In such circumstances decision making of purchasing management can play a key role in cost reduction. The seller selection process would be simple if only one criterion was used in the decision making process. However in many situations, purchasers have to take account of a range of criteria in making their decisions. If several criteria are used then it is necessary to determine how far each criterion influences the decision making process, whether all are to be equally weighted or whether the influence varies accordingly to the type of criteria [3]. The selection process involves the evaluation of various alternative suppliers based on many attributes. This is a multicriteria decision problem that is caused by a variety of material and immaterial factors. Analytical Hierarchy Process approach is suitable for solving the problems of this type. Complex problems the method hierarchically separated and partially solved, the solutions then reassembleand thus leading to the best rational decision. AHP can be used in order to determine the importance of the criteria, and for the relative ranking of the potential suppliers. Taking into account the problems that companies have during inadequate choice of suppliers, ranging from an incorrect estimate during purchasing the materials or components, or the preference of one factor (such as prices), as well as other similar and unexpected problems, AHP model is the best solution in the process of selecting suppliers, because errors are reduced to minimum or they are eliminated. The power of this method lies in its ability to incorporate immaterial factors as relevant factors in the problem

solving process, and as such has found application in various areas of management, marketing , engineering, education and the economy.

ANALYTIC HIERARCHY PROCESS AND CHOICE OF SUPPLIERS

The hierarchically structured model of decision-making in general consists of a goal, criteria, several levels of sub-criteria and alternatives. The goal is on the top, and it does not compared with either one of the other elements. At level 1 is n criteria in pairs, and each with each, are compared in relation to the immediate superior element at a higher level (this is the aim at a zero level). It takes a total of n x (n-1)/2 comparisons. The same procedure is applied going through the hierarchy to the bottom, until at the last level k does not perform comparisons of alternatives with respect to the superior sub-criteria in the penultimate, k-1 level [4][5].
Many years of research have formulated a set of criteria that are important for the selection of the suppliers. The researchers are started from the assumption that many organizations spend considerable amount of time in evaluating their supply chain partners, and the fact that the selection of suppliers is strategic important to the organization [6]. The fact is that there is no single model that would fit every situation. In Figure 1, it is shown the process of choice of suppliers using AHP method.

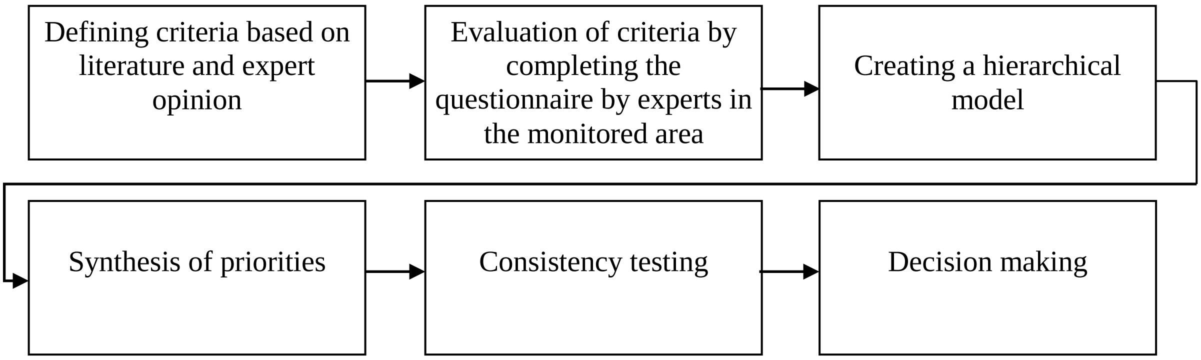

Figure 1. Process of a suppliers choice using AHP [6]

In most cases, it is possible to obtain a product of several suppliers. Determining the number of suppliers should be approached carefully from competitive reasons. It should be have in mind that each suppliers receives such a proportion that will stimulate investment in the maximum effort in meeting the needs of customers. The evaluation of suppliers begins with phase of finding the suppliers that are present in the market, ie the formation of the initial list of information about suppliers. Sources of information may be catalogs, trade shows, publications related to commerce, trade associations, informal exchange of information among professionals in the field of procurement, on-line market. The next phase is to generate a shortened list of suppliers who could meet the requirements of the customer and the formation of requirements and capabilities - the ability of different suppliers to solve them. The third phase is done by reducing the short-list of the suppliers who best meet the requirements of customers. The last phase is done by making the decision, and the final choice of the suppliers.
There is no unambiguous, universal criteria that would apply to all companies or for all circumstances supplies. Every company must to know the conditions of selection and determining criteria for selection of the suppliers. How the criteria will be in the evaluation take into account depends on the type of goods to be procured. The general criteria for selecting suppliers include: quality, price, delivery, payment, location, kindness, financial condition, operating results, flexibility.

MODEL DEVELOPMENT

The first step of every procedure in the evaluation of suppliers is to determine the criteria for their evaluation. Because of space limitation, the significant factors for suppliers selection used only the three most relevant categories for consideration in this demonstration. For an assessment and final decision of the supplier to equip the Laboratory of Transport technics and logistics on the Faculty of Mechanical

Engineering, University of Niš, with belt conveyor with rotary table, with an automatic selection there are established the following criteria: *Technical capability* indicates that the supplier may technically be out to meet customer requirements. The supplier must have the technical expertise and adequate production facilities in order to be able to provide the necessary amount of resources required by the customer. Also, the supplier must provide technical support before and after delivery. As the sub-criteria there are taken: *Technological knowledge*: it is expected that the supplier can meet customers requirements using the new technology, and *Service adequacy*: the supplier should have a service infrastructure that is integrated and has a good knowledge and experience and can solve the problems quickly.

A *quality* refers to the conformity of the goods delivered to the customer's standards. Previous deliveries can also serve as a factor in predicting the quality of future deliveries. Cooperation between the supplier and the customer does not end after the receipt of the delivery, but in case of any deviations from the expected quality of the delivered goods, the supplier is expected that as soon as possible and as efficiently respond to perceived shortcomings. With this as a criterion takes *Commitment* - commitment to the customer in terms of quality, costs, and services as well as the *quality of the product.*

Price, this is one of the most important criteria. Generally the cheapest one will be preferred. But the cheapest one is not always the best Fig. 1.

The evaluation of the suppliers is made by experts. The experts answers the surveys and for evaluation they used Saaty's 1-9 scale. Every expert answered the survey individually and then the geometrical average was calculated and a single value was found.

First of all the pairwise comparisons are made for the main and sub-criteria. The weights of the main and sub-criteria are found and then these weights are multiplied. And the final weights are found. Then the sub criteria re compared to the alternative suppliers. AHP in some way mitigates this problem by measuring the level of inconsistency and inform decision makers. It also provides the ability to measure errors of judgment, so that the calculated index of consistency for the resulting judgments matrix, and then calculates the degree of consistency. Inconsistency is permissible in AHP so long as it does not exceed a ratio of about 0.10 justified in the theory as a cut-off point [4]. In the case of the matrix comparing the factors, the inconsistency ratio was 0,05.

Table 1 represents judgments matrix and also shows weight of factors. The most important criterion is technical ability with 0,532 relative importance, followed by quality with 0,366, and finally the least important criterion is price with 0,101 of relative importance. The price may be the most important factor only if all other factors are of equal importance (which is usually not the case), or when the customer is in financial trouble. Since, in the present case, the buyer has the budget approved for purchase, we have technical ability and quality far more important than the price.

Table 2 shows the results of calculations with values relative importances to the criteria and sub-criteria. For the sub-criteria is most important Technological knowledge with 0.426 because it is a modern automated system. Followed by sub-criteria Product quality with 0,244 for the equipment intended for everyday work within the student exercises. Customer commitment with 0,122 and 0,106 with Service adequacy because it is a reputable supplier with mostly wide network of branch offices. Based on the analysis of the selected supplier is supplier D3.

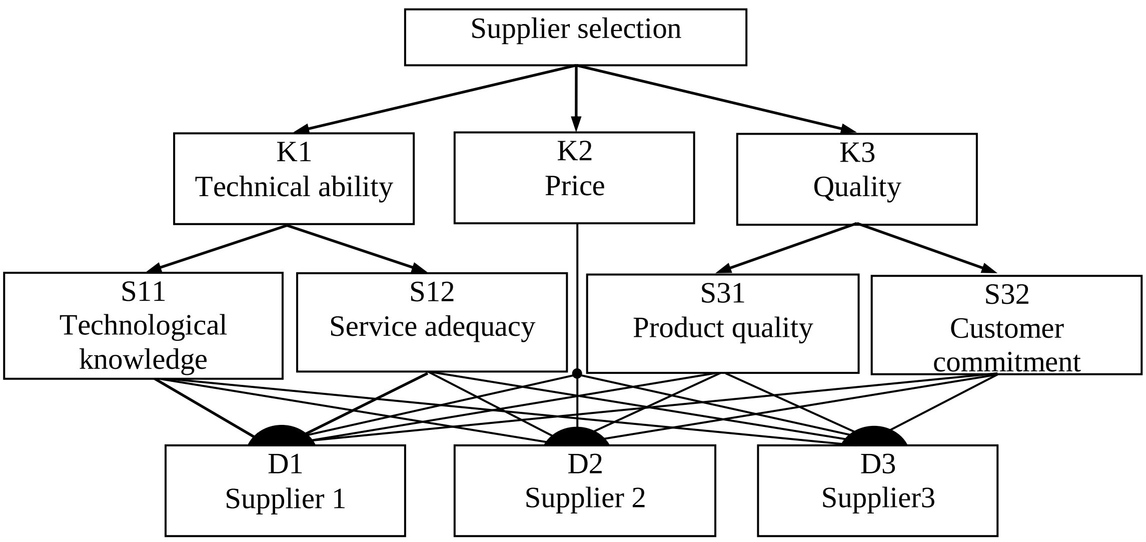

Figure 1. The AHP Supplier selection model

Table 1. Judgments matrix and weight of factors

With respect to goal	K1	K2	K3	Relative importance
K1	1	2	4	0.532
K2	0.25	0.2	1	0.101
K2	0.5	1	5	0.366

Table 2. Priorities of factors, sub-factors and suppliers evaluation

				Suppliers evaluation		
Factors		Sub-factors		D1	D2	D3
K1	0,532					
		S11	0,426			
				0.039	0.119	0.268
		S12	0,106			
				0.021	0.011	0.074
K2	0,101					
				0.006	0.020	0.075
K3	0,366					
		S31	0,244			
				0.028	0.067	0.149
		S32	0,122			
				0.012	0.032	0.078
Supplier selection				**0.106**	**0.248**	**0.644**

CONCLUSION

When an organization is confronted with choosing the best supplier to deliver a good or service, the decision can often be very complex. Supplier selection problems are multiobjective problems which have many qualitative and quantitative concerns. This paper has presented the AHP as a decision analysis tool in supplier selection problems. We proposed a comprehensive AHP model to select the best supplier.

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ARC BOND SPUTTERING EQUIPMENT FOR DEPOSITION OF INNOVATIVE INDUSTRIAL COATINGS

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Abstract: The deposition of coatings is widely used in the modern industry. The pursuit of a high quality and an environmental friendliness increasingly extends the application of the PVD technology. This article describes one designed and manufactured equipment for Arc Bond Sputtering deposition which is able to create coatings with valuable industrial properties. Its most important assemblies are shown and the principles in its design are explained. At the end two promising coatings deposited by this equipment are described: a nanocomposite Ti/TiN/TiCN/nc-TiCN:a-C/nc-TiC:a-C/a-C and a superlattice Ti/TiN/CrN-ml. Their experimentally determined value of the wear rate is comparable with the best known results for similar coatings.
Key words: Arc Bond Sputtering, coatings, DLC, nanocomposites, PVD

INTRODUCTION

The deposition of hard, wear resistant coatings on parts and tools is an important trend in the modern industry, which increases rapidly [1, 2]. Such coatings possess a wide range of properties - a high hardness and wear resistance, a low coefficient of friction, an excellent adhesion, a remarkable thermal stability and oxidation resistance, etc. Thus they allow significant increase in the machining speed and simultaneously the lifetime of the coated tools [1, 2].
Physical vapour deposition (PVD) is a fundamental method for growth of condensate coatings with similar properties. Both variants thereof, which have acquired the most practical importance, are Vacuum Arc Deposition (VAD) and Magnetron Sputtering (MS). The VAD allows a high-speed growth of the layer and the vapour's particles have a higher degree of ionization (the last favours the creation of complex compounds in the coatings). Also, the etching of the samples, which is feasible by this method, significantly increases the adhesion of applied layers. On the other hand, by this process large cluster formations are deposited (so-called "droplets") which affect the properties of the layer mainly detrimentally. These droplets absent when using the MS, but the achievable deposition rates and the degree of ionization are lower, although the Unbalanced Magnetron Sputtering (UBMS) deals with the latter disadvantages largely. In a nutshell, both methods have their advantages and disadvantages when depositing coatings.
The last has created the idea that these two methods could complement each other. This resulted in one combination of them in a single coating process - Arc Bond Sputtering (ABS) [3, 4, 5]. In this process, typically the etching and deposition of the first adhesive layer is made by the VAD and the main functional layers are grown by the UBMS. The layers have very good mechanical properties, although the presence of a small amount of droplets (deposited in the beginning of the process when using the VAD), somewhat reduces their chemical resistance [4]. The fundamental difficulty in the design of an ABS equipment is to make cathode units capable of operating as vacuum arc evaporators and unbalanced magnetrons (consecutively) - this solution saves space and reduces the equipment's cost [3].
This article examines the structure of one designed ABS equipment HVP100RHD (Fig. 1a) and its capabilities to deposit coatings for industrial applications. Two similar coatings are investigated here (the focus is on their wear resistance): a nanocomposite Ti/TiN/TiCN/nc-TiCN:a-C/nc-TiC:a-C/a-C and a superlattice Ti/TiN/CrN-ml.

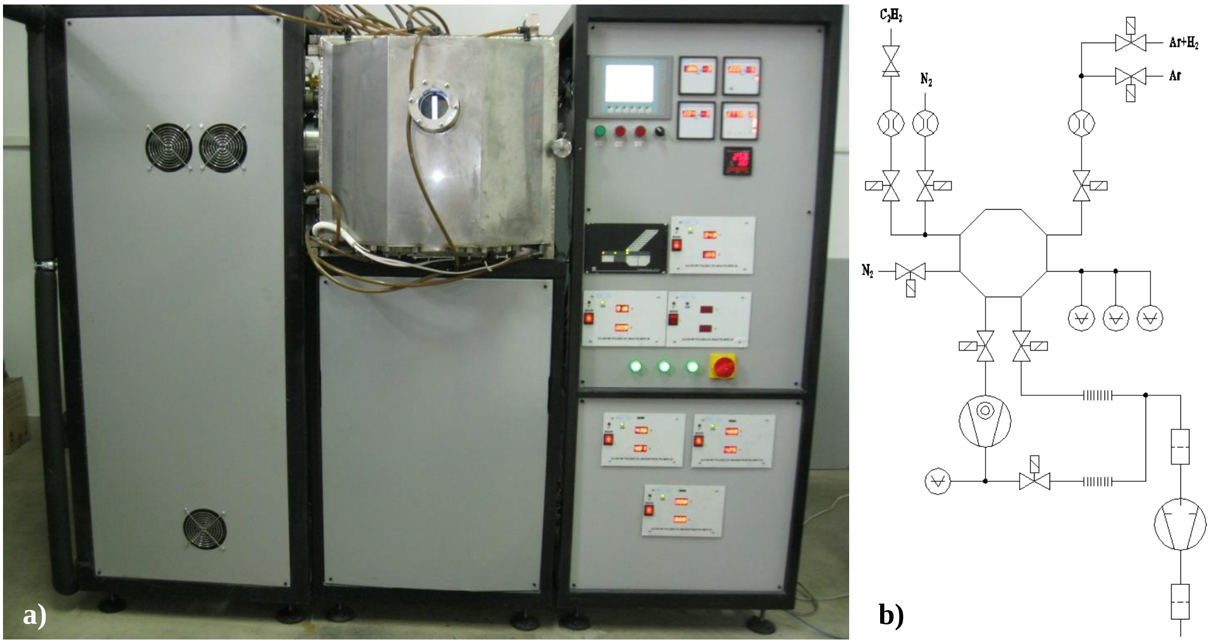

Figure 1. The HVP100RHD equipment: a) overall view and b) schematic diagram of the vacuum system

CONSTRUCTION OF THE EQUIPMENT

Vacuum System

The working chamber is almost one regular octagon. This shape allows a rational arrangement of the cathodes, especially an implementation of a Closed Field Unbalanced Magnetron Sputtering (CFUBMS) scheme of their work [3]. The internal dimensions are W500 x H450 mm, where "W" is the span of the octagon. It was made of stainless SS304L steel and its walls are water cooled.

On three of the walls of the vacuum chamber rectangular planar cathodes were placed by a flange and a tubular water-cooled anode was mounted laterally, in the vicinity thereof, to increase the plasma volume and the ionization degree. On the chamber's door several tubular heaters with total power of 6 kW were installed through which samples can be heated to ca. 400 °C. On the bottom of the chamber one high load HV current/rotation feedthrough was assembled which drives a carousel with the samples and fed them the bias voltage. The carousel itself is one modular planetary gear with three axes of rotation, providing continuous movement of the specimens in the chamber during the coating process.

A scheme of the vacuum system is shown in Fig. 1b. The pumping unit is composed by two-stage rotary-vane pump BW63 (Zakład Techniki Próżniowej "TEPRO" SA) with pumping speed 63 m^3/h and turbomolecular pump TURBOVAC 600 C (Oerlikon Leybold Vacuum GmbH) with pumping speed 600 l/s (Fig. 1b). All valves are electrically driven and the system does not need compressed air during the operation. The vacuum measuring is done by a two channel vacuum gauge Pirani PRVG 02 (Milko Angelov Consulting Co.), a single channel Penning vacuum gauge PNVG 01 (Milko Angelov Consulting Co.) and a capacitive diaphragm vacuum gauge Baratron 627B (MKS Instruments, Inc.). The latter is for an accurate measurement of the total gas presure during the coating deposition. A venting of the chamber is done by a N_2 flow which ensures a high purity and lack of moisture.

There are three gas lines where the flux control is through mass-flow controllers. Through the two N_2 and C_2H_2 are submitted and the third are fed by Ar or Ar + H_2 via switching over solenoid valves.

The batch cycle is fully automated and provides options for creating, editing and saving technological recipes. The oversight is made by 7" monochrome touch screen panel, mounted on the housing and connected to SIMATIC S7-1200 (Siemens AD) PLC (with/without external networked PC). There is a connection to the Internet or LAN to control the deposition process and for diagnostics (regular or emergency). All batch parameters are recorded on the PC's hard drive by the control system for further use.

Targets and Supplies

The cathodes are the heart of every PVD equipment. In this case, there are three (Fig. 2). Their targets have W102 x D9 x H381 mm dimensions and have a copper diaphragm type indirect cooling. Water cooled screens were included in cathode design. There are orifices for the flux of working gases near the targets so gas injection mode is realized as follows: the Ar flow is got in near the target's surface and the reactive gases flow is directed to the substrates through the plasma volume.

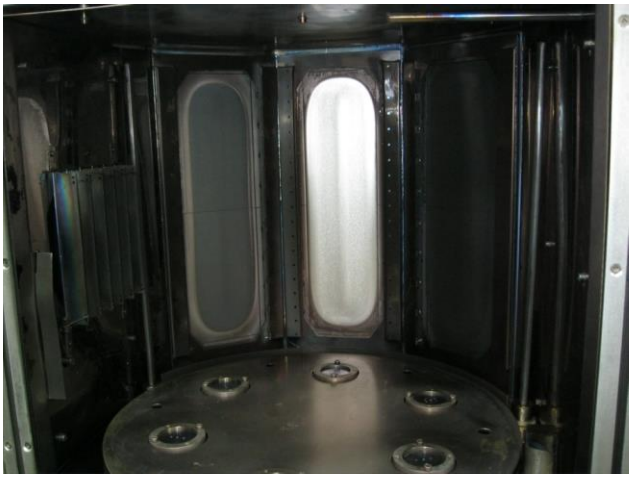

Figure 2. Disposition of the cathodes

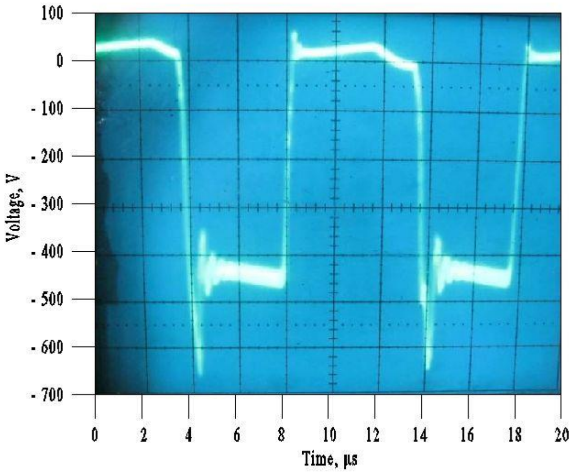

Figure 3. Oscillogram of the supply voltage

The cathodes are designed to operate in both highly UBMS and VAD processes which is done by repositioning of their magnetic systems and switching of their supplies. Furthermore, they have one movable magnetic system which scans the target surface for enhanced material utilization. The three cathodes work in the CFUBMS whereby a high degree of ionization and plasma concentration in the working volume in the vicinity of the specimens are achieved [3, 6].

In the highly UBMS mode three inverter type 2.0 kW MF pulsed DC magnetron power supplies IMPS 20 (Milko Angelov Consulting Co.) working on fixed frequency of 100 kHz are used. They are unipolar (negative pulses only) with duty cycle range from 0 to 75 %. The original accent in their conception is the addition on the front edge short (up to 600÷800 ns long), high voltage, low average current peak, superimposed with the basic average voltage pulse (Fig. 3).

It considerably increases the electron emission, ionization and current growth on the front edge respectively. This permits to limit the voltage magnitude during main pulse, which allows lower output inductance value [7]. It is well known that this value determines the delivered energy to a single arc. On the other hand, current waveform with improved current increase provides same average currents simultaneously with shorter “on” time, which limits charging of poisoned islands on the target surface.

When cathodes operate in the VAD mode, one Manual Metal Arc (MMA) welding inverter E 250 CDi (TEC.LA Srl.) with a nominal current 5 ÷ 250 A output range and maximum power of 9,4 kW is used. To this device was added one special module for remote PLC control via analog output 0 ÷ 20 mA DC.

For sample's biasing two 2.0 kW MF pulsed DC bias power supplies (Milko Angelov Consulting Co.), working on fixed frequency of 100 kHz are provided. The first one has voltage amplitude -930 V and it is used for a glow discharge cleaning and a metallic ion etching. The second one biases the samples during the deposition having voltage amplitude -100 V. An +200V/5A inverter type power supply (Milko Angelov Consulting Co.) is used for powering the anode.

All power supplies are PLC controlled.

Samples' Transportation

One appropriate movement of the samples is very important to obtain a suitable structure of the deposited on them coatings. The periodic passing of the samples near the cathodes creates so-called "modulation periods", which highly influence over the coating's properties [1, 2, 8]. Also, for processing of a large amount of samples with a small size of the sample relative to that of the chamber, more axes of rotation are required [9].
Complying with the above requirements, one special three-axial planetary mechanism with a modular structure has been designed (Fig. 4a). It possesses six spindles (2-axial satellites) and each of them can be on several levels, i. e., to have several boxes with samples. These gear boxes are with 9 or 20 positions (everyone of them is a 3-axial satellite) and may be combined on every particular spindle (Fig. 4b). The structure of the planetary mechanism allows rapid removal/insertion of the spindles (with fastened boxes and samples) minimizing the period when the chamber is opened. The motor and its gear reducer, which actuate the carousel, are capable of moving a large number of specimens, even their mass is huge (WC/Co tools for example). The carousel itself is primarily made of stainless SS304L steel.

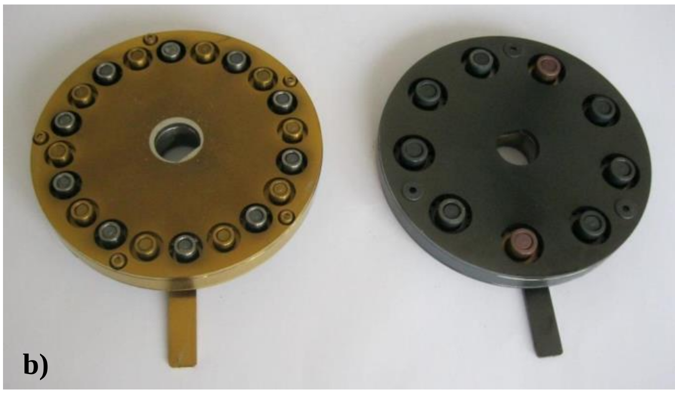

Figure 4. The carousel: a) a general view and b) two types of gear boxes

A treatment of samples with larger dimensions is done by simpler 2-axial or 1-axial developed constructions. The maximum shaft load, which may apply to the high load HV current/rotation feedthrough, is 160 kg. If the rotation stops for some reason then one special shutdown will be activated and general alarm will be switched on.

RESULTS AND DISCUSSION

The presented here HVP100RHD equipment is primarily designed for deposition of coatings on industrial instruments. Using it, some traditional and approved coatings (TiN, AlTiN, CrN, TiCN, etc.) have been deposited. The achieved quality is comparable to the best results known to the authors.
In the field of tool coatings everybody works in a permanent competition. Currently, state-of-the-art are different nanostructured coatings which significantly increase tool's lifetime. In this respect, two basic coatings have been developed: a nanocomposite Ti/TiN/TiCN/nc-TiCN:a-C/nc-TiC:a-C/a-C and a superlattice Ti/TiN/CrN-ml. The both show a complex of mechanical properties which make them attractive for industrial customers. Some samples with these coatings are shown in Fig. 5a (for Ti/TiN/TiCN/nc-TiCN:a-C/nc-TiC:a-C/a-C) and Fig. 5b (for Ti/TiN/CrN-ml with external layer of TiN).
For this type of coatings one key property is the wear resistance on which tool's lifespan is depended. For these two coatings, it was measured using a ball-on-plate tribological stand, which is circumstantially described in [10]. The conditions of the experiments was as follows: substrate - annealed 1.2343 steel (50÷52 HRC), counterpart - Al_2O_3 bearing ball, load - 1 N, sliding distance - 50 m. The obtained results are illustrated in Fig. 6.

The reported wear rate of both coatings is very low and comparable to the best results for similar coatings [11, 12, 13, 14]. The wear mechanism of the samples is not considered in details here because its survey is still underway. Nevertheless, it is clear that the Ti/TiN/TiCN/nc-TiCN:a-C/nc-TiC:a-C/a-C has a lower wear rate than Ti/TiN/CrN-ml over the all three sliding speeds (Fig. 6). This could be explained mainly by the carbon lubricant influence in the presence of small amounts of moisture in the environment. However, the above results do not prove certainly that this coating absolutely excels the other one in the wear resistance. The practical performance of the coated tools sometimes is not fully consistent with the expectations which were formed on the basis of laboratory tests [11]. Furthermore, the coatings have other important mechanical properties altogether, therefore it can be expected that the both will have their suitable fields of industrial application.

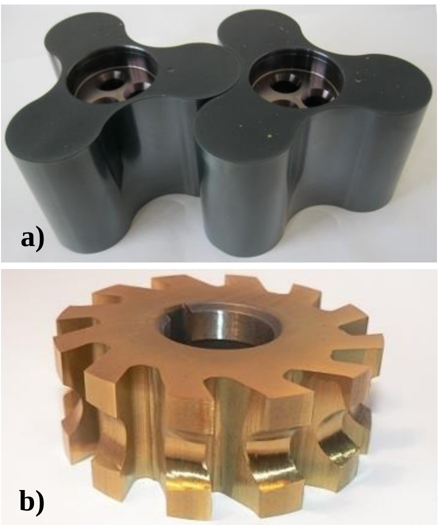

Figure 5. Coated samples: a) 3-lobed rotors and b) profile cutter

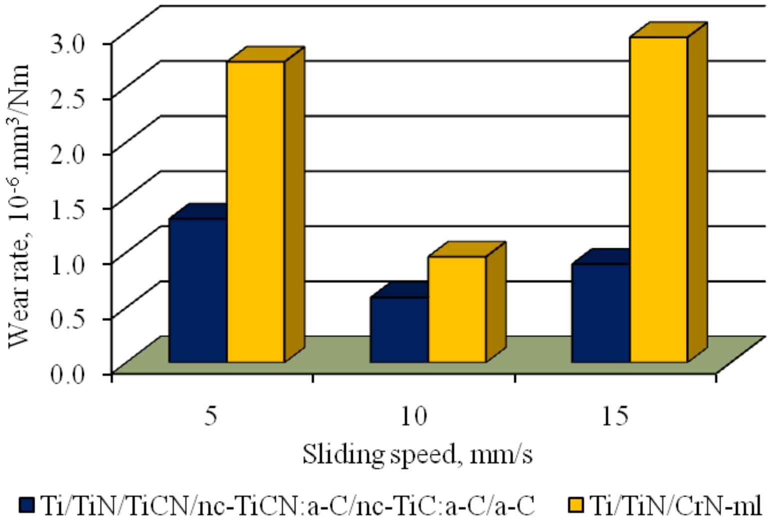

Figure 6. Diagram of wear rate vs. sliding speed (the counterpart was rotated before each test ignoring its wear)

The found nanohardness and Young's modulus of the coatings are as follows: H = 25 GPa, E = 340 GPa about Ti/TiN/TiCN/nc-TiCN:a-C/nc-TiC:a-C/a-C and H = 31 GPa, E = 360 GPa about Ti/TiN/CrN-ml. This hardness of Ti/TiN/CrN-ml was measured with bilayer period of 20 nm (10 nm TiN and 10 nm CrN). Studying of other bilayer periods showed lower hardness, the obtained results are consistent with the Hall-Petch relationship [15, 16]. It can be seen that the ratio H^3/E^2, which is proportional to the wear resistance [1, 16], is greater in the coating Ti/TiN/CrN-ml, but the commented above tests (Fig. 6) showed that this coating has a greater wear rate. This means that in this case the coefficient of friction has a determinative role in the wear resistance.
The adhesion of these coatings has been estimated by a classical Daimler-Benz test and the results could assume that they are into HF1 or HF2 grade. The lack of droplets in the coatings retains the initial roughness of the substrates. Even one negligible reduction of the roughness parameter Ra (ca. 5%) when its initial value is about 0,2 μm can be observed, probably mainly because of an elimination of a part of the peaks on the surface during the ion etching.
The complete evaluation of these coatings needs a future research including for their composition and structure. However, the obtained at this stage results allow us to affirm that they have excellent mechanical properties.

CONCLUSIONS

By the designed and built equipment HVP100RHD is possible to deposit a variety of nanostructured coatings with appropriate industrial properties. The presence of three cathodes and the possibility to flow two reactive gases create opportunity for many different combinations of their composition. The precise control over the working process and the continuous three-axial rotation of samples make possible an attainment of many different combinations of coating structure and a repeatability of the batches. Obtained results so far give a reason to assert that this equipment can fully answer the current needs of the deposition of industrial coatings.

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Session 11.

Process management

THE ROLE OF GIS IN ENERGY AUDIT OF PUBLIC LIGHTING

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Abstract: Public lighting is a small but very important part of electricity consumption in every country. Energy audit of public lighting is one way of fulfilling energy policy of EU and is a legal obligation in Croatia since 2014. The audit must be conducted every 5 years according to the Ordinance on energy audits of buildings and energy certification of buildings which regulates the obligation to conduct energy audits of public lighting. Auditing is done according to the national methodology for energy audits of buildings. Geographic Information System is not specified as a tool for energy audit but in practice it is very useful. This paper describes the usage of open source GIS tools in energy auditing of public lighting system.
Key words: energy audit, GIS, public lighting system

INTRODUCTION

Public lighting (PL) is a very important part of electricity consumption in every country. PL has an aspect of security, because it provides visual conditions which ensure normal transport and communication in public traffic areas. Furthermore, a very specific aspect of PL is providing the psychological and physical safety of people and property. Another aspect of PL importance is generation of specific aesthetic atmosphere and attractiveness of inhabited areas (illumination of squares, parks, buildings and monuments) [1]. Public lighting represents 0.1 percent of total energy consumption, but its significance is far greater than the modest energy representation. Street lighting must meet criteria to ensure visibility, visual comfort and energy efficiency that must be considered in the designing process. Requirements for public lighting, especially road lighting are defined with EN 13201 [2]. As an example for the writing of this paper, the energy audit of a small lighting system with four supply point and 135 lamps was taken. In order to prepare a report on the conducted energy audit, GIS tool was used for mapping of system components. Energy audit conducted according to methodology includes: gathering basic information about the user, the analysis of available project documentation, a description of the public lighting system with mapping of the existing installation, measuring the existing light quantities, measuring electrical quantities, the analysis of energy consumption bills and proposal for measures to improve energy efficiency.

TECHNICAL REQUIREMENTS ON PUBLIC LIGHTING

The basic aspects of PL can be divided into three areas:

1. Functionality - the primary function is to provide the minimum required uniform illumination values without discomfort glare;
2. Aesthetics -the play of light and shadow creates a special atmosphere;
3. Cost-effectiveness - the total cost includes the cost of construction, design, management, maintenance and energy required for the unobstructed operation.

PL Functionality

Functionality refers to obtaining luminance levels, luminance uniformity, degree of glare limitation, lamp spectra and effectiveness of the visual guidance. Level of luminance isn't important as uniformity and spectra, because of scotopic/photopic characteristics of the eye [2].

Cost-effectiveness

Cost-effective criteria is based on the efficiency of the used light source. Classic light sources (based on incandescent) are gradually eliminated in the EU (the Directive on Energy Efficiency). There is a large variety of modern light sources on the market. For PL purposes, the following contemporary light sources are available:

- High-pressure sodium (HPS) 80-140 lm/W, CRI 20-30; 1900-2800 K, life time 10,000 - 24,000h
- Metal-halide lamp 100 lm/W, CRI 68, 4000-5000 K, life time 20.000h
- Mercury-vapour lamp (abandoning technology) 30-60 lm/W, CRI 20-60, 6800 K life time 20,000
- Fluorescent 45-105 lm/W, CRI 65-75, life time 10,000 - 45,000h
- LED/OLED 115 lm/W, CRI 65-75, 6500 K, life time - 50,000h
- Light Emitting Plasma HEP/LEP 120 lm/W, CRI 75-90, 5600 K, life time 50,000h

Color Rendering Index (CRI) is a measurement of a light source's accuracy in rendering different colors. Requirements which are placed on the lamp are in compliance with standards, proper distribution of the light output, glare limitation (through shaping and shading, the cut-off, semi cut-off, not cut off) and mechanical consistency [1].

MAPPING OF PL

There are numerous ways to map installation, the easiest one is to use GSM smart phone with GPS. Accuracy of public GPS systems is in the range of 3 to 10 meters. In areas with distance between lamps of 30 meters, this is quite satisfactory. Mapping of existing installation is done with Android Open Street Map tracker application which exports data in GPX format with waypoints that we entered during audit [3]. Small change is made in the optional xml file (more info in [4]) to provide the necessary menu entries for PL, as can be seen in Fig. 1.

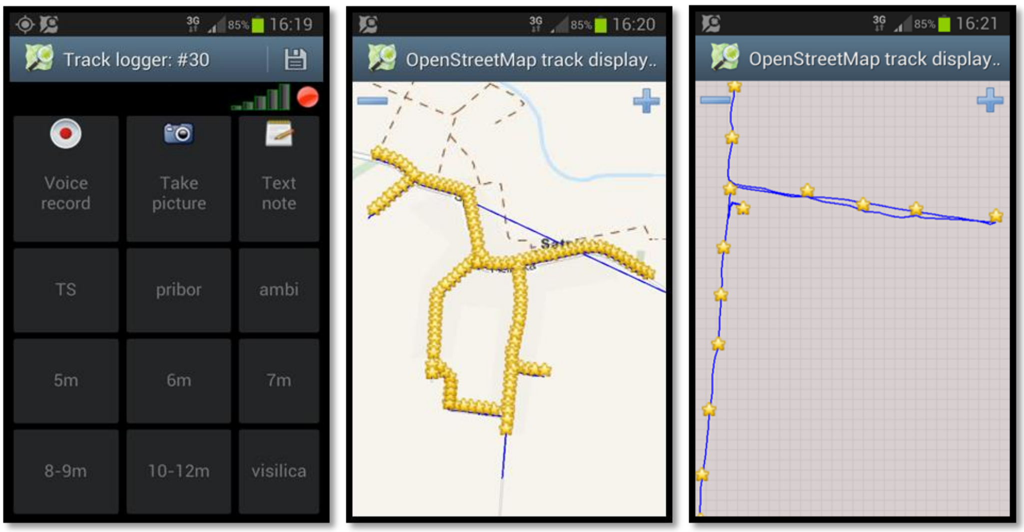

Figure 1. OpenStreetMap tracker layout, mapped PL system and mapped details

We found that layouts customization should be done after walk-through audit in order to ensure optimal layout menu that matches with the system elements on field. During tracking it is important not to enter elements twice and to check that tapped element is correctly entered (wait for the confirmation). After finishing mapping we can upload data to open street map server or download the GPX file on computer.

GIS data processing

Data collected by mapping is exported (in GPX file) as the GPS Exchange Format that can be reviewed as a text but it is more useful to use GIS editor. In Fig. 2. we can see waypoints for collected data: latitude, longitude, elevation, time and name of waypoint. Name reveals type of lamp, High Pressure Sodium, power of lamp 150 W, producer of lamp, power supply through self supporting cable bundle SKS and height of the concrete pillar. There are other data in the GPX file, but for the energy audit, waypoint are data that we entered through OpenStreetMap tracker layout.

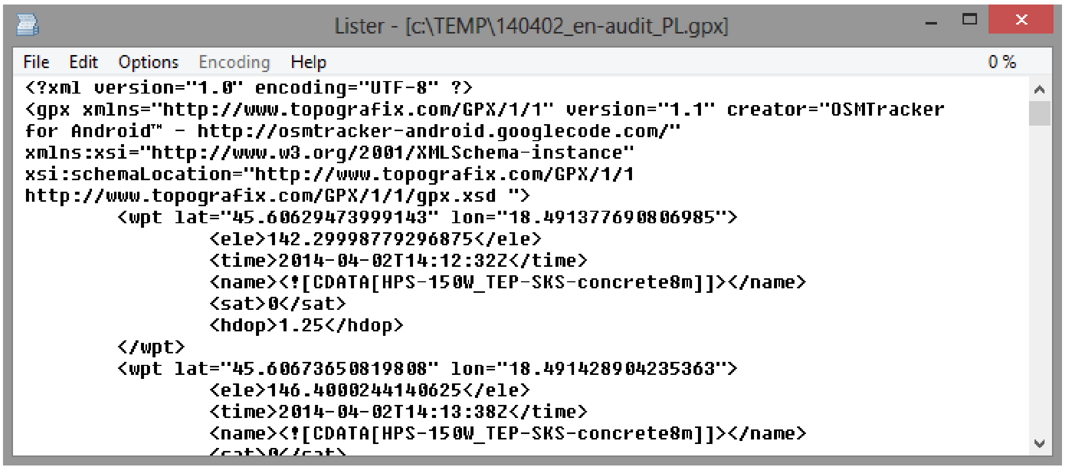


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Figure 2. Insight into the GPX file

Benefit of GIS usage can be seen when we open GPX file in GIS editor. For this propose we used QGIS a free and open source Geographic Information System [5]. We could use JOSM, an extensible editor for OpenStreetMap (OSM) written in Java, but QGIS provides much more for further PL analysis. On Fig. 3. it can be seen open GPX file.

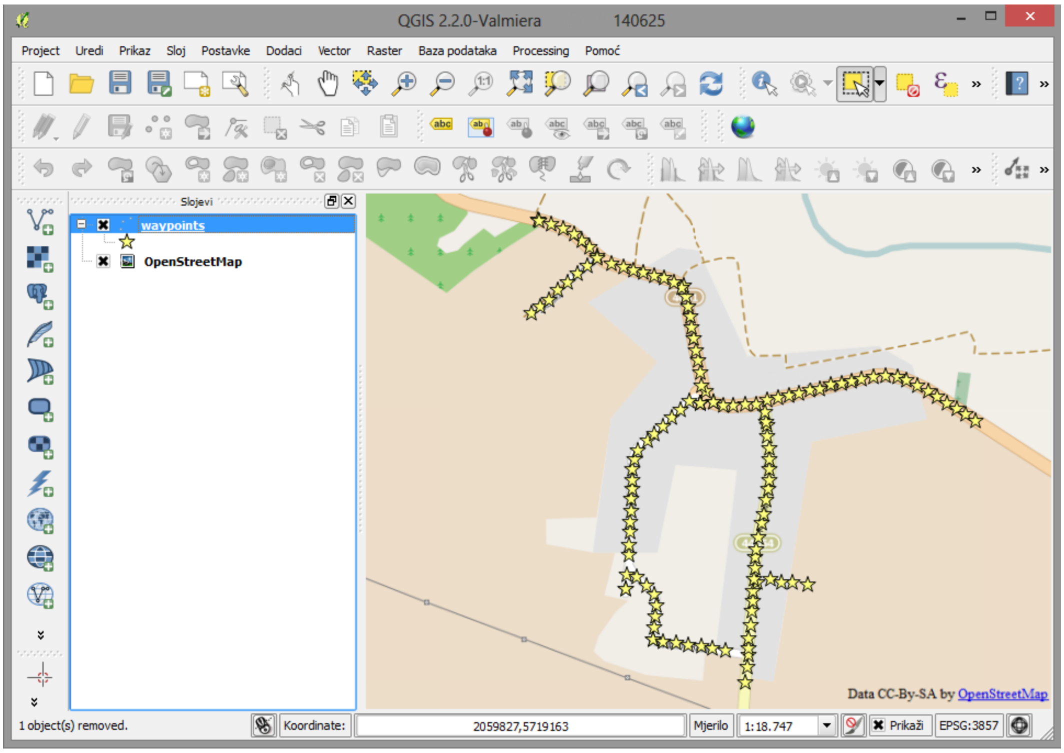

Figure 3. Data from GPX file in QGIS

Entering in attribute table of waypoints and grouping according to the attributes new layers can be made as presented on Fig. 4. Comparing Fig. 3 and 4., we can notice that some elements are missing, better to say we did not see lamps in two side streets during first round of mapping. In the second round, they are mapped and merged with existing records.

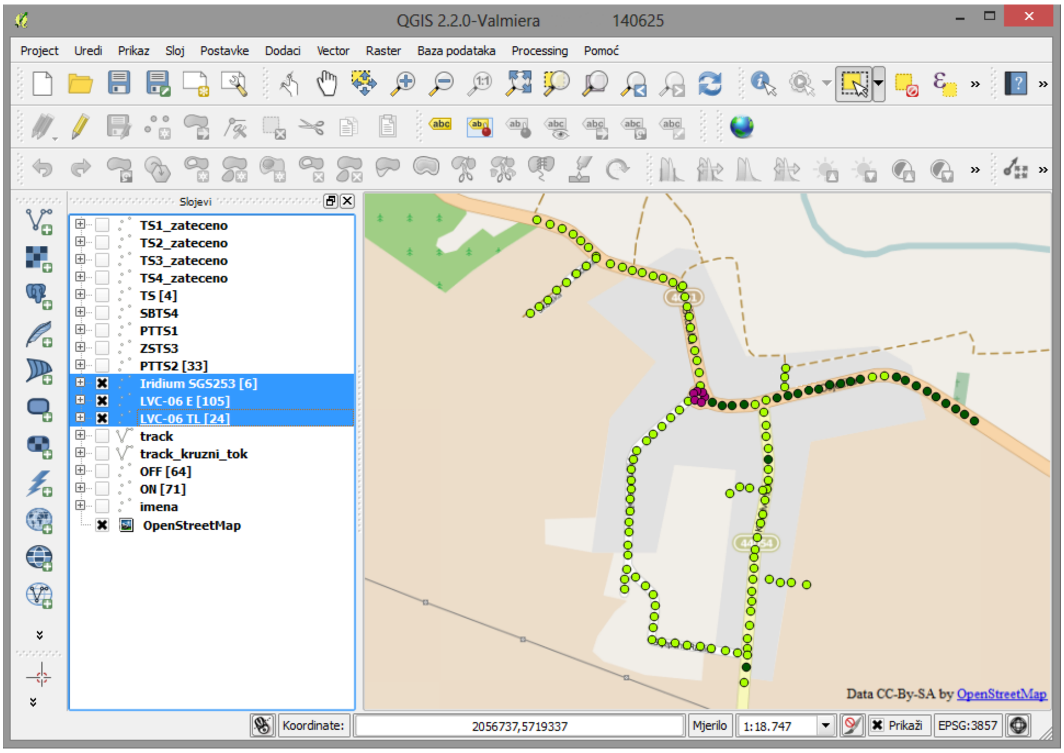

Figure 4. Newly created layers with lamps types and position

Highlighted layers on the left side contain position of three type of lamps that we accounted during the audit. As can be read, there are 6 Philips Iridum, 105 TEP LVC-06E and 24 TEP LVC-06TL lamps installed in the system. In order to define zones of lighting, electrical measures were made in supply points. In order to define zones of lighting, electrical measures were made in transformer stations on all PL lines. During measurement on active line, active lamps are marked visually in order to define zone of lighting. Energy balance must be determined, measured power in supply point must correspond to the consumption of active lamps. It is important to note two things. First, measurement must be performed when the system enters the steady state, 6-12 minutes after switching on depending on the type of lamps. Second, while analyzing energy balance consumption, ballast and all possible losses must be taken into account. After measurement, we come to the situation shown in Fig. 5. newly created layers with supply points and PL zones.

Once becoming familiar with the system, its zones and electricity consumption, the only thing remaining is to determine the light levels on road surface. Measurements must be conducted during night while system is in function and traffic is minimal. Data obtained by measurements of illumination is mapped in order to determine position of lamps with failure or poor maintaining. Fig. 5. presents lighting levels in lx measured on road surface. as we can see from Fig. 6. every second lamp is out of function due to savings of electricity. Turning off every second lamp is not a recommended measure, because a decrease of luminance uniformity results in a longer time required to spot objects on road.

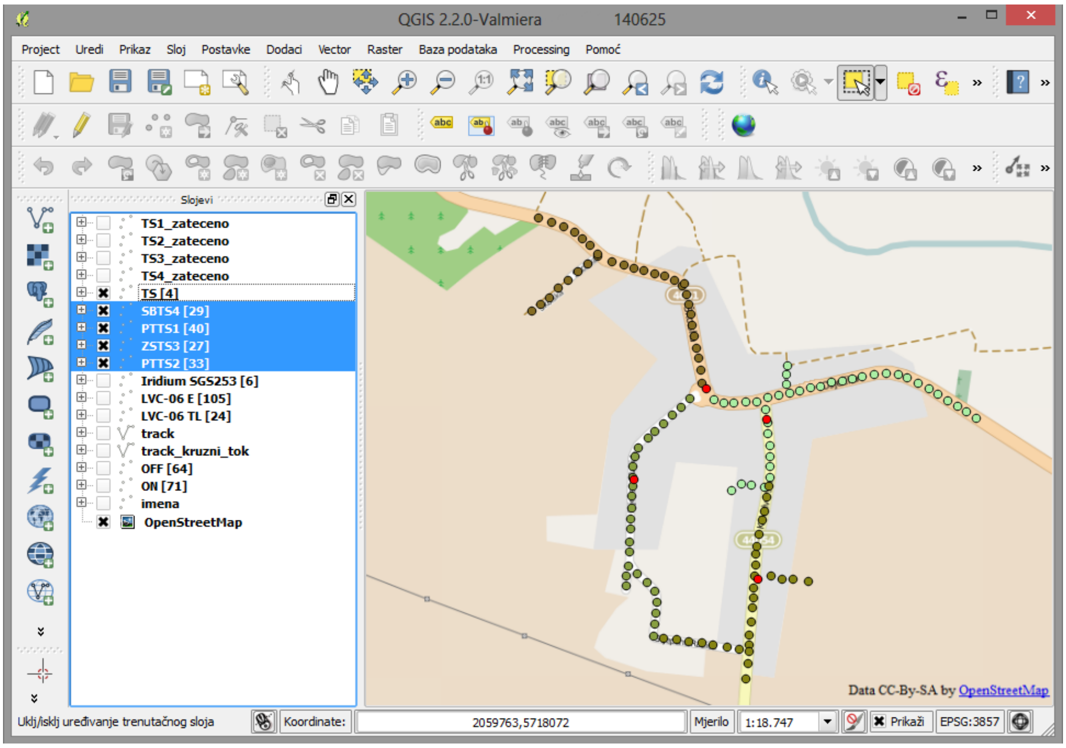

Figure 5. Newly created layers with supply points and PL zones

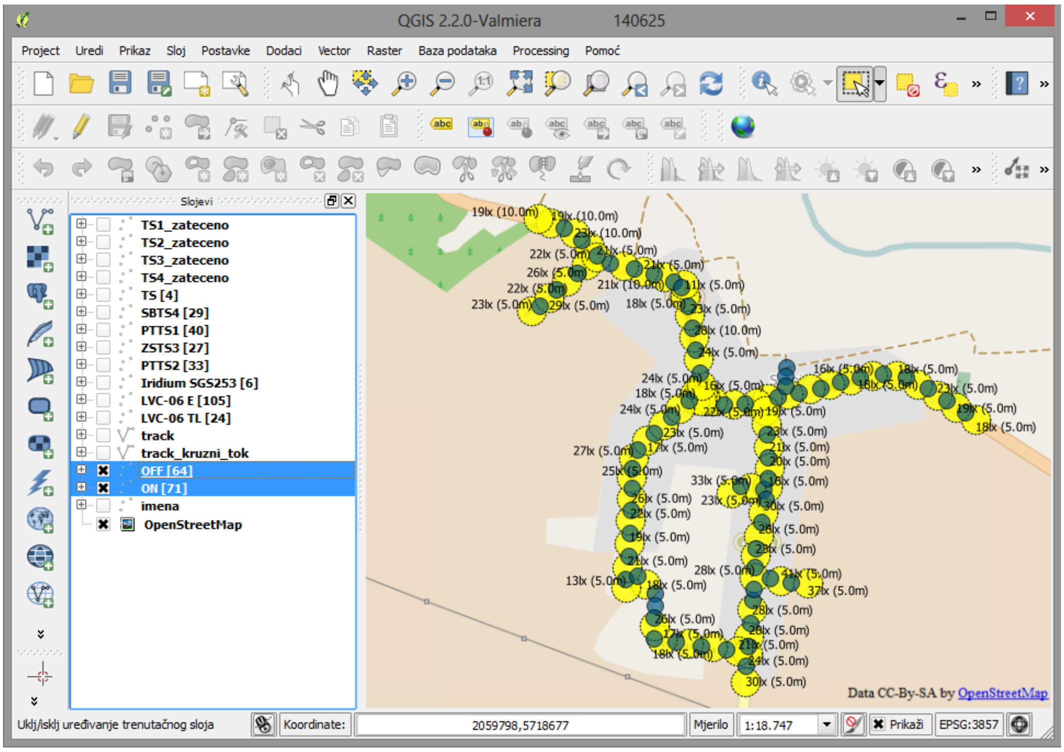

Figure 6. Layers with illumination measurement data

In addition to the usage presented above, GIS can be used for geo-tagging of photo documentation, which is an integral part of every energy audit. Easiest way is to use camera with GPS but pictures can be added manualy on mapped lamps. Fig. 7. presents photos taken with camera that have integrated GPS. Documented lamps on picture represents position of poorly maintained lamps.

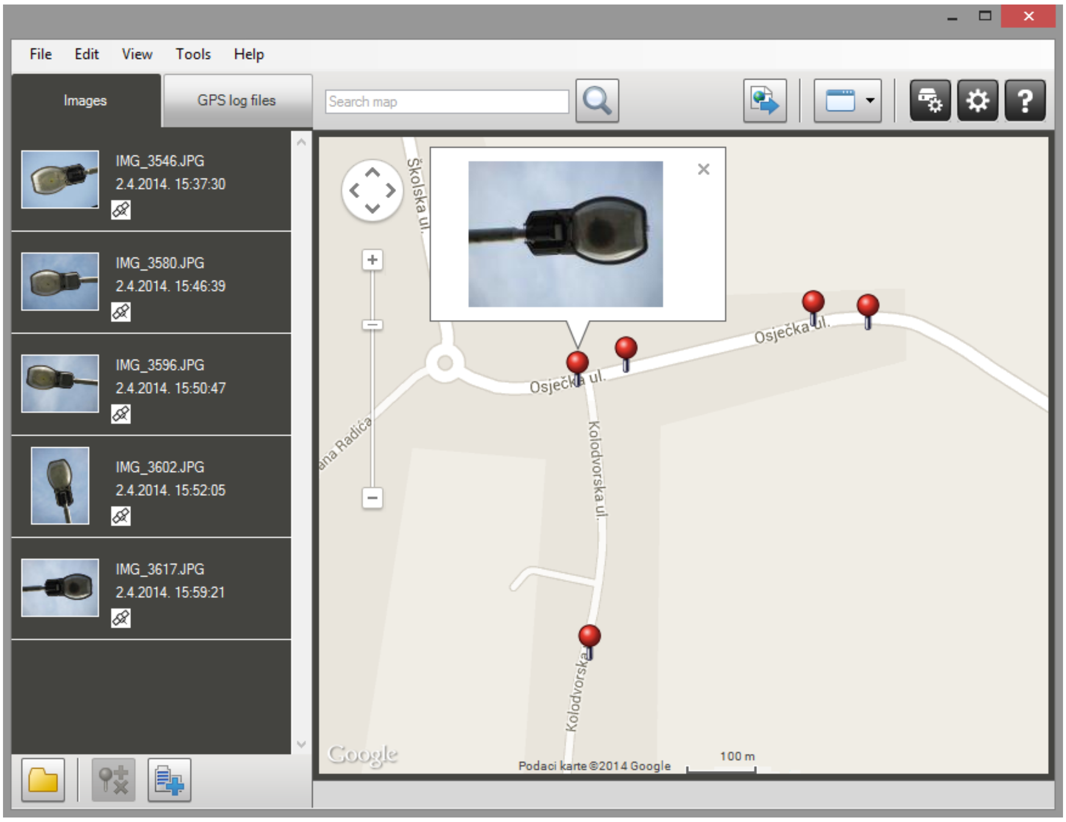

Figure 7. Layers with illumination measurement data

CONCLUSION

Public lighting is important because it provides visual conditions for normal transport and communications in public traffic areas. In Croatia, the Act on Energy Efficiency in Direct Consumption is an ordinance on energy audits of buildings and energy certification of buildings. The ordinance lays down the obligation to conduct energy audits of public lighting every 5 years. An energy audit is a systematic process of acquiring the appropriate knowledge about existing energy consumption, and can be performed only by an authorized physical person or legal entity. PL infrastructure includes: lamp posts, lighting fixtures, light sources and management system. Mapping of the lighting system is the easiest way to conduct energy audit of PL because collected data is momentary digitalized.

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REDUCING THE IMPACT OF SWITCHING VIBRATORY CONVEYOR DEVICE ON A POWER NETWORK

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Abstract: At the beginning of the work is given on general electromagnetic vibratory transport. Construction of the conventional EVA and simplified EVA a presented. Two-mass vibratory conveyor with plate springs and model of the VCS are given. Simulation circuit of the VCS and characteristic waveforms in case of phase control are presented. Reducing the impact of switching vibratory conveyor device on a network is the main topic.
Key words: AC–DC power conversion, actuators, conveyors, current control, phase control, , switching circuits.

INTRODUCTION

Vibratory movements represent the most efficient way of granular and particulate materials conveying. The conveying process is based on a sequential throw movement of particles. Vibrations of tank, i.e., “load-carrying element” (LCE), in which the material is placed, induce the movement of material particles, so that they resemble a highly viscous liquid, and the material becomes easier to transport and to dose. Due to influences of many factors, the process of conveyance by vibration of granular loads is very complicated. The conveying material flow directly depends on the average value of particles throw movements, being on a certain LCE working vibration frequency. This average value, on the other hand, depends on *vibratory width*, i.e., doubled amplitude oscillation, of the LCE. Optimal transport is determinated by drive type. It is within the frequency range 5 Hz–120 Hz and the vibratory width range 0.1 mm–20 mm, for most materials. Application of electromagnetic vibratory drive in combination with the power converter provides flexibility during work. It is possible to provide operation of the vibratory conveying system (VCS) in the region of the mechanical resonance. Resonance is highly efficient, because large output displacement is provided by small input power. In this way, the whole conveying system has a behavior of the controllable mechanical oscillator.

ELECTROMAGNETIC VIBRATORY ACTUATOR (EVA)

All main types of vibratory actuators can be seen as two-mass systems. The majority of them generate harmonic excitation forces, while some types generate transmitting impact pulses.
The EVA can be single- or double-stroke construction. In the single-stroke type, there is an electromagnet, whose armature is attracted in one direction, while the reverse stroke is completed by restoring elastic forces. In the two-stroke type, two electromagnets, which alternately attract the armature in different directions, are used. In Fig. 1, two of the most common single-stroke constructions are shown. One of them has armature on its active side, while the inductor is on its reactive side, as shown in Fig. 1(a). The other construction is set vice versa, as shown in Fig. 1(b). Simplified constructions of the above-mentioned vibratory actuators are shown in Fig. 2. The mathematical model of EVA is based on presentation in Figs. 2(a) and 3 with details. An electromagnet is connected to an ac source and the reactive section is mounted on an elastic system of springs. During each half period when the maximum value of the current is reached, the armature is attracted, and at a small current value it is repelled as a result of the restoring elastic forces in springs. Therefore, vibratory frequency is double frequency of the power supply. These reactive vibrators can also operate on interrupted pulsating (dc) current. Their frequency in this case depends on the pulse

frequency of the dc. A mechanical force, which is a consequence of this current and created by electromechanical conversion in the EVA, is transmitted through the springs to the LCE.

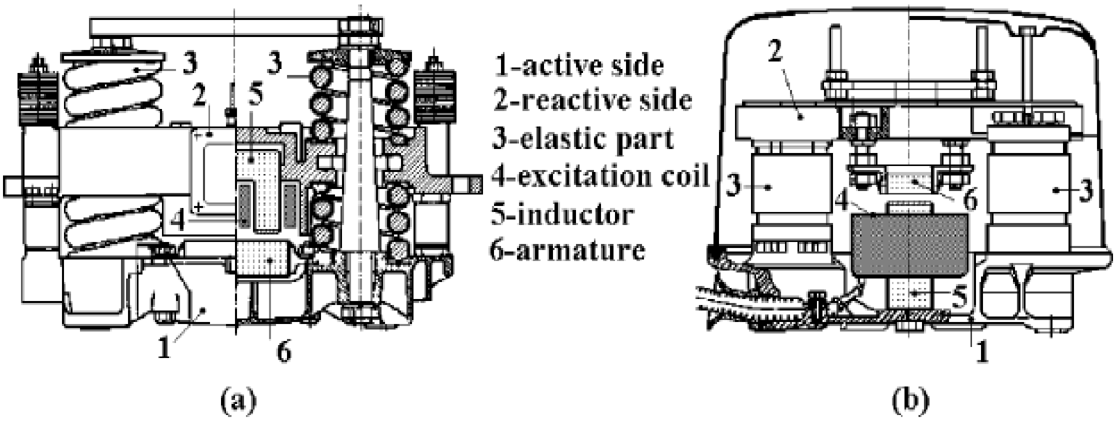

Figure 1. Constructions of the conventional EVA. (a) Inductor on reactive side. (b) Inductor on active side.

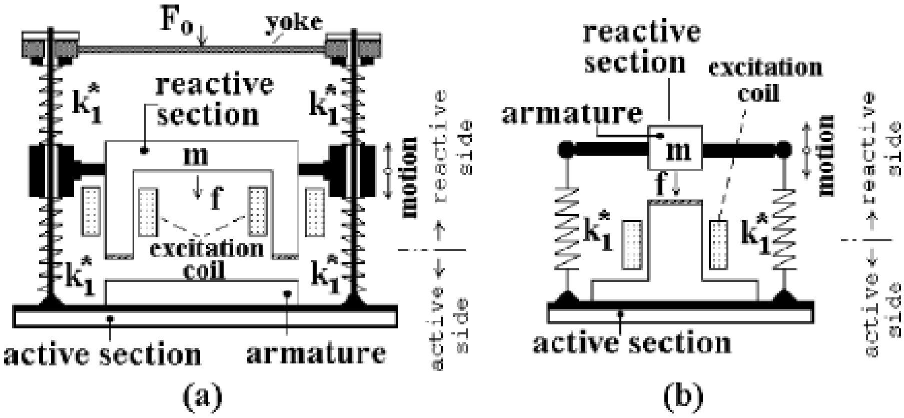

Figure 2. Simplified EVA presentations. (a) Inductor on reactive side. (b) Inductor on active side.

MODEL OF THE VCS

Electromagnetic vibratory conveying system VCSs are divided into two types: single-drive and multidrive. The single-drive systems can be one-, two-, and three-mass; the multiple-drive systems can be one- or multiple-mass [1]. A description of one type single-drive two-mass electromagnetic vibratory conveyor is shown in Fig. 3(a). Its main components are the LCE, to which the active section of the EVA is attached, comprising an *active section* and *reactive section*, with built-in *elastic connection*. Flexible elements, by which the LCE with material is supported, are composed of several leaf springs, i.e., *plate springs*. These elements are rigidly connected with the LCE on their one side, while on the other side, they are fitted to the base of the machine and sloped down under angle . The described construction is used in further analysis. Oscillatory displacement is a relatively small excursion with respect to its value at a point of static equilibrium of the system. Therefore, displacement of the LCE in the -direction is much less than displacement in the -direction, as shown in Fig. 3(b).

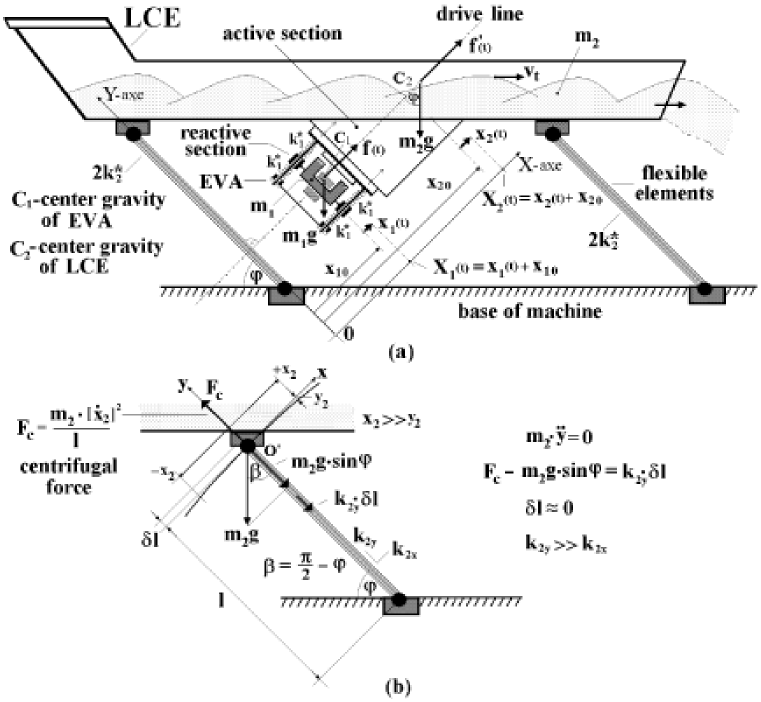

Figure 3. Two-mass vibratory conveyor with plate springs. (a) Electromechanical model. (b) Static equilibrium forces in y-direction

Given the assumptions above, this construction is a system with two degrees of freedom, which is shown in Fig. 4. The system will be analyzed as follows: the mass of the EVA reactive section is presented by m1 , while the mass m2 constitutes a sum of masses (the LCE, conveying material, and the active section of EVA). The mass m2 is a variable parameter within the system, because mass of the conveying material is varied under real conditions.

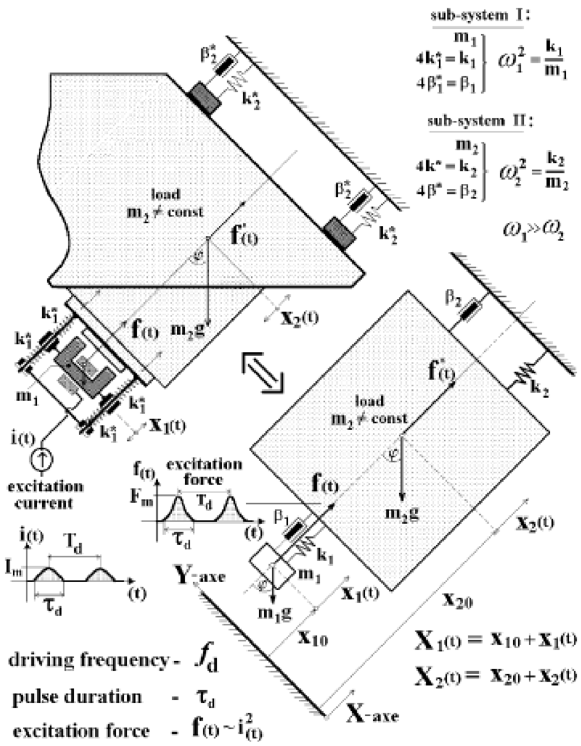

Figure 4. Model of the VCS for analysis.

SIMULATION CIRCUIT

Simulation circuit of the VCS is created on the basis of previously derived differential equations. A functional diagram is shown in Fig. 5, upon which the simulation model is based. Mechanical quantities are shown with equivalent electric quantities according the table of electromechanical analogs for inverse system A simulation model is generated in the program package PSPICE and a subcircuit is formed for application within different simulation diagrams, when analyzing various types of power converters for electromagnetic vibratory drive.

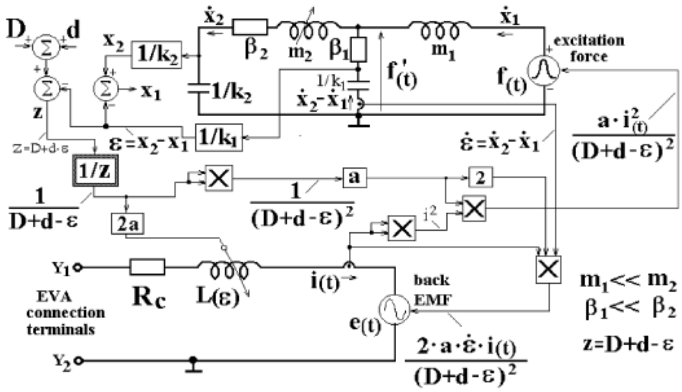

Figure 5. Simulation circuit of the VCS.

Simulation results for phase angles 126^0 and 54^0 are shown in Fig. 6(a) and (b), respectively. Characteristic values are: mains voltage u_m, control voltage u_c, coil voltage u, coil current i, and the LCE displacement x_2. It can be concluded from simulation results that the change of vibratory width is due to a change of phase angle. By decreasing phase angle, the effective voltage and coil current increase. This is caused by an increase of the oscillation amplitude of LCE too, which is created by a stronger impulse of excitation force, i.e., by entering greater energy into the mechanical oscillating system. On the other hand, an increase of phase angle causes decrease of the oscillation amplitude of LCE.

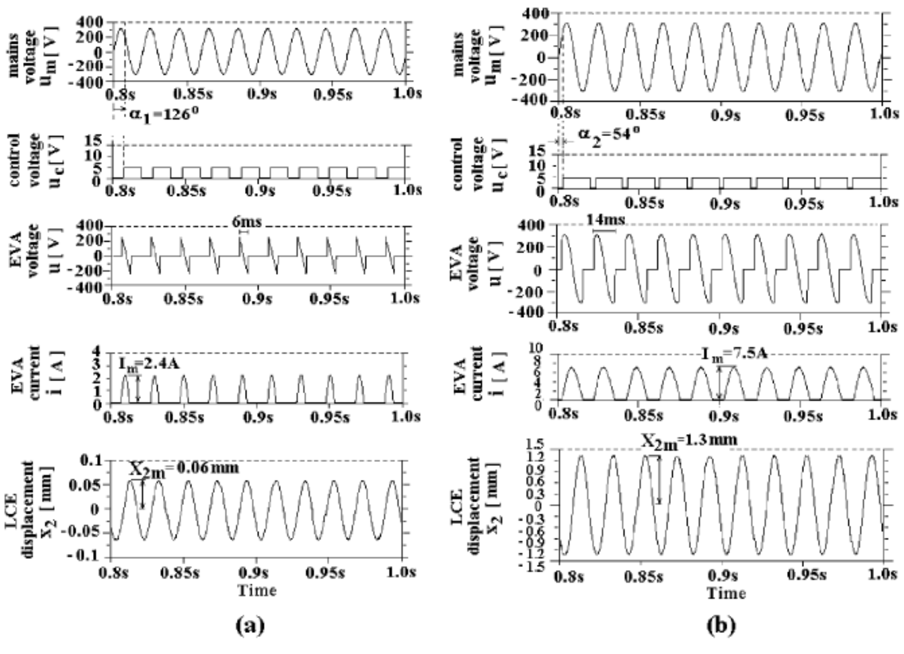

Figure 6. Characteristic waveforms in case of phase control. (a) Phase angle 126^0.
(b) Phase angle 54^0.

SPECTRAL COMPOSITION OF INPUT CURRENT OF SWITCH MODE RVCD

The spectral composition of the input current for the case of switching regulated RVCD(regulated vibratory conveying drives) can be studied by simulating the converter topology that is shown in Fig.7. The input converter is in fact diode rectifier which is possible with a direct connection to the mains power supply network (in this case, the switch SW is ON) or by L_{in} choke (or optionally by coupled inductors). At the output of diode rectifier is used current controlled asymmetric half-bridge to excite EVA.

Through the switching half-bridge is provided amplitude and frequency of control of vibratory conveying. The synchronization of current pulses i_{out} with moments in which LCE passes through the equilibrium position, establishes a regime of mechanical resonance. In this case, the output power stage compensates only losses which are the most dominant losses in the windings EVA and losses due to mechanical friction.

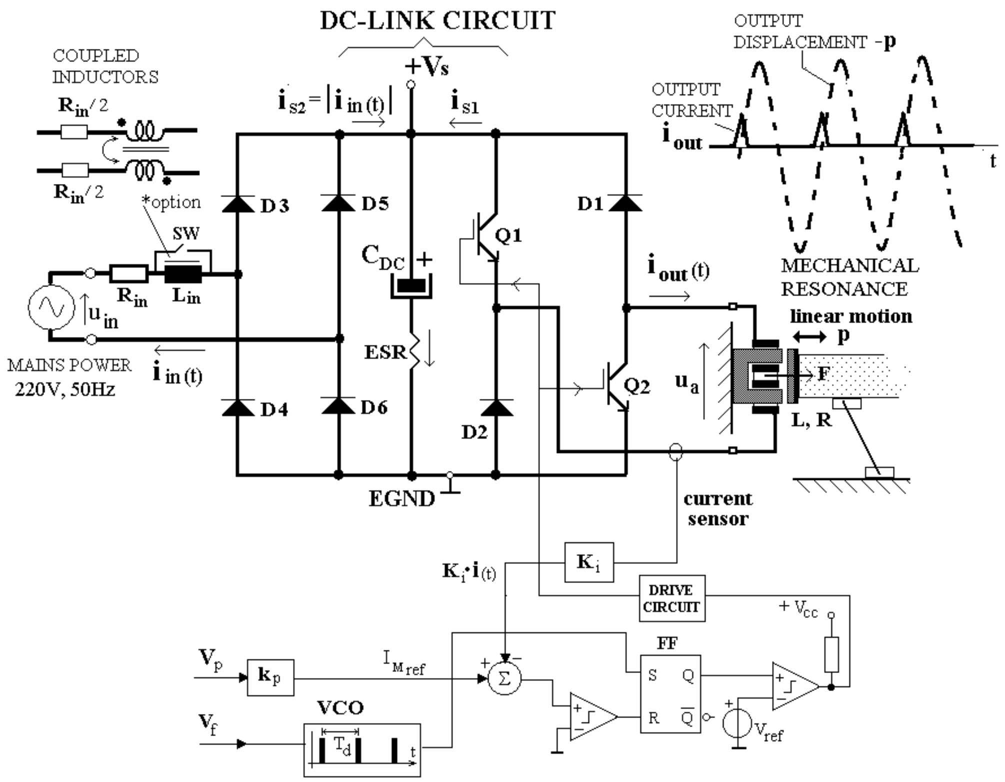

Figure 7. Power converter AC/DC topology to study the spectral composition of switch mode RVCD to the supplying network

For most the mechanical systems, which are used to vibratory conveying, resonance frequency of the mechanical part of the system is in the range of 5Hz-150Hz. In this paper will be discussed the case when it is equal or close to the power supply network frequency of 50Hz. This case is the most critical and gives the most unfavourable spectral composition of the input current of RVCD.

For that purpose it is formed the simulation electric circuit corresponding to topology in Fig.7. In the simulation will be discussed spectral composition of the input current of such RVCD for cases without input inductance (when SW is ON) and with input inductance (when SW is OFF).

The most unfavourable case is there when the exciting frequency of EVA is equal mains supply frequency 50Hz. Fig.8 presents the simulation results for the case when the interval of excitation current pulses of EVA coincides to the passing of the mains supply voltage through zero. In this case there are two possible scenarios. One, when the phase shift of the EVA current pulse is equal to 0 and 180º. These two cases are shown in Figure 8 (a) and 8 (b) respectively. It may be observed that the input current is characterized with bipolar and asymmetric pulses.

More worse is the case when the phase shift of EVA current pulse is equal to 90º. The simulation results for this case are given in Figure 9. Characteristic waveforms are shown in Fig. 9 (a), and the spectral composition of the input current is given in Fig. 9(b) and 9 (c). Precisely, if the interval is acting triangular current pulse overlaps with the maximum of mains voltage, then the complete RVCD from the power supply grid take unidirectional current pulses. The spectral composition of the input current is very unfavorable and even includes a DC component which makes great problems to a power supply network.

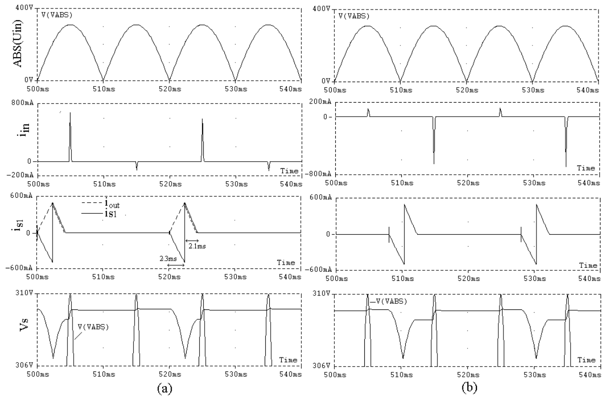

Figure 8. Influence RVCD on power supply network when driving frequency of EVA is equal 50Hz-simulation results; (a) phase shift of EVA current pulses 0º, (b) phase shift of EVA current pulses 180º

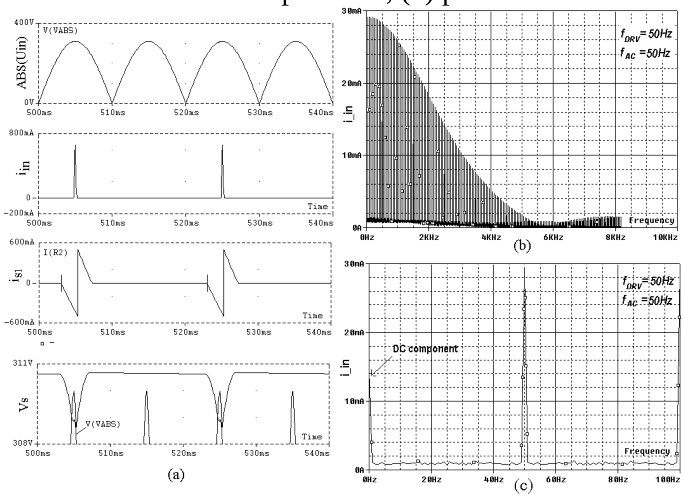

Figure 9. Influence RVCD on power supply network when driving frequency of EVA is equal 50Hz-simulation results; (a) phase shift of EVA current pulses 90º, (b) FFT spectrum, (c) FFT spectrum range 0-100Hz**.**

PFC CONVERTER FOR SUPPLYING RVCD

Block diagram for implemented AC/DC transistor converter is shown in Fig. 10. The transistor converter comprises two power converters. One is input AC/DC converter with power factor correction, while the other one is DC/DC (pulsating current) converter for driving EVA.

Input converter is in fact a controllable transistor rectifier with two "*boost*" stages (M1-D3 and M2-D4) and inductance L_{in} on the AC side. This converter with advantages over the conventional power factor corrector (diode bridge rectifier-power switch-diode-inductance on DC side) is described in detail, in .

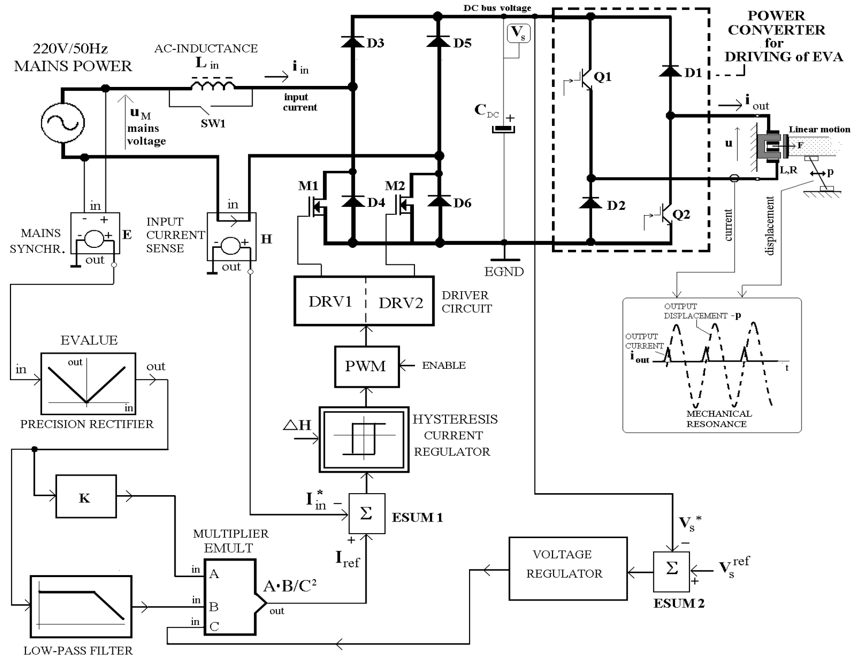

Figure 10. Principle block scheme of PFC control circuit for supplying switch mode RVCD

The basic functional block in the PFC control circuit is a hysteresis controller. The controller has the ability to adjust the width of the hysteresis ΔH. To the input of a hysteresis controller is error signal i.e. the difference of two signals I_{in} and I_{ref} . The controller output is brought to the PWM circuit that has the implemented function ENABLE or DISABLE. The signal I_{in} is a in fact the actual value of network current, while the I_{ref} is signal from the output of multiplier AB/C^2. Input A of multiplier is signal which is obtained by measuring and rectifying of the input mains voltage U_m. Input B is filtered mains voltage, while input C is output of voltage controller (PI regulator).

When the switch S1 is a *turned on* and when the signal ENABLE = "0", the entire system can be easily reconfigured in the basic circuit without PFC. In fact, the experimental results obtained for both of configurations.

Fig.11 shows the oscilloscopic records of the mains voltage, input current and DC link voltage for the case when RVCD is supplied from the PFC converter. Fig.11 (a) shows the characteristic records for the case when the driving frequency of EVA is equal to 48Hz, while Fig. 11(b) shows the same records for the driving frequency 52Hz. As can be seen, from the experimental results, that the obtained phase shift between the input current and mains voltage is zero i.e. the power factor of the entire RVCD is near to one.

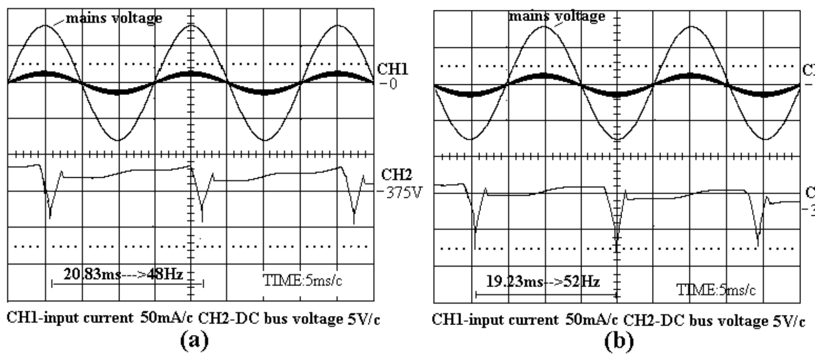

Figure 11. Oscilloscopic records of the mains voltage, current, and DC link voltage for the PFC converter of a RVCD: the driving frequency of EVA (a) 48Hz and (b) 52Hz

CONCLUSIONS

The impact on a power network is more drastic if a number of RVCD's is used. In fact, this is quite common in practice, where, for technological reasons, a processing line is fed from a number of conveying devices in order to form a final mixture of a required homogeneity. For this reason it is necessary to carry out an additional optimization of switch mode RVCD's i.e. optimization of the input (AC/DC) rectifying circuit. A solution for the power factor correction circuit which provides a sinusoidal input current is proposed.

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JUSTIFIABILITY OF EXECUTION OF SERBIAN TELESERVICE IN INDUSTRY

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Abstract: This paper presents a teleservice as the process of removing electronic failures on machines from a distant place. Service is explained in details as new service, who gives a new concept of maintaining the production.
Also included are all the positive and negative features of this service. The aim of the study was to analyze the reasonableness of performing Teleservice compared with the conventional way of service. The paper will be justification of service execution teleservice show an example of a machine for filling water.
Key words: Teleservice, service, machine, the maintenance, failure.

INTRODUCTION

The teleservice means remote service that is process of technical services through telecommunications networks to remote location. This service includes remote access to the machine by an authorized company. Remote maintenance will provide servicer that he can from his work place directly on machines performs certain procedures. Each press of the keyboard and the mouse movement is directly transferred to a PC of person who ordered service.Servicer that can see the state of the PLC on that workstation. The main focus here is placed on proactive service, remote service and multimedia communication. The most important industries to support e-service are now in the process industry and medicine.
On the market today there are over 200 companies in e-services with different approaches and different technological parameters [1].
All bigger international competitions machine manufacturers forces the same to provide their customers with very good quality service network and not just big machinery manufacturers, but also even the little ones. Very important business activity of machine manufacturer after their sell are also after-sell services. This is primarily related to the repair and especially on maintenance. Customers today, from the manufacturer, not only expect a very high quality product, but a very high quality and efficient service.
In many areas of business services has a major impact on the decision for any manufacturer to decide, often even higher than the price or features. So, the classical servicers meet the above requirements only partially. To meet the above mentioned requirements is necessary to develop new concepts and methods, and one of them is the teleservice [2].
Competition has become very intense increase in the globalization of markets. Companies are forced to adopt new strategies in order to ensure their competitiveness. In the classical concept of service a large part of the supporting service was provided locally, in the sales, local cooperation or service personnel acting in the world. This concept requires huge financial, organizational and legal risk. Therefore, there must be developed alternative methods of service. The constant growth of is innovative machine manufacturers who are already using new information and communication technologies effectively in servicing the machines. These IT (information technology) services operate at a great distance and can be considered as teleservice [3]. The early 20 th century was the beginning of the development process teleservice on technical systems. The process is a technical point of view developed over time so that today are based on peer-to-peer connection via modem. Teleservice is characterized by a reactive service strategy. Remote services, which means the use of the service process across networks, especially the Internet has expanded the potential scope of services teleservice and strengthen it. Due to the increasing integration of production machines in the environment, teleservice centers are also increasingly necessity for the successful operation of any equipment. Teleservice significance and its potential variety in terms of global competition is

undoubtedly an extremely large. Manufacturers as users can take advantage of a number of benefits that provide access to information and communication technology support. To fully exploit these advantages in practice, it is necessary to fulfill these demands acceptance by users, organizational integration, and technical aspects. If this meet teleservice provides adequate rational potential. In addition, the increasing development of information and communication technologies will result in the realization, in today's conditions visionary concept and the constant increase in the spread of teleservice. Companies that intend to remain competitive today on international market will have to use a teleservice [4].

JUSTIFICATION OF TELESERVICE

Teleservice can still be defined as a method for data exchange based on remote access to the venue or technical equipment (machines, production lines, computers, etc.) to detect fault diagnosis, maintenance, data analysis and optimization. The connection between the user and the system can be established using the following communication media: analogue telephone network, ISDN, cellular networks and the Internet [5].
The complexity of modern machines and equipment that are used in industrial production requires new methods for easier troubleshooting. Troubleshooting and repairs in a classical way service machines require high costs and adds the following problems [6]:

- Journey from servicer to user. During that time machine does not work causing great financial loss. Often technicians on-site find even trivial defect;
- Some errors can occasionally appear and disappear. In most cases, the customer just looked at this problem, and still operate. When the repairman arrives to the machine, all traces are gone. So it often happens that no one can find the cause of the failure;
- Servicers must bring with them a lot of funds for the work, equipment for measuring and tools. Often it can happen to forget the important special tool, then you have to wait until tool gets there;
- Service and transport costs a lot.

As the basic requirements for the introduction of services Teleservice stand out [1, 7]:

- limiting local manpower or reduce to a minimum,
- risk reduction in hazardous working environments, e.g. in explosive environments,
- entral expertise (locally solve small problems a remote, centralized complex problems by service personnel),
- efficiency and faster response from servicer and improving procedures for preventive maintenance due to constant monitoring of performance machines.

In order to eleservice possibly work there need to be fulfilled the following conditions [1]:

- Geographical distance: Service should be provided with spatial distance. This means that the service must provide a service technician who is far away from the user;
- The use of information technology - use of information and communication technologies is essential in performing services (i.e. Using ISDN or modem for the transfer of process or control data);
- Industrial service - Derivative services should be in the field of industrial services, for example, maintenance, diagnostics and repairs.

Benefits of a teleservice bring the user the equipment and the equipment manufacturer are shown in Table 1.

Table 1. Advantages of the use Teleservice for users of equipment and equipment manufacturers

Equipment user	Manufacturer of equipment
• Long-term reduction of labor costs • Reduction of cancellation • Minimum cost service out of warranty • Support during commissioning • Increase competence within the company to resolve problems • Increase employee satisfaction by expanding the knowledge base and expanding the scope of implementation of tasks • Internal staff training	• Reducing costs (labor and transport) • Increased availability of experts within their own company • Optimizing the structure of the service • Improving the efficiency of service • Intensified the obligations of the user • Economic presence in remote regions • Increase performance service • Reducing the response time

MATERIALS AND METHODS

The paper will be the justification of service Teleservice in Serbia show on one machine for filling bottled water in water factory Water Villa Ltd Novi Sad. The above machine is used for filling Fruskogorska spring water in plastic bottles from 0,5 to 2,5 liters. To demonstrate the justification of performing services Teleservice it will be compared the conventional way of service on the example of a failure on the same machine. For the analysis of justification types of services will be analyzed following costs:

- costs of a halt in the service,
- travel expenses and
- the cost of diagnosis and resolve a failure.

RESULTS AND DISCUSSION

Machine to a standstill using the services Teleservice spent one hour, instead of the most minimal of six hours using the conventional way of service. Time turned into money needed for travel service in the classical way of service on the route to 150 km of that was 150 €. Total cost of the services Teleservice to fix the fault on the machine for filling water would amount to € 900, while the application of the conventional type of service the total cost of repair services amounted to € 2100, table 2.

Demonstrated on the example of two methods of maintenance is possible by applying a Teleservice reduce costs by up to 2.33 times. Online support, shown by the example of removing clients save time and money, reduces machine downtime period and reduces the number of personnel engaged.

Table 2. Comparison of the cost of services Teleservice with traditional service on the machine for filling water

Cost of services, which are compared	Teleservice	The classical way of service
Cost of service downtime in the process of servicing	1h x 300=300 €	6h x 300=1.800 €
Travel expenses (arrival and departure)	-	1€ x 150 km =150 €
Cost of diagnosis and the solving of a cancellation	600 €	150 €
Total costs =	**900 €**	**2.100 €**

The above shows online support on technical systems saves time and money, as do 90% of all electronic faults in machines and plants can be eliminated by using a Teleservice. Using a network connection and computer sharing, can monitor the status on your computer or on that workstation. Online support includes electronic services in the form of: system configuration, consulting services regarding support, support questions, upload and download data management it. Through online support can be a software update, if there is a need for it. Online teleservice training also saves valuable time when it comes to training courses. It is not rare that an online support can provide training for new software programs or special requests that they provide.
For example free access to the remote service can be based on the use of prepaid telecommunications services. With the consent of the Employer Services Teleservice, for example may be granted a loan of five hours. During the process of Teleservice, may at any time check how much credit or. time remaining. So, the customer service always knows what his current loan and, if necessary, it can always supplement. When concluding the first contract for remote maintenance is usually more well-known companies give 5 to 10 credit hours for free.

CONCLUSION

Users of Teleservice need to realize the benefit of cost reduction-Reduction of failure, greater flexibility and productivity services. Teleservice Service providers on the other hand should look for their advantage to improve efficiency, customer loyalty and commitment to a better job. All of these justifies teleservice as a very current topic that is brought into context with the reliability of technical systems and defines it as an issue which is yet to speak, and an area that is yet to develop in the years to come.
Demonstrated on the example of service to the Teleservice filling machine bottled water maintainers funds for work in production could reduce their costs by up to 2,33 times compared to traditional ways of service.

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MONITORING COMPONENTS IN POWER PLANTS

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Abstract: This paper presents a practical application of technical diagnostics through monitoring in power plants. Application of technical diagnostics and condition monitoring systems is the result of years of research in the area of reliability of technical systems and the design of technical systems work in the energy industry. The function of preventive maintenance is increasingly represented in a new form known as proactive maintenance processes where monitoring systems play a key role. Monitoring of systems process in power plants includes periodic quality control of parts of the system, and its results represent a significant support for technical diagnostics. Automating the process of monitoring systems promotes preventive maintenance, and at the same time, technical diagnostics.
Key words: condition monitoring, technical diagnostics, maintenance.

INTRODUCTION

In this paper, we aim to describe a technique for determining the state of the system, ie. trying to answer the following questions:

- Is the system able to work and for how long?
- Whether it should be maintained, and how?
- Does it have cancelations where you should immediately shut down the system in order to eliminate failure?
- How long can system operate with failure and under which conditions?

To answer the above questions there has to be explored: what exactly is meant by condition and whether it can be measured.
Seeking for a clear definition of the status we see that all the questions above are related to how the system will be working until a certain event occurs, eg., failure, and this leads to the definition that the state of the object (plant) during which the plant operates in a specific mode, until the specified probability of failure in the allotted time is reached. If maintenance policy is applied, ie., replacements upon cancellation (without maintenance), then the probability will be equal to one, and if the system is maintained "by the state", then the probability of failure would be at a value that gives the best compromise between minimizing repairs and maintenance costs, and maximizes system capabilities [1].
It is believed that the definition in this form is the one which provides information leading directly to the planning of maintenance and repairs, and allows us to evaluate different operating strategies, and that they are of utmost importance for those who are responsible for the profitable operation of the power plant.
Increasing the safety and reliability of operation of plant and equipment in the production system, largely depends on timely detection of potential sources of failure of the equipment.
Solution to this important task contributes significantly to the application of methods and means of technical diagnostics.

TECHNICAL DIAGNOSTICS

Technical diagnostics (hereafter TD) is the science of identifying (recognizing) the operation of technical systems, with the aim of detecting a malfunction. It is based on the proven experimental methods and results, as well as the reciprocity of the functional dependence on the output of the measured diagnostic quantities (signals, parameters) of vehicles structured parameter, i.e., condition of the structure of technical diagnostics [1].

There are three levels of TD, as follows:

- monitoring and identifying deviations about diagnostical parameters and signals from their nominal value,
- analysis of the nature and cause of deviations diagnostic parameters and diagnostic signal from the nominal value, and
- forecast of possible work unit or units without delay.

At the power plants and processing facilities, the most important thing for good economical value of technical system is:

- availability of the property,
- operational safety, and
- lifespan of subsystems and their components.

Unplanned cancellations of process equipment (turbines, generators ...) have resulted in:

- accidents that cause property damage and endanger human lives,
- high costs for repairs and
- significant production losses.

In order to minimize failures in processing and power equipment and avoid damage, it is necessary to timely recognize changes in systems state, and that is possible with the supervision of employees (hearing, seeing, feeling) and the application of certain TD methods (Figure 1).

There should be distinguished two types of technical diagnostics:

- General TD - aims to determine the state of the object according to the general criteria: operating status and fault condition (often the diagnosis is called functional or express) and
- Local TD - aims to determine the technical condition of certain elements, and to determine the causes and characteristics of hidden faults.

In the development and preparation of TD methods, it is necessary to solve three problems:

- define all possible (expected) occurrence of faults that need to be distinguished,
- select a set of parameters that will, as symptoms, through signals emitted by the equipment, give the informations about performance of the equipment and
- establishing a link between the failure or damage and symptoms (a defect corresponding to a symptom or vice versa, or the fault manifests itself through several symptoms).

In the process of diagnosing, there are few significant TD procedures [7]:

- Installation of sensors on the subject of diagnosis,
- Stabilizing facilities working regime and diagnostic equipment,
- record diagnostic signals,
- Registration and measurement of the diagnostic parameters,
- Comparison of the values obtained with the calibrated values,
- obtaining diagnostic solutions and information about the current state of the constituent elements of the system and
- generating conclusions.

For a fuller insight into the state of the system and its functions computers are used as example (Figure 2), which configuration is mechanized to completely replace a large number of workers, for permanent external monitoring of the system and determining its status.

Diagnostics (permanent or temporary) of the state of the system (Figure 3), it is possible to improve the economics and security specifications of the system and to [4]:

- improve the safety of early detection of failure, so the faults could be reduced without greater consequences and protect operating personnel,
- increase the availability of plants constant supervision, in order to reduce the number of audits, inspections and unscheduled downtime,
- reducing the duration of the audit, repairs and rates, etc. ; diagnostics monitoring the state of the system during the drive, can determine what causes disturbance of the normal operation of the system and plan in advance the measures to be taken, when the drive stops, (by replacing damaged parts, procurement, other repairs...)
- extension of the life of the plant by optimizing the starting, stopping and transients and reducing adverse operating conditions.

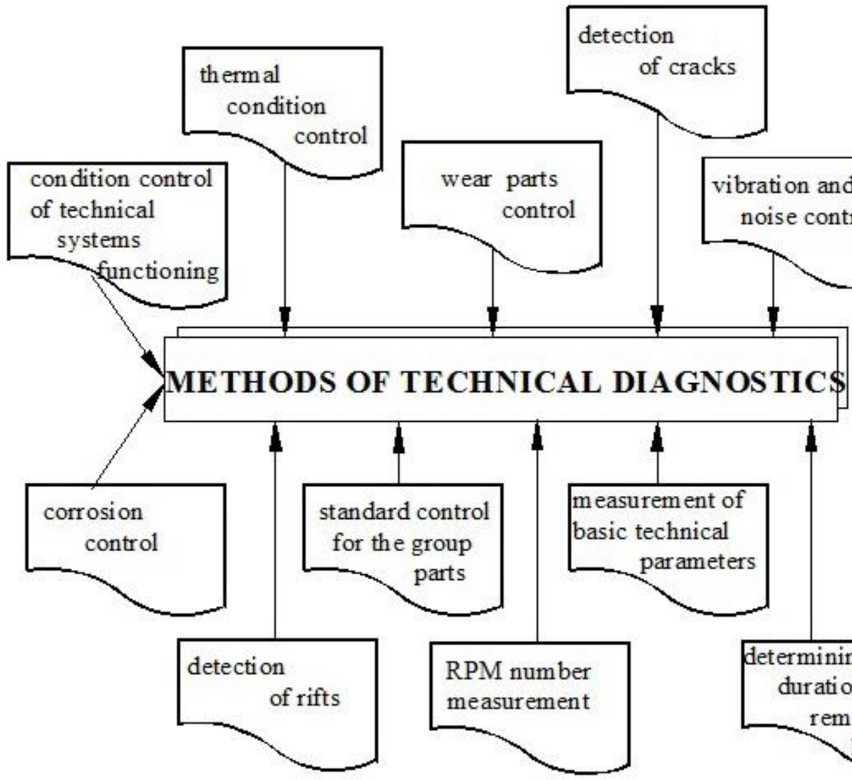

Figure 1. Basic methods of technical diagnostics

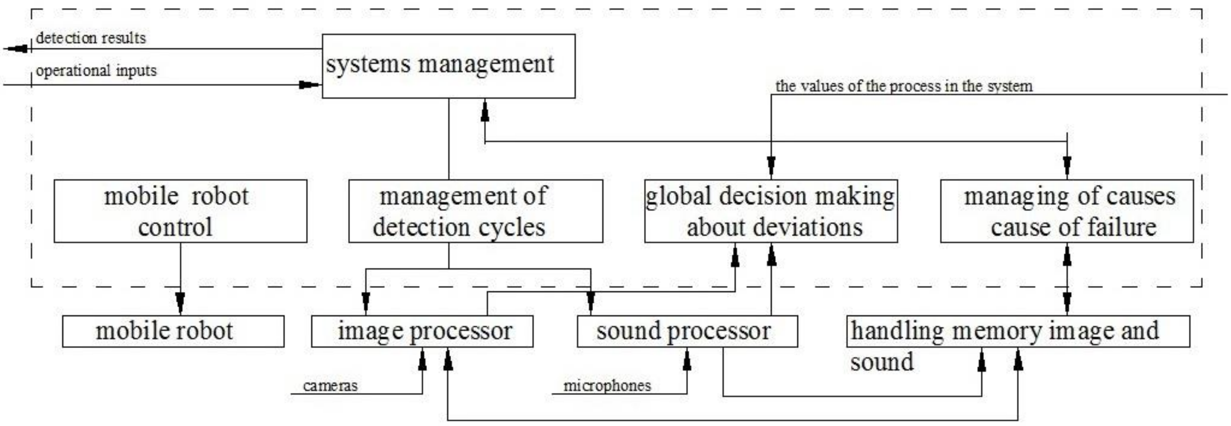

Figure 2. Functional system configuration

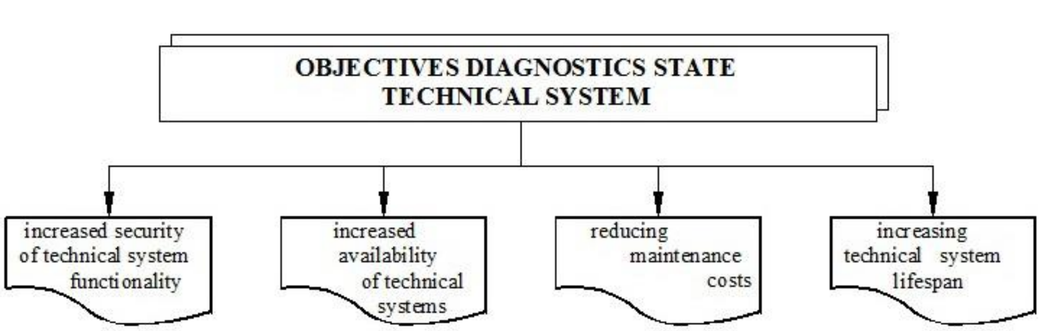

Figure 3. Technical and economic objectives of diagnosis

MAINTENANCE

Maintenance, as well as a set of tasks with which system is able to function with predicted or expected performance, along with the existing conditions of operation system, is a complex technical science with a number of strategies, methods, techniques and organizational forms [2,4].
Here we will only mention the maintenance strategy in which the diagnosis has an important place, which is to "maintain the state" - CBM (Condition Based Maintenance).
This methodology maintenance includes three main phases [3]:

- history of changes to the state in the past - what is it,
- Technical diagnostics of the system - what is now,
- Weather conditions in the future - what will be.

Experiences in operation have shown that the majority of working funds do not lose their functional characteristics at once, but it is a continuous process. Indications of damage, failures and breakdowns occur earlier.
The introduction of diagnostics and organizations in the maintenance of the state (Appendix 1) is a process (and condition) that determine state (health) of each part of the technical system, that could be measured and whose behavior we can control with certain parameters.
Condition based maintenance is based on the results of the diagnostic process, which allows the determination of the state of each component involved in the diagnostic monitoring, on the basis of which is determined by the following test plan, inspection, replacement, repair, thus increasing the time of the effective work of the technical system, eliminating unnecessary downtime [5,6].

CONCLUSION

It is the great importance of the application of technical diagnostics, primarily because of the possibility of discovering failures in the early stages of their occurrence.
Ability to apply the technical diagnostics in predicting the future state of the equipment, is important in maintaining complex systems.
Preventive maintenance, by the state, with the use of diagnostic methods and techniques, i.e., with a diagnosis of the situation, gives conditions for the foreseeable maintenance.
Practice shows that the diagnostic condition monitoring is cost effective operation, because the investment costs are amortized through an unplanned downtime due to repairs.
New technical requirements diagnostics lead to the development of software and hardware modules to improve expert systems with large diagnostic assessment and confident forecasts.

Acknowledgement

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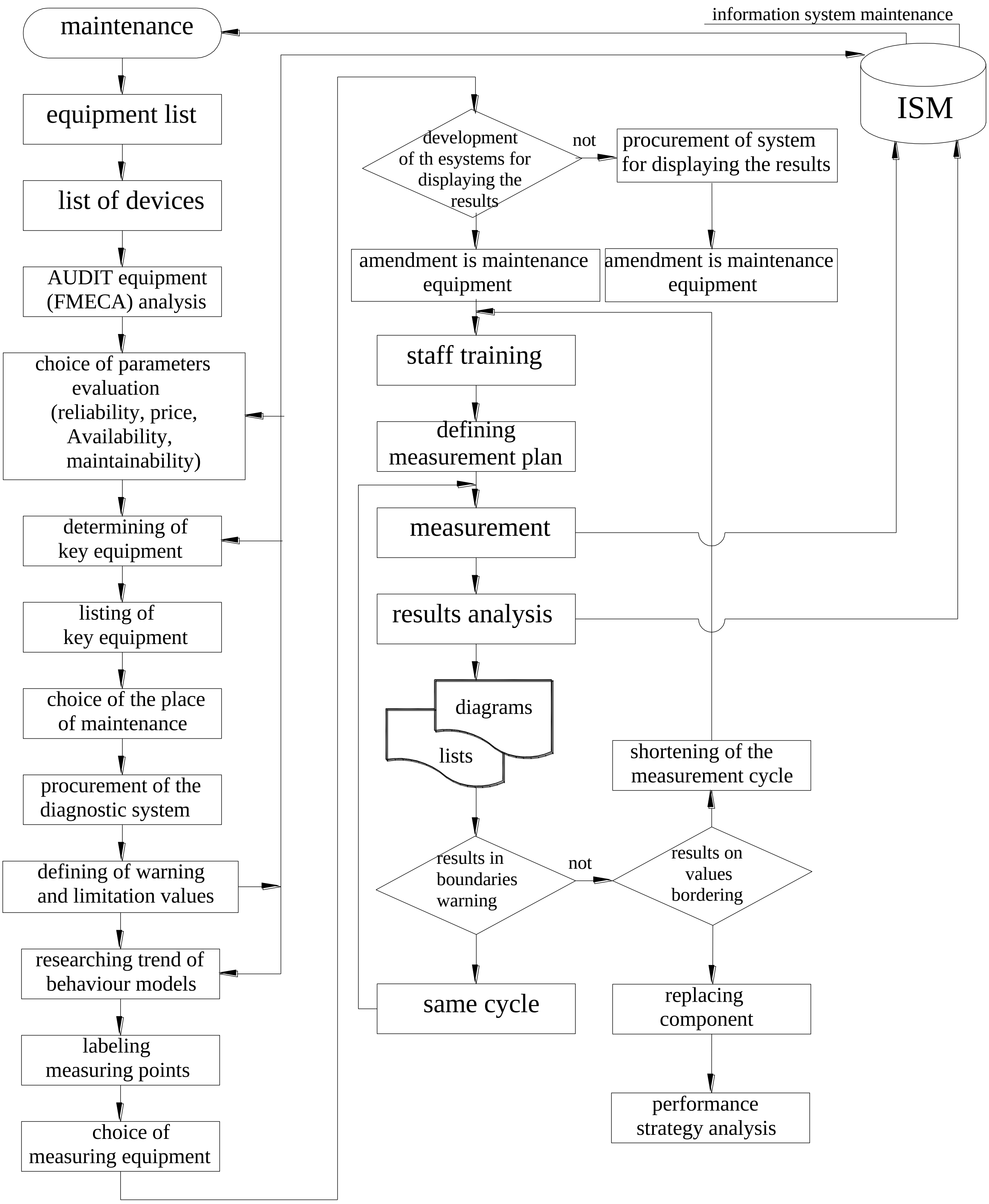

Annex 1. Algorythm of introducing diagnostic and maintenance "by the state"

CONTROL OF THE PERMANENT MAGNET LINEAR SYNCHRONOUS MOTOR WITH FUZZY AND PID REGULATORS

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Abstract: This article analyzing mathematical model of the permanent magnet linear synchronous motor (PMLSM) with three-closed loop control system. Combined the advantages of traditional PID control algorithm and fuzzy control algorithm, according to the characteristics of linear motor and the possible factors of uncertainty, a set of adaptive fuzzy PID control system is designed for the speed loop of the proposed control system, moreover, fuzzy inference rules is established to realize the Fuzzy PID controlling of the speed loop. In the end, the simulation models of the motor and the whole control system are built on Simulink environment, and compare and analyze the fuzzy PID control and conventional PID control.
Key words: PMLSM, adaptive, fuzzy PID Control, Simulink simulation

INTRODUCTION

Linear motor is a transmission device by which electrical energy changes to linear motion mechanical energy directly without any intermediate transfer mechanism. With the increasing demand for industrial machining quality and precision of positioning movement and so on, linear motor has received extensive attention [1].

Conventional PID control is widely used in motion control because of its simple algorithm and high reliability. However, some of the controlled object has no precise mathematical model in practice, which leads to set the PID parameters complexly, moreover, the parameters usually have poor performance and difficult to meet the high precision motion control of linear motor. If fuzzy algorithm is used to set the online PID parameters such as K_p, K_i, K_d, it can not only retain the merits of simple principles and convenient use of the conventional PID control system, but also own the characteristics such as flexibility and adaptability of the fuzzy control, which can enhance performance of the control system effectively [2-4].

MATERIAL AND METHODS

The overall design of control systems

According to the characteristics of linear motor and an intensive study on the control theory， the permanent magnet linear synchronous motor control system is designed as shown in Figure 1 in this paper.

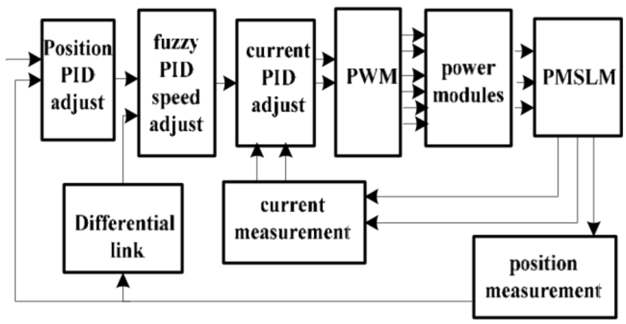

Figure 1. Block diagram of linear motor control system.

The above block diagram shows that the control system is consist of 3 close-loops, including displacement close-loop, velocity close-loop, and current close-loop. Among which displacement close-loop and current close-loop adopt the conventional PID control strategy, while velocity close-loop uses fuzzy PID control strategy. The paper focuses on the study of fuzzy PID controller of velocity close-loop.

Establish the model of PMLSM on Matlab/Simulink platform

The simulation model of electric motor is built by Simulink in Matlab. On the basis of the linear motor voltage equation, the voltage equation simulation model of PMSM (Permanent Magnet Synchronous Motor) is shown in Figure 2.

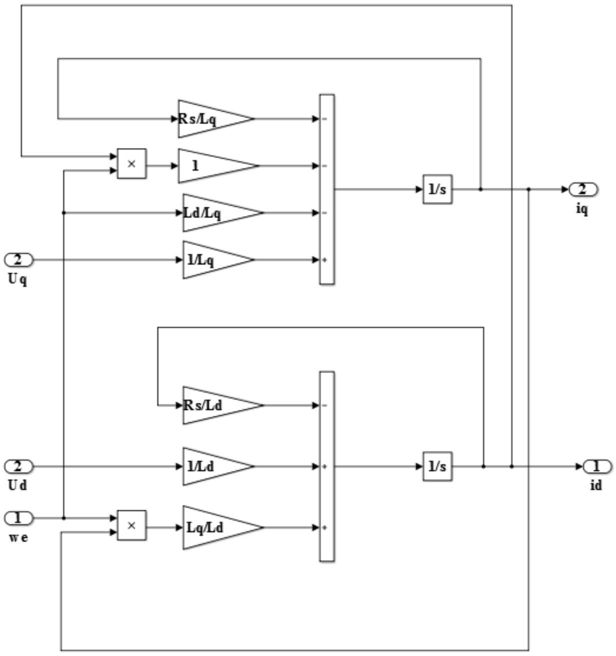

Figure 2. The voltage equation simulation model of PMSM.

According to the mechanical motion equations of the linear motor, the mechanical motion equations simulation model of PMSM is shown in Figure 3.

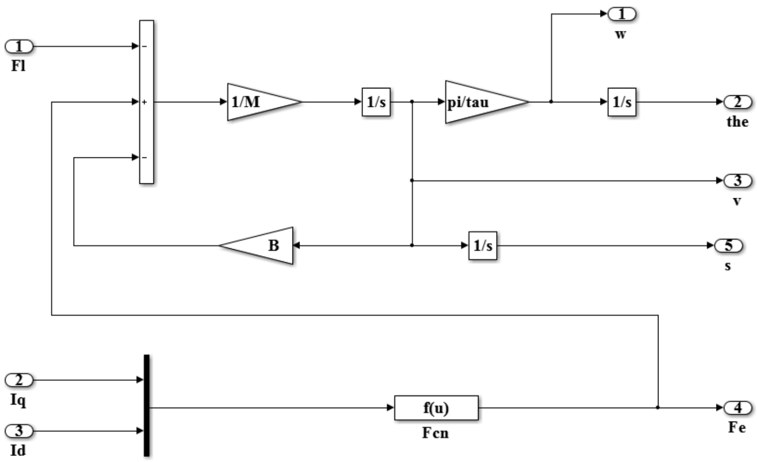

Figure 3. The mechanical motion equations simulation model of PMSM.

On the basis of the voltage equations and mechanical motion equations established previously, the simulation model of electric motor is built by Simulink in Matlab is shown in Figure 4.

Design of fuzzy PID controller

Adaptive fuzzy PID control applies the modern control theory to set the parameters of the on-line controlled object, which makes the control system adapt to the requirements constantly to achieve better control effects. First of all, fuzz up the experts' practical operation experience which is difficult to describe accurately as well as various semaphores and evaluation index in the control process by fuzzy set theory, then executes the fuzzy inference according to the actual response, finally defuzzication to set and adjust the best on-line parameters of the PID [5].

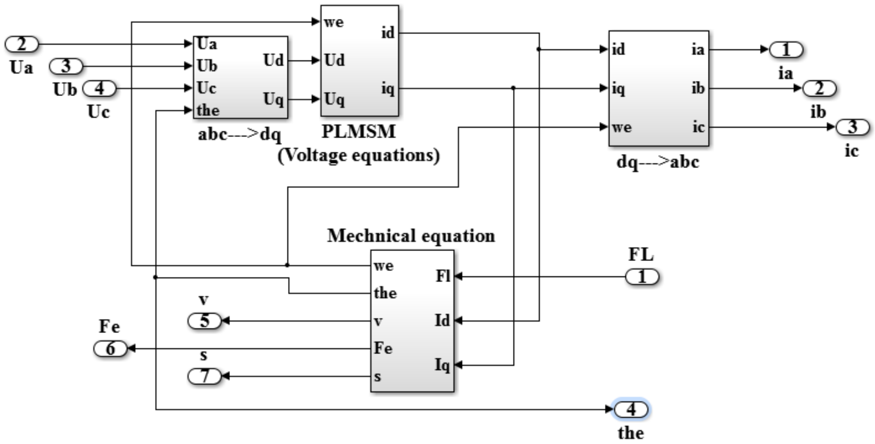

Figure 4. The simulation model of electric motor.

The inputs numbers of the fuzzy controller is called dimensions. If the dimensions of the fuzzy controller are comparatively low, the control will be coarse and the performance won't measure up to the specified requirements. The higher dimensions are, the more precise control is. However, the structure of the controller will be fairly complex if dimensions are excessive, and the implementation of the algorithm will be also difficult [2]. This paper proposed a two-dimensional fuzzy PID controller according to the requirements of the actual control system, the inputs are deviation signal and its variance ratio, while the outputs are K_p, K_i, K_d.The structure diagram of fuzzy PID controller is shown in Figure 5.

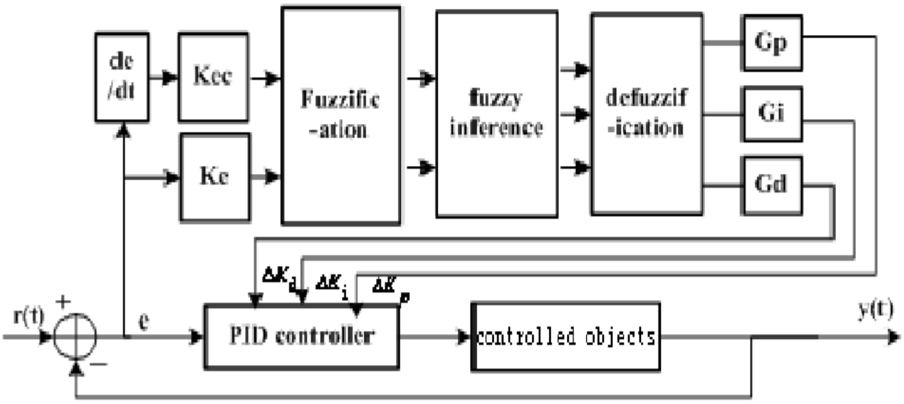

Figure 5. The structure diagram of fuzzy PID controller.

Establishment of the fuzzy rules

Linguistic values used in this paper are the following 7 linguistic variables: NB (Negative Big), NM (Negative Middle), NS (Negative Small), ZO (Zero), PS (Positive Small), PM (Positive Middle), PB (Positive Big), the corresponding fuzzy sets as {NB NM NS ZO PS PM PB}. The controlled object in this paper is permanent magnet linear synchronous motor. In order to meet the requirements of control precision and response speed, it is necessary to reduce the overshoot as well as to improve the response speed and stability of the whole system when the control rules are established [6]. According to the expertise, the fuzzy rules about K_p, K_i, K_d of the fuzzy controller can be obtained as shown in the following tables:

Table 1. The fuzzy rules about ΔK_p

E / ΔE	**NB**	**NM**	**NS**	**ZO**	**PS**	**PM**	**PB**
NB	PB	PB	PM	PM	PS	ZO	ZO
NM	PB	PB	PM	PM	PS	ZO	NS
NS	PM	PM	PM	PS	ZO	NS	NM
ZO	PM	PS	NS	ZO	ZO	NS	NM
PS	PS	PS	ZO	NS	NS	NM	NM
PM	PS	PS	NS	NM	NM	NB	NB
PB	NS	ZO	NM	NM	NB	NB	NB

Table 2. The fuzzy rules about ΔK_i

E / ΔE	**NB**	**NM**	**NS**	**ZO**	**PS**	**PM**	**PB**
NB	NB	NB	NM	NM	NS	NS	ZO
NM	NB	NB	NM	NS	NS	NS	ZO
NS	NB	NM	NS	NS	ZO	PS	PM
ZO	NM	NM	NS	ZO	ZO	PS	PM
PS	NM	NS	ZO	PS	PM	PM	PB
PM	ZO	ZO	ZO	PS	PM	PM	PB
PB	ZO	ZO	PS	PM	PM	PB	PB

Table 3. The fuzzy rules about ΔK_d

E / ΔE	**NB**	**NM**	**NS**	**ZO**	**PS**	**PM**	**PB**
NB	PS	NS	NB	NB	NB	NM	PS
NM	PS	NS	NB	NM	NS	NS	ZO
NS	ZO	NS	NM	NM	NS	ZO	ZO
ZO	ZO	ZO	NS	NS	NS	NS	ZO
PS	NS	NS	ZO	ZO	ZO	ZO	ZO
PM	PB	NS	PS	PS	PS	PM	PB
PB	PB	PB	PM	PM	PS	PS	PB

Carry on the fuzzy inference operations using relation generation rule based on Mamdani fuzzy algorithm and new inference synthesis rule in accordance with the above three tables of the fuzzy rules. Finally, defuzzify on the basis of gravity method, and then the three parameters K_p, K_i, K_d can be set dynamically.

Simulation of the system

Based on the structure diagram of the whole linear motor control system, simulation model of each module is established on Simulink platform. Then connect each module to create an entire linear motor under the requirements of the entire control system, the whole simulation model diagram of the control system is shown in Figure 6. Compare with the conventional PID and the fuzzy PID control strategy in the simulation analysis, that is to say two different control strategies are used in the location of velocity close-loop. The better control effect is determined through comparing the speed response curves of the two different control strategies.

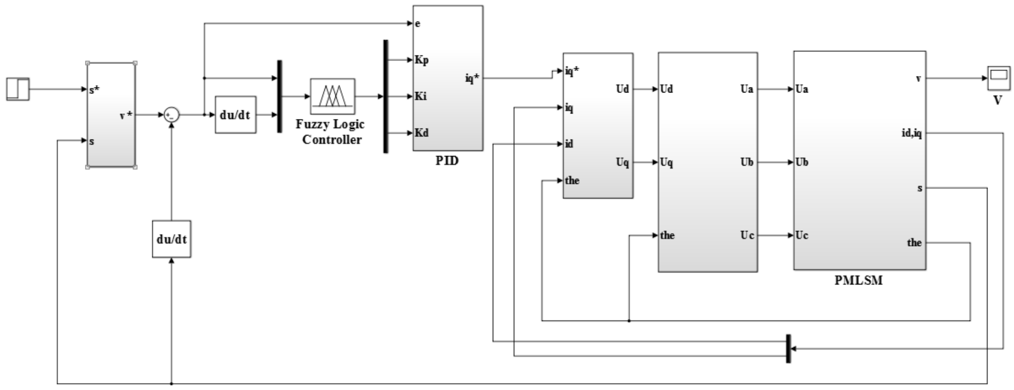

Figure 6. The fuzzy PID simulation system of linear motor.

The simulation parameters of PMLSM are set as follows:

$\Psi_{PM} = 0{,}085 V.s$, $\boldsymbol{\tau} = 33$ ***mm*** , $\boldsymbol{B.v} = 0{,}2$ ***N.s / m*** , $L_d = L_q$ $L = 0{,}007 = H$, $M = 8kg$, $r = 2.3\ m$

Only the speed response curves are analyzed in this simulation experiment. First of all, in the situation without load, the simulation time is set to 0.5s and the motor velocity is set to 1m/s. The simulation results is shown in Figure7, it concludes that the overshoot is 0.15 and stability time is 0.1s of the conventional PID control system, while the overshoot is nearly zero and stability time is 0.05s of the fuzzy PID control system. Through comparative analysis, the fuzzy PID controller responses faster and has smaller overshoot than conventional PID controller.

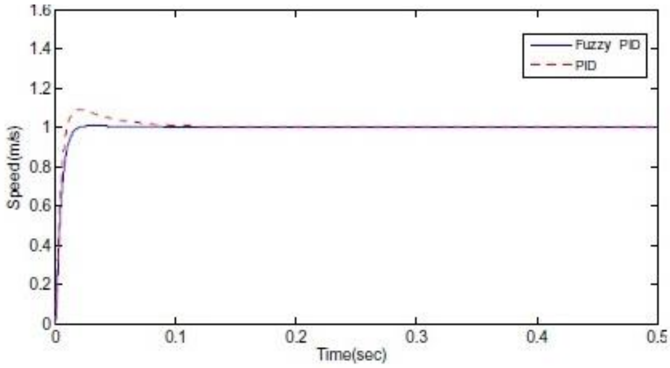

Figure 7. The speed response curves without load.

There are kinds of interference in the process when the electric motor runs, the anti-jamming capability of the control system plays a decisive role in determining whether the precision of the linear motor can meet our requirements, and it’s also one of the key elements determining the performance of the control system. In the following parts, the interferential noise is added to the velocity close-loop of the simulation system to detect its anti-interference capability. The simulation time is set to 0.5s while the velocity maintains 1m/s. The velocity response curves are shown in Figure 8, got by using PID control and fuzzy PID control respectively in the velocity close-loop. Through analysis, it indicates that disturbances of the response curves are obviously slighter by using fuzzy PID control system than by using PID control system. In addition, both the response time and overshoot of the former are less than those of the latter. It can be concluded that the fuzzy PID control system deals with the interference of the external

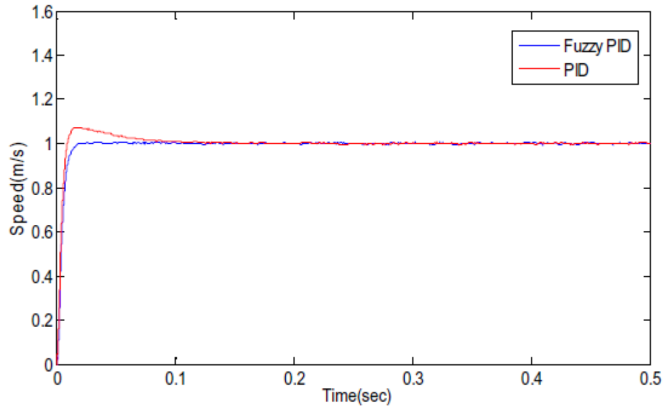

Figure 8. The velocity response curves with disturbances.

In order to further prove the anti-interference capability of fuzzy PID is better than the PID control system, the following simulation experiment is carried on: the simulation time is set to 1s and the velocity is set to 1m / s. After adding 50N load resistance to the system when t=0.5s, it gets the simulation result shown in Figure 9, which indicates that the velocity of the conventional PID controller fluctuates within 10% when t=0.5s, and it needs 0.12s to restore. By contrast, the velocity of the fuzzy PID controller fluctuates within 3% when t=0.5s, and it needs 0.1s to restore. Fuzzy PID controller obviously has faster speed of response on condition that external load is added, and need shorter response time to reach a steady state.

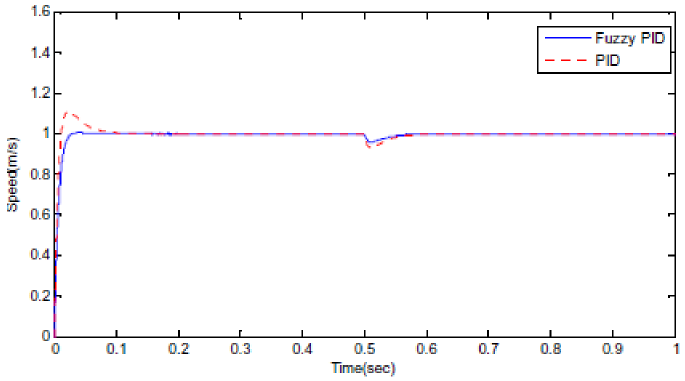

Figure 9. The velocity response curves with load.

From the above three simulation experiments, it concludes that fuzzy PID controller has better static and dynamic characteristics as well as anti-jamming capability in comparison to conventional PID controller. Thus as to the PMLSM mentioned in this paper, without any change in other close-loops, the velocity close-loop using the fuzzy PID controller would make the electric motor response fast and run stably, which can achieve the purposes of control well.

CONCLUSION

Because of the non-linearity of the PMLSM, and the influence of some uncertain factors such as load disturbance, the conventional PID control system is difficult to live up to the ideal control performance. This paper puts forward a set of adaptive fuzzy PID control system to tune the parameters on-line, for example, the proportion, integration and differentiation, according to the characteristics of linear motor combined with the conventional PID and fuzzy algorithm. The control system is characteristic of simple structure and convenient use of PID control on one hand, and has the advantages of great flexibility and adaptability of fuzzy control on the other. The simulation results indicates that the adaptive fuzzy PID control system is a good control method, which is excellent in the control performance, capable of reducing the overshoot and has high control precision. The simulation experiments have proved conclusively that the control system is feasible for the PMLSM.

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PROCESS OF STARTING UP HOT WATER BOILERS – ANALYSIS OF DYNAMIC BEHAVIOUR

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Abstract: This paper presents mathematical - empirical model of the hot water boilers in transient regimes. The dynamic behaviour of the boiler will be discusses in mode of starting up, as one of the most critical transient modes. On the basis of presented model a case study is done for hot water fire tube boilers manufactured by "Minel – Kotlogradnja" and "Djuro Djaković – Slavonski brod". Three different boilers, different capacity and fuel used, were analysed in this paper. Hot water boilers represent in general the most commonly used central units in district heating system. In recent years the main focus is on the analysis of reliability, safety and efficiency of their operation. Considerable exploitation experience and former development have indicated the new demands and possibilities of using hot water boilers, both in the municipal heating plants and in the process industry. Today, it is not only expected to have efficient operation in terms of energy efficiency of primary fuel use, but also there are a number of strict requirements in terms of cost-effective, reliable and safe operation.
Key words: hot water boiler, start up, dynamic behaviour, transitional operating modes

INTRODUCTION

Hot water boilers operate in condition of high temperature and pressure, so that in addition to their efficiency, it is needed to be considered and their system safety and reliability, in order to avoid the major disruption and downtimes [1]. During operation of the boiler plant, its basic elements are exposed to the effects of high pressure and temperature of the working fluid, and very often the aggressive action of the heat transmitter and heat receiver. In addition, sometimes stresses occur caused by thermal expansion of individual elements or assemblies. These stresses are typical for large boiler load, especially in transient processes, such as starting up, stopping and load changing [2].
Failures of the boiler piping system of thermal power plants represent an important parameter in defining the reliability, availability and efficiency of the plant. As an example it can be mentioned the results of research conducted by the North American Electric Reliability Council, which have shown that with the failures of boiler piping system it can be caused an average decrease plant availability of over 6% [3]. Failures of the boiler piping system represent the primary cause of delays of thermal plants. More than 80% of such failures result in unplanned downtime, where the average downtime lasts three days and causes high costs [3].
As one of the most critical mode, it is considered that is the starting up of the boiler plant, where there is the greatest thermal stress in the elements of boiler. Thermal stresses are the results of temperature caused by differences in the structure of the boiler. This is due to high time gradients of temperature of combustion products during the process of starting up the boiler. Thermal stresses are particularly high in certain parts of the thick walls of the boiler, where it appears the greatest temperature difference. As far as the hot water boiler it is pipe plate of the first deflecting chamber. On this plate, it is noted, the numerous accidents have occurred. This paper presents methods of determining the basic operating parameters of the process of starting up the boiler. Based on the described methods it is analyzed the dynamic behaviour in the process of stating up the boiler of three different hot water fire tube boilers: type TE110V manufactured by "Minel - kotlogradnja", type Optimal 800 and boiler type Optimal 2500 manufactured by "Djuro Djaković – Slavonski brod".

THE PROCESS OF STARTING UP THE BOILER

When the steam boiler starts the combustion chamber is partially filled with flame. Flame of some burners in size and shape depends on the structure and strength of the burner. Burner ignition and fuel that is used in these cases (oil, gas) should ensure the normal operation of each burner independently of the total load of the combustion chamber. Insufficient flame fulfilment of the combustion zone leads to the not all fuel particles are under condition suitable for ignition and complete combustion. Due to the low temperatures in the combustion chamber during the process of starting up, insufficient mixing fuel with air forms a large amount of soot, and the most massive drops of fuel oil, which do not come into the combustion zone, are cooled in stream of cold air and flue gases and as unburned, go out from the combustion chamber. This leads to the decrease of efficiency of combustion chamber and unfavourable working conditions. Terms of ignition and combustion of fuel are also getting worse because of the wall temperature of the combustion chamber [4].

In the process of starting up the hot water boiler, the problem is much simpler. There is a great similarity to the problem that is presented by Cwynar, but the hot water boilers have only one burner and as far as the combustion chamber, its role has the flame pipe. Problems that may occur in this case are due to possibility of tearing the flame and damaging the boiler structure at the end of the flame tube.

From the above mentioned it follows that the considered conditions during the process of starting up the boiler depend on many parameters, which are determined by construction of the burners and combustion chamber and their technical condition, and also the organizational chart of the process of starting up and heat state of the boiler. In the process of starting up the boiler, it is necessary to determine the changes in the following basic values related to the operation of the combustion chamber: the amount of heat that is released in the combustion chamber, temperature and the flow rate of combustion products that leaves the combustion chamber. For their determination it is needed to be known the change of properties of combustion chamber efficiency η_c^r, excess air ratio λ^r and temperature of combustion products ϑ^r.

EFFICIENCY OF THE COMBUSTION CHAMBER AND COEFFICIENT OF EXCESS AIR RATIO DURING THE PROCESS OF STARTING UP THE BOILER

Efficiency of the combustion chamber during the process of starting up the boiler is changed with the load change, depending of the coefficient of excess air and the changing conditions of ignition and combustion of fuel. Load change of combustion chamber in the process of starting up the boiler is determined by the variable u_Q. Value u_Q represents the ratio of the current boiler load and nominal load.

$$u_Q = \frac{Q^r}{Q^z} \tag{1}$$

Therefore the efficiency of the combustion chamber during the process of starting up, in the wide range of load change, can be described by [4]:

$$\eta_C^r = 1 - S^z / u_Q \tag{2}$$

where $S^z = 1 - \eta_C^z$ represents the loss in the combustion chamber during the nominal load.

Graphical representation of change of combustion chamber efficiency, eq. (2), for some values of S^z can be seen on Fig. 1.

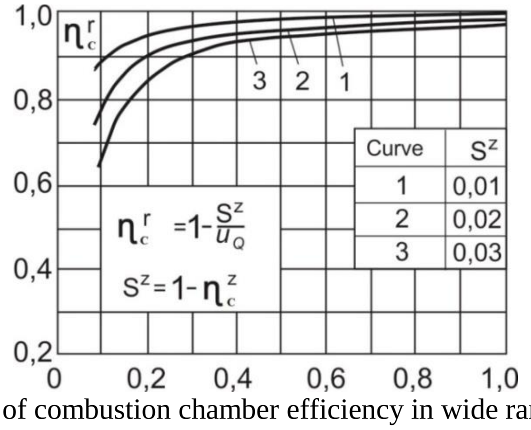

Figure 1. Change of combustion chamber efficiency in wide range boiler load [4]

Coefficient of excess air during the starting up the boiler λ^r is defined by the following assumptions [4]:

- starting up the boiler is carried out at constant sub-pressure in the combustion chamber, which is equal to the vacuum, which is maintained in stationary mode.
- suction of the "waste" air from the atmosphere, which depends of the degree of non-hermetic properties of boiler, it is considered as constant value that is determined by the constructive scheme of the fuel supply and technical condition of the boiler.

According to this assumptions, the mass flow of intake air L_f, entering in the combustion chamber from the environment, during the starting up of the boiler is approximately equal to the air suction in the combustion chamber at nominal load, $L_f^z = L_f^r = L_f$. For nominal load applies:

$$\lambda^z = \lambda_1^z + \lambda_f^z \tag{3}$$

where: λ_1^z - coefficient of excess air in nominal mode;

$\lambda_f^z = n_1 \lambda_1^z$, n_1 – coefficient which characterize non-hermetic properties of the lower level of combustion chamber (known from the calculations or measurements).

According to the mass balance in the burner zone during the process of starting up the boiler and the mathematical procedure presented in [4,5,6] the following equation for the coefficient of excess air in the burner zone during the starting up the boiler can be conducted:

$$\lambda_p^r = \lambda_1^r \left(1 + n_1 / u_Q\right) \tag{4}$$

Graphic dependence of the coefficient of excess air during the process of starting up the boiler λ_p^r as function of the u_Q of different values $\lambda_1^z = \lambda_1$ and n_1 are presented in Fig. 2.

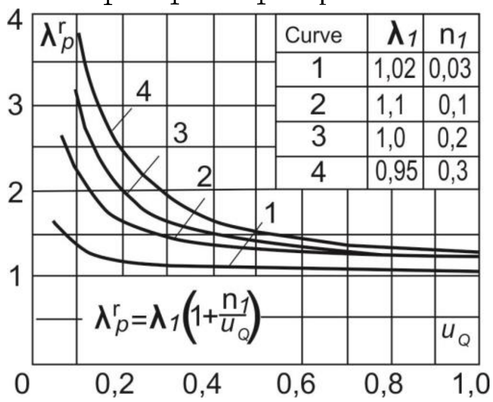

Figure 2. Characteristics of excess air ratio in the wide range of boiler load [4]

METHODS FOR DETERMINING THE AMOUNT OF HEAT DURING THE COMBUSTION PROCESS AND TEMPERATURES OF COMBUSTION PRODUCTS IN THE COMBUSTION CHAMBER DURING THE PROCESS OF STARTING UP THE BOILER. CWYNAR'S METHOD [7, 8].

The method is based on the assumption that on the basis of measurements or calculation results are known the basic parameters, which describes the process of heat transfer in the combustion chamber, for all stationary states of boiler operation. Knowing the function that describes the change of specific parameters for different boiler load [5, 6], can be analytically extrapolated to the area of low load. Occurred failure during this procedure depends of the range and accuracy of the known values of the parameters for medium and nominal load.

The function that describes the change in amount of heat, which receive screens of combustion chamber during the process of starting up the boiler, can be determined form the equation:

$$Q_0^r = N_0 \varphi^r a_F^r \left[\left(T_G^r / 100\right)^4 - \left(T_n^r / 100\right)^4\right] \tag{5}$$

$$T_G = \sqrt{T_t^r T_2^r}; T_t^r = \vartheta_t^r + 273; T_2^r = \vartheta_2^r + 273; T_n^r = t_n = 273 \tag{6}$$

Where: φ - parameter, which characterize the position of burners compared to the basic position and a_F - coefficient of flame emission. In accordance with the assumptions it is known the following parameters $Q_0^z, \vartheta_t^z, \vartheta_2^z, a_F^z, \varphi^z$ or their dependence in certain range of loads.

Knowing the dependence $N_0(u_Q)$ it can be conducted the value for the heat flow that is received by the irradiated surfaces of the combustion chamber, that written in the form [5,6,7]:

$$Q_0^r = N_0 \varphi^r a_F^r \left\{ \left[\left(\vartheta_t^r + 273 \right) / 100 \right]^2 \left[\left(\vartheta_2^r + 273 \right) / 100 \right]^2 - \left[\left(t_n + 273 \right) / 100 \right]^4 \right\} \quad (7)$$

The theoretical combustion temperature in the process of starting up the boiler ϑ_t^r can be determined from the known dependence [9]:

$$\vartheta_t^r = \left(Q_w^r \eta_C^r + \lambda_p^r L_t^r \bar{c}_L \bar{t}_L^r \right) / V_{Gp}^r \, \bar{c}_{Gp} \quad (8)$$

The temperature of the combustion products, which leaves the combustion chamber ϑ_2^r, in the process of starting up the boiler can be determined from the heat balance equation :

$$Q_C^r - Q_0^r - Q_G^r = 0 \quad (9)$$

$Q_c^r = u_Q Q^z = u_Q b^z (Q_w^z + \lambda_1 L_t^2 i_L^z)$ - the heat generated in the combustion chamber;
$Q_G^r = V_G^r c_G^r (T_2^r - 273) b^r$ - the heat quantity of gases that leaves the combustion chamber.

GURVICH'S METHOD FOR DETERMINING THE AMOUNT OF HEAT DURING THE COMBUSTION PROCESS

According to the carefully thought empirical method of A. M. Gurvich for determining the heat exchange in the combustion chamber, the temperature of the combustion products that leaves the combustion chamber is given with the following equation:

$$\vartheta_2^r + 273 = \left(\vartheta_t^r + 273 \right) \left(Bo^r \right)^{0,6} / \left[M \left(a_F^r \right)^{0,6} + \left(Bo^r \right)^{0,6} \right] \quad (10)$$

where:

$$Bo^r = \left(10^8 / 4.9 \right) \left\{ b^r V_G^r c_G^r / \left[\xi H_{opr} \left(\vartheta_t^r + 273 \right)^3 \right] \right\} \quad (11)$$

$$M = A - BX \quad (12)$$

In the last equation is $A = 0{,}59; B = 0{,}5$ for coal combustion and $A = 0{,}52; B = 0{,}3$ for fuel oil or gas combustion; $X = X_0 + \Delta X$, where $X_0 = h_1/h_2$, h_1- height of the combustion chamber from the floor up to level of the maximum flame temperature (when the boiler starts - up to the level of burners position), h_2 - full height of the combustion chamber; ΔX – correctional member, which takes into account the distribution of burners position, their tilting angles, the quality of minced coal etc. (detailed data for ΔX and coefficient of flame emission a_F, can be found in [9]).
Knowing the temperature of the leaving flue gases ϑ_2^r from eq. (10), their flow and heat quantity brought into the combustion chamber $Q_c^r = u_Q Q_c^z$, it can be determined the heat quantity Q_0^r, received by the screens of the combustion chamber (according to eq. (7)).
If the values $Bo^u, b^u, V_G^u, \vartheta_t^u, c_G^u$ are known for variable boiler load, it can be determined the Boltzmann constant as condition for starting up the boiler:

$$Bo^r = Bo^u \frac{b^r V^r c_G^r}{b^u V^u c_G^u} \left(\frac{\vartheta_t^u + 273}{\vartheta_t^r + 273} \right)^3 \quad (13)$$

CASE STUDY - THE PROCESS OF STARTING UP THE BOILERS

As reference objects three different hot water boilers manufactured by “Djuro Djaković - Slavonski brod” and „Minel – kotlogradnja“ were taken. Their technical data is given in Table 1.

Table 1. Technical data of the boilers

	Djuro Djaković - Slavonski brod		***Minel – kotlogradnja***
The parameters	**Optimal 800**	**Optimal 2500**	**TE 110V**
Used fuel	Oil fuel	Natural gas	Natural gas
Capacity	5,38MW	16,96MW	8,7MW
Efficiency	0,87	0,91	0,91
Operating pressure	12,5 bar	15,7 bar	12 bar
Total surface for heat transfer	136,5 m2	434,7 m2	351 m2
Water content in boiler	10,845 m3	40 m3	27,8 m3

The boilers are shaped as a cylindrical tube, closed with chambers on both sides and thermally insulated all over the volume. The boilers have three pressurized gas channels. The flame pipe (first pass), located in the pressurized water body, is heated by thermal energy generated by combustion of natural gas. After combustion, exhaust gasses pass through a diverter chamber coated by water piping, go into the second pass gas piping (II pass gas pipes), placed above the flame tube. On the front side of the boiler is a frontal diverting chamber that redirects the exhaust gasses and leads them into the third pass gas piping, located on the sides of the boiler (III pass gas pipes). After leaving III pass gas pipes, exhaust gasses splash the water-cooled front of the diverting chamber, passing through the deflection chamber and then leaving the chamber through the chimney. During operations hot water boilers are completely filled with water normally. Boiler Optimal 2500 has two flame pipes but construction of gas flow remain the same as for flame-tube three pass boiler, as well as the boiler Optimal 800 and TE110V.

In order to observe the process of starting up the hot water boilers and based on the procedures set forth above, it is necessary to take into account the actual parameters of the technical documentation and based on them to conduct the appropriate calculation. Based on the above mentioned procedure it may be determined the value of combustion chamber efficiency at different heat load. As it can be seen on the Fig. 3, it will be considered the heat load from 10% to 100% compared to the total heat load of the combustion chamber. The procedure set out in previous section allows that at different heat loads of combustion chamber can be adopted different coefficient of excess air during the process of starting up the boiler. To determine the quantity of generated heat, the combustion temperature and temperature of flue gases that leaves the combustion chamber in the process of starting up the boiler are used both above exposed methods. According to the Cwynar's method [4] can be determined theoretical combustion temperature in the process of starting up the boiler. Graphical dependence of theoretical combustion temperature is presented in Fig. 4. Using the Gurvich's method is determined the temperature of flue gases that leaves the combustion chamber, this graphical dependence is shown in Fig. 5.

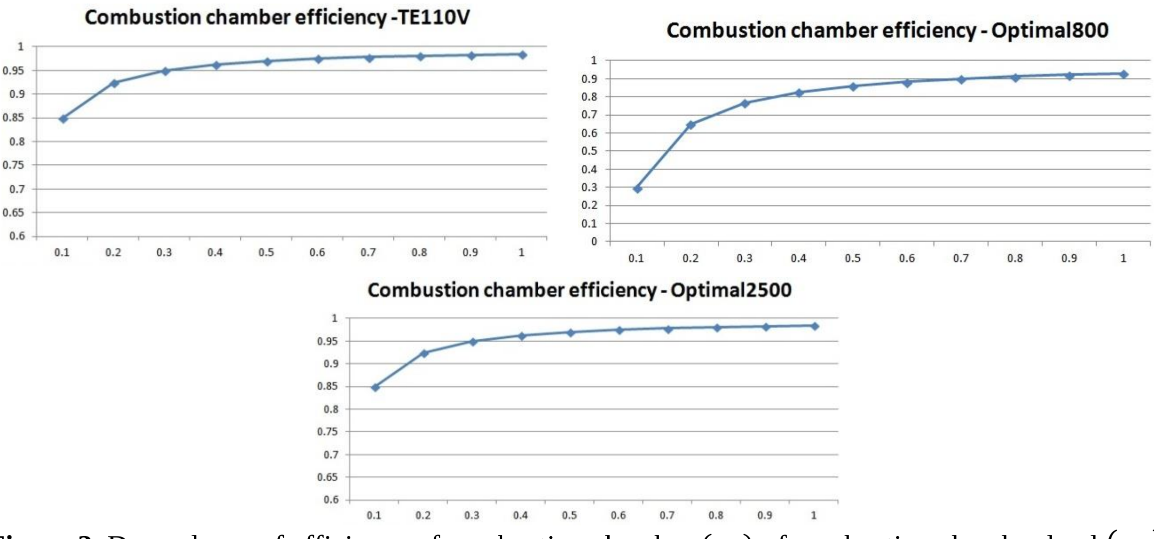

Figure 3. Dependence of efficiency of combustion chamber (η_F) of combustion chamber load (u_Q)

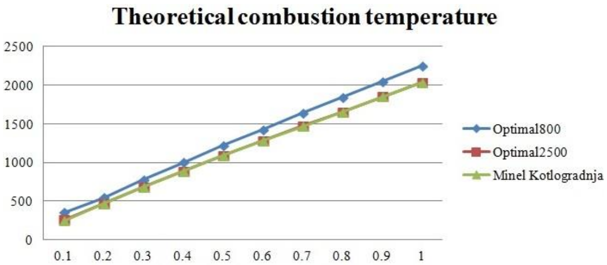

Figure 4. Dependence of theoretical combustion temperature (ϑ_t^r) of combustion chamber load (u_Q)

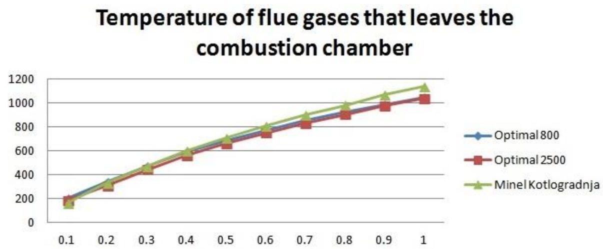

Figure 5. Dependence of combustion products temperature which leaves the flame pipe (ϑ_2^r) of combustion chamber load (u_Q)

CONCLUSION

The most sensitive elements of the hot water boilers are certainly the pipe systems. They mainly affect the reduction in the availability, reliability and time utilization, and even in energy efficiency. Stresses in hot water boiler elements, subjected to high pressure of the working fluid, are substantially different from the stresses occurring in other machines and objects. The difference is primarily that the stresses in the boiler elements are not only the result of the external forces but also internal as well, which depend on number of structural details, as well as technological and exploitation factors. In addition, many of the elements of the boiler are exposed to very high temperatures and variable loads, which can cause, especially in the transitional operating mode, extremely high stresses. Damages of the pipes of heating surface both the hot water and steam boilers, especially those with greater capacity are rare. They occur usually sudden and can have devastating consequences. They can be prevented only by careful handling and maintenance of the plant and expert monitoring of phenomena and processes in exploitation in built-in screen pipes [13, 14].

In previous studies of the availability of boilers and its models it is needed that the main focus is in condition of ignition and combustion in combustion chamber, as well as in operation of burners and flame pipe in regimes that differ from the nominal. However, describe conditions, as well as the heat transfer at low loads (less than 40%) haven't been so far sufficiently explored. This paper presents the methods of determining the basic parameters that characterize fuel combustion and heat transfer in the combustion chamber. It is also analysed, based on the presented procedure, the process of starting up different boilers, not only in capacity but also in type of used fuel. There are also graphical representation of parameters changing depending on the heat load. Observed method allows to see changes all relevant characteristics of the mode from 0% of load up to nominal. Further analysis of the mathematical model of the combustion chamber, with the use of the obtained data will give us completely quantitative analysis of the process of starting up the hot water boilers.

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ABOUT "THE QUALITY ASSURANCE" AND "THE QUALITY CONTROL" TERMS IN THE ROLLS MANUFACTURING

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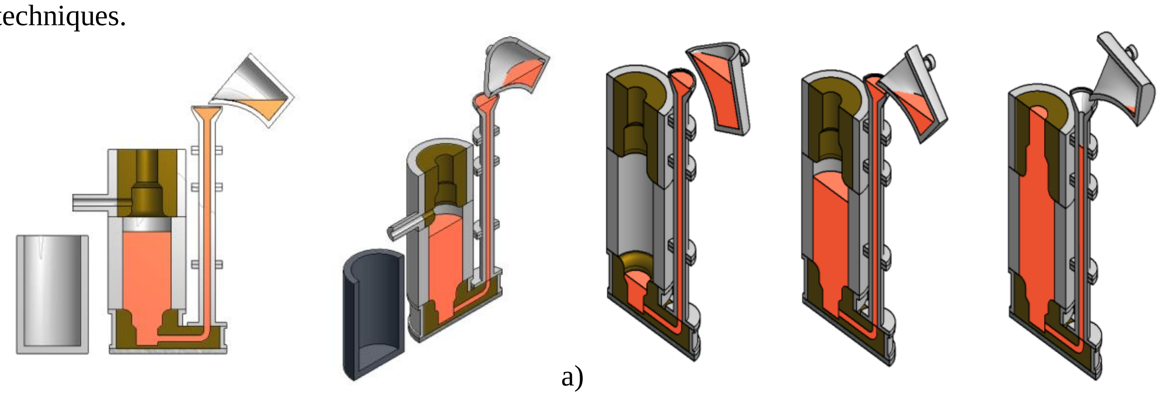
Abstract: Quality assurance is the activity of providing evidence needed to establish quality in work, and that activities that require good quality are being performed effectively. All those planned or systematic actions necessary to provide enough confidence that a product or service will satisfy the given requirements for quality. Quality assurance covers all activities from design, development, production, installation, servicing and documentation. It includes the regulation of the quality of raw materials, assemblies, products and components, services related to production, and management, production, and inspection processes. The terms "quality assurance" and "quality control" are often used interchangeably to refer to ways of ensuring the quality of a service or product. The terms, however, have different meanings.
Key words: quality assurance, rolls manufacturing, laboratory research, mathematical modeling

SHORT REWIEW OF THE ROLLS MANUFACTURING

Rolls are the most important means of hot– and cold–forming bulk products in the ferrous industries. The concept and introduction of rolling mills made the forming of large quantities of metal economically feasible. Rolling mill construction and the art of rolling experienced a sharp growth when production of steel in molten form began and, along with improvements in roll materials, have remained closely connected with the development of the steel industry.
From the standpoint of materials, the above line–up of rolls for hot–rolling remained unchanged although advancing metallurgical and material developments improved the quality significantly. Roll producers learned how to improve the cast–steel rolls by suitable heat treatment and to adapt cast–iron rolls to specific applications by properly balanced charges and further advances in modeling techniques.

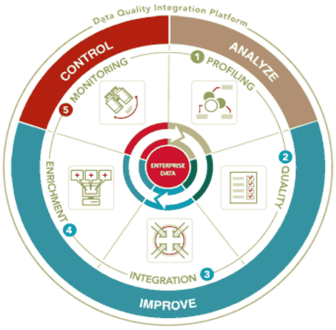


a) b)

Figure 1. The rolls'casting technology: a) the casting equipment; b) the casting phases

Alloying additions for cast–iron rolls probably first came into consideration for rolling sheet, where improvements in the surface of the hot–rolled product were especially necessary. Subsequently it was found possible to increase the performance of shape rolls also by alloying. The innovations in rolling mills placed unprecedented requirements on rolls and users demanded better surface quality on the rolled products, which were often high–strength and therefore difficultly workable steels. Thus, the rollers insisted on longer roll life. Further improvements in the existing types of rolls were made and new roll materials were developed. Today, the roller has available a number of roll types but it is not always simple to select the best one.
The rolls must present high exploitation qualities, which are determined from the hardness, resistance and high temperature stability. These qualities guarantee the high resistances at wear in the dried friction conditions and the unexpected temperature variation stability in the rolling operation. In

addition, they assure the resistance at the thermal fatigue, (because the rolls are heated at the contact with the laminate), high resistance at the thermal shock stress, and the bending strain resistance. Also, the rolls must assure the clamping of materials, as well as the high quality of the laminate surface.



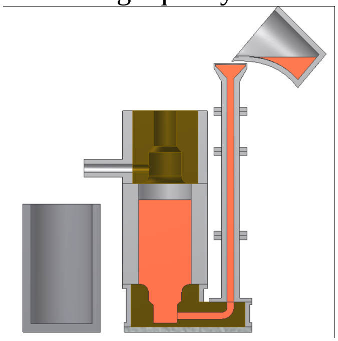


Figure 2. The Quality control phases

Quality of rolls is determined through hardness and through wear resistance, last index having a special importance for all modern rolling mills with a growth production. Of major importance for the rolls exploitation is not merely growth resistance, but also the ability to oppose to different types of wear. Thus, rolling mill rolls considerable influence the specific production and the qualitative level of laminates, reason for which they are given a special attention, in manufacturing, as well as in usage. These requirements can not be completely fulfilled, compelling to the granting of priorities depending on the type of laminates, therefore to compromises. At large, the problem is reduced to the correct material choice, eased by the rich available experience in the current conditions of manufactured and burdened, in the same time, by the large diversity of material used.
Although the manufacture of rolls is in continuously perfecting, the requirements for superior quality rolls are not yet completely satisfied, in many cases, the absence of quality rolls preventing the realization of quality laminates or the realization of productivities of which rolling mills are capable.
To the selection of materials is considered the type of rolling mill, the sizes of rolls (in specially this diameter), the speeds of lamination, the stands from the train of lamination for which is achieved rolls, the working temperature in the lamination process, the module of cooling during work, the size caliber, the pressure on rolls, the rolled material hardness, etc.
The choice of material for rolls is the operation which takes into consideration the own solicitations of the lamination process afferent to the type of rolled products, and the features of different materials considerate optimum in the fabrication of different typo–dimensions of rolls.

"QUALITY ASSURANCE" AND "QUALITY CONTROL"

The terms "quality assurance" and "quality control" are often used interchangeably to refer to ways of ensuring the quality of a service or product. The terms, however, have different meanings.
- ✓ *Assurance:* The act of giving confidence, the state of being certain or the act of making certain.
- ✓ *Quality Assurance:* The planned and systematic activities implemented in a quality system so that quality requirements for a product or service will be fulfilled.
- ✓ *Control:* An evaluation to indicate needed corrective responses; the act of guiding a process in which variability is attributable to a constant system of chance causes.
- ✓ *Quality Control:* The observation techniques and activities used to fulfill requirements for quality

Figure 3. Quality Assurance (QA) vs. Quality Control (QC)

The difference is that QA is *process* oriented and QC is *product* oriented. *Testing*, therefore is product oriented and thus is in the QC domain. Testing for quality isn't *assuring* quality, it's *controlling* it.

- ✓ Quality Assurance makes sure you are doing the right things, the right way.
- ✓ Quality Control makes sure the results of what you've done are what you expected.

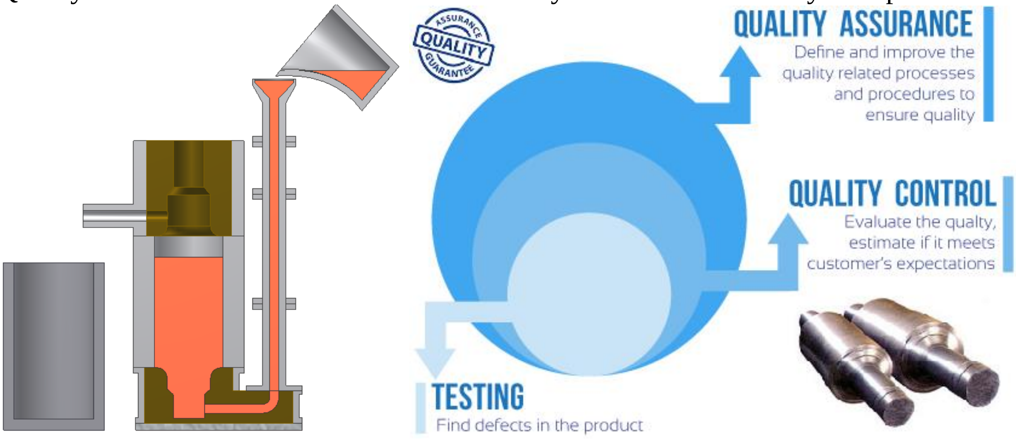


Figure 4. Quality Assurance vs. Testing

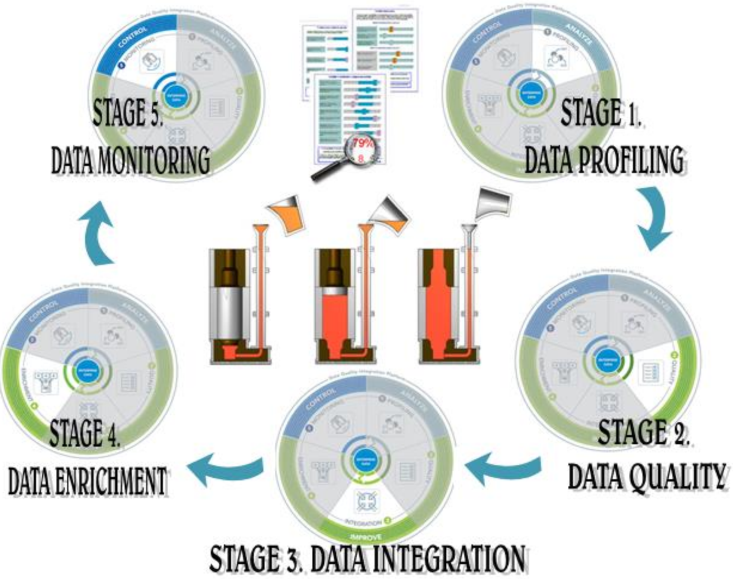


Figure 5. Quality assurance phases in the rolling industry (general flow)

Quality control is a process that is used to ensure a certain level of quality in a product or service. Most often, it involves thoroughly examining and testing the quality of cast rolls. Basic goal of this process is to ensure that the cast rolls that are provided meet specific requirements and characteristics, such as being dependable, satisfactory and safe. The goal of the quality control team is to identify products that do not meet a company's specified standards of quality. If a problem is identified, the job of a quality control team or professional might involve stopping production (casting) until the problem has been corrected. Depending on the particular product as well as the type of problem identified, production or services might not cease entirely. Usually, it is not the job of the quality control team or professional to correct quality issues. Typically, other individuals are involved in the process of discovering the cause of quality issues and fixing them.

CONCLUSION

Often, "quality control" is confused with "quality assurance". Though the two are similar, but there are some basic differences. Quality control is concerned with examining the product (in our case, the rolling rolls). The quality assurance is concerned with examining the process that leads to the end result (the cast product). A company would use quality assurance to ensure that a product is manufactured in the right way, thereby reducing or eliminating potential problems with the quality of the final product (rolls).

In the rolling industry, the quality of the product (of the rolls, in this case) is in directly accordance with the quality of technologies (defined by the casting equipments, materials, applied procedures, etc), and also, by the quality of the manufacturing process (charging, melting, inoculation, ladle treatment, casting, cleaning etc). Assuring quality is about confidence. It's about the processes by which we go about doing what we do. Part of that knows that we're doing the right things at the right time, and part of it is that we are doing them the right way. This all should be done or known before we start working, not afterwards. "Assurance" means that you know you did everything needed to make something that works right, while "control" means that you have no idea whether any or all of your processes are worth anything until we will examine each item. In this way, the terms "assurance" mean process-related and the "control" mean product-related.

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Session 12.

Student papers

CAD/CAM TEHNOLOGY IN DESING PACKING

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Abstract: CAD/CAM technology is the basis of the modern development of products and processes. Presence of CAD/CAM technology in the industry is highly expressed, because they represent a synthesis of a number of scientific- technical - technological disciplines. The design and packaging construction of a product play a vital role in determining the expiration date of a product. The right choice of packaging materials and packaging technology maintain product quality and keep the product in good condition during storage and distribution. Packaging is no longer used only for transport of goods to distant markets, but is an important factor when selling products to customers.
Key words: CAD/CAM technology, materials, packing, product.

CAD/CAM TEHNOLOGY

Development techniques has a provided engineers a powerful tool to facilitate the work and improve quality. The development of computer technology has enabled the efficient solution of problems of design. CAD (Computer Aided Design) or "design supported by computer" is highly advanced in recent decades, and the effects began to be felt in every phase of construction and design. If ever the technique was something that could be considered a revolution, then it is CAD. The concept of "design supported by computer" is a term that was introduced in 1956. T. Ross at MIT (Massachusetts Institute of Technology) in Boston in the development of programming language APT (Automatically Programmed Tools).
Application of computers in designing and constructing provides complete computerization of the production process, which is the primary goal of modern production. Correlation and the availability of data necessary for the production enable rapid development of high quality and inexpensive products.
Modern development and production of products is one of the key prerequisites for survival and success in the global market, which includes the use of modern CAM (Computer Aided Manufacturing) software. Production using a computer is applied in solving various engineering, research and development and industrial problems. CAM systems are software tools that support the extensive use of computers for planning and design of production and technological processes and operations and production management and production processes. Today there are a large number of high-quality software packages. Companies may not have the time but the opportunity to fully explore new tools and use them in the design of the production process. New technologies are developing rapidly aggravating the user to know about the advantages offered by the system.
The use of CAD/CAM software contributes to better design, faster and better production in enterprises. It turned out that in the eighties production has become dependent on all systems to solve critical problems. Complex parts can quickly design with the help of software that allows the user a visual representation of parts and dimensions using CAD. CAD software programs can ensure the compatibility of all components and their checking and allows you at any time we add another part. CAM software programs allow complex parts work by calculating tools and writing code for their production on CNC machines such as milling machines and lathes. Human error is reduced and high accuracy is achieved in the production of parts that would be difficult to create manually. There are companies on a global and local level, use of outdated packages for design and production. Technology is changing rapidly, and most companies cannot keep the changes. In today's global market, the production relies on new technologies that greeted the current market trends. Today, the company relies on a CAD / CAM system that would facilitate and perfected the development of complex parts. The progress of this system consists in the effort manufacturers to communicate with suppliers and take advantage of the software.

THE DESING AND MATERIALS

The meaning of the word design is a drawing, blueprint, pattern or a project. The design is used as a replacement for: technical aesthetics, industrial aesthetics, industrial design and modeling. Technical aesthetics refers to aesthetics of technical products. The industrial design refers to the activities of creating the shape of a product. Modeling a product indicates the formation of the final product as a model. When it comes to design the next terms should be distinguished: Industrial design (design of cars, household appliances, furniture, phones, clothes, toys), graphical design (design of books, posters and packaging), web design, fashion design, jewelry design, design of ceramics and glass and eco-design. [4]

Materials are substances of which something is composed or made. Under substance it is assumed for example: pure metal, chemical compound or a group of substances or alloys. Materials relevant to technology should meet the following criteria: to have technically usable qualities in at least one state of matter and to be technologically and industrially reproducible. Materials that are traditionally used for packaging include: glass, metals, paper, cardboard, wood and plastics. Several different forms of plastics is used in rigid and elastic form. Today's packaging is often made up of several materials to take advantage of functional and aesthetical benefits of each material. [4]

Scientific and technical discoveries improved the technologies and materials for packaging. Small-sized cubes, aluminum tubes and packaging made of foil products are designed to provide protection, comfort, affordability and longer expiration dates. [4]

Manufacturers with many branded products have come to acknowledge the need for engineers to be part of the development team for wrapping and packaging of a product and the designers the marketing team. The demand for convenience and valuable products has dictated many aspects of the development of materials and marketing. The need for efficiency, reusability and the environmental concerns also gained in importance as a reflection of changes in the values of consumer society. [4]

The packaging is today fully integrated in overall development strategy of a company's brand. With their long history of brand management, packaging designers are of vital importance for the partnership business and they are required not only to be able to create a visual design of a product but also to understand marketing, finances, sociology, psychology, economy and international trade. [4]

Packaging is increasingly used not only for transportation of goods to distant markets, but also represents an important factor in selling the products to demanding customers. In recent years the importance of packaging is increasingly emphasized as one of the main factors not only for transport of goods but also in selling them on demanding foreign markets. The packaging plays a very important role in attracting the attention or customers, providing information about the product and often influences the decision for buying the product. Today packaging represents an integral part of a product and it need to be adjusted to the needs and demands of the consumers. The design and construction of a package play a vital role in determining the lifespan of a product. The right choice of packaging materials and technologies will maintain product quality and good condition during storage and distribution. [4]

POLYMER MATERIALS

There are several advantages in the use of polymer materials for food packaging. Polymers can be produced as sheets, figures and structures providing significant flexibility in the design. Polymeric materials are chemically resistant, inexpensive, and lightweight with a wide range of physical and optical properties. Some of the polymeric materials have the ability of heat welding, they are easy to print, can be integrated in the production processes where the package is formed, filled and closed in the same production line. The main drawback if the polymeric material is their variable permeability to light, gasses and steam (Figure 1). [4]

Polymeric materials can be:

- Thermosetting plastic, and
- Thermoplastic plastic.

Figure 1. Plastic packaging [5]

Thermosetting plastics are polymers which become rigid or permanently shaped when heated and cannot be re-shaped. Due to their strength and endurance their primary use is leaning towards the auto industry and in construction as adhesives and coatings. [4]
The use of polymers in food packaging has continued to grow thanks to the low cost of the material and functional advantages such as welding, optical properties, unlimited size and shape. Multiple types of plastic is used for packaging food including: polyethylene, polyester, polyvinyl chloride, polystyrene, and polyamide. The main packaging materials are poliofileni and polyesters. [4]

POLYETHYLENE AND POLYPROPYLENE

Polypropylene and polyethylene are commonly used for food packaging. Polypropylene and polyethylene have good combination of properties including elasticity, rigidness, brightness, stability, resistance to moisture and very suitable for recycling and repeated use. Polyethylene can be of low or high density. High density Polyethylene is used for making bottles for milk, juice and water, cereal boxes, margarine boxes, shopping bags and garbage bags. Low density Polyethylene is elastic, strong, sturdy, easy to close and moisture resistant. Low density Polyethylene is relatively transparent, mainly used in cases when thermal closure is necessary. Bags for bread, frozen food, flexible lids and bottles are examples of low density Polyethylene (Figure 2). High density Polyethylene containers are mainly recycled from plastic packages. [4]
Polypropylene has good resistance to chemicals and efficiently stops water vapor. Polypropylene has a high melting point which makes it suitable for applications where thermal resistance is required. Polypropylene is used to make yoghurt pots and margarine. [4]

Figure 2. Packaging of polyethylene [6]

POLYVINYLIDENE CHLORIDE (PVDC)

PVDC has the capability of thermal welding and serves as an excellent barrier to water vapor, gases, and fat and oil products. It is used for inelastic packaging as a monolayer film and coating. PVDC is used for packaging of canned meat, cheese, snacks, tea and coffee. PVDC is also used for storage at low temperatures. [4]

POLYSTYRENE

Polystyrene is a polymer of styrene. It is a hard, clean and highly flammable material with a relatively low melting point, used for protective packaging of cookware, disposable cutlery, lids, cups, plates, bottles and trays for food. [4]

POLYAMIDE (NYLON)

Polyamide is mainly used in the textile industry. Nylone offers good chemical resistance, strength and low gas permeability. [4]

POLYESTER

Polyethylene terephthalate (PET), polycarbonate (PC), polyethylene and oil (PEN) are polyesters. PET is the most common polyester for food packaging. PET has good resistance to gas and moisture, has good heat resistance, mineral oils, solvents and acids. PET is used for creating packages for many food products, beverages and mineral water. The main reasons to use PET packaging are its transparency like as glass, corresponding barrier for keeping the carbonation of drinks, light weight and resistance to breaking. Recycled PET (Figure 3) bottles are used for insulation and nonfood packaging. [4]

Figure 3. PET [7]

POLYVINYL CHLORIDE (PVC)

Polyvinyl chloride is a tough, heavy, flexible and amorphous material. PVC is highly resistant to chemicals, fats and oil and has stable electrical properties. PVC packaging is used in medical and nutritional purposes. Its use in the food industry includes bottles and films for packaging. PVC (Figure 4) is difficult to recycle and its burning is a major environmental problem due to the high chlorine content. [4]

Figure 4. PVC [8]

CELLOPHANE

Cellophane is obtained by chemical processing of cellulose but it has no fibrous structure like the paper. Cellophane is used for packaging consumer products. Unpainted cellophane is transparent like glass, with a smooth and shiny surface. It serves as an excellent barrier to air, odor and dust. It is used for packaging products that need to be protected from dust, packaging of food products, tobacco products and textiles. High resistance to water and water vapor also makes it a very widely used packaging material, especially in packaging confectionery dried products containing fats and oil. [4]

METAL

A metal is a material (an element, compound, or alloy) that is typically hard, opaque, shiny, and has good electrical and thermal conductivity. Metals are generally malleable that is, they can be hammered or pressed permanently out of shape without breaking or cracking as well as fusible (able to be fused or melted) and ductile (able to be drawn out into a thin wire). [9]

CONCLUSION

With the introduction of CAD systems, streamline the work in the initial stage of the manufacturing process, the product design stage, thus leaving additional time available for other segments in the process, which directly increase the quality of the product, but the process as a whole. Na function design technological process closes the interaction between product design and design technology. Application of CAD/CAM systems provide many benefits to users, so that today virtually no question of whether they should be used, but that best solutions for specific production.

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CHEMICAL PREPARATION OF WATER „MLEKOPRODUKT“ DOO ZRENJANIN

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Abstract: Water always circulates in nature. One part of surface water dissipates and returns in the form of rain. Because of the natural purport of carbon dioxide in the atmosphere, precipitation becomes slightly acidic, and therefore a great solvent. Such precipitation solves matter of organic and non-organic origin even in deeper layers of earth. During heating and passage of water through pipes, minerals present in water (salts of calcium and magnesium) cause subsidence of lime scale on pipe walls, and thereby a decrease of pipe diameter, pipe obstruction and heat transfer decrease. This occurance is particularly detrimental for boilers.
Key words: water, solution, resin, refinement, impurity, filter, eilmination, removal

INTRODUCTION

The water production line is conceptualized so that it can provide water quality which is fitting to the quality of drinking water according to the book of regulations on hygenic propriety of drinking water (S1. List SRJ nr. 42/98 and 44/99). This water cannot contain high concentrations of iron, manganese, organic matter, a hightened degree of blurriness, such as is the case with well-water in the "MLEKOPRODUKT" DOO Zrenjanin object.
For this reason and considering the fact that this is well-water, on the very entrance an automatical filter for mechanical impurity elimination has been placed. Filter porocity is 100 mcr and it has a role in holding large impurities, while smaller impurities are removed by hyper-filtration on a filter with a special filling of porocity 3-5 mcr. Water relieved of machianical impurities is sent to a filter for deferrization and demanganization. After removing iron and manganese, water is sent to a filter with special ion exchange resin for organic matter elimination. Water prepared in such a way, relieved of all potential pollution and matter which may cause deposition, is sent to the water refinement system which functions on the principle of reverse osmosis.

FACILITY DESCRIPTION

On the basis of the formerly mentioned, the water preparation line is composed of these units, (Table 1., Fig.1):

1) Mechanical filter, type: Cintropur NW500 1 set
2) Mechanical impurity elimination filter, type: AGP 2469 1 set
3) Water deferrization filter, type: DEF 3072 1 set
4) Organical matter elimination filter, type: SCAD 2469 1 set

Table 1. Part characteristics from figure 1

6	Reverse osmosis 6m/h	1	6/4"	
5	Organic matter removal Scad 2469	1	2"	
4	Deferrizator 3072	1	6/4"	
3	Sand filling filter AGP 2469	1	2"	
2	Backwash filter 100 mcr	1	2"	
1	Raw water input	1	2"	
Pos.	System parts	Quantity	Material/dimensions	Note

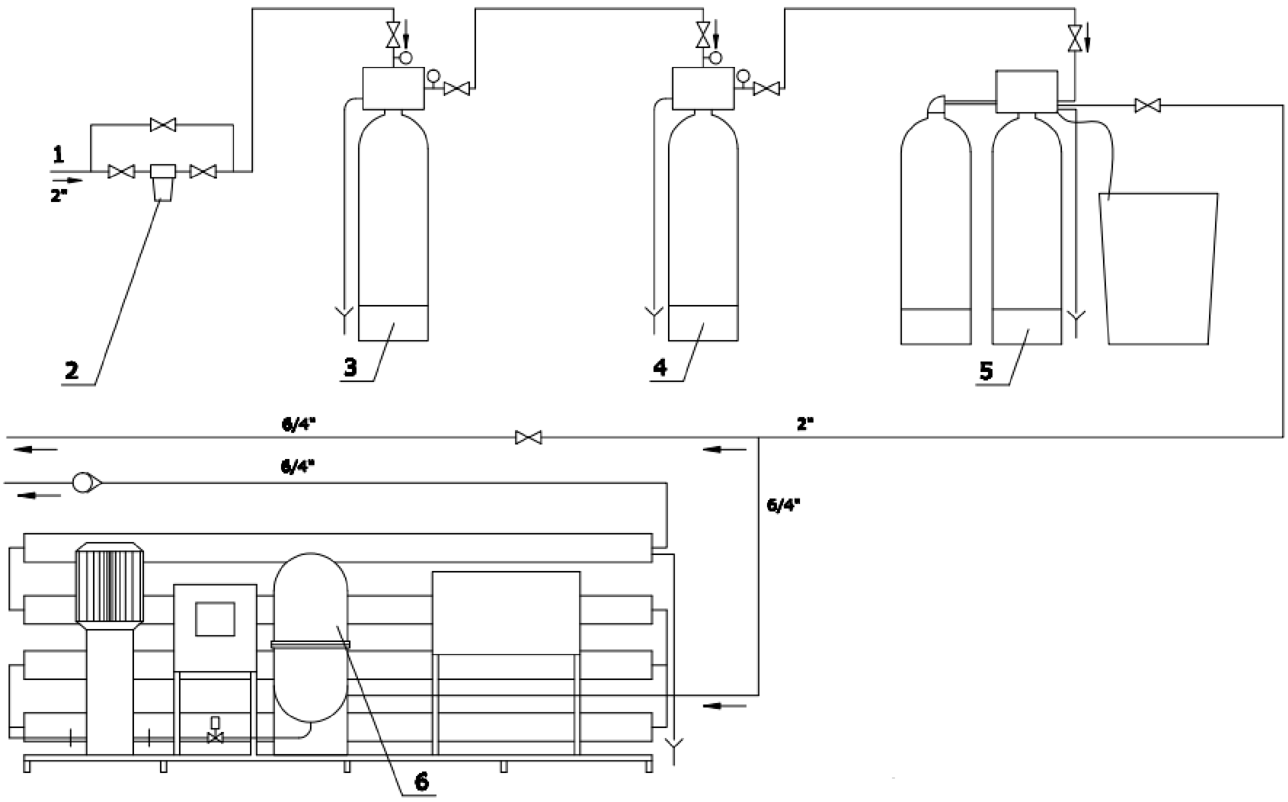


Figure 1. Water preparation scheme

TECHNICAL SPECIFICATION OF EQUIPMENT

Mechanical filter - type: Cintropur NW500.

The pre-filter which is placed on this system part for water preparation has the role of refinement of raw water. It's role is protective, and the goal is to remove particles of impurity which may be present in the influent raw water (particles of rust, clay, sand, lime scale). Mechanical filter - type: Cintropur NW500 is present on Fig.2

Groups of mechanical filters have different connection sizes and filtration degrees with manual or automatic self-cleaning.With such characteristics these mechanical filters can be installed and used in almost any situation.In technical use these filters are used in pre-filtration, microfiltration, pump protection, heating systems, water softening devices, dechlorination or demineralization.

TECHNICAL CHARACTERISTICS: **Type: Cintropur NW500.** System work parameters: Nominal flow: 18 m^3/h, Connections: 2", Colander delicacy: 100 µm, Work pressure: 10 bar, Temp. of treated water, : max 50°C, Environment temp. (°C) : max 40°C.

NW 500
∅2"

Figure 2. Mechanical filter - type: Cintropur NW500

Mechanical impurity elimination filter, type: AGP 2469

For elimination of mechanical impurities and suspended particles we use the AGPlus filter which presents a unique material of natural origin, it has a variety of advantages in comparison to classic sand or multimedial filters. Because of the structure of ore granulate, whose porocity is less than 3 mcr, the filtration surface is up to a 100 times higher in comparison to quartz sand. In this manner the amount of impurities and suspended matter dissolved in water is very efficiently lowered.

TECHNICAL CHARACTERISTICS: <u>System work parameters: </u>Nominal flow: 7 m^3/h, Maximum flow: 8 m^3/h, Connections (input/output/drainage): 5/4” / 5/4” / 3/4”, Power supply 230 V; 50 Hz; Work pressure: 2.5- 6 bar, Water temperature: 10 - 25 °C, Column dimension (fi x H, mm) : 610 x 1753.<u> System parts:</u> Tank :1set, Structural, Pentair Water, Control valve: Fleck 2850 f, Filtration medium : AG Plus / quartz sand.

Water deferrization filter, type: DEF 3072

The removal of iron, manganese and hydrogen-sulphide is an important assignment in water refinement because they can form insoluble hydroxides which can endanger vital parts of the water refinement system. Deferrizators work on the principle of oxidation of soluble bivalent iron and mangenese into their form which is non-soluble and separable. This principle is often used in practice. The fill is on a specially refined manganese dioxide (MnO2) and quartz sand, different granulations. Because non-soluble particles of these metals are lapsed inside, the filter requires backwash rinsing.
On the water input into the deferrizator there is a dosage pump for dosing sodium-hypochlorite (NaOC1) which is used for improved effects of catalystic oxidation.

TECHNICAL CHARACTERISTICS:**Type: DEF 3072.** <u>System work parameters: </u>Nominal flow : 7 m^3/h, Maximum flow : 8 m^3/h, Connections (input/output/drainage): 6/4” / 6/4” / 3/4”, Power supply 230 V; 50 Hz; Work pressure: 2.5- 6 bar, Water temperature: 10 - 25 °C, Column dimension (fi x H, mm): : 762 x 1829. <u>System parts:</u> Tank : 2 units Structural, Pentair Water, Control valve: Fleck 2850 f, Filtration medium : Pyrolusite / quartz sand

Organic matter removal filter, type: SCAD 2469

A high amount of organic matter in water, expressed in consumption of potassium-permanganate $KMnO_4$, presents a problem in water technology. Natural organic matter solute in water encumber ion exchange resin and filtration mediums which are located in the following elements of the WCP line.
In industrial processes which use the reserve osmosis system for demineralization of water, the presence of organic matter is especially unwanted, because we're talking about macromolecules (molecules of large molar mass and chain structure) which can make a big problem in RO membranes - accumulation of these causes a flow decrease of produced water, pressure hightening and a distorted water quality. Also, their presence changes organoleptic properties of water, which will by all means cause a negative effect on drinking water quality, which is why it is very important to remove them from the water.
Ion exchange resin, which has the ability to hold organic molecules within its porous structure and to release them during backwash rinsing, is used to lower the concentration of organic matter solute in water. After being saturated it is regenerated with a solute of kitchen salt (sodium chloride, NaC1 in tables) in the same manner as is the softening resin. Waste waters are not aggressive nor toxic and neutralization is not needed. The capacity of ion exchange resin is determined very roughly since the composition of organic matter in that water is always unknown. It is recommended to add NaOH from time to time during the process of regeneration, according to instructions on resin specifications, but only in the presence of an expert individual who delivers the resin, "CWG Balkan". In this manner complete purification of accumulated organic matter from the surface of the resin is enabled, and it's cycle capacity is preserved. In spite of everything, because of the mentioned sluring with organic matter this type of resin's useful life span is considerably smaller and a replacement should be predicted in a 2-5 year work period, this is monitored by changing the expenditure KM_nO_4 in front and behind the filter. As long as the resin removes organic matter on a level of 4-8mg/l KM_nO_4 or less, it's efficiency is considered excellent.
TECHNICAL CHARACTERISTICS: **Type: SCAD 2469,** System work parameters: Nominal flow: 7 m^3/h, Maximum flow: 8 m^3/h, Connections (input/output/drainage): 5/4" / 5/4" / 3/4", Power supply 230 V; 50 Hz; Work pressure: 2.5- 6 bar, Water temperature: 10 - 25 °C, Column dimension (fi x H, mm) : 610 x 1753. System parts: Tank : 2 kom Structural, Pentair Water, Control valve: Fleck 9500/1700 sxt, Filtration medium : Ion exchange resin, Resinex TPX 4500, Jacobi Carbons.

Reverse osmosis

Membrane separation processes, especially reverse osmosis as a universal technique for separation, functioning and concentration of organic and inorganic matter, are getting an increasing importance and are finding wide use in chemical engineering and some chemical technologies.
The technique of reverse osmosis was started with a basic goal to use it for desalination of sea and other saline waters. Nowadays the use of this process has been widened to separation of a variety of organic and inorganic matter from water, especially for refining of waste waters, to concentrating individual matter from water solutions (drugs, fruit juices) and to fractioning of individual solute matters one from the other, or on the basis of molecular weight difference (monomers from polimers) or on the basis of different physico-chemical characteristics (salt from organic molecules). The newest development is going in the direction of using reverse osmosis for the afore mentioned operations for non-water solutions.

Reverse osmosis facility technical data: UO 5000 AS
Reverse osmosis, type: UO 5000 AS is present on Fig.3.Permeate flow: 5000 l/h, Min. Salt removal: 97 %, Recovery: 75%, Work pressure: 12 bar, Membrane element/number: 8040/4, Voltage:3x400V/50Hz, Engine power: 5,5 KW, Pre – fusing: 16A, Fitting feed water: DN 40, Permeate/concentrate fitting: DN 32/DN32, Dosage fitting: R1/2, Extent conductivity: 2-200 µS/cm, Min./max. feed water pressure: 2/6 bar, Min./max. feed water temperature: 5/35ºC, Max. ambijent temperature: 40ºC, pH: 3-11.Dimension:Hight: 1.793,00 mm, Width: 2.800,00 mm, Depth: 750 mm, Approximate weight: 500 kg.

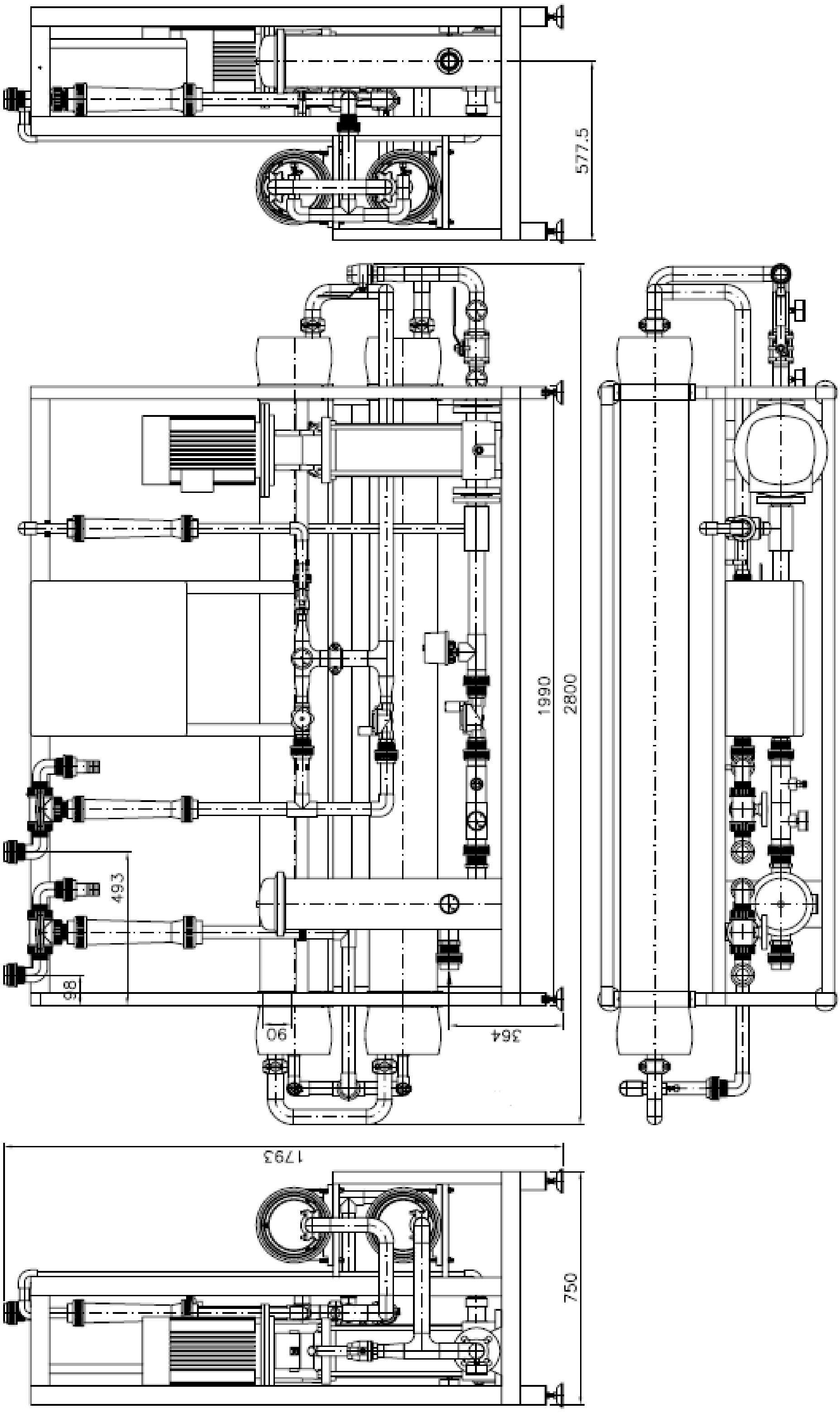
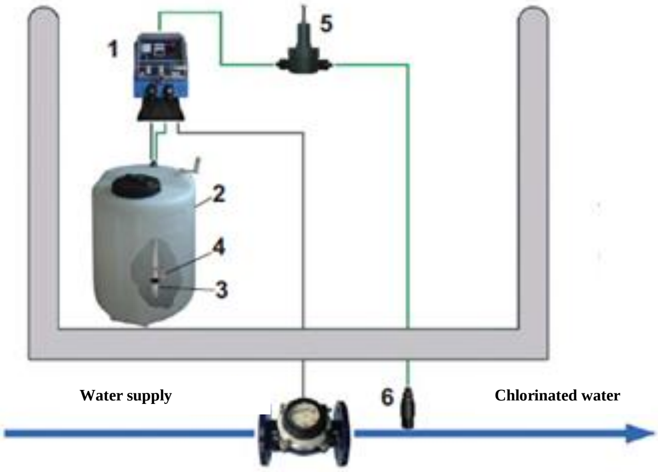


Figure 3. Reverse osmosis, type: UO 5000 AS

CHLORINATION

Previously demineralized water is afterward chlorinated with the plynule chlorination system. Plynule chlorination systems (Fig.4) are used for forthcoming chlorination and in cases when the chlorinated water consumption isn't big, for example (water disinfection in hotels, schools, pools, smaller pipeline systems, dairies) and so on… This kind of chlorination is usually used for capacities of up to 10l/s of clean water, but if need be, it can be used for larger capacities. The medium used in such cases is a disinfection agent – sodium-hypochlorite solution. Hypochlorite dosing can be input directly into the pipelines with a dosage pump and the according injector or into a water reservoir. The dosage pump can be manipulated in a variety of ways and according to the user's needs, aswell as the ability to install adequate support equipment on the pump work regulation object, pump regulation can be manual, semi-automatic and automatic. The automation of the process of chlorination decreases the effect of "human error" by a significant amount during manual regulation. A well configured automatic chlorination system continually holds the residual water chlorite on the assigned level, without human intervention.



1. Dosage pump
2. Hypochlorite reservoir
3. Intake basket
4. Probe level
5. Overlap valve
6. Injector
7. Impulse water-meter

Figure 4. Plynule chlorination system

The plynule chlorination system is made of a dosage pump, a hypochlorite reservoir, intake basket, probe level, overlap valve, injector, impulse water-meter. This kind of system is used when the chlorinated water flow is variable. For lesser water amounts, less chlorite is added, and for higher amounts, proportionally more is added.

The dosage pump continually gets flow information from an adequate flow measuring tool (impulse water-meter) and on the basis of the number of impulses it receives it either increases or decreases dosage. This kind of control is called "flow control".

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EQUIPMENT AND SUPPLIES FOR STERILIZATION

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Abstract: This paper defines the use of materials and equipment for sterilization. We analyzed their performance, reliability and the ways in which it can occur. We have considered the use of traditional methods but will base on the use of new modern methods of sterilization. The role of supersonic vibration lyophilization osmotic pressure is defined. Great importance is given to the use of ethyl oxide and formaldehyde.
Key words: sterilization, lyophilization

INTRODUCTION

There are many methods used for sterilization. They require the use of a variety of materials and equipment. They must have certain characteristics and each of them has to be of certain quality. Sterilization is defined as destruction of all microorganisms in a particular environment. It is very important to work on their removal but in some cases a complete destruction is required. Sterilization by removing microorganisms is performed by appropriate filters and is known as the mechanical sterilization. The usual ambient temperature of sterilization is of 160-180 ° C. [1] Usually is carried out by applying high temperatures. In doing so, the microorganisms are destroyed by dry and moist heat. The most important device used in the sterilization is the Koh's pot in which the sterilization is done by steam without pressure. On the other hand, the unit where sterilization is performed with steam with pressure is called the autoclave.

PHYSICAL METHODS OF STERILIZATON

The physical methods of sterilization refer to the application of high temperatures, radiation, supersonic vibration, lyophilization osmotic pressure. The action with elevated temperature can be performed in two ways: with dry and moist heat. Also, when using dry heat we have to apply a dry sterilizer (160°S - 2h, 170°S - 1h, 180°S - 30 min.)

Table 1: Physical sterilization methods

Methods	Usual conditions	It is recommended primarily for	Limitation
1. Moist heat			
a) pasterization	$62{,}8^0$C/30 min. 71,6 °C/15 s.	Milk, wine and other beverages	Not complete sterilization
b) cooking	100 °C/ minor more	Disinfection of instruments	Does not destroy spores or viruses
c) autoclaving	10^5 Pa/121 °C, 45-30 min.	Osmosis and accessories	Limited to thermosetting
2. Dried heat:			
	170-180 °C/ 1-2h	glass; metallic instruments; oils and waxy materials	Limited to thermosetting
3. Radiation:			
a) ionizing	2,5 nm during a long period of time	; Composite sensitive to an elevated temperature	Very expensive methods; necessary caution in the work; poorly penetrates
b) ultraviolet	260 nm during a long period of time	-II-	-II-

4. Filtration			
	Membrane or fibrous filters corresponding changes in pore	Thermo sensitive osmosis, waves	Does not remove viruses and mycoplasmas

Figure 1. Dry sterilizer [1]

HUMID HEAT STERILIZATION

Sterilization with humid heat is more effective compared to dry heat sterilization. It can be implemented in several ways: heating water, boiling water, steam without pressure and steam with pressure. The sterilization method with water heating is carried out in a water bath with automatic regulation of water temperature. This sterilization process is applied only in exceptional cases where we need to preserve the original characteristics of substance.

Figure 2. Water bath with automatic regulation of temperature [2]

STERILIZATON WITH WATER STEAM – KOH POT

Koch pot is cylindrical in shape with a lid that is used for fractional sterilization. The central part of the cylinder chamber has a grid at the bottom, where the material for sterilization is placed. Below the grille is space for water with a heater, so water steam circulates to the lid. This device has a thermometer that monitors the temperature, and time of sterilization is measured from the moment of reaching the desired temperature. This device is used for sterilization of nutrient base whose ingredients are change by the boiling water (sugar, urea, gelatin, etc.). Sterilization is carried out for 30-60 minutes three days in a row, and in the meantime, the substrate is placed in a thermostat so that spores that are not destroyed would sprout up the next day. Better effects of sterilization in Koch pot can be achieved in a shorter time if the method of intermittent or fractional sterilization is used. [3]

CENTRIFUGES

Centrifuges are devices that consist of heads with cuvette and engine carriers, which are connected with it and have the function to develop a centrifugal force. Cuvette bearings are made of metal, and the space where they are turning is closed with metal walls. During centrifugation, centrifugal force is developed which causes the precipitation of larger particles, and sedimentation depends on the rotational speed centrifuge, the size and the specific weight of the particles, the viscosity and surface tension of liquids in which the centrifuging is carried out. Depending on these parameters, the individual particles after centrifugation are found in the sediment or in the supernatant (liquid above sediment). In order for centrifuge to work well, it has to be balanced, which is achieved by placing a cuvette against each other. When there is odd number of cuvettes, one additional is placed with an equal volume of liquid (usually water), as well as the opposing cuvette. Classical centrifuges for bacteriological examination achieve 3000-6000 rpm / min. Ultracentrifuge for virus isolation have a cooling device and generate 50,000-100,000 rpm / min.

THERMOSTATS

Thermostats are devices that provide a constant, optimum temperature required for the growth of microorganisms. Thermostats are made of double metal walls lined with some insulator with a stream of air or water between them, which are heated by an electric heater. Thermostats have two doors to provide better thermal insulation. At the top of the thermostat is a thermometer, with a bolt to program desired temperature that is automatically maintained. Thermostats should be closed tightly, and sometimes it is necessary to check the temperature on the thermometer. [4]

Figure 3. Koh's pot

STERILIZATION WITH STEAM UNDER PRESSURE

The autoclave is used for sterilization with moist heat under pressure. It is a cylindrical device usually positioned horizontally, with double walls and massive steel lid that can be closed by 6 screws oppositely placed. In this way, it is hermetically closed, preventing the release of water vapor, ie. providing conditions for the development of the required pressure. The central part of the cylinder is a chamber where objects are placed to be sterilized. Below the bottom of the chamber there is a space for the water, which is heated by an electric heater. On one side of the autoclave is a funnel for water from the tap. On the opposite side is the vertical pipe, which shows the water level in the device. Each autoclave has a thermometer and a manometer, which are in connection with the chamber, and allow monitoring of temperature change or pressure during sterilization. The autoclave has a safety valve, in order to reduce the pressure if it is higher than predicted. The material to be sterilized is placed in a chamber (the height of the third chamber, no more) and then the lid is closed at the same time by closing the two opposing bolts. It is very important to tightly close the lid. To enable the sterilization of moisture and to prevent the burning out of the heater, it is necessary to always check the level of water in the autoclave. If it is below the designated limit, it is necessary to pour distilled deionized water into the machine. When the faucet is open for steam release, the heater is turned on until the tap releases thick steam. It is a sign that the area where there were air pockets is now filled with steam and sterilization can begin (air pockets interfere with sterilization). The tap is then closed until temperature and pressure climb to the desired level. Sterilization starts from the moment you reach the desired temperature in the device, and usually lasts for 15-20 minutes (sometimes longer), if sterilization is performed at a temperature of 1200C and a pressure of 1 atmosphere. When it's time for sterilization is over, the heater is turned off until the pressure and temperature spontaneously decline. Then the tap to release steam is opened. When all the steam is released, the lid screws (alternating) are carefully unscrewed. After a few minutes, the lid is carefully opened, as steam that is left behind in the chamber can cause burns. When the sterilized material cools, it can be removed from the device. [5]

Figure 4. Laboratory autoclave

MECHANICAL METHODS FOR FILTRATION

Sterilization of liquids can be carried out mechanically, with bacteriological filtration, in the case where they contain thermo labile substances and the use of other forms of sterilization is impossible or impractical. Filters have a pore size of one to a few micrometers and retain the bacteria from fluids passing through them. Filtration is carried out by applying a positive pressure above the liquid or the negative (vacuum manual). There are several types of filters:

1. Seitz's filter. This filter is made of asbestos, and placed on the funnel over the net. The top of the funnel is recessed into the rubber stopper, which is located on the container into which the filtrate is collected. A cylindrical container is placed on the funnel where the sterilized liquid is poured. There are three types of these filters, which differ in permeability (EC EKSJÖ, EKSJJ).
2. Chamberland's filter. It is made of porcelain without enamel (kaolin), in the form of a hollow tube which is opened at one end and closed at the other in the form of a hemisphere. There are 7 types of these filters (L1-L7), which differ in transmittance (L7 has the smallest pores).
3. Berkefeld's filter. It is made of kieselguhr and is used for rough sterilization. There are three of these filters, which differ in permeability (V, n, and W).
4. Membrane filters are made of nitrocellulose, and the pore diameter is less than one micrometer (normally 0.3mm). This form of sterilization is not only mechanical, but also greatly influenced by the electric charge (filter and bacteria) and the properties of the liquid to be filtered.

Figure 5. Laboratory filters

SUPERSONIC VIBRATIONS

The frequency greater than 500 kHz leads to damage and destruction of the cytoplasm of bacteria. The mechanical damage is caused by the release of gas bubbles in the cytoplasm and the changes of pressure in the cell. Damage of bacterial enzymes and denaturation of the protein also occure.

LYOPHILIZATION

This is a process of bacteria conservation by fast drying at low temperature in vacuum. This way the antigenic structures of bacteria, and other biochemical characteristics of bacterium are preserved, so this procedure is used for storing bacterial cultures, serum etc.

Figure 6. Lyophiliser

OSMOTIC PRESSURE EFFECT

Hypertonic environment happens as a result of reversible process of water loss from the bacterial cells, which causes condensation of the cytoplasm and its separation from the cell membrane and cell wall of bacteria.
Hypotonic environment is created by irreversible process that leads to the death of the bacteria. In hypotonic environment the entry of water into the cell happens, when cell membrane ruptures and spills cytoplasm near bacteria.

CHEMICAL METHODS OF STERILIZATION

The chemical agents lead to alkylation SH, COOH, OH and NH_2 groups of proteins and nucleic acids; oxidation of SS bonds in the cell wall proteins and enzymes; denaturation of proteins and changes in the permeability of the cell wall. Most frequently used substances for chemical sterilization are: GAS (ethylene oxide, formaldehyde) LIQUIDS (glutaraldehyde, Peracetic acid, H_2O_2)

STERILIZATION WITH ETHYLENE OXIDE AND FORMALDEHYDE

Sterilization with ethylene oxide - very toxic gas; colorless and odorless; in a specially constructed sterilizers with temperature of 40-60ºC, 2-4 hours at a relative humidity of 50-60%; sterilization with formaldehyde - the equivalent of ethylene oxide, temp. 60-70ºC, 1-3 hours. The basic characteristics of formaldehyde and ethylene: gas, with very intense smell, toxic, mutagen, not explosive.

PLASMA STERILIZATION

Sterilization medium is plasma from the hydrogen peroxide (H202), obtained in the field of high-frequency electro-magnetic waves. Using high-frequency wave energy, hydrogen peroxide decays into free radicals that are microbicidal. The heat generated in the physical - chemical reaction of plasma sterilization is not higher than 45 ° C.

Figure 7. Plasma sterilization

CONCLUSION

Prevention of infectious diseases is very important and integral part of the prevention consists of sterilization and disinfection. Sterilization is a method of killing or removing all living organisms: all forms of bacteria, both vegetative and sporogenic, as well as all viruses and fungi. Sterilization is an absolute term and there is no degree of sterilization. Sterilization is now widely spread in scientific fields as well as medicine, food industry, in order to preserve and improve the quality of life.

Sterilization of packaging can be discontinuous in rotating autoclaves or continuous where the bottles are transferred through sections for heating, sterilizing and cooling. In this second way, utilization of heat and energy is higher, and the quality of the product better. In addition to the heat, there are other physical methods of sterilization, as well as radiation (UV, microwave). Chemical methods of sterilization (acids, alkalis, salts) are used only for preserving the sample for analysis in product quality control.

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SOLAR CELL MATERIALS

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Abstract: This paper defines the materials that are the most used for solar cells manufacturing. Also, there is their efficiency, price and production processes. Types of photovoltaic cells which will be further processed are: monocrystalline silicon (c-Si) and polycrystalline silicon (p-si) solar cells, amorphous silicon (a-Si) solar cells, polycrystalline and monocrystalline thin-film photovoltaic cells, organic / polymer cells, and it also describes the role of new material graphene for building solar cells.
Key words: solar cells, materials, graphene

INTRODUCTION

Different materials have different efficacy and price. Materials for efficient solar cells must have characteristics that match the spectrum of available light. Some cells are designed to efficiently convert wavelengths of sunlight that reaches the Earth's surface. There are also cells that are optimized for the absorption of light outside the atmosphere. Materials that absorb light can often be used in „multiple physical configurations" to use different mechanisms of light absorption and charge separation. Materials presently used for building photovoltaic solar cells include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride and copper indium selenide/sulfide..etc[1] Many currently available solar cells are made from pieces of material cut into chips (wafers). Their thickness is between 180 to 240 micrometers. They are processed like other semiconductors. Other materials are made as thin-film layers, the organic pigment or the organic polymer that are deposited on a supporting substrate. The third group is made from nanocrystals and used as quantum dots (electron-confined nanoparticles). Silicon is still the only material which has been well researched in the form of „pieces" and „thin film". Hereinafter will be described a significant characteristics of the material which the most common solar cells are made.

SILICON C-SI SOLAR CELLS

Photovoltaic cells made from monocrystalline silicon have a uniform structure, which means that they are composed of the same material which has been modified so that on one side of the cell there is p-layer and the second is n-layer of the semiconductor Si. Within the cell, the p-n layer is located so that the maximum solar radiation is absorbed near the conjuction. Area of such cells depends on the size of the monocrystal cross section and it is about 5 to 10 cm^2; the thickness is between 200 and 300 μm and the voltage of such cells is from 0.55 to 0.70 V. The theoretical efficiency is about 22%, and the actual efficiency about 15%. The only drawback of monocrystalline silicon cells is high production price, due to the complicated production process.

Figure 1. Solar cells made of monocrystalline silicon chips [10]

SILICON P-SI PHOTOVOLTAIC CELLS

Identical to the c-Si cells, photovoltaic cells made from polycrystalline silicon have so called uniform structure. Contrary to the single crystal silicon, polycrystalline silicon is composed of many small crystals, which leads to the limit occurrence. Boundaries oppose to the electrons progress and encourage them to recombine with holes, resulting as a reduction of such cells output power. The process of obtaining polycrystalline Si solar cells is identical to the procedure in c-Si cells. Likewise, the p-Si cell's cross-section is identical to the cross-section of c-Si cells. The only difference is in the form of a p-Si cell, which are the square and it can be better assembled into a photovoltaic module. The manufacture process of the polycrystalline silicon cells is considerably cheaper than the production process of monocrystalline cells, but the p-Si PV cells have a lower efficiency than c-Si cell. The theoretical efficiency of them is about 18% and the actual efficiency is between 10 and 13%. Analysts predict that prices of polycrystalline silicon will drop because companies build additional polysilicon capacity to produce faster than the projected industrial demand. On the other hand, the cost of improved metallurgical silicon rank production , also known as UMG Si, can potentially have a sixth part of the making polysilicon costs.**Error! Reference source not found.**

AMORPHOUS SILICON, A-SI SOLAR CELLS

The atoms within the amorphous material are arranged in a regular structure, and do not form a crystalline structure. Also, amorphous materials contain a large number of structural defects and poor connectivity of atoms, which means that the atoms do not have a "neighbor" with whom they could relate to. For that reason, the electrons will recombine with holes instead of forming a circuit. Since defects limit the flow of electric current, these types of materials are normally unacceptable in electronic devices. Defects can be removed if it is part of the amorphous silicon a small amount of incorporated hydrogen. The consequence of such amorphous silicon treatment is a combination of hydrogen atoms with atoms of amorphous silicon which are not neighbors (not related) so that electrons can travel freely through the material. Amorphous silicon absorbs solar radiation 40 times more efficient than monocrystalline silicon, so that the layer thickness of 1 μm can absorb about 90% of solar radiation, of course when it is flooded. This characteristic of amorphous silicon could reduce the cost of photovoltaic technology. Other advantages of amorphous silicon are also economic in character, so for example, amorphous silicon can be produced at low temperatures and can be deposited on cheap substrates (plastic, glass, metal, etc..) making it ideal for the integration of photovoltaic technology as an integral part of the facilities. The biggest drawback of photovoltaic cells made from amorphous silicon is instability. Because of Stabler-Vronsky effect a-Si cells output after the first exposure to sunlight decreases over a certain period of time. The output effect power results in a loss of 20%, while the a-Si cell is not stabilized. It should be noted that a-Si according to the division of the cell belong to the so-called thin-film materials. The theoretical efficiency of the a-Si cells is about 11.5% and the actual efficiency about 7%.[6]

POLYCRYSTALLINE THIN-LAYER PHOTOVOLTAIC CELLS

The term "thin film" refers to the technology of taking the film, not the film thickness, as the thin-film photovoltaic cells are laid in a very thin, successive layers of atoms, molecules or ions. Photovoltaic cells made of thin film technology have many advantages over a cell created by classical methods. In a thin film cell preparation we use much less material, since the thickness of these cells varies from 1 to 10 μm, while the Si classical cell is about 100 to 300 μm. Thin-film cells are manufactured by automated, uninterruptible processes and can be laid on cheap substrates (glass, stainless steel, plastic, etc..). Also, the flexibility of production technology depositing layers of thin film cells with standard size (125 mm x 125 mm) and the module made as one large-cell (75 cm x 150 cm) can be produced by the same apparatus. Cells made of thin film technology are not required for the metal top contact (as c-Si cells), but use a thin layer of transparent conductive oxides. Layers of thin-film take on a selected surface including anti-reflection layer and a transparent conductive oxide layer, thereby shortening the production process. Polycrystalline thin-film cells are made from small grains of crystalline semiconductor material. The materials used for the production of polycrystalline thin-film cells have different properties than silicon semiconductor materials. Therefore, to create an electric field within the cell we can use two different semiconductor materials, and such a cell structure is called a mixed structure. Typical polycrystalline cells made by thin film technology has a very thin (less than 0,1 μm) upper layer n-type, which is called the "window" layer (the literal translation of layer that acts as a window). The role of the upper layer is focusing solar radiation and only high-energy part of the spectrum. Therefore it must be very thin and have a wide enough energy gap (2.8 eV or more), to let a larger amount of solar radiation go to lower (absorbing) layer. The bottom layer is mostly doped p-type semiconductor and it is usually located under the "window" layer. Semiconductor material p-type must have highly absorbent nature and thereby it must have a suitable energy gap (band gap) in order to obtain higher values of voltage cells. However, the lower p-layer is very thin, with a thickness of 1 to 2 μm.[6]

Figure 2. Thin Film Solar Panel [11]

Copper-indium-diselenide ($CuInSe2$ or CIS) polycrystalline thin-film material has extremely high ability to absorb, which means that 99% of the sunlight that falls on the photovoltaic cell made by CIS thin-film must be absorbed. CIS cells usually have a mixed structure, the upper layer is usually made of cadmium sulfide and the lower (adsorbent) layer is often added a small amount of gallium in order to enhance the effectiveness of the components (CIGS structure). Theoretical efficiency of these cells is about 15% and the actual efficiency is much lower. Cadmium-teluirid (CdTe) thin-film polycrystalline material has a nearly ideal energy gap of 1.44 eV and a large absorption ability. [3] Although commonly used in photovoltaic components without the addition of other materials, it is relatively easy to achieve alloy with zinc or mercury in order to improve the properties of the components. Just like in the CIS thin film, CdTe films can be deposited on cheap substrates (plastic, glass, etc..). CdTe cells have a uniform structure, with cadmium sulfide as an upper layer of n-type semiconductor. The anti-reflection layer and a transparent conductive layer use a thin layer of oxide. Due to the internal resistance of the p-type CdTe materials, the p-type material use zinc telluride (ZnTe). Theoretical efficiency of these cells is about 15% and the actual efficiency is much lower.[4]

Figure 3. Photovoltaic solar cells made by thin-film technology [12]

MONOCRYSTALLINE THIN-LAYER PHOTOVOLTAIC CELLS AND MULTI-LAYER CELL STRUCTURE

Monocrystalline thin-film photovoltaic cells are mostly made of gallium arsenide. Gallium (Ga) is the product of the certain materials deposition , particularly aluminum (Al) and zinc (Zn), and it is rarer than gold. Arsenic (As) is not a rare chemical element but it is toxic. We can use it in a photovoltaic technology, LEDs, lasers, and other electronic components that use the light. Cells made of gallium arsenide usually have a multi-layered structures, which are often called the cascade structures. Multilayer structure photovoltaics achieves high efficiency transformation since it covers most of the solar spectrum.[5] In a typical multi-layered structure the cells with different energy gaps are stacked one above the other in such a way that sunlight falls on the first material with the highest energy rift. Photons that are not absorbed in the first cell, are transferred to another cell that absorbs high-energy part of the remaining solar radiation during which remains transparent to high-energy photons. Such a selective absorption process continues until the last cell (that has the smallest energy gap). When "stacking" layer, cell structures can be connected mechanically or eventually merge into a cascade structure. The most researches focuses on the cascade structure of the gallium arsenide cells as well as one (or all) of the components of such structures. The theoretical efficiency of such cells would be above 35%, but under the action of a focused solar radiation. [6] Therefore, the semiconductor material of gallium arsenide is suitable for highly efficient photovoltaic cells and cells that have a multilayer structure due to the following reasons: the energy gap of the 1,43 eV is almost ideal for high-efficiency PV cells; because of the extremely high absorption properties, photovoltaic cells made of Ga-As have thickness of a few micrometers relative to the Si cell, which have thickness of 100 μm or more; unlike the cell Si, Ga-As the cells are relatively insensitive to the temperature and the operating temperature of Ga-As cells may be extremely high; Ga-As alloys with aluminum, phosphorus, antimony or indium retain the properties of Ga-As which allows flexibility in the design of such cells; -as it is extremely resistant to damage caused by sunlight it is ideal for space applications. The biggest drawback of gallium arsenide is the high cost of monocrystalline Ga-As layers. Therefore, the Ga-As cells are predominantly used in the such systems, where the surface of the cells is up to 0.25 cm2. Because of the highly efficient transformation, Ga-As photovoltaic cells price is competitive to conventional photovoltaic cells. The theoretical efficiency of such cells is about 28%, while the actual efficiency is 17%.[6]

Table 1: Summary of technologies and materials that are commonly used for the photovoltaic cells production [9]

	Technology				
	Monocrystalline c-Si	Polycrystalline p-Si	Amorphous a-Si	Cadmium-Telluride CdTe	Copper-Indium-Diselenide CIS
Cells efficiency	16-19 %	14-15 %	4-8 %	8-11 %	7-11 %
Panel efficiency	13-15 %	12-14 %			
Area per 1 kW	7 m²	8 m²	14 m²	11 m²	10 m²
Price per 1 kW	1300 €		800 €	3000 €	5500 €
Life-span	25 years		20 years	15 years	5 years

ORGANIC AND POLYMER SOLAR CELLS

Organic solar cells are a relatively new technology that has the potential to significantly reduce the price (compared to silicon thin film) and therefore to enable a faster return on investment. These cells can be processed from solution, hence the possibility of a simple printing process that leads to a cheap large-scale production. Organic and polymer solar cells are made from thin films (typically 100 nm) of organic semiconductors such as polyphenylene vinylene and small-molecule compounds like copper phthalocyanine (a blue or green organic pigment), fullerenes and fullerene derivatives such as PCBM. Efficiency of energy conversion using conductive polymers are low compared to inorganic materials. Highest certified efficiency of these cells is 6.77%. These cells could also be useful in applications where are important mechanical flexibility and the possibility of safe disposal. The active area of the organic cell is composed of two different materials, one acting as an electron donor and the other as recipient. When a photon is converted into electron-hole pair, typically in the donor material, the charges tend to remain bound in the form of excitons, and they separate when the exciton diffuses to the donor-recipient of the compound. Short exciton diffusion distance of most polymer systems limit the efficiency of such devices. Nanostructured compounds also may improve the efficiency.[7]

GRAPHENE AND ITS ROLE IN BUILDING PHOTOVOLTAIC CELLS

Scientists at the Helmholtz Centrum Berlin (HZB - Helmholtz Zentrum Berlin) have discovered that graphene retains its excellent electrical conductivity properties even in close contact with materials such as glass and silicon. This could be a key discovery to develop better thin (thin-film) solar cells.

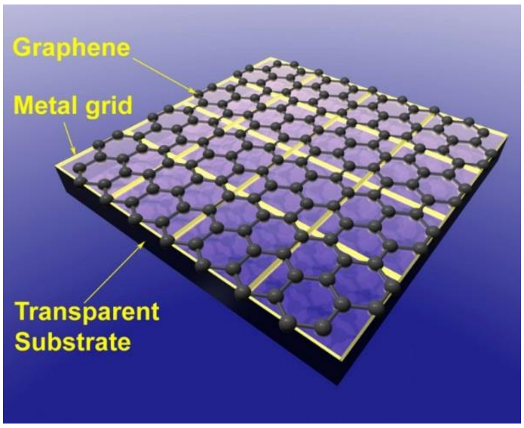

Figure 4. The hybrid film that combines a single-layer sheet of highly conductive graphene with a fine grid of metal nanowire [13]

Graphene, sheet of carbon atoms, is often touted as a miracle material: it is a powerful, versatile and has excellent electrical properties that made it one of the prime candidates for the construction of a new generation of transistors. Essential for photovoltaic applications is that it is also transparent, which means you can not miss the photons in the solar cell without interruption. However, graphene is extremely thin, and since the materials in electronics often have to be placed on each other with very little free space, scientists have long suspected that the close contact of a single sheet of graphene with adjacent layers of a solar cell can seriously degrade the performance of solar cells, which make it useless in practical use. Dr. Mark Glub and professor Norbert Nickel from HZB, wanted to quantify the loss in performance when they put a sheet of graphene sandwiched between layers of a typical thin-film solar cells. To do this, they had to set up a sheet of graphene on top of a glass substrate and then coated the sheet with a thin layer of silicone. The result was quite surprising: electrical properties of graphene list were little changed, the material could still be detected and has not lost its structural integrity, despite being only about 0.03 nanometers thick. Built-graphene showed a possibility of transmitting approximately 30 times greater than the zinc oxide, which is a typical material used in the industry. This is crucial because in the semiconductor greater portability is associated with better device performance. New designs of thin film solar cells could one day benefit greatly from this improved performance. The researchers are now faced with the challenge of connecting the contact layer thin graphene, which is just one atom thick, with the outer layers for further testing.[8]

CONCLUSIONS

Humanity has come to the stage where it is very important to think about the frequent use of renewable energy sources. Solar energy is free, but devices that convert solar energy into electricity are not. The costs of maintenance and operation are small, but the price of the device is relatively high and the payback period is relatively long. Therefore, the majority of developing countries do not dare to trigger the implementation of solar power plants and systems. One thing is certain, the use of solar energy opens up a new dimension in preserving the environment and our planet's resources.

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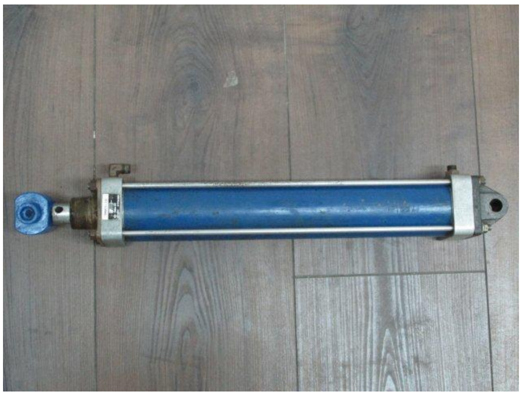

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