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**NATIONAL SCIENTIFIC TECHNICAL SOCIETY
AUTOMATION IN DISCRETE PRODUCTIONS**

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OPERATIONS SYSTEM AGILITY – THE UNDERLYING FACTOR FOR MASS CUSTOMIZATION AND THE MOST IMPORTANT FEATURE OF NEW INDUSTRIAL REVOLUTION

O. Andreev

Abstract: Modern products become more and more complex and along with this, the requirements for reducing time-to-market and costs are increasing continually. The demand for customized products is growing at the same rate, as well as the search for more effective and efficient utilization of resources and energy, which is already a distinguish feature of industrial development nowadays. In turn, increased agility and velocity of production processes significantly increase the requirements for modern production systems. In order for industrial companies to survive and keep their competitiveness in such a dynamic environment, they must not only increase their productivity, but to improve their operations strategy in terms of agility as well, offering their goods and services. Latter puts new challenges to modern companies.

Introduction

First industrial revolution “elaborated the hardware” for the modern factories and founded the beginning of their industrialization. **Second industrial revolution** provided the “software” – new forms of organizing manufacturing processes (i.e. flow line), the basics for scientific planning and optimizing operations. This contributed to a sharp improvement in productivity. This way, mankind faced next issue (again a “hardware” one) going up on the spiral – the automation. With the introduction and use of electronics and information technology to help the automation, the **Third industrial revolution** began – so-called “Digital revolution”. It is also characterized by the integration of programmable logic controllers for automated production systems (SPS). With the increasing product complexity and reduced production batches, however, again new demands are put on the flexibility of production system that are now associated with: market globalization, consideration of the effects and characteristics of

individual countries/regions, as well as products/services customization [1,2].

This brings us to the present day and the **Fourth industrial revolution**. It implies a qualitatively new level of organizing and managing the entire value chain, which is oriented now towards individualized customer desires. Essentially, value chain covers the entire life cycle of products, including: the concept, design, development, manufacture, product delivery, its after-sale use and recycling, including related services [1,3,4,5]. Companies already use their operations systems (machines, equipment etc.), as well as the ones of other companies through internet thereby forming so-called *Virtual organizations*. This leads to implementing integrated IT concepts for the whole value added chain, based on the Cyber-Physical Systems – Smart Enterprises, Smart Cities [6, 9]. Involving such intelligent components, the way is paved to the new technology era [7,10,11] (Fig. 1).

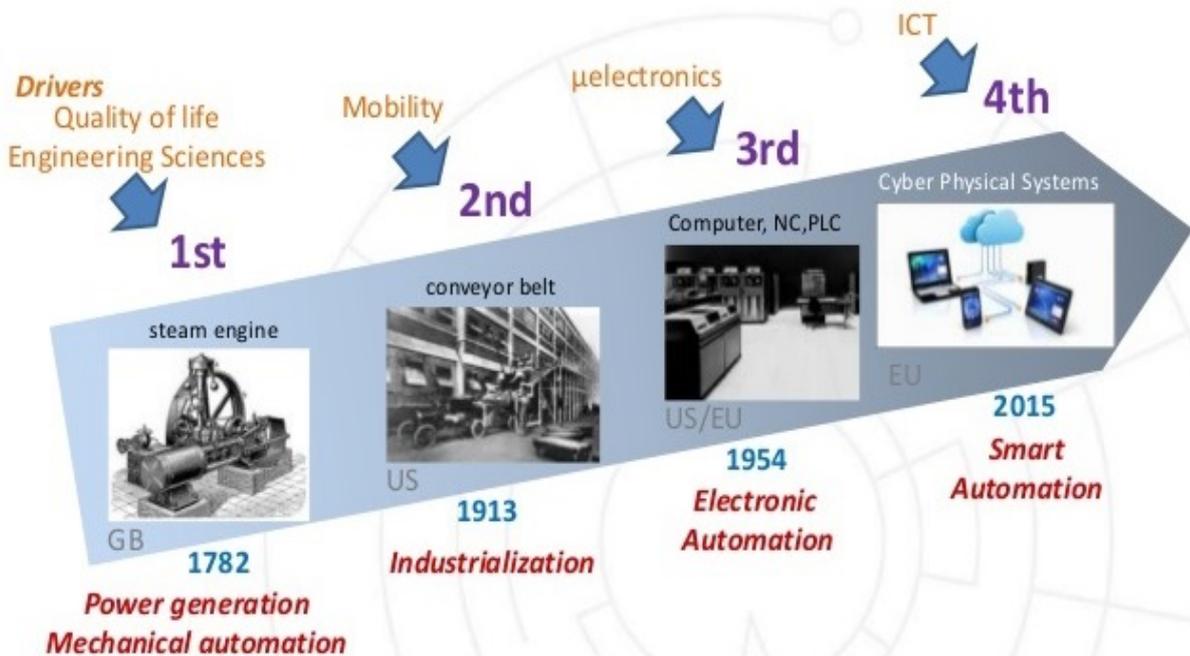


Figure 1. Four industrial revolutions – progressive development of the “hardware” and “software” of factories, i.e. – technology and operations management. Source: German Research Center for Artificial Intelligence (DFKI) [5]

New Industrial Revolution and Agility

Industry 4.0 is radically changing operations and business models, providing opportunities for greater flexibility and efficiency not only in the field of manufacturing, but in the use of resources as well. Among the factors that force these changes are [3,4,5,9]:

- Increasing requirements in terms of flexibility and agility in all phases and areas of operations development;
- Product customization and efficient resources utilization;

- Integration through the whole supply chain and value chain;
- Reengineering of supply chain and value chain with respect of globalizing market.

Given the above, industrial development is focusing on:

- Intelligent production systems that are able to match customers’ individual requirements, profitably producing small batches and/or single pieces;
- Agile creation/planning and execution of

- manufacturing/services;
- Creating new “forms” of added value and new technology/business models;
- Facing challenges such as resource and energy efficiency, demographic changes and trends, “urbanization” of manufacturing etc.;
- More intense and flexible cooperation with business-partners, as well as with the employees;
- Flexible and social-responsive working places;
- Based on the intelligent systems, releasing employees them from routine tasks and helping them to focus on the creative activities with bigger added value. Having in mind upcoming shortages of skilled workers, it is possible that way to prolong professional life and productivity of older specialists and workers, who would combine in a better way their professional life with the private one, as well as with a better training;
- Communications agility allows the direct incorporation of the clients into the creation and manufacture of the products/services, and thus leads to a cheaper customization.

Agility and Opportunities to Optimize Added Value Chain

The challenges and requirements for value chain optimizing can be considered as requirements for a greater flexibility and agility in the following areas [1,2,6,8]:

- Joint development of information technologies and production/operations devices/machinery;
- Shortening Time-to-Market solutions and introducing new technological solutions;
- Implementing agile IT systems without introducing production IT platforms;
- Safety at work without additional investments in complex safety infrastructure;
- Integration and an active support to SMEs with the required IT and manufacturing technologies.

Requirements to the manufacturing companies that are a result of further development of IT cannot be achieved only by focusing on the automation of operations. The establishment and implementation of comprehensive technological approaches is

needed. This approach involves a "massive flexibility" to meet the growing and individualized customer requirements [1,4,5].

The Role of ERP Systems in Agility Growth

The new generation ERP (Enterprise Resource Planning) systems support dynamic processes, which are used to increase operations agility. Companies use such ERP systems, according to the conditions of the new operations and market environment. These are intelligent ERP systems with service-oriented architecture (Service-Oriented Architecture – SOA). It enables using services of other software vendors through standardized interfaces. The most important is that it creates opportunities for direct communication of ERP system with the Cyber-Physical Systems (CPS) and “smart products”. Thus, when changes are needed in the production, a simulation is performed using the “in-memory” technology. Operations processes improvement is going now faster and better. Direct access to production data from such ERP system provides much needed “transparency” of technology and business processes while processing individual orders. These solutions are easy to implement as simulations and forecasts ERP system creates are presented in a user friendly way on mobile devices, such as tablets, smartphones etc.

In addition, new ERP systems use the opportunities of Cloud Computing for the so-called Internet-Of-Services (IOS), including these, being performed as web-based software components.

Individualization of Mass Production

The individualization of mass production is characterized with the following important features [1]:

Radically Increased Agility

The high degree of the production system agility is vital for the company’s ability to offer a wide variety of customized products (small batches and/or single pieces of end items) at prices that are comparable to those which were typical for the mass production until recently. The trend is increasing the flexibility/agility of the production system on account of reducing batches (Fig. 2).

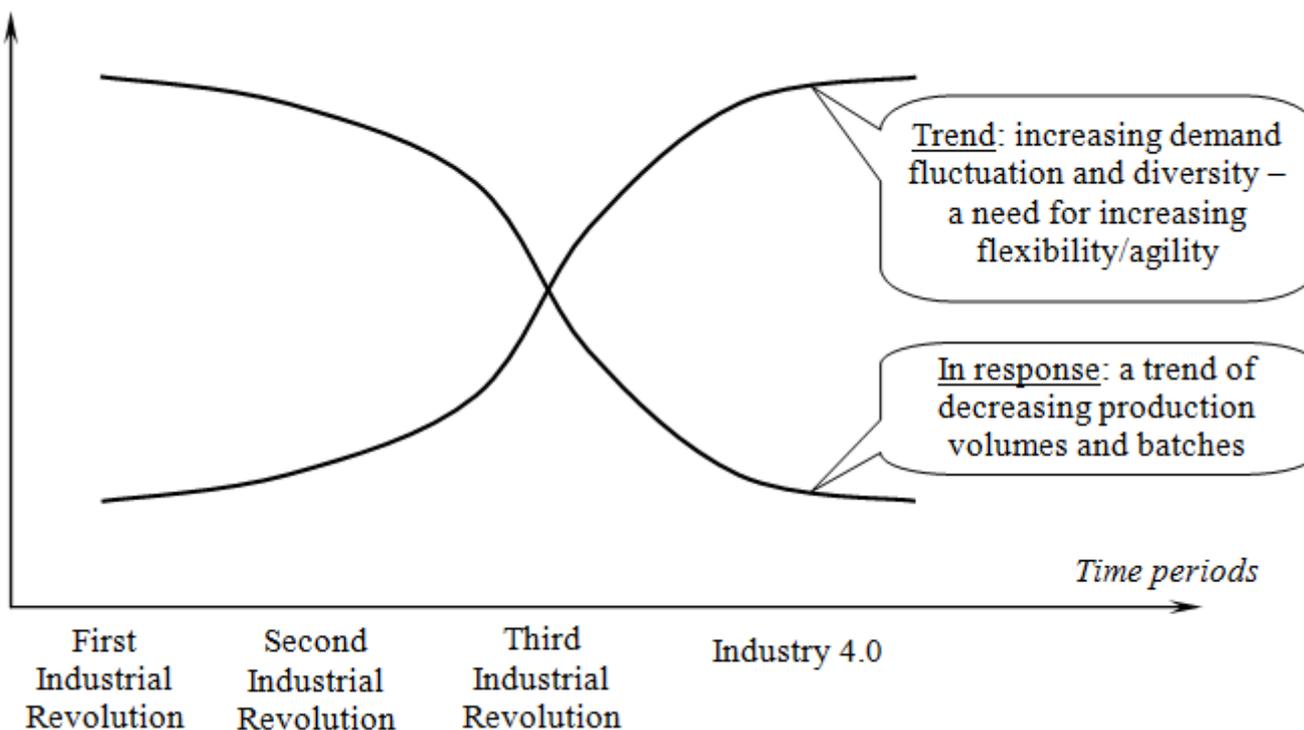


Figure 2. Growth of Flexibility/Agility in response of a changing demand

Quick Innovation Obsolescence

a) Изострената и глобализирана конкуренция води до

все по-малки жизнени цикли на продуктите и необходимост от съответно скъсяване на иновационните цикли – пътят от идеята

до пазара, както и тяхното „застъпване“ с оглед запазване конкурентната позиция на предприятието.

б) Освен посоченото продуктите стават все по-сложни и комплексни, което увеличава тяхната потребителска стойност и себестойност при неумолими ограничения „отгоре“ за

цените.

Много често едното е за сметка на другото, което увеличава пресата върху производствената система на предприятието (фиг. 3).

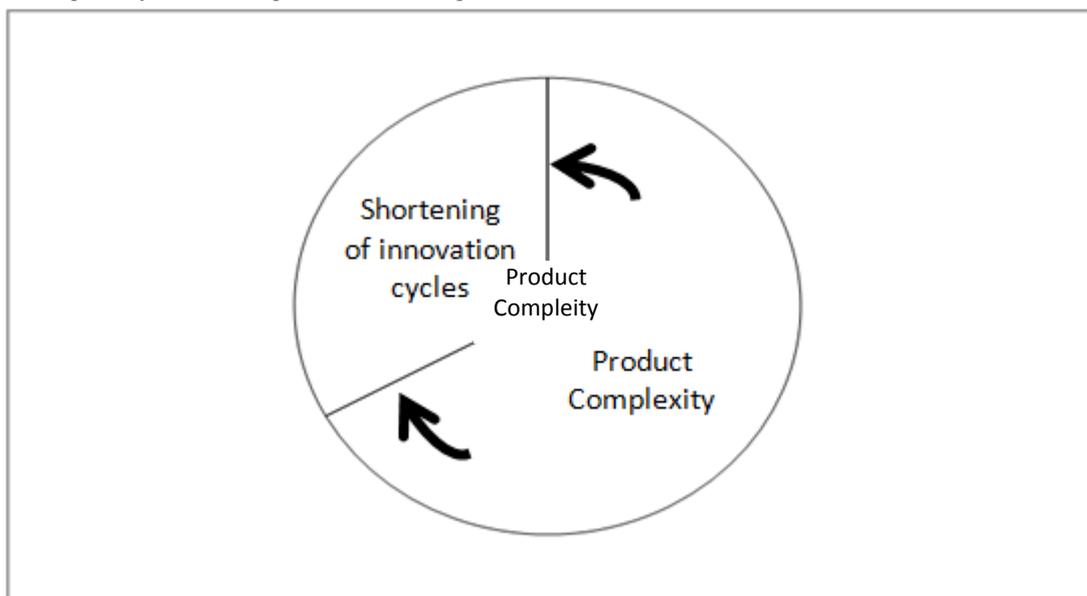


Figure 3. Complexity and innovation obsolescence of products and services

Increasing Efficiency of the Production System

One of the main factors for production system efficiency increasing is the utilization of raw-materials and energy consumption in company operations. The trend is: continuously

growing efficiency to maintain or improve company competitive position (Fig. 4).

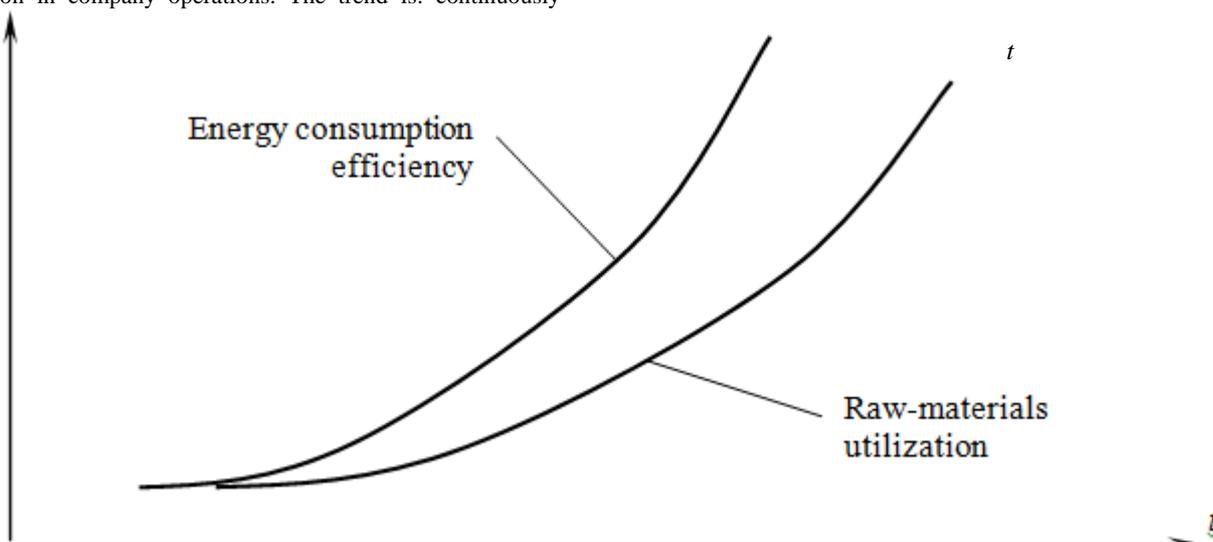


Figure 3. Continuously growing efficiency of operations

Industrial Software Packages

Over the past 15 years, many industrial companies build their own portfolios of software products that enable customers to take participation through the entire value chain, i.e. they participate in the creation, production and/or distribution of products. This process is increasingly expanding and imposes the principles of mass production to be applied to individual orders – so-called Mass Customization Era came into power. The same trend is also evident in the software market – software platforms with "inter-operations" solutions (customization and integration – Fig. 5). Among the companies in Bulgarian market, the most common and acceptable

solutions seem to be the products of Siemens AG [12]:

PLM Software

Siemens software „Product Lifecycle Management“ (PLM) enables an effective management of the entire product life cycle – from the idea, through design, production, after-sale support and service, to the recycling. By PLM, the packages of Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), Computer Aided Engineering (CAE), Product Data Management (PDM), Digital Manufacturing etc., complement seamlessly.

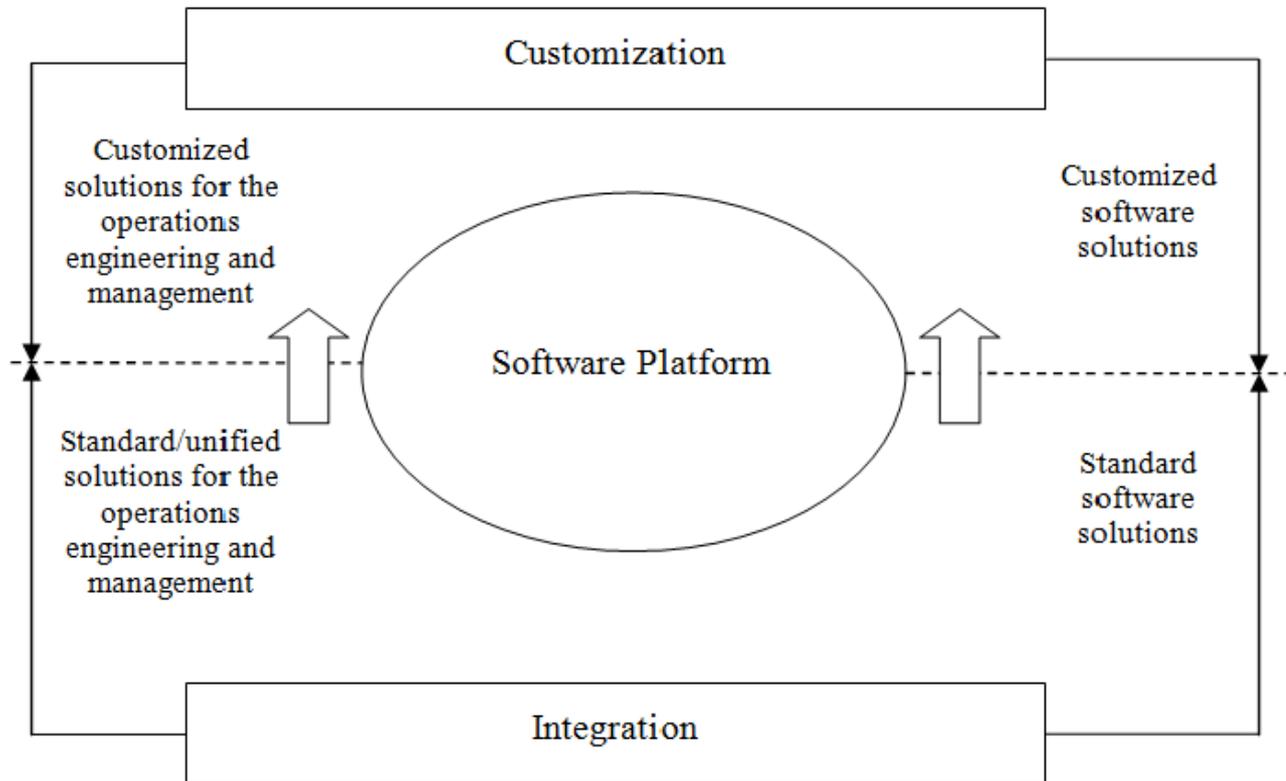


Figure 5. Features of software solutions

Manufacturing Execution System (MES)

SIMATIC IT is a modern MES, which offers a wide variety of functions and allows to efficiently combine productivity with quality, as well as to accelerate time-to-market. This way, the company can react more quickly to the changes in volumes and diversity, i.e. to ensure greater agility. MES from SIMATIC IT is a component of MOM (Manufacturing Operations Management) of Siemens AG for the digital companies. This solution supports the whole chain of product/service added value.

Digital Enterprise Software Suite is a complete solution of Siemens Industry and also covers the entire product life cycle.

Conclusion

From the foregoing, it can be concluded that today's service-oriented society, as well as the customization of production/services, i.e. co-participation of customers in the production process will have important consequences for the society as a whole in terms of:

- Creation of new technology and business models based on the product life cycle and service orientation, focusing on digital processing and customization of their manufacturing;
- Systematic development of above models and their implementation in practice is to be based on the product/service customization;
- Creation of independent software platforms for small special solutions that lead to increased flexibility/agility;
- Creating opportunities for the end customers directly and accurately inform manufacturers through Internet about their needs and requirements – in terms of variety and time;
- Alternative solutions are now becoming easier to be found by the customers, and potential business models – easier to be "killed in the bud";
- Industrial companies must dramatically reduce production time and increase their flexibility/agility in terms of the trend of mass customization, and in reducing the consumption of raw-materials and energy;
- The process of transformation should help to correct determination of the necessary professional skills and

the needs of qualified personnel;

- Engines for development in this direction are mostly SMEs. This process reflects in the growth of new businesses and self-employed people.

Bibliography

- [1] Koleva, N. (2014). Improving Production/Operations System Management by Selecting the Location of Customer Order Decoupling Point, Technical University of Sofia, PhD Dissertation Thesis, in Bulgarian;
- [2] Lefterova, T. & Koleva, N. (2015). An Approach for Selecting the Method for Industrial Enterprise Location Determination, XIII-th International Scientific Conference "Management and Engineering'15", Sozopol, Conference Proceedings, in Bulgarian;
- [3] Bauernhansl, T. (2014), Industrie 4.0 in Produktion, Automatisierung und Logistik Anwendung, Technologien und Migration, Wiesbaden: Springer Vieweg;
- [4] Deuse, J., K., Weisner, A.Hengstebeck und Felix Busch (2015), Gestaltung von Produktionssystemen im Kontext von Industrie 4.0;
- [5] German Research Center for Artificial Intelligence (DFKI), Innovative Factory Systems, <http://www.dfki.de/web> , accessed on 30.05.2016;
- [6] Gorecky, D., (2014) Innovative Factory, Industrial Informatics (INDIN), 12th IEEE International Conference;
- [7] Kagermann, et al, (2011) Mit dem Internet der Dinge auf dem Weg zur 4. Industriellen Revolution, VDI-Nachrichten;
- [8] Nikolova, I. (2014), Quality Management, King, Sofia, in Bulgarian;
- [9] Report of the World Economic Forum in Davos (2016);
- [10] Sauer, O. (2014), Developments and Trends in Shopfloor-related ICT Systems, IEEE'14;
- [11] Spath, D and Weisbecker, A. (2013). Potenziale der Mensch-Technik Interaktion für die effiziente und vernetzte Produktion von Morgen, Stuttgart;
- [12] http://www.plm.automation.siemens.com/en_us/, accessed on 30.05.2016.

UNIT ENGINEERING OF SOLID MATERIALS COMPLEX POWDER PRODUCTION BY HIGH-SPEED PROCESS.

РАЗРАБОТКА УСТАНОВКИ ДЛЯ ПОЛУЧЕНИЯ МНОГОКОМПОНЕНТНОГО ПОРОШКА ТВЕРДЫХ МАТЕРИАЛОВ, ВЫСОКОСКОРОСТНЫМ СПОСОБОМ.

Titov Y., Rechenko D., Tsarenko I., Petrov I.
Omsk State Technical University - Omsk, Russia

At the present time, one of the main directions of mechanical engineering technology comes updating of existing and engineering of new non-waste, material-saving production processes, i.e. such processes that provide preforming with minimum allowance or without them for the next machining with reducing of expenses on scarce materials. Powder metallurgy has certain role in this problem solution.

At present, powder metallurgy in general and producing of powder of small dispersitivity in particular find big application in many different areas. Specific interest to nano- and ultra-disperse powders is connected to their application as a feedstock for production of ceramic, magnetic and composite materials, superconductors, solar batteries, filters, and additives to lubricating stuff, high-impact solder alloy components, feedstock for 3D printers and any others.

Methods of nano- and ultra-disperse materials process are divided into physical, chemical, biological and mechanical, i.e. nature of receipt of materials process is in base of this classification. [1]

Main and most common type of mechanical powder production is grinding with the use of mill. There are many grinding mills in different modifications. Their construction depends on production type and customer's demand, but all of them work under the same principles. Relatively big material elements travel around revolvable cylindrical vessel all the time, they communicate with grinding balls, and as a result these elements are grinded up to finely-divided range. [2,3].

Benefits of mechanical grinding approaches are:

- 1) Comparative easiness of installation and technologies;
- 2) Ability of grinding of different materials;
- 3) Ability of producing powders from alloys;
- 4) Ability of producing materials in great numbers.

Disadvantages of mechanical method:

- 1) Probability of grinding powder polluting by cutting agent;
- 2) Difficulties of producing powders with narrow particle size distribution;
- 3) Product contents regulation difficulties during grinding process;
- 4) Mill flow differs in energy intensity and cost [4].

Analyzed benefits and drawbacks of this approach, there is suggested high-speed approach of producing of ultra-disperse powder. Patented machine is engineered on the base of special tool and cutter grinding machine, semiautomatic VZ-326F4 with computer numerical control (CNC) [5].

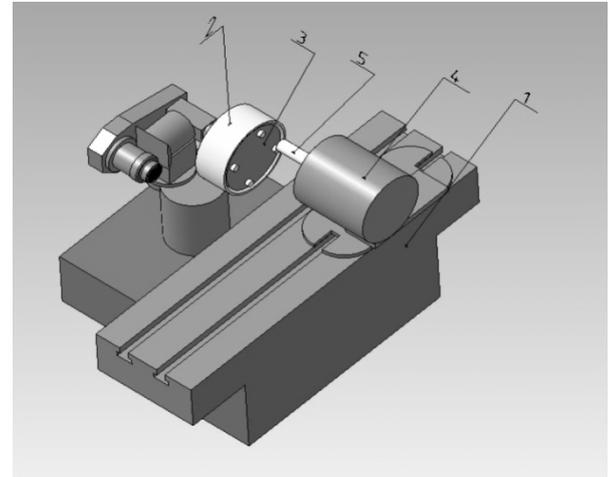


Fig.1.3D-model of machine for producing powder by high-speed process (1 – frame; 2 – gathering case ; 3 – grinding blade; 4 – feeding device; 5 – raw stock).

This machine represents comparatively new mechanical approach of powder process from solid materials, where material grinding, in the form of cylindrical work, is completed with the help of grinding blade with an abrasant (grinding) wheel [6,7].

The machine is modernized for high-speed method of ultra-disperse powder producing. Modernization involved installation of CNC system and new head for high-speed processing. Domestic CNC system “Mayak-600” was installed on this machine. Application of this system lets work the stock in automatic mode, setting the process once a shift, and then just setting new material. Also, the standard grinding head was changed to the head meant for high-speed processing. Special antifriction bearing and seamless band were applied. After modernization, the machine provides spindle rpm up to 30000 rpm.

Mean particle size of produced powder ranges from 100 nm to 800 nm. (fig.2).

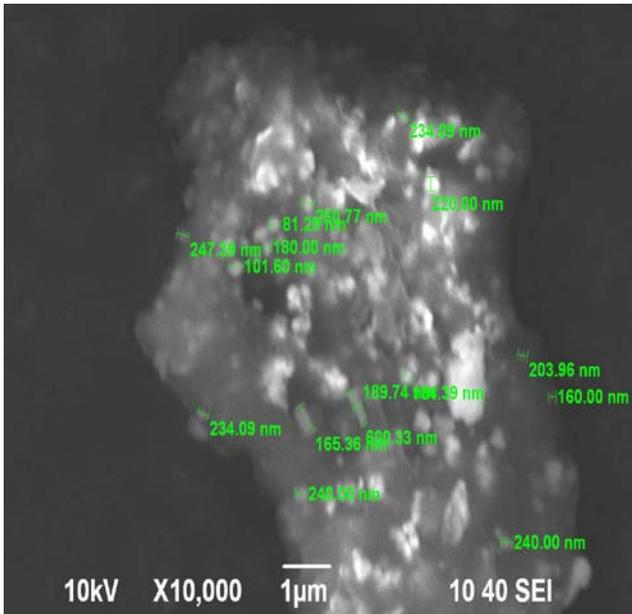


Fig.2. Powder of multicomponent neodymium magnet produced by high-speed method.

Represented method provides ultra-disperse powder producing from any solid material, including multicomponent. There is, also, reducing of producing particles' dimensional variation and making it possible to produce particles of less than 800 nm. Adding of liquid nitrogen reduces probability of high temperatures that appears while grinding on high-speeds; consequently, there is no possibility of fire risk in this process. Besides, nano-powders produce in liquid nitrogen environment are covered with thin surface oxynitride film, thereby they keep increased resistance to sintering and save particles size while heating up to 900-950°C. [8]

References

1. A. s. 1112655 (USSR). Metal powder producing approach / Davydovich V., Yavorovskiy N., Lerner M., Krysin S. – 1984.
2. Powder metallurgy. Materials, technology, characteristics, application area: reference book /I. Fedorchenko [and others]; editor in chief I. Fedorchenko. – Kiev: Naukova Dumka, 1985. – 624 p.
3. Davydovich V. Metal powder producing approach: a.s.USSR № 1112655, IQR V2269/24, from 10.12.81. - / Metal powder producing approach / Davydovich V., Yavorovskiy N., Lerner M., Krysin S.
4. Lerner M. Dependence of metals' nano-powders disperivity and their sintering process from gas atmosphere temperature while electric conductor explosion / Lerner M., Davydovich V., Svarovskaya N. // Physical mesomechanics. – 2004. – № 7; P. 2. – P. 340–343.
5. Pat. 030364 Russian Federation, IPC B22F 9/00 Machine for producing metal powders. / D. Rechenko, A. Popov, Yu. Titov, K. Gosina, R. Kamenov; applicant and patent holder Omsk State Technical University. - № 201411922922; pend. 13.05.14 ;

6. Pat. 55665 Russian Federation, IPC B24D 17/00. Grinding wheel for diamond-abrasive processing / D. Rechenko, Yu. Nurtudinov, A. Popov; applicant and patent holder Omsk State Technical University – № 2006111080/22;pend. 05.04.06; published. 27.08.06. Bulletin. № 24. – 2 p.: fig.
7. GOST 2447-82 Grinding heads. Technical regulations. Moscow; Standard, 1980. – 12 p.
8. Kisel A., Rechenko D., Popov A.Y, Titov V. Producing of ultra-disperse powder with mechanic method using liquid nitrogen/NANOTECHNICS. - №1 (37). – 2014. - P. 73-74.

INCREASING THE RESISTANCE OF PRECISION INSTRUMENT-MAKING ELEMENTS FROM OPTICAL GLASS TO EXTERNAL THERMO-INFLUENCES BY PRELIMINARY ELECTRON-BEAM PROCESSING OF SURFACES

ПОВЫШЕНИЕ СТОЙКОСТИ ЭЛЕМЕНТОВ ТОЧНОГО ПРИБОРОСТРОЕНИЯ ИЗ ОПТИЧЕСКИХ СТЕКОЛ К ВНЕШНИМ ТЕРМОВОЗДЕЙСТВИЯМ ПУТЕМ ПРЕДВАРИТЕЛЬНОЙ ЭЛЕКТРОННО-ЛУЧЕВОЙ ОБРАБОТКИ ИХ ПОВЕРХНОСТЕЙ

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Abstract: The results of experimental studies to improve the properties of the surface layers of the elements of optical glass (K8, K108, K208, BK10, TF110) after their processing by mobile electron beam with density of heat exposure $F_n = 7 \cdot 10^6 \dots 8 \cdot 10^8 \text{ W/m}^2$ and displacement speed $V = 5 \cdot 10^{-3} \dots 5 \cdot 10^{-2} \text{ m/s}$ (a reduction of residual microroughness height at the surface from 4 ... 6 nm (unprocessed elements) to 0.5 ... 1 nm (processed elements), the occurrence of melted layers of thickness up to 250 ... 300 microns with a modified structure, which is close to the quartz glass) are presented. It was found that the improvement of these properties increases the resistance of elements to external-heat: an increase in 1.3 ... 1.7 times of the critical value of external heat fluxes and the time of their exposure, the excess of which leads to the destruction of elements and damage to the test instrument turndown external pressure $10^5 \dots 10^7 \text{ Pa}$; increasing the maximum permissible values of thermal stress in the elements from 20 ... 40 MPa to 90...100 MPa heating temperatures 300 ... 1200 K; an increase of the probability of failure-free operation in the 2 ... 2.5 times by increasing the speed of the external heating from 100 K/s to 400 K/s.

KEY WORDS: optical glass, electron beam, elements of precision instrument-making

1. Introduction

Modern devices with elements of optical glass (K8, K108, BK 10 and so on) for measuring and thermal control of different physical nature objects (flat plates and discs as optical integrated circuit substrates, aerophoto lenses and plates of double curvature for space mirrors and aerospace applications, the input protective windows and lenses in sight for observation in the visible and infrared regions of the spectrum, optical fibers on optical monofilaments in laser medical devices for the diagnosis and treatment and so on) in operating conditions are exposed to intense external-heat (higher heating temperature and external pressure, shock thermal and mechanical stress in a shot and the flight, etc.) [1 - 3]. Under these conditions, a change in the properties of the surface layers of the optical elements up to their destruction (cracking and chipping, deep surface melting to form a sagging, undulating surfaces, changing the geometrical shape and others defects) takes place and leads to significant deterioration of the technical-operational characteristics of devices and their failure.

Therefore, the prevention of forced destruction of the optical elements of the instrument gets a significant importance in terms of their operation, taking into account the impact of external-heat.

As shown by experimental studies of various authors [4 - 8], in order to prevent the destruction of optical elements the electron-beam methods of finishing processing their work surfaces have the practical value at the manufacturing stage, and allow to improve the properties of the surface layers of elements and thus make them more resistant to external-heat, improving basic technical and operational characteristics of devices (reliability, service life and so on). However, studies of thermal exposure of the electron beam to change the properties of the surface layers of optical glass elements are currently insufficiently investigated. Therefore, the aim of this work is to prevent the destruction of optical glass elements of instruments for measuring and thermal control objects of different physical nature by improving the properties of the surface layers of the elements and increasing their resistance to external-heat by electron-beam processing.

2. Results and discussion

As a result of experimental studies they established the following optimal ranges of electron beam parameters: $F_n = 7 \cdot 10^6 \dots 8 \cdot 10^8 \text{ W/m}^2$, and $V = 5 \cdot 10^{-3} \dots 5 \cdot 10^{-2} \text{ m/s}$, within which there is the most significant improvement of the properties of the surface layers of the optical elements (more than in a few times).

The results of electron microscopic examination of the surface of the optical glass elements made it possible to establish that on their surfaces after machining there are such heterogeneity as scratches, cracks and unevenness, the number of which is markedly reduced after electronic processing. In addition, the surface of elements has unevenness and defects which are a result after mechanical polishing, and which are virtually absent after electron beam processing. On the unprocessed by electron beam surface portion of elements there are characteristic etch pits defect layer, while on the processed part of the surface there are much less or practically absent.

In the study of fracture surfaces (fracturegramm) of optical glass elements before and after electronic processing they revealed that the nature of the fracture is different. It is found that a fine-grained fracture occurs in the processed layer. In the elements that are exposed to the electron beam, there is a fine-grained fracture. The individual small crystals are found on the surface of the parent element. Furthermore, the nature of electron diffraction on the microdiffractographs indicates crystal hexagonal structure of inclusions.

The analysis of transverse sections, chips, fractures of optical glass elements after mechanical polishing and electronic processing shows that: a clear boundary between the processed surface by electron beam and the very foundation of the element material is not observed; there is a significant difference between sides of the element - processed and unprocessed; there is a modification of the surface structure to the depth of 200 ... 220 microns with its most significant change in the sintered layer with the elements of "viscous" destruction.

The results of studies of optical glass elements surfaces by electron microscopy scanning showed that on the surface after

machining, the most characteristic there is a presence of various microroughnesses - small cracks of the depth up to 0.1 ... 0.7 microns, thin scratches up to 2 ... 5 microns, as well as "tubercles" bubbles etc., a size of which $10^{-3} \dots 10^{-2}$ microns. After electron-beam processing bubble sizes (diameters) on the elements surface are reduced in 2 ... 4 times, therefore " tubercles " and other unevenness of less than 1 ... 2 microns are not observed, that is in result of processing by electron beam the elements surface, as it were "cleaned", small defects are eliminated.

The analysis of electron-microscopic images of the surfaces of optical glass elements, the study of surfaces of the polished sections of chipped elements before and after electron beam processing indicates that in the first case the microroughness height is 30 ... 40 nm, and in the second one it is reduced to the level of 0,5 ... 6 nm.

The study of fracturegrams of optical glass elements surface layers before and after electronic processing showed that the depth of main-heat zone or the thickness of the deposited layer can be up to 250 ... 300 microns, and essentially depends on the magnitude F_n and the moving speed V of the electron flow (Fig. 1, 2). Thus, an increase of F_n from $7 \cdot 10^6$ W/m² to $8 \cdot 10^8$ W/m², when used in practice the electron flow moving speed $V = 5 \cdot 10^{-3}$ m/s leads to increasing depth of fusion from 50 microns to 230 microns for elements from optical glass K8; from 30 microns to 150 microns for elements from optical glass K108; from 25 microns to 140 microns for elements from optical glass K208; from 30 microns to 180 microns for elements from optical glass BK10; from 40 microns to 170 microns for elements from optical glass TF110. And an increase in the electron beam moving speed from 10^{-3} m/s to 10^{-2} m/s, when used in practice of F_n values already leads to a reduction of the melting depth: from 200 microns to 70 microns for elements from optical glass K8; from 160 microns to 40 microns for elements from optical glass K108; from 130 microns to 30 microns for elements from optical glass K208; from 170 microns to 80 microns for elements from optical glass BK10 and from 160 microns to 40 microns for elements from optical glass TF110.

A detailed study of scans of sections of the surface of optical glass elements after electronic processing indicates a local smoothing of irregularities, a significant dependence of the surface shape of the processing modes. So, with a deep reflow (200 ... 250 microns) it is observed a well-defined wavy surfaces. This modified melted layer has clearly oriented structure on melting depth.

The layers, formed by electron beam on the optical elements surface are modified to different degrees in chemical composition. Thus, the analysis of change in the elemental composition of the surface of elements of optical glass K8, K108, K208, conducted with the help of the wave dispersion spectrometer, showed a decrease of Na and O concentration, an increase of Si concentration and the constant K concentration. At the same time, by X-ray analysis on the example of untreated and treated by electron beam elements of the optical glasses BK10, TF110 it is shown that significant quantitative changes in the chemical composition of its surface are not observed, however, it is possible to make a conclusion as for the improvement of the homogeneity of the distribution of elements in micro-surface layer after electronic processing .

In the result of conducted researches, it was found that after electron beam pre-treatment of the optical elements an increase comes in the critical values of the external heat flows q_n^* and their impact time t^* in 1,5...2 times (Fig. 3). При этом увеличение внешнего давления до 10^7 Па приводит к увеличению значений q_n^* и t^* только в 1,4...1,5 раза. The increase in external pressure up to 10^7 Pa leads to reduction in the values q_n^* and t^* only in 1.4 ... 1.5 times.

In addition, it was also shown that the limit values of thermoelastic stresses $\sigma^*(T)$ at different temperatures for heating the optical elements treated by electron beam in 1.7 ... 2.3 times higher than for untreated elements (Fig. 4).

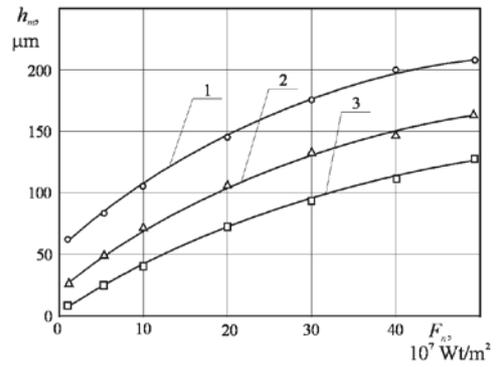


Fig. 1. The dependence of the thickness of melted layers in the elements of optical glass K8 (1), K108 (2) and K208 (3) on the density of the thermal effects of the electron beam ($V = 5 \cdot 10^{-3}$ m / s); Δ , \circ , \square - experimental data.

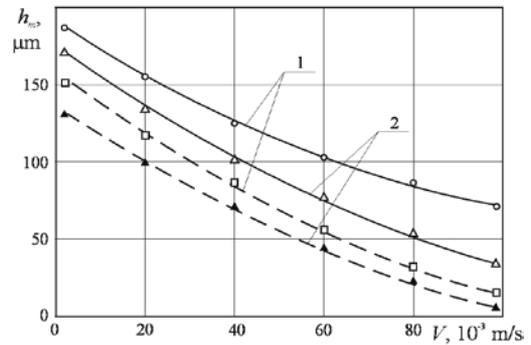


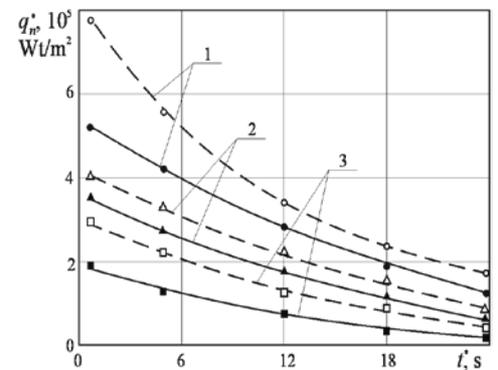
Fig. 2. The dependence of the thickness of melted layers in the elements of the optical glasses BK10 (1) and TF110 (2) on the moving speed of the electron beam: — — — $F_n = 5 \cdot 10^8$ W / m²; - - - - - $F_n = 7 \cdot 10^6$ W / m²; Δ , \circ , \square , \blacktriangle - experimental data.

The tests of the optical elements under conditions of alternating external heating, which simulates actual operating conditions of the optical devices with the influence of external-heat showed that in the case of an electron beam-treated elements it is observed in 2 ... 2,5 times less of their destruction and failure of devices on their basis than for untreated elements (Table. 1).

The safety factor as a measure of efficiency of the optical device at a predetermined heating rate V_n (or time t , which is given to the test at a controlled heating temperature) is determined by the following formula [8]:

$$W(V_n) = 1 - N(V_n) / N_0, \quad (1)$$

where $W(V_n)$ - probability of preservation of working capacity of the device of sighting system under external thermal effects; $N(V_n)$ - the number of devices that fail at a heating rate V_n (the destruction of the optical element is taken as the failure of the device as a whole); N_0 - the total number of devices that are tested.



a)

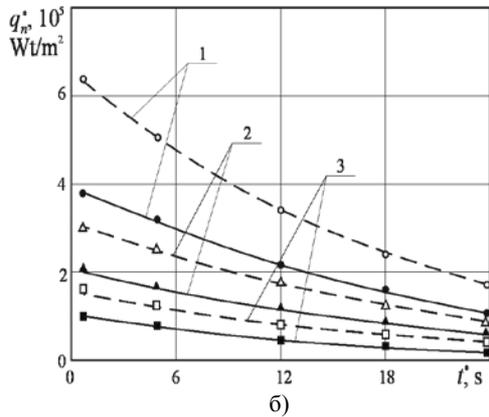


Fig. 3. The dependence of the critical values of the external heat flows q_n^* from the time of their exposure t^* on the elements of optical glass K8 (1), TF110 (2) and BK10 (3) for a variety of external pressures (the thickness of the element $H = 10^{-2}$ m): a) – $P = 10^5$ Pa; b) – $P = 10^7$ Pa; ——— elements which are not processed by electron beam; - - - - processed items; ●, ○, △, ▲, □, ■ - experimental data.

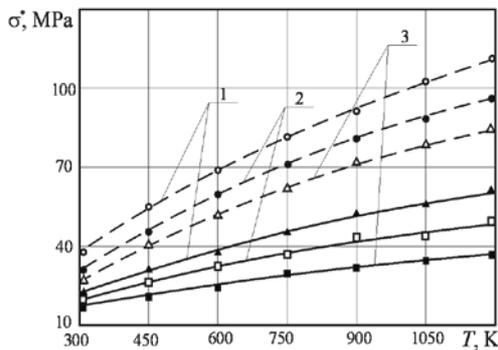


Fig. 4. The dependence of the value of the maximum allowable thermal stresses in the elements of the optical glass K8 (1), TF110 (2) and BK10 (3) on the heating temperature ($P = 10^5$ Pa, element thickness $H = 10^{-2}$ m, $F_n = 1,5 \cdot 10^7$ W/m², $V = 5 \cdot 10^{-3}$ m/s): ——— elements that are not treated by electron beam; - - - - processed items; △, ○, □, ▲, ■, ● - experimental data.

From the formula (1) it follows that with increasing heating rate of the devices of the suggested devices (e.g., from 100 K/s to 400 K/s) leads to decrease in the probability of trouble-free operation under external-heat terms in 4.9 times; while in the case of input windows which are pre-treated by electron beam, the probability of trouble-free operation of devices increases in 2,3 times (Fig. 5).

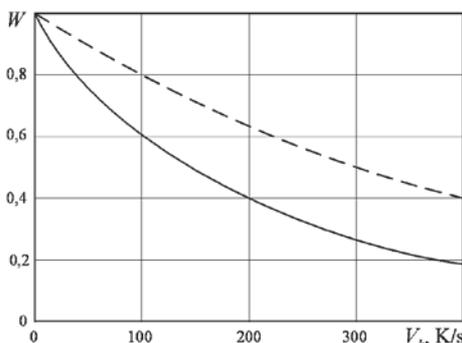


Fig. 5. The dependence of the probability of trouble-free operation of sighting devices complexes under conditions of external-heat from an external heat rate of their input protective windows: ——— the input windows that are not processed by electron beam; - - - the input windows, the outer sides of which are processed by electron beam (beam parameters $F_n = 5 \cdot 10^8$ W/m², $V = 5 \cdot 10^{-3}$ m/s).

Table 1

The influence of electron beam processing of working surfaces of the elements in the form of plates of optical glass K8 on the dependence of the relative amount of their damages (k) from the heating rate *)

Input protective window External heating rate, K/s	k , %	
	unprocessed by electron beam	processed by electron beam
100...150	40...50	20...30
150...200	50...60	30...40
200...300	60...70	40...50

*) Note. $k = k_p/k_0$, where k_0 , k_p - a total number of test elements and the number of exposed to fracture respectively.

It is shown that the use of the results in the design and manufacture of new instruments, as well as the modernization of serial devices to considered optical elements for measuring and thermal control of the objects of different physical nature (optical integrated circuits substrates, aerophoto lenses, laser sights for observation in the visible and infrared regions of the spectrum, laser medical devices etc.) allows to improve basic technical characteristics (the reliability, service life and durability) when used in accordance with the influence of external-heat, for example during storage or transport under the conditions of occurrence of high-temperature fire sites, as well as the design of products with infrared devices in a shot and the flight (external thermal shock effects and others).

3. Conclusions

1. It was found that after the pre-treatment of the working surfaces of the elements of optical glass (K8, K108, K208, BK10, TF110) by mobile electron beam for change ranges of its settings (density of the heat effect $F_n = 7 \cdot 10^6 \dots 8 \cdot 10^8$ W/m² speed of its movement $V = 5 \cdot 10^{-3} \dots 5 \cdot 10^{-2}$ m/s) the basic properties of the surface layers are improved:

- after electron beam processing the surface of elements are completely cleared of defects, which were obtained by the mechanical polishing (fine cracks sized 0.1 ... 0.7 microns, long thin scratches 2 ...5 microns and other defects in size $10^{-3} \dots 10^{-2}$ microns); thus there is a smoothing of irregularities, substantial dependence of the surface shape from the processing modes (with deep reflow (up to 200 ... 250 microns) a well-defined wave-like surface is observed, and the modified melted layer has clearly oriented structure for melting depth);
 - the electron-beam processing of the elements of optical glass by melting leads not only to homogenization of the surface, but also to oriented restructure near the surface of the silicon-oxygen grid, which is becoming close to the quartz glass structure, which considerably increases the resistance of the elements to external-heat;
 - the depth of the main-heat zone or the thickness of the melted layer can reach 250 ... 300 microns and essentially depends on the density of heat exposure of the beam F_n and its moving speed V : for example, increasing F_n from $7 \cdot 10^6$ W/m² to $5 \cdot 10^8$ W/m² and decreasing V from $5 \cdot 10^{-3}$ m/s до $5 \cdot 10^{-2}$ m/s leads to an increase in depth of melting from 20...60 microns to 130...220 microns.
2. It was found that improvement of the properties of the surface layers of the optical elements after electron beam processing leads to increase their resistance to external-heat:
- increase in 1.5 ... 2 times the critical values of the external heat flows and times of their effects that lead to destruction of elements; thus increasing the external pressure from 10^5 Pa to 10^7 Pa reduces the critical values of these parameters in 1,3 ... 1,4 times;
 - increase in 1.7 ... 2.3 times the value of the maximum permissible thermal stress in the optical elements processed by

electron beam, to change the heating temperature range 300 ... 1200 K.

3. It was found that electron beam pre-treatment of plates of optical glass used in the devices for measuring and thermal control of objects of different physical nature, reduces the amount of damage in the 2 ... 2.5 times and increases the probability of failure-free operation in 1.9 ... 2.3 times under variable external heating conditions.

3. References

1. Vashchenko V. A., Kotelnikov D. I., Lega Y. G., Krasnov D. M., Yatsenko I. V., Kirichenko O. V. *Teplovye protsesy pri elektronnoi obrabotke opticheskikh materialov i ekspluatatsii izdelii na ich osnove* (Thermal processes in the electronic processing of optical materials and use of products based on them) Kiev: Naukova Dumka, 2006, 368 p.
2. Vashchenko V. A., Yatsenko I. V., Lega Y. G., Kirichenko O. V. *Osnovy elektronnoi pbrobky vyrobiv z optychnykh materialiv* (The basics of electronic processing of optical materials) Kiev: Naukova Dumka, 2011, 562 p.
3. Bochok P. M., Budko N. P., Vashchenko V. A., Kanasevich G. V., Kotelnikov, D. I. *Spetsialni metodu obrobky optychnogo skla. Navchalnyi posibnyk* (Special methods of processing optical glass. Tutorial) Chernihiv: Chernihivskiy derzhavnyi technologichnyi Universitet, 2001, 215 p.
4. Dudko G. V., Kulov, S. K., Rose Y. A., Maksimova N. G. *Issledovanie elektronno-luchevykh protsessov v sozdanii bazovykh technologii ELEFP* (Investigation of electron-beam processes in the creation of basic technologies ELEPP) *Elektronnaya promyshlennost*, 1991, Vol. 1, P. 41 – 45.
5. Vashchenko V. A., Kanashewich G. V., Dubrovskaya G. N., Kotelnikov D. I. *Modifikatsiya struktury i svoystv zony termovozdeystviya pri obrabotke lentochnym elektronnykh luchem opticheskikh materialov* (Modification of the structure and properties of the zone of heat when handling the tape with electron beam optical materials) *Materials of IV All-union conference "Application of electron-ion technology in the national economy"*, M.: MEI, 1991.
6. Dubrovskaya G. N., Kanasevich G. V., Vashchenko V. A., Kotelnikov D. I., Yatsenko I. V. *Poluchenie funktsyonalnykh sloev v opticheskom stekle i keramike metodom elektronnoy obrabotki* (Obtaining functional layers in the optical glass and ceramics by means of electronic processing). *Collection of reports of International scientific-practical Symposium "Functional coatings on glass"*, Kharkiv: NTC HFTI "Konstanta", 2003, P. 135 – 137.
7. Vashchenko V. A., Dubrovskaya G. N., Kanashewich G. V., Pozdeev S. V. *Opticheskie svoistva podlozhek OIS iz stekla posle nizkoenergeticheskoi elektronno-luchevoi obrabotki* (Optical properties of substrates OIC of glass after low-energy electron-beam processing). *Proceedings of the 3rd International Symposium vacuum technology and equipment*, Kharkiv, 22 – 24 September 1999, P. 115 – 118.
8. Vashchenko V. A., Kirichenko O. V., Kotelnikov D. I. *Optimizatsiya elektronnoi obrabotki izdelii infrakrasnoi tehniki* (Optimization of electronic processing of products of infrared technology) *Elektronnaya obrabotka materialov*. Institute of applied physics Academy of Sciences of Moldova, 2004, No. 6, P. 44 – 48.
9. State standard of Ukraine 27.002-89. *Nadiinist u technitsi. Osnovni ponyattya. Terminy ta vyznachennya* (Reliability in technique. Basic concepts. Terms and definitions).

POTENTIAL PREPARATION OF TECHNICAL DOCUMENTATION WITH MEASUREIT IN BLENDER

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Abstract: It is customary for the preparation of technical documentation to use CAD (computer aided design) systems. Depending on the design and functionality they are divided into low, medium and high class. In certain cases, there are developed alternative software applications or such added to other basic systems with broad opportunities for development. At the present time open source programs are more widely used. This reinforces the interest of designers, engineers and architects to find possible application of such programs in the workflow. Contemporary and very good solution gives Blender free software with specialized application "MeasureIt".

Keywords: BLENDER, TECHNICAL, DRAWING, SKETCH, MEASUREIT

1. Introduction

It happens so that sometimes the high cost of specialized CAD systems and specialized programs for preparation of technical documentation become an obstacle to consumers, causing many professionals to seek other options for carrying out their work. Open source software programs offer somewhat solution to this issue, with some remarks about the functional capabilities and competitiveness of proven paid programs. At this stage a free license, accessible and popular programs are FreeCAD, LibreCAD, NanoCAD, TigerCAD, and others [1, 2]. Of course each of these programs is specific in nature and has positive aspects. Typically, the free license leads to a lack of the necessary renewal of activity in functionality and as a rule this type of programming to some extent lag functionally behind the leading paid CAD systems [3, 4]. An exception is GNU 3D software Blender [5 - 8]. Originally developed as a 3D graphics system later on there were created a number of additional features including the ability to draw up technical documentation. This can be considered a breakthrough in 3D graphics systems because of their main purpose. A very good application is the free application MeasureIt Addon specially developed for Blender software.

2. Prerequisites and ways to solve the problem

Opportunities provided by MeasureIt are of great importance in the development of technical documentation, as well as ordinary dimensioning and annotation. MeasureIt has the following functionality:

- create annotations;
- display orthogonal segments;
- mesh vertex to vertex measure (length between vertices in the same mesh);
- mesh vertex labeling (add a label to any mesh vertex; identify different areas or objects in the scene);
- object to object (distance between object origins, vertex to origin or vertex to vertex);
- object to origin (distance between object origin to scene origin or vertex to scene origin);
- arrows (line, triangle, TShape);
- vertex to origin in one axis measure;
- work with different scales;
- calculate areas (edit and object mode);
- sum automatically several segments;
- measures rendering (opengl and final render).

For integration of the application MeasureIt Addon in Blender software it is required to be taken off and added to Blender User Preferences Addon. Fig.1 shows the scheme of integration of MeasureIt Addon in Blender.

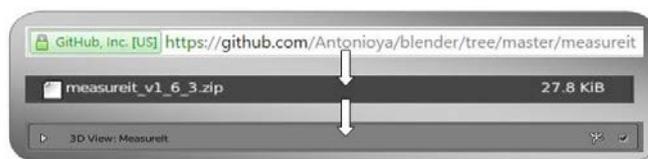


Fig. 1 Integration of MeasureIt Addon in Blender

General view of MeasureIt Addon is shown in Fig.2

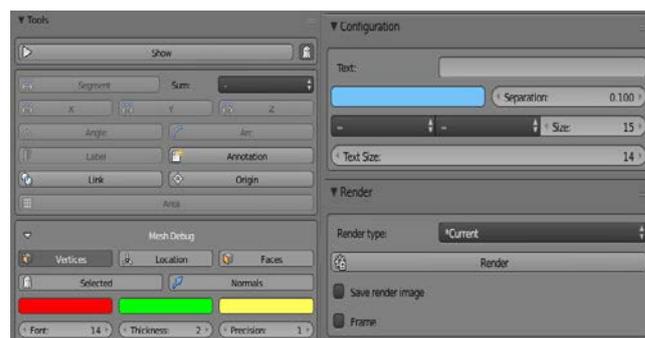


Fig. 2 General view of MeasureIt Addon

3. Solution of the researched problem

The aim of this study is specifying the functionality of MeasureIt Addon. For a detailed study of capabilities of MeasureIt Addon is necessary an exemplary model to be developed. Fig. 3 illustrates an exemplary model of Hot-Rolled Steel - ot-Finished Structural Hollow Section - Rectangular Tube with size 250x150h10x10mm (Standard ISO 657-14) [9-16], which will serve as a research model on which will be applied capabilities of MeasureIt Addon for preparation of technical documentation in Blender software.

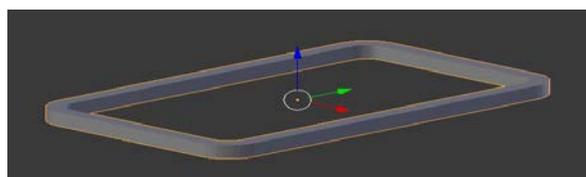


Fig. 3 Hot-Rolled Steel – Hot-Finished Structural Hollow Section – Rectangular Tube with size 250x150x10x10mm (Standard ISO 657 – 14)

Before starting the sizing it is necessary to make the required settings and definitions on the scene, the camera and render (Camera Ortho View; Blender scene render freestyle; World: horizon color: white, zenith color: black, ambient color: white; Render layers: freestyle lineset, lineset color: black; Camera

location: X:0, Y:0, Z:0.5; camera rotation: X:0, Y:0, Z:0; camera Orthographic scale: 0.6). Fig. 4 shows the correct configuration of the scene.

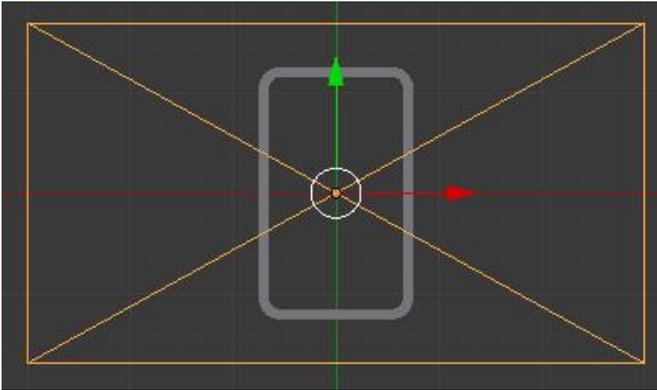


Fig. 4 Configuration camera view (Ortho)

Fig. 5 shows a general view of dimensional settings (in standby Edit Mode) at stage before starting the final render.

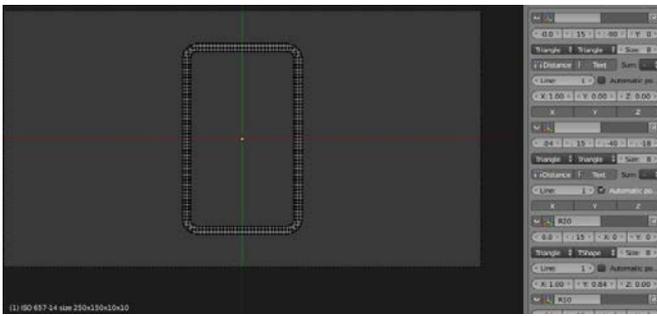


Fig. 5 General view of dimensional settings in Edit Mode

4. Results and discussion

Results of sizing of the model Hot-Rolled Steel – Hot-Finished Structural Hollow Section – Rectangular Tube (Camera Ortho View; size 250x150x10x10mm; Standard ISO 657 – 14) in Blender is shown on Fig.6.

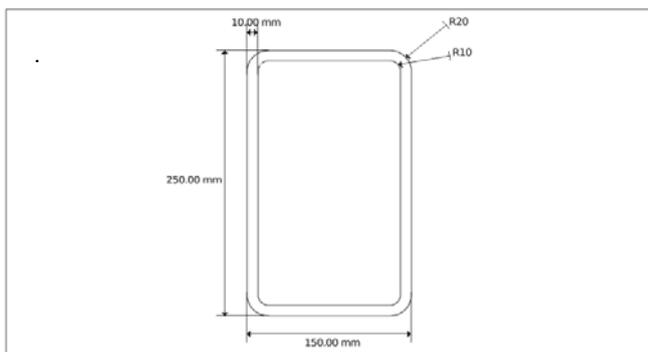


Fig. 6 Technical drawing - scheme result

In developing the technical documentation of exemplary model impresses the great importance of how the network nodes of the model are located. This is especially important when defining geometrical relationships in automatic dimensioning. This is certainly a factor that influenced the creation of any drawing (technical or architectural) of a set model. As of today (December 2015) the current version MeasureIt Addon 1.6.3 is actual, where these errors are removed in: quadview, object to vertex link, alpha for lines. Along with this there are limitations that should be noted in the set of tools necessary for designing vocational technical

documents according to standards. Despite the inconveniences the positive aspects of MeasureIt Addon are undeniable in terms of: very convenient management, well-structured functional panels, innovative approaches, very good quality of the final image and mostly successful adaptation of automatic and drafting tools, which is a breakthrough in systems of this type. Because of its specificity of a no CAD system, application MeasureIt Addon in Blender lays the foundation for a progressive beginning, which in favorable conditions can turn into a fully functional application.

5. Conclusion

Blender software is one of the fastest developing systems. Originally created in the field of 3D graphics Blender gradually began to develop in many other functional areas. With its free license, easy, affordable and innovative interface, Blender boosts multiple users and developers to contribute to the positive progress of the program. The application MeasureIt Addon, specialized in the preparation of technical documentation opens new and important opportunities for designers, engineers and architects. MeasureIt Addon fills a very important segment in the system Blender, which makes the program suitable and successful choice in the realization of technical documentation.

6. Literature

- [1]. Daniel Falck. FreeCAD How to: Solid Modeling with the Power of Python. Packt Publishing. Birmingham, UK, 2012.
- [2]. Daniel Falck. Brad Collette. FreeCAD [How-to]. Packt Publishing. Birmingham, UK, 2012.
- [3]. И. П. Норенков. Основы автоматизированного проектирования. Издательство МГТУ имени Н. Э. Баумана. Москва, Русия, 2009г.
- [4]. И. П. Норенков. Автоматизированное проектирование. Уфимский Государственный Авиационный Технический Университет Москва, Русия, 2000г.
- [5]. Felician Alecu, Blender Institute – the Institute for Open 3D Projects, Open Source Science Journal Vol. 2, No. 1, Economic Informatics Department, ASE Bucharest, Romania, 2010, 36 – 45p.
- [6]. Ami Chopine, 3D Art Essentials The Fundamentals of 3D Modeling, Texturing, and Animation, Elsevier, ISBN: 978-0-240-81471-1, USA, 2011, 249 – 252p.
- [7]. Tihomir Dovramadjiev. Modern accessible application of the system blender in 3d design practice. International scientific on-line journal "SCIENCE & TECHNOLOGIES" Publisher "Union of Scientists - Stara Zagora". ISSN 1314-4111 140. Bulgaria, 2015. 10 - 13p.
- [8]. James Chronister, Blender 3D Basics 3rd Edition, Creative commons attribution-NonCommercial-share alike 3.0 Unported License, 2009,146 p.
- [9]. NCASI. Life cycle assessment of u.s. average corrugated product. Research Triangle Park, NC. USA, April 2014.
- [10]. Planet Ark Environmental Foundation. Sydney, Australia, 2014. <http://planetark.org/>.
- [11]. Corrugated Packaging Alliance (CPA). Corrugated Packaging Life-cycle Assessment. Summary Report. USA, 2010.
- [12]. Guide to Sustainable Design using SolidWorks Sustainability. Dassault Systemes SolidWorks. USA, 2014.
- [13]. Benjamin Tan. Green Design with SolidWorks. Dassault Systemes.
- [14]. OLTIKAR, AKHIL MANOHAR. Computer-Aided Engineering of Plywood Upholstered Furniture Frames. USA, 2000.
- [15]. Michael Lee. Cardboard Chair Project. Research Report.
- [16]. Greg Saul, Manfred Lau, Jun Mitani, Takeo Igarashi. SketchChair: An All-in-one Chair Design System for End Users. TEI'11, January 22–26, 2011, Funchal, Portugal.

SYNCHRONIZATION T-CHAOTIC SYSTEM

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Abstract: In this paper, we study on chaos, one of the most important phenomenons based on complex nonlinear dynamics. We will focus on T-system chaos and in continue, using three synchronization methods, Brain Emotional Learning Based Intelligent Controller (BELBIC), Generalized Backstepping Method (GBM) and adaptive method, the chaotic system will be synchronized. To prove usability of the controllers, the results will be compared with the results obtained by Active Control and Backstepping Controllers. According to the results, proposed controllers synchronize chaotic systems with higher speed, lower setting time, lower overshoot and smaller control signal versus active control and backstepping controllers.

Keywords: CHAOS, BELBIC, GENERALIZWD BACKSTEPPIG METHOD, ACTIVE CONTROL

1. Introduction

Chaos is an important phenomenon, happens vastly in both natural and man-made systems. Lorenz [1] faced to the first chaotic attractor in 1963. In continue, a lot of researches were achieved on chaotic systems [2-11]. A new 3D chaotic system (T-system) from the Lorenz system was derived in [12,13]. Over the last two decades, chaos control and synchronization have been absorbed increasingly attentions due to their wide applications in many fields [14–25]. Active control [28], backstepping [28] and adaptive control [28] are three different methods for synchronization of T system. Active control [28] and backstepping [28] methods are selected when system parameters are known, and adaptive control [28] method is applied when system parameters are unknown. GBM [26,27], a new method to optimize backstepping method, controls chaos in nonlinear systems better than backstepping design.

A kind of BELBIC model was introduced to control nonlinear systems [29] and aerospace launch vehicle control [30]. Another model of BELBIC was proposed for control and tracking of vehicles [31] and Intelligent autopilot control design [32]. This paper proposes new controllers to control and Synchronize T chaotic system according to three models, BELBIC [29,30], GBM [26,27] and adaptive method, and Simulation results shows that mentioned controllers synchronize this chaotic system more better and faster than active control and backstepping controllers.

2. Generalized Backstepping Method (GBM)

GBM [26-27] will be applied to a certain class of autonomous nonlinear systems which are expressed as

$$\begin{aligned} \dot{X} &= F(X) + G(X)\eta \\ \dot{\eta} &= f_0(X, \eta) + g_0(X, \eta)u \end{aligned} \quad (2)$$

In which $\eta \in \mathfrak{R}$ and $X = [x_1, x_2, \dots, x_n] \in \mathfrak{R}^n$. In order to obtain an approach to control these systems, we may need to explain a new theorem as follow.

Theorem. Suppose (2) is available, then $\varphi_i(X)$ for the i_{th} state could be determined i a manner which by inserting the i_{th} term for η , $V(X)$ would be a positive definite (3) with negative definite derivative.

$$V(X) = \frac{1}{2} \sum_{i=1}^n x_i^2 \quad (3)$$

Therefore, the control signal and also the general control Lyapunov function of this system can be obtained by (4) and (5).

$$u = \frac{1}{g_0(X, \eta)} \left\{ \sum_{i=1}^n \sum_{j=1}^n \frac{\partial \varphi_i}{\partial x_j} [f_i(X) + g_i(X)\eta] - \sum_{i=1}^n x_i g_i(X) - \sum_{i=1}^n k_i [\eta - \varphi_i(X)] - f_0(X, \eta) \right\}; k_i > 0; i = 0, 1, 2, \dots, n \quad (4)$$

$$V_i(X, \eta) = \frac{1}{2} \sum_{i=1}^n x_i^2 + \frac{1}{2} \sum_{i=1}^n [\eta - \varphi_i(X)]^2 \quad (5)$$

3. Genetic Algorithm

The genetic algorithms are used to search the optimal parameter k ($k_j; j = 1, 2$ is positive constant) in order to guarantee the stability of systems by ensuring negativity of the Lyapunov function and having a suitable time response [33-34]. The fitness function used is

$$f = \frac{1}{n} \sum_{i=1}^n e_i^2 \quad (6)$$

Table 1: Genetic Algorithm Parameters

Parameters	Values
Size population	100
Maximum of generation	300
Prob.crossover	75
Prob.mutation	0.001
k_j search interval de	[0.1 10]

4. T-Chaotic System

State space of T system is expressed as

$$\begin{aligned} \dot{x} &= a(y - x) \\ \dot{y} &= (c - a)x - axz \\ \dot{z} &= -bz + xy \end{aligned} \quad (7)$$

Where $a = 2.1, b = 0.6, c = 30$ are system constants. Fig.1 displays state trajectory of (7) and its xyz phase portrait diagram is displayed in Fig.2 in $t = 250$ Sec with initial conditions $(0.1, -0.3, 0.2)$.

5. Synchronization T-System using GBM

For synchronization, we consider master system as (8):

$$\begin{aligned} \dot{x}_1 &= a(y_1 - x_1) \\ \dot{y}_1 &= (c - a)x_1 - ax_1z_1 \\ \dot{z}_1 &= -bz_1 + x_1y_1 \end{aligned} \quad (8)$$

And slave system by adding control inputs u_1, u_2 as (9).

$$\begin{aligned} \dot{x}_2 &= a(y_2 - x_2) \\ \dot{y}_2 &= (c - a)x_2 - ax_2z_2 + u_1 \\ \dot{z}_2 &= -bz_2 + x_2y_2 + u_2 \end{aligned} \quad (9)$$

We define error between (8) and (9) as

$$\begin{aligned} e_x &= x_2 - x_1 \\ e_y &= y_2 - y_1 \\ e_z &= z_2 - z_1 \end{aligned} \quad (10)$$

Now, by putting (10) in (8) and (9)

$$\begin{aligned} \dot{e}_x &= a(e_y - e_x) \\ \dot{e}_y &= (c - a)e_x - a(x_2z_2 - x_1z_1) + u_1 \\ \dot{e}_z &= -be_z + x_2y_2 - x_1y_1 + u_2 \end{aligned} \quad (11)$$

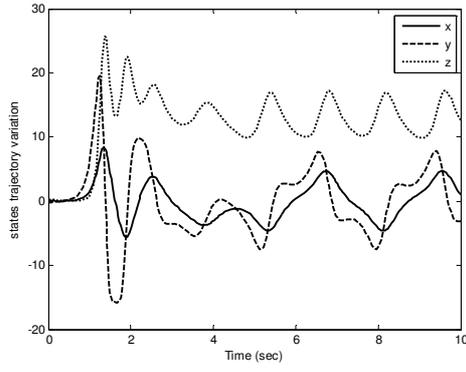


Fig. 1 State trajectory of (7)

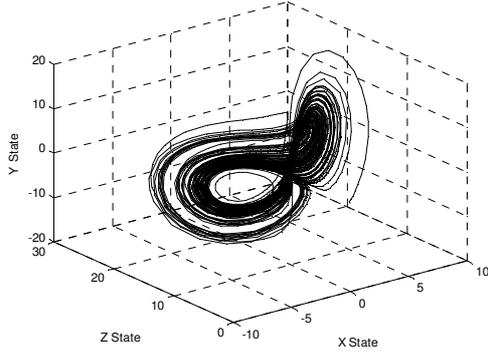


Fig. 2 xyz phase-page diagram of (7) in $t = 250$ Sec

Now, based on GBM method, we consider virtual control signals as

$$\varphi_{11} = \varphi_{12} = \varphi_{21} = \varphi_{22} = 0 \quad (12)$$

Finally, according to (3), control signals for synchronization between these systems are obtained by

$$\begin{aligned} u_1 &= -[ce_x + k_{11}e_y + k_{12}e_z - a(x_2z_2 - x_1z_1)] \\ u_2 &= -[k_{21}e_y + (k_{22} - b)e_z + x_2y_2 - x_1y_1] \end{aligned} \quad (13)$$

According to (4), Lyapunov function is expressed as

$$\begin{aligned} V &= \frac{1}{2}[e_x^2 + e_y^2 + e_z^2 + (e_y - \varphi_{11})^2 + (e_y - \varphi_{12})^2 \\ &\quad + (e_z - \varphi_{21})^2 + (e_z - \varphi_{22})^2] \end{aligned} \quad (14)$$

Now, using genetic algorithm and according to fitness function in (6), optimize GBM controller in (13). For this purpose, we consider gains $k_{11}, k_{12}, k_{21}, k_{22}$ as genetic algorithm inputs. After optimization, the best values for these gains are obtained as

$$k_{11} = 8.7165, k_{12} = 1.9697, k_{21} = 2.127, k_{22} = 7.0108 \quad (15)$$

For master and slave systems, assume initial condition

$$\begin{aligned} (x_1(0), y_1(0), z_1(0)) &= (0.1, -0.3, 0.2) \\ (x_2(0), y_2(0), z_2(0)) &= (2.4, -3.3, 14.5) \end{aligned} \quad (16)$$

After applying GBM controller, we compare obtained results with the results of active control and backstepping controllers [28]. The states e_x, e_y, e_z are depicted in Fig.3-5 respectively. Control signals for synchronization of these chaotic systems using GBM and Backstepping controllers has been displayed in Fig.6-7 and three control signals using Active control [28] are shown in Fig.8.

According to GBM method, a controller was designed for synchronization. Designed controller has gains with positive values. GBM controller possesses different behaviors for each value of these gains which probably conducts system to inconstancy.

In order to find the best values for this controller, genetic algorithm was utilized. Genetic algorithm minimizes fitness function. Also this function is considered based on Total Square Error. Comparing GBM controller with Active control [28] and backstepping [28] controller, we could prove its better usefulness and effectiveness.

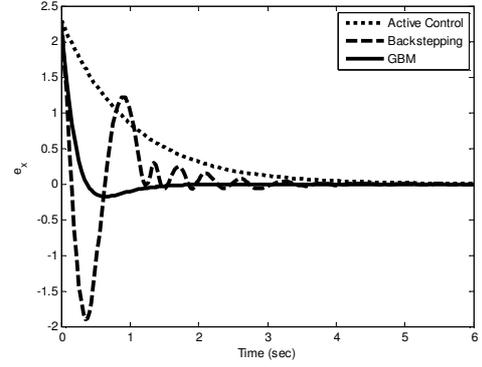


Fig. 3 Trajectory of error e_x

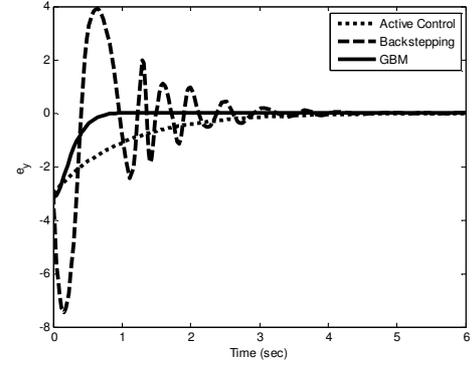


Fig. 4 Trajectory of error e_y

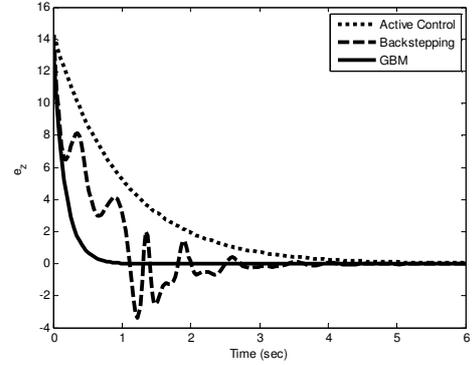


Fig. 5 Trajectory of error e_z

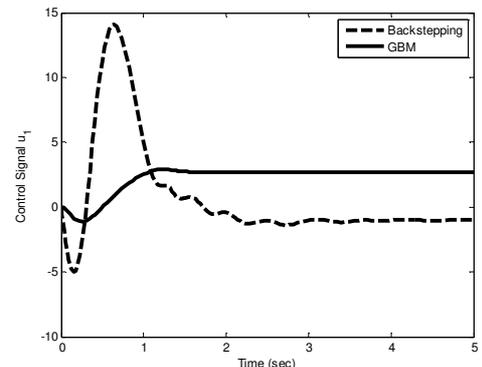


Fig. 6 Control signal u_1 for synchronization using GBM and BM [28]

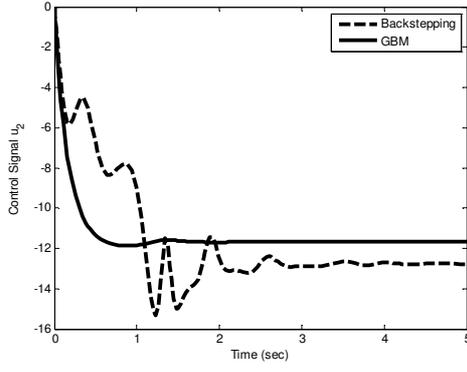


Fig. 7 Control signal u_1 for synchronization using GBM and BM [28]

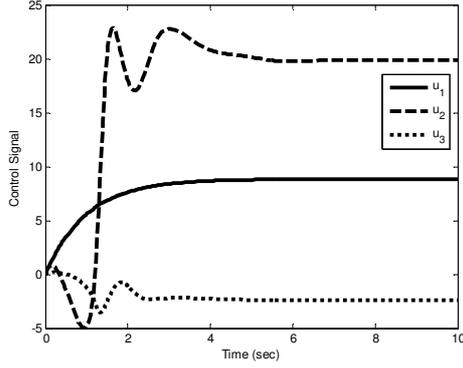


Fig. 8 Control signals for synchronization using active control

6. Synchronization T-System using Adaptive GBM

The parameters a, b, c in (11) are unknown and a_1, b_1, c_1 are respectively estimated values of them which are updated by

$$\begin{aligned}\dot{a}_1 &= -e_x^2 - e_y(x_2 z_2 - x_1 z_1) \\ \dot{b}_1 &= -e_z^2 \\ \dot{c}_1 &= e_1 e_2\end{aligned}\quad (17)$$

Now by using GBM, we consider virtual control signals as

$$\varphi_{11} = \varphi_{12} = \varphi_{21} = \varphi_{22} = 0 \quad (18)$$

Finally, according to (3), control signals are

$$\begin{aligned}u_1 &= -[c_1 e_x + k_{11} e_y + k_{12} e_z - a_1(x_2 z_2 - x_1 z_1)] \\ u_2 &= -[k_{21} e_y + (k_{22} - b_1) e_z + x_2 y_2 - x_1 y_1]\end{aligned}\quad (19)$$

Now, using genetic algorithm and according to fitness function in (6), we optimize adaptive GBM controller in (19). For this purpose, we consider gains $k_{11}, k_{12}, k_{21}, k_{22}$ as genetic algorithm inputs. After optimization, the best values for these gains are obtained as:

$$k_{11} = 9.8584, k_{12} = 1.6731, k_{21} = 7.9422, k_{22} = 8.8094 \quad (20)$$

We assume initial conditions as (16).

7. Brain Emotional Learning Based Intelligent Controller (BELBIC)

According to this method, learning is based on emotional factors such as excitement and anxiety [31-32]. In this paper, the factors that designer has sensitivity on them, are considered as stimuluses which make system disturbed and control system should decrease system anxiety versus them. BELBIC possesses some sensor inputs selected by designer. BELBIC has two states for each sensor input; amygdala and orbitofrontal output as

$$\begin{aligned}A_i &= s_i v_i \\ O_i &= s_i w_i\end{aligned}\quad (21)$$

Where s_i is i^{th} sensor input. v, w are two states depended to sensor input and calculated as follow

$$\Delta v_i = \alpha s_i \max(0, \text{rew} - \sum A_i) \quad (22)$$

$$\Delta w_i = \beta s_i - (\text{rew} - \sum A_i - \sum O_i) - \max(s_i)$$

Where α, β are learning parameters. rew is reward signal selected as a linear function of system error. Control signal u is obtained as

$$u = \sum A_i - \sum O_i \quad (23)$$

8. Synchronization T-System using BELBIC

To synchronize, we consider master system as (24) and slave system by adding three control inputs as (25).

$$\begin{cases} \dot{x}_1 = a(y_1 - x_1) \\ \dot{y}_1 = (c - a)x_1 - ax_1 z_1 \\ \dot{z}_1 = -bz_1 + x_1 y_1 \end{cases} \quad (24)$$

$$\begin{cases} \dot{x}_2 = a(y_2 - x_2) + u_1 \\ \dot{y}_2 = (c - a)x_2 - ax_2 z_2 + u_2 \\ \dot{z}_2 = -bz_2 + x_2 y_2 + u_3 \end{cases} \quad (25)$$

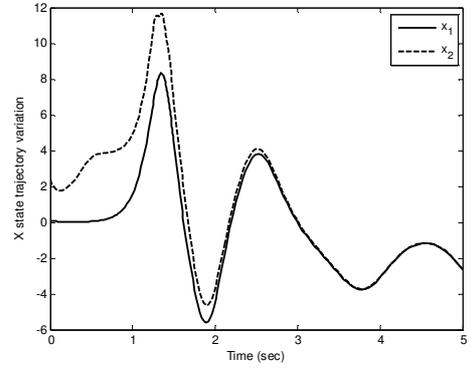


Fig. 9 Trajectory of state x

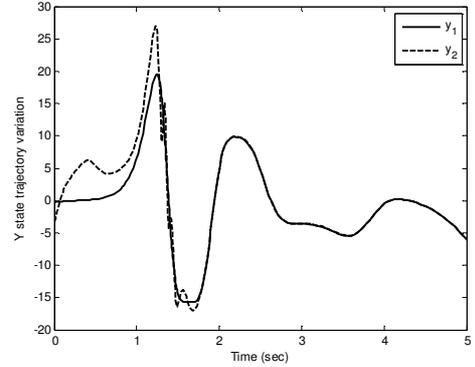


Fig. 10 Trajectory of state y

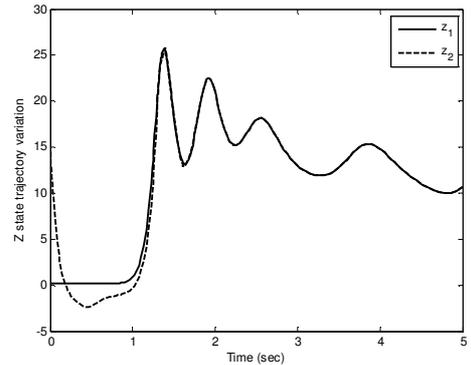


Fig. 11 Trajectory of state z

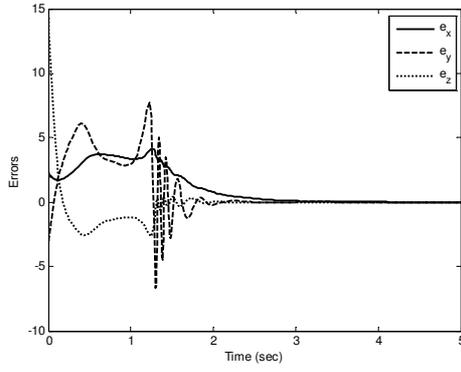


Fig. 12 Error trajectory between slave and master systems

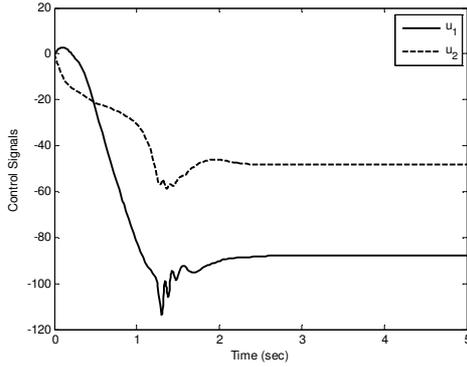


Fig. 13 Control signals for synchronization

We define error between (24) and (25) as

$$\begin{cases} e_x = x_2 - x_1 \\ e_y = y_2 - y_1 \\ e_z = z_2 - z_1 \end{cases} \quad (26)$$

Now, Sensor input for BELBIC and reward signal for each control signals u_1, u_2, u_3 are selected as (27-28) and parameters α, β are equal to 1 and 3 respectively and initial conditions as (16).

$$s_i = [e_1; e_2; e_3] \quad (27)$$

$$rew_i = [4e_1 + 4; 4e_2 + 4; 2e_3 + 7] \quad (28)$$

After using BELBIC, we compare the results with the results obtained by Active control and Backstepping [28] controllers. Fig.14-16 display error changes between master and slave systems using BELBIC, backstepping [28] and active control [28]. Control signals of BELBIC, backstepping [28] and active control [28] for synchronization are indicated in Fig.17-19 respectively.

9. Conclusions

In this paper, T-chaotic system was studied. Then we addressed the synchronization problem and proposed three methods for it; BELBIC, GBM and adaptive method. By comparing these methods versus active control and BM, we could prove their better usefulness. The results obtained from simulations demonstrated that BELBIC, GBM and adaptive methods synchronize system with higher speed, lower settling time, lower overshoot and lower control cost against active control and BM.

References

1. Lorenz, Deterministic non-periodic flows, J Atmos Sci, **20**, 130–141, (1963).
2. C. Sparrow, The Lorenz equations: bifurcations, chaos and strange attractors, New York: Springer-Verlag; (1982).
3. G. Chen and X. Dong, From chaos to order: methodologies, perspectives and applications. Singapore: World Scientific; (1998).

4. OE. Rossler, An equation for continuous chaos, Phys Lett. A, **57**, 397–398, (1976).
5. G. Chen and T. Ueta, Yet another chaotic attractor, Int J Bifurcat Chaos, **9**, 1465–1466, (1999).
6. J. Lü and G. Chen, A new chaotic attractor coined, Int J Bifurcat Chaos, **12**, 659–661, (2002).
7. C. Liu, T. Liu, L. Liu and K. Liu, A new chaotic attractor. Chaos Solitons and Fractals, **22**, 1031–1038, (2004).

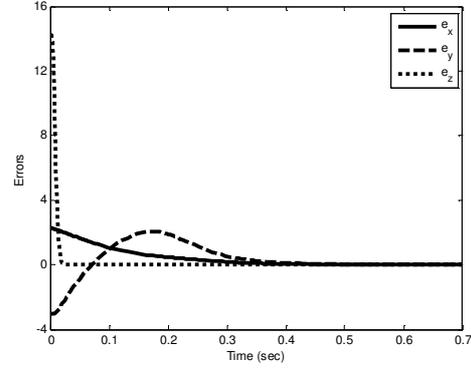


Fig. 14 Error changes between master and slave systems using BELBIC

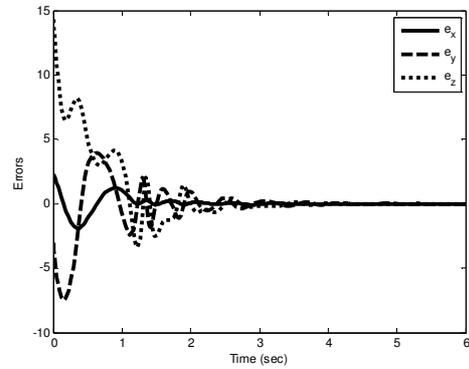


Fig. 15 Error changes using BM [28]

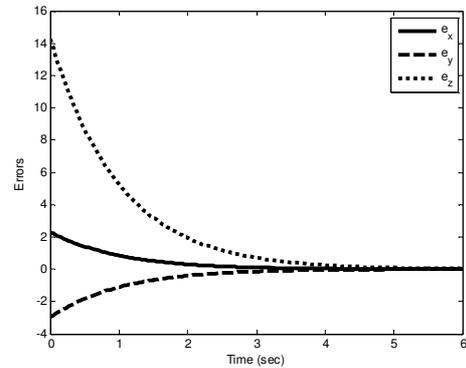


Fig. 16 Error changes using active control [28]

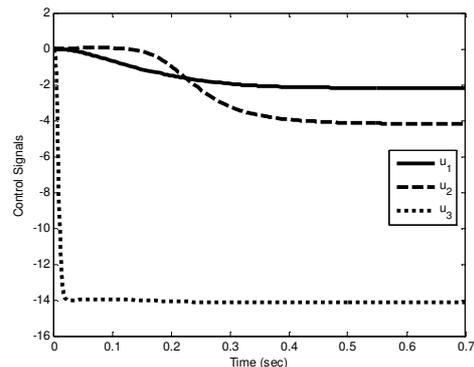


Fig. 17 Control signals for synchronization using BELBIC

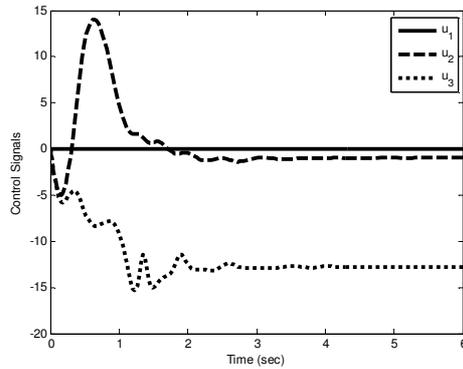


Fig. 18 Control signals for synchronization using backstepping [28]

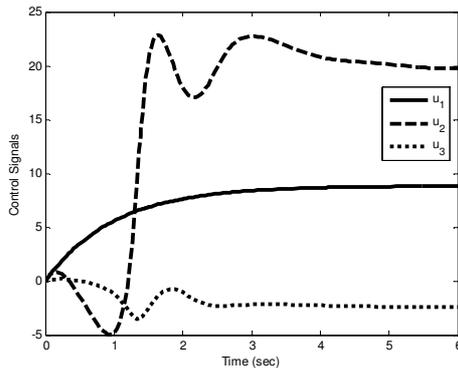


Fig. 19 Control signals for synchronization using active control [28]

8. G. Qi, G. Chen, et al. Analysis of a new chaotic system, *Physica A*, **352**, 295–308, (2005).

9. L. Liu, Y. Su, et al. A modified Lorenz system, *Int J Nonlinear Sci*, **7**, 187–191, (2006).

10. G. Qi, G. Chen and Y. Zhang, On a new asymmetric chaotic system. *Chaos, Solitons and Fractals*, **37**, 409–423, (2008).

11. G. Qi, Chen G., et al. A four-wing chaotic attractor generated from a new 3-D quadratic autonomous system. *Chaos, Solitons and Fractals*, **38**:705–21(2008).

12. G. Tigan, Analysis of a dynamical system derived from the Lorenz system. *Sci Bull Politehnica Univ. Timisoara*, **50**, 61–72, (2005).

13. G. Tigan and O. Dumitru, Analysis of a 3D chaotic system, *Chaos, Solitons and Fractals*, **36**, 1315–1319, (2008).

14. LM. Pecora and TL., Carroll Synchronization in chaotic systems, *Phys Rev Lett*, **64**, 821–824, (1990).

15. TL. Carroll and LM. Pecora, Synchronizing chaotic circuits, *IEEE Trans Circ Syst. I*, **38**, 453–456, (1991).

16. Cuomo and AV. Oppenheim, Circuit implementation of synchronized chaos with applications to communications, *Phys Rev Lett*, **71**, 65–68, (1993).

17. G. Perez and H. Cedeira, Extracting messages masked by chaos, *Phys Rev Lett*, **74**, 1970–1973, (1995).

18. T. Liao and N. Huang, An observer-based approach for chaotic synchronization with applications to secure communications, *IEEE Trans Circ Syst I*, **46**, 1144–1150, (1999).

19. S. Boccaletti, J. Kurths, et al, The synchronization of chaotic systems, *Phys Rep*, **366**, 1–101, (2002).

20. F. Wang and C. Liu, A new criterion for chaos and hyperchaos synchronization using linear feedback control, *Phys Lett A*, **360**, 274–278, (2006).

21. MT. Yassen, Adaptive control and synchronization of a modified Chua's circuit system, *Appl Math Comput*, **135**, 113–128, (2003).

22. C. Wang and S. Ge, Adaptive synchronization of uncertain chaotic systems via backstepping design, *Chaos, Solitons and Fractals*, **12**, 1199–1206, (2001).

23. Y. Yu, S. Zhang, Adaptive backstepping control of the uncertain Lü system, *Chin Phys*, **11**, 1249–1253, (2002).

24. F. Wang and C. Liu, Synchronization of unified chaotic system based on passive control, *Physica D*, **225**, 55–60, (2007).

25. J. Yan, M. Hung, et al. Robust synchronization of chaotic systems via adaptive sliding mode control, *Phys Lett A*, **356**, 220–225, (2006).

26. A.R. Sahab, and M. Haddad Zarif, Chaos Control in Nonlinear Systems Using the Generalized Backstepping Method, *American J. of Engineering and Applied Sciences*, **1** (4): 378–383, (2008).

27. Ali Reza Sahab and Mohammad Haddad Zarif, Improve Backstepping Method to GBM, *World Applied Sciences Journal* **6** (10): 1399–1403, (2009).

28. Yue Wu, Xiaobing Zhou, Jia Chen, Bei Hui, Chaos synchronization of a new 3D chaotic system, *Chaos, Solitons and Fractals*, **42**, 1812–1819, (2009).

29. Ali Reza Mehrabian and Caro Lucas, Emotional Learning based Intelligent Robust Adaptive Controller for Stable Uncertain Nonlinear Systems, *International Journal of Computational Intelligence*, **2** (4), (2005).

30. Ali Reza Mehrabian, Caro Lucas, Jafar Roshanian, Aerospace launch vehicle control: an intelligent adaptive approach, *Aerospace Science and Technology*, **10**, 149–155, (2006).

31. Saeed Jafarzadeh, Rooholah Mirheidari, Mohammad Reza Jahed Motlagh, Mojtaba Barkhordari, Designing PID and BELBIC Controllers in Path Tracking Problem, *Int. J. of Computers, Communications & Control, Proceedings of ICCCC*, 343–348, (2008).

32. Saeed Jafarzadeh, Rooholah Mirheidari, Mohammad Reza Jahed Motlagh, Mojtaba Barkhordari, Intelligent Autopilot Control Design for a 2-DOF Helicopter Model, *Int. J. of Computers, Communications & Control, Proceedings of ICCCC*, 337–342, (2008).

33. Z. Michalewicz, Genetic Algorithm+Data Structures=Evolution Programs, 2nd Edition, Springer Verlag (1994).

34. Ali Reza Sahab, Masoud Taleb Ziabari, Seyed Amin Sadjadi Alamdari, Chaos Control via Optimal Generalized Backstepping Method, *International Review of Electrical Engineering (I.R.E.E.)*, **5**(5), 2129–2140, (2010).

THIN FILM COATINGS FOR LOW WEAR METAL-POLYMER SYSTEMS

ТОНКОПЛЁНОЧНЫЕ ПОКРЫТИЯ ДЛЯ МАЛОИЗНАШИВАЮЩИХСЯ МЕТАЛЛОПОЛИМЕРНЫХ СИТЕМ

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Abstract: Investigated the features of the structure of the thin-film coatings based on polymeric and oligomeric matrix formed by dipping, spraying or rubbing. It was found a significant effect of energy substrate parameters and components of the coating on the mechanisms of interfacial interactions that determine the parameters of strength, tribological and protective coatings. The active layer morphology of the surface of the substrate formed by mechanical, laser or chemical influence, characterized by the presence of low-dimensional components of different habitus, which affect the energy and mechanical component adhesive strength. By managing service parameters of composite material components on the basis of polymeric and oligomeric matrix manages to change the mechanisms of formation of coatings on metal substrates of carbon steels and non-ferrous metals. Coatings based on the thermal ablation of PTFE products are effective in the process of running heavy-duty friction units and their operation at reversing the motion. Installed effect Nanophase formation regions in the volume of the coating, which help to increase their durability in friction without external supply of lubricant.

KEYWORDS: THIN FILM, MORPHOLOGY, FLUORINE-CONTAINING OLIGOMERS, WEAR MECHANISM, NANOSCALE STRUCTURES AND MODIFIERS

1. Introduction

One of the most important conditions for sustainable functioning tribosystems different structures is the presence of a frictional contact zone so called "the third body", which is formed as a result of physical and chemical processes of interaction of the surface layers of the details included in the friction unit design, elements of technological couples "tool-blank" and technological protection— of air, lubricating or cooling lubricants [1].

It is obvious that the main task of any constructive-technological, or material science solutions tribological device (assembly friction and the technological scheme) is to create a separation layer with the parameters in the optimal degree of ensuring its equilibrium.

Thin film inhibitors wear tribosystems formed from the active gas phase and the solutions rotaprinting and plasma chemical methods, commonly used in tribotechnology including precision [1–4]. Despite the difference in technology of forming the fluorine-containing coating (FCC), differing in composition, structure and geometric parameters, there are general patterns of manifestation of their anti-friction and anti-wear mechanism of action due to the specificity of the molecular and supramolecular structure.

Therefore, the aim of this study was to investigate the general laws of the formation of separation layers on the basis of fluorine-containing components of different composition and structure.

2. Research methods

For the conducting research were chosen of fluorine compounds of various compositions and molecular weight – fluoro chemical oligomers with a molecular weight of up to 1000 units, produced under the trademark "Foleoks" and polymer composites based on polytetrafluoroethylene (PTFE) with a different toppings and modifiers. Coatings on metal substrates formed of fluorine-containing components in the solution by dipping or rotaprinting method. The surface layer of the substrate was exposed to various energy flows - laser, ionizing or deposition of thin film layers in the active phase of the vacuum.

3. Results and discussion

An analysis of the literature and own studies of features structure of the fluorine-containing coating formed by different technologies [1-4] have allowed to carry out their classification according to the criterion by the molecular weight used of the matrix (Fig. 1).

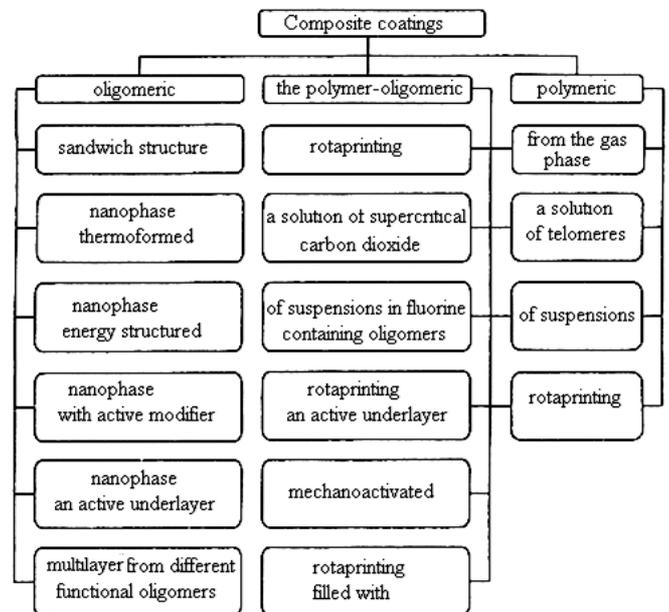


Fig. 1 Classification of fluorine containing tribological coatings

Without pretending to be exhaustive of the proposed classification, consider the typical structural features of composite coatings of various compositions and imaging technologies.

Preferential attention will coatings which are formed by the interaction of the friction modifier the fluoropolymer component on mainly the under layer, which is applied to the metal substrate. The most widely used coatings were prepared based on titanium compounds (nitrides, carbides, alitins), which is formed using vacuum technology. Widely used methods chemical treatment (for example phosphating) to form a surface layer of desired morphology.

When applying nitride titanium sub layer of the steel substrate, depending on the technological conditions, is formed the film with a different morphology. Analyzed influence sub layer of TiN, wherein there was no so-called "drip phase" when varying thickness (denoted "nitride titanium -1" and "nitride titanium-3") and a sub layer with a dropping phase (the designation "nitride titanium -4").

There are two basic methodological approaches to the formation of separation layers in the friction pair. The first is based on the management of kinetics migration of fragments Tribo destruction polymer component in the mating surface and fixing them under the influence of physical and chemical processes in the

friction zone. Management of the parameters of this process can be accomplished by adjusting the roughness parameters of the opposing member surfaces.

Another more effective by forming the separation layer is tribosystem prior application of thin films, including polymeric and oligomeric components on the surface of the friction pair [3, 4]. This area is currently developing intensively in the production of high-precision systems, tools, parts tribosystems increased resource.

We believe that the combination of these two approaches would achieve a synergetic effect in the creation of low wear systems.

It is found that regardless of the technology of preparation of the surface layer of steel metallic counterface of steel 45 (underlayer of TiN without dropping phase and a droplet phase, treated with a jet of sand underlayer or phosphated for 5–30 min) and the type of oligomer used (F-1, F-14) observed intensification of the migration process and the formation of the separation layer (Fig. 2-4).

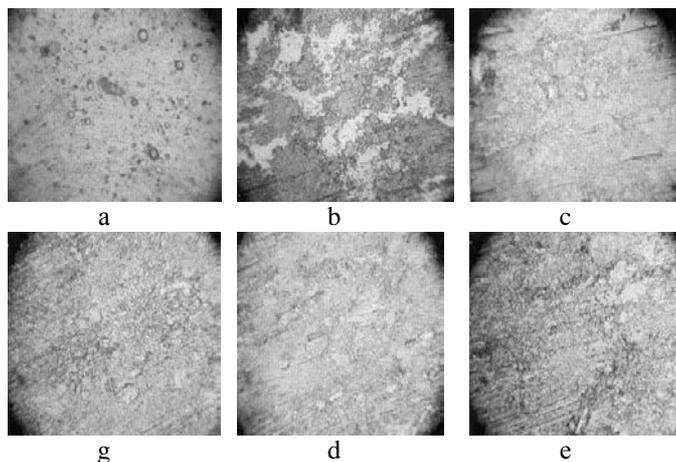


Fig. 2 The morphology of the surface layer of a sample of steel 45 with a under layer of TiN without dropping phase, modified oligomer F-14, after frictional engagement with a graphite sample: a - the original; b - after 10 cycles; c - after 20 cycles; g - after 30 cycles; d - after 40 cycles; e - after 50 cycles. $\times 300$

Applying to the surface a under layer of TiN with a smooth morphology of a thin film of a fluorine-containing oligomer grades of F-1 contributes to the fact that after 10 cycles of contacting loops formed separating layers with a sufficiently homogeneous structure and a high resistance due to the lateral movement without exfoliation, aided oligomeric component (Fig. 3).

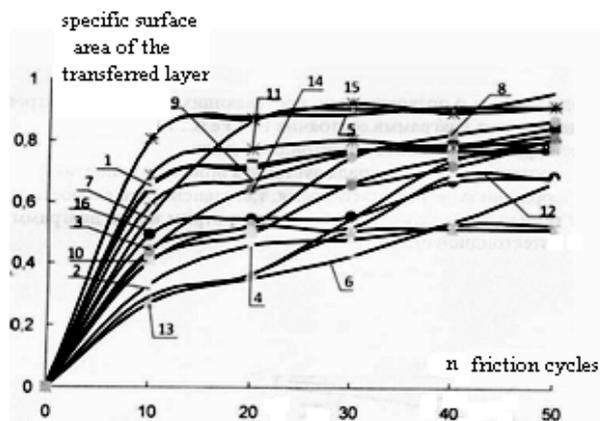


Fig. 3 The kinetics of mass transfer during friction carbon sample for counter body with various pre-treatment: 1 - TiN + F-1; 2 - phosphate. layer 5 m + F-14; 3 - phosphate. layer 15 m + F-1; 4 - TiN + F-14; 5 - TiN ("drip." phase) + F-1; 6 - phosphate. layer 15 m + F-14; 7 - steel 45 sand jet + F-1. 8 - steel 45 sand jet + F-14; 9 - TiN ("drip." Phase) + F-14; 10 - 30 m + fosfat. layer F-14; 11 - fosfat. layer 30 m + F-1; 12 - steel 45 + F-14; 13 - steel 45 + F-1; 14 - phosphate layer 5 m + F-1 + F-14 +; 15 - fosfat. layer 5m + F-1; 16 - TiN + F1 + F-14

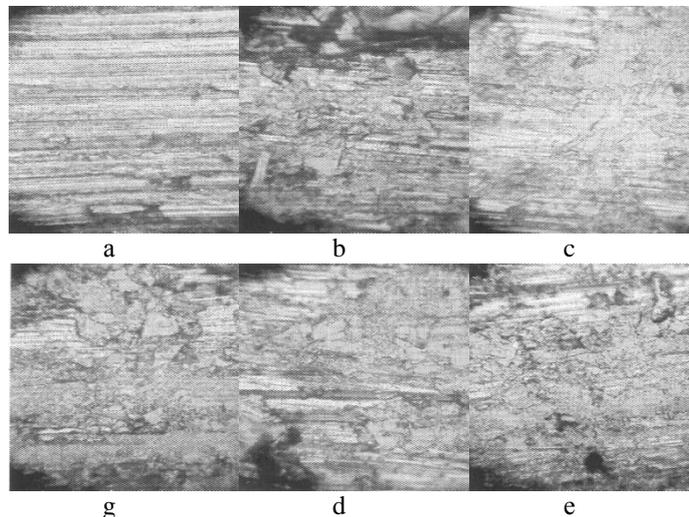


Fig. 4 The morphology of the surface layer of a sample of steel 45 with a sub layer of TiN without dropping phase, modified by oligomer F-1, after the frictional interaction with composites based on PTFE: a - the original; b - after 10 cycles; c - after 20 cycles; g - after 30 cycles; d - after 40 cycles; e - after 50 cycles. $\times 300$

The choice of specific technology of preparation of the morphology of contact surface of the hydraulic elements, oligomeric composition thin film coatings and components forming the separating layers of a given structure, due to technical requirements, defining the resource, the quality of the product and implementation costs [5].

4. Conclusions

The effectiveness of the fluorine-containing wear inhibitors approbation was realized for the manufacture of production tools (molds) and tools for cold deformation of sheet semis. Tests are indicating increase of wear resistance for the movable joints of molds and tools for the production of tubular billets by at least 1.5-2.0 times after a single application to an active sub-layer of fluorinated oligomers "Foleoks" or "Epilam".

5. References

1. **Goldade, V.** Wear inhibitors of metal-polymer systems / V. Goldade, V. Struk, S. Pesetsky. – M.: Chemistry, 1993. – 240 p.
2. **Struck, V.** Tribochemical concept of creating of anti-friction material on the basis of tonnage produced polymer binders: dis. ... dr. tehn. sciences. – Gomel, 1988. – 325 p.
3. **Avdeychik, S.** Tribochemical technology of functional composite materials / S. Avdeychik [and al.]; ed. V. Struk, F. Lovshenko. – Grodno: GGAU, 2007. Part 1. – 320 p; 2008. Part 2. – 395 p.
4. **Auchynnika, Y.** Structure and tribological properties of coatings on the basis of solutions of fluorinated oligomers: dis. ... cand. technical sciences. – Grodno, 1997. – 124 p.
5. **Avdeychik, S.** Nanocomposite engineering materials: design and application experience / S. Avdeychik [and al.]; ed. V. Struk. – Grodno: GrSU, 2006. – 403 p.

CFD MODELLING OF A COMPLETE ELECTRIC ARC FURNACE ENERGY SOURCES

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Abstract: This paper, concentrates on a three-dimensional (3D) computational fluid-dynamics (CFD) model for coal combustion and electrode radiation inside an electric-arc furnace (EAF). Simulation of the complete EAF model includes combustion reactions of coal particles and radiation from electrodes. Particle surface and gas phase reactions were used to predict injected coal particle combustion. The CFD model provided detail information for the coal particles combustion and radiation interactions phenomena inside the electric-arc furnace. Results showed that CFD simulation could efficiently be used to develop and investigate EAF in design phase.

Keywords: ELECTRIC ARC FURNACE, CFD, COMBUSTION, RADIATION, HEAT TRANSFER

1. Introduction

Generally electric arc furnaces consume high levels of energy to run the steelmaking processes that uses the coal and the electricity as the main resources of the energy. In order to increase the efficiency of these types of huge processes expensive experimental investigations using trial-error methods are required. Recently developed computational resources can solve interpenetrating physical phenomenon such as the solid particles combustion and the evaporation as well as the turbulence and the radiation together. CFD is an advanced simulation tool with a capability to comprehensive model for the industrial applications such as EAF. In this study commercial CFD software ANSYS FLUENT 14.0 [1] is used to develop a simulation methodology on EAF. One of the important targets to create an extensive CFD model of EAF is to investigate the combustion phenomena of injected coal particles, electric arc radiation and slag surface temperature distribution in order to analyze and verify the accuracy of simulations. In addition, the CFD model provided detailed information on the spatial distribution of the jet velocity, combustion species distributions and heat output from the EAF walls.

A number of reference studies have been carried out on combustion for the EAF. CFD model on post combustion reactions in the EAF has been studied [2] by simulating the radiation heat transfer, post combustion reactions, and de-post combustion reaction which is reacted between CO₂ and carbon in the liquid metal or the electrodes. Also radiation heat transfer from the electric-arc has significant effect to melt the metal mixture in the EAF. Guo and Irons [3,4] simulated the EAF radiation using CFD in order to introduce the energy distribution of the radiation heat transfer. They studied the radiation energy distribution for the sidewall refractory, water-cooled side panels and the furnace roof. Based on Guo's study some assumptions on heat transfer coefficients, radiation emissivity of the walls and the electric-arc surfaces were applied in the current model.

EAF are widely used to melt scrap metal in the steelmaking industry. Taking this into account, the studies on energy efficiency are of a great significance. Therefore, this study aims to develop a comprehensive three dimensional CFD model for the coal combustion and the radiation heat transfer process. In this model, the location or quantity of the injectors, the injection angle, chamber dimensions of the EAF, the oxygen or the coal contents and radiation rates of the electrodes etc. can vary to reach the targeted temperature on the melt surface. On that sense the model provides flexibility on design parameters. Such a flexible CFD model can provide optimization the combustion and the electrode radiation to decrease the energy consumption in an EAF.

2. Computational Simulation

In this study, an EAF produced by CVS Technologies for scrap melting process has been modeled. The EAF parameters are internal height 3505.25 mm, internal furnace radius 3600 mm, internal slag surface radius 3080 mm electrode radius 305 mm used to create the 3-D model for the computational domain. Boundary conditions which include inner surfaces of the furnace walls, upper and sidewalls of the chimney were given particularly in Figure 1. All injectors located 1.07 m above from the slag surface and aiming 45° downwards. In order to simplify the model, bottom surface of the computational domain was accepted as a slag surface instead of modeling the overall melt volume. Combustion products and the other unburned gasses leave the computational domain from the exhaust surface of the EAF. Bottom surfaces of three electrodes generate electric arc and the radiate energy with the constant heat flux.

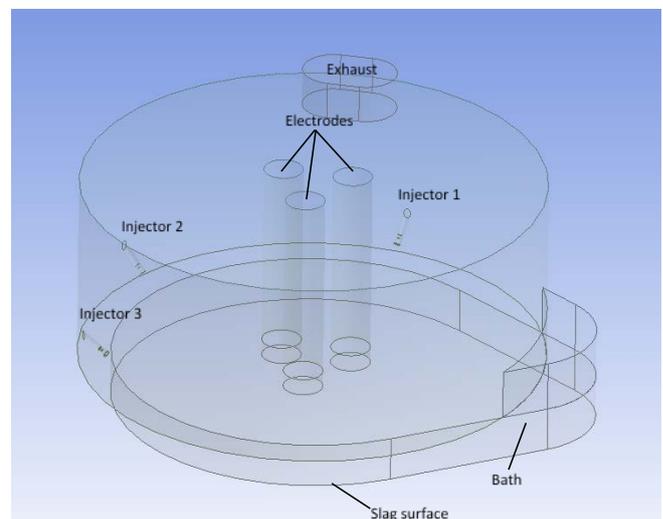


Fig. 1 3-D CAD model of the EAF

The skewness is an important parameter to understand the grid structure quality therefore great attention has been given to the skewness. Triangle prism mesh structures were used to create small computational domains in the model. The boundary layer mesh and weight factors are also used to create some critical zones for the computational accuracy. The sufficient grid refinement at the slag surface, arc generated surfaces of the electrodes and the injectors are necessary to capture the surface interactions and provide computational stability. The mesh structure of the EAF model, mesh inflation at the slag surface and dense grids at the injectors can be seen in Figure 2.

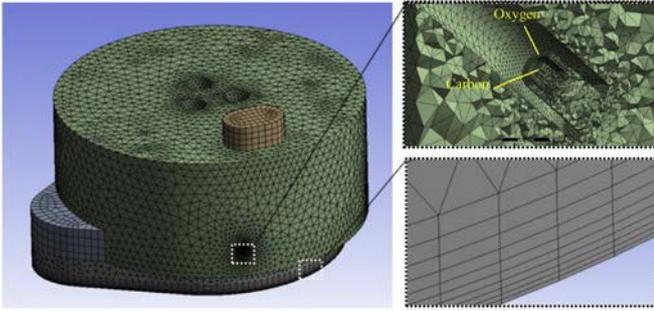


Fig. 2 EAF mesh structure

The model of EAF includes turbulent flows, combustion reactions, radiation, conduction and convection heat transfer. The realizable $k-\epsilon$ model was applied in the model to solve the turbulence which shows a good agreement with experimental observations of the gas flows with the coal particles combustion according to literature [5]. Previous studies on the liquid fuels and the coal combustion modeling [6,7,8] were showed that discrete phase model which has applied in current study, is a useful method to simulate the particle trajectory. The particle diameter distribution of the coal was modeled using Rosin-Rammer method with spread parameter of 4.52 and 10 groups. The minimum, the maximum and the mean particle diameters were chosen as respectively $70e-06$ m, $200e-06$ m and $134e-06$ m. Discrete random walk model was enabled for stochastic tracking of coal particles. P1 radiation model has been chosen in order to solve the radiation originated from the electrodes and combustion reactions in the current model.

In the CFD code, the coal is simply classified as a single species due to the quantities of the fixed carbon and volatile matter [1]. Several classifications for the coal can be found in the FLUENT depending on property of the coal density, the specific heat and component fractions etc. In this study the volatile matter (VM) break up was assumed as a single hypothetical hydrocarbon component consist of Carbon (C), Hydrogen (H), and Oxygen (O). After injecting the coal particles into the computational volume, volatile matters in the coal particles are initially converted to a pseudo gas phase species with using the constant rate devolatilization model [9].

Three-step volumetric reactions with six species including the volatiles matter combustion were applied to the model. These gas phase reactions deals with the local chemical equilibrium are calculated by Arrhenius type chemical kinetics. Three-step gas phase and surface reactions were listed in table 1 including Arrhenius Reaction Rate and Activation Energy.

Table 1: Gas phase and heterogeneous particle surface reactions.

Gas Phase reactions				
No	Reaction	A	Ea (j/kgmol)	
1	$mv_{vol} + 1.706O_2 \rightarrow CO_2 + 1.543H_2O$	$2.119e+11$	$2.027e+08$	
2	$H_2 + 0,5O_2 \rightarrow H_2O$	$1e+15$	$1e+08$	
3	$CO + 0,5O_2 \rightarrow CO_2$			
Heterogeneous Particle surface reactions				
No	Reaction	A	Ea (j/kgmol)	Diffusion rate constant
4	$C < s > + 0,5O_2 \rightarrow CO$	0.002	$7.9e+07$	$5e-12$
5	$C < s > + CO_2 \rightarrow 2CO$			
6	$C < s > + H_2O \rightarrow H_2 + CO$			

3. Results and discussion

Figure 3 (a) shows the velocity profiles on a plane intersecting the center of the injector 1. Velocity data plotted in the figure 3 (b)

is obtained from a straight line (demonstrated in the figure 3(a) with a dash line) from the slag surface to the injector. Values range from a maximum from 349 m/s to zero for the O₂ stream and outer flow. The speed of the jet decreases as it expands and mixes with the coal particles and gases. Swirls and high temperature combustion effects expand the velocity gradients to the larger volumes. Jet reaches the melt surface about 75 m/s.

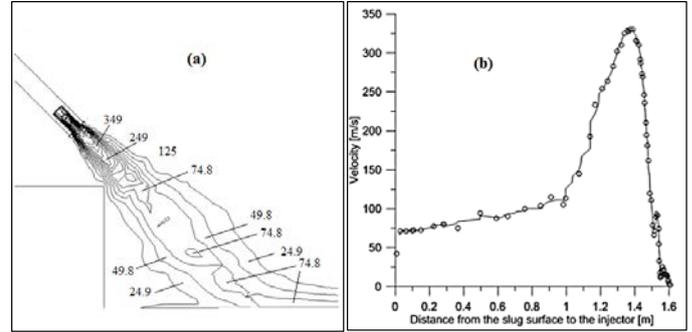


Fig. 3 Velocity (m/s) magnitude for a plane intersecting the injector 1; (a) Velocity distribution profile and (b) Velocity data graph.

The temperature profiles inside the EAF are presented for a plane intersecting from the center of the injectors. The combustion temperature profiles of injector 1, 2 and 3 are shown in Figure 4. The temperature at the jet flow after injector 1 and 3 is distributed between 2270 and 3200 K. Injector 2 which is located between two injectors, the maximum combustion temperature at the jet flow is investigated as 3000 K. The minimum temperature values are obtained at the near furnace walls as 692 K because of the heat transfer effects from the cooled furnace walls. The maximum combustion temperatures at the injector exits are continuously decreased to around 2200 K on the slag surface.

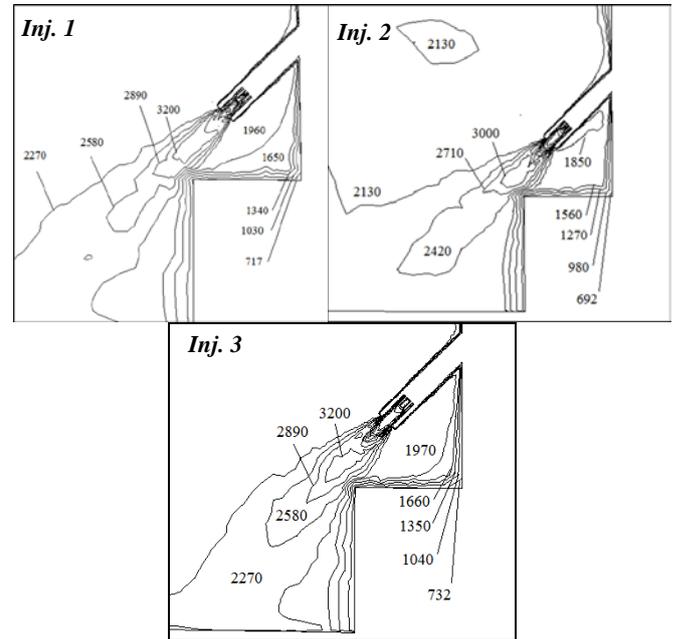


Fig. 4 Temperature (K) profile for a plane intersecting the injector 1, 2 and 3

The radiation temperature distribution which is identified on the bottom surface of the electrode can be seen in Figure 5. The radiation temperature is between 2050 K and 1860 K inside the furnace chamber.

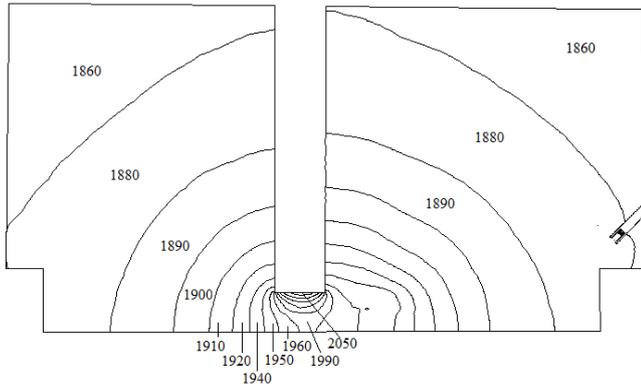


Fig. 4. Radiation temperature (K) profile for a plane intersecting one of the electrode.

Temperature distribution on the slag surface were introduced in Figure 6. According figure the slag surface static temperature variation is between 1860 K and 1970 K and the temperature of the slag surface mostly accumulated around 1880 K which is enough to maintain melt temperature at around 1800 K [10].

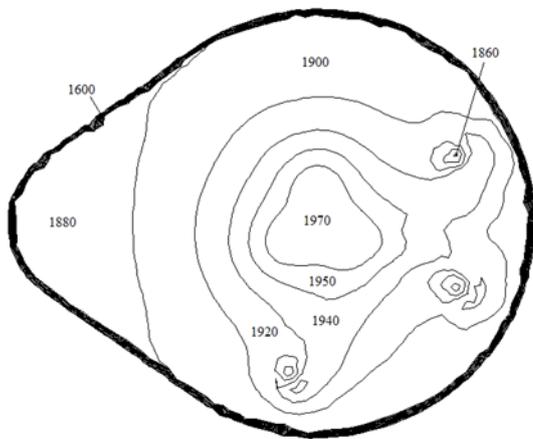


Fig. 5. Temperature (K) distribution profile on the slag surface

Figure 6 shows CO and CO₂ mass fraction distribution around the injector 1. Formation of CO from combustion reactions is lower than the slag surface diffusion as indicated in Fig. 9

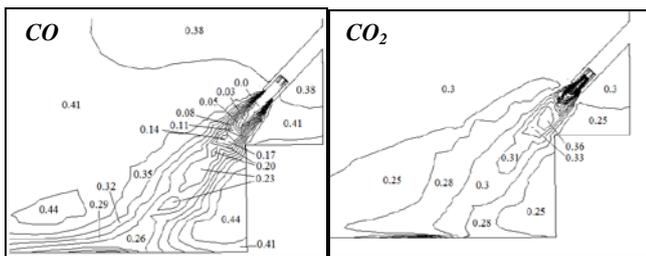


Fig. 6. CO (left) and CO₂ (right) mass fraction in combustion field on a plane intersection the injector 1

4. Conclusion

In this study thermal effects of carbon combustion and electrode based radiation are modeled for a commercial EAF using state of art simulation technique of CFD. Core temperature occurred with combustion in jet area and the temperature distribution on the slag surface is analyzed in detail with the model. The variation of the CO and CO₂ which are occurred by the carbon combustion reactions are given visually. The effect of the radiation temperature inside the EAF and on the slag surface is visually examined. The total and average temperature distribution on the slag surface is in satisfactory agreement with the real conditions.

The developed model can help us to increase the EAF efficiency by testing at the design level of the EAF. It was determined that the model is fast, reliable, low cost and able to give detailed results. This model gives us an alternative method for high cost experimental methods and the methods of zero dimensional calculations which have less consistency.

Acknowledgements

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References

- [1] ANSYS, Inc. FLUENT, Version 14.0; ANSYS, Inc.: Canonsburg, PA, 2013.
- [2] Y. Li, R. Fruehan, Computational Fluid Dynamics Simulation Of Post Combustion In The Electric Arc Furnace, Metallurgical and Materials Transactions, 34 (3) (2003) 333-343.
- [3] D. Guo, G. Irons, Modeling Of Radiation Intensity An EAF, Third international conference on CFD in the Minerals and Process Industries, Melbourne, Australia, 2003, p. 10-12.
- [4] J. Alexis, M. Ramirez, G. Trapaga, P. Jönsson, Modeling of a DC Electric Arc Furnace - Heat Transfer from the Arc, ISIJ International, 40 (2000) 1089-1097.
- [5] J. Zhang, W. Pratiño, L. Zhang, Z. Zhang, Computational Fluid Dynamics Modeling on the Air-Firing and Oxy-fuel Combustion of Dried Victorian Brown Coal, Energy Fuels 27 (2013) 4258-4269.
- [6] J. Broukal, J. Hájek, Validation of An Effervescent Spray Model With Secondary Atomization And Its Application To Modeling of A Large-Scale Furnace, Applied Thermal Engineering 31 (2011) 2153-2164.
- [7] R. I. Singh, A. Brink, M. Hupa, CFD Modeling To Study Fluidized Bed Combustion And Gasification, Applied Thermal Engineering 52 (2) (2013) 585-614.
- [8] B. Rahmanian, M. R. Safaei, S.N. Kazi, G. Ahmadi, H. F. Oztop, K. Vafai, Investigation Of Pollutant Reduction By Simulation Of Turbulent Non-Premixed Pulverized Coal Combustion, Applied Thermal Engineering 73 (1) (2014) 1222-1235.
- [9] M. M. Baum, P. J. Street, Predicting the Combustion Behavior of Coal Particles. Combustion Science and Technology 3 (5) (1971) 231-243.
- [10] E. Gomez, D. Rani, C. Cheeseman, D. Deegan, M. Wise, A. Boccaccini, Thermal Plasma Technology For The Treatment Of Wastes: A Critical Review, Journal of Hazardous Materials, 161 (2-3) (2009) 614-626.

ERGONOMICS STANDARDS'S INFLUENCE TO THE EFFECIENCY AND COMPETITIVENESS OF LOGISTICS EQUIPMENT

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Abstract: *This paper provides an overview and an analytical overview of the current standards in Bulgaria and the European Union related to ergonomic of logistic equipment. The point is to show the impact of standards on ergonomics, efficiency and competitiveness of logistics equipment, and to specify the types of ergonomic parameters. All this determines the decision area at the design stage of the logistics process and equipment and serves as a basis for the development of a computer system for automated and modular design. The availability of this information allows to achieve and a higher level of operating standards applied ergonomics.*

KEYWORDS: LOGISTICS, ERGONOMIC, STANDARDS, ANALYZE, EUROPEAN DIRECTIVES AND REGULATIONS, LOGISTICS EQUIPMENT, SAFETY, ERGONOMIC PARAMETERS

1.INTRODUCTION

The development of a computer system for researching and defining the database of parameters influencing the relationship between ergonomics and efficient operation of the operator to define and explore the field of solving this problem. Usually this area is determined by a number of restrictions, most of which are statutory requirements. These requirements strongly influenced the design of the machine and logistic nature of the logistics process in which they participate. Therefore the design stage it is important to take into account, which will lead to the creation of competitive equipment and service process.

It is known that logistics equipment and its maintenance of the production process to form 70% of total production costs [4].

But the use of logistics technology in a logistics process is not always 100% of the production time. It strongly depends on the mode of operation of this equipment. In many cases this time is below 50%, which is associated with the impact on human (operator). The question arises to what extent should realize the norms and standards of ergonomics that machines be as simple, cheap and productive without any effect on the efficiency of the staff. In this work in logistics equipment will of course material handling and warehouse equipment operated by an operator ie forklifts, trucks, stacker cranes, cranes, container, etc.).

In terms of the rapid development of science and technology and the emergence of new models of machines, human activity becomes more complicated and tense. According to statistics increase the reliability of the technical parts of a system loses its meaning because the system "man-machine" is limited by the reliability of the people. [1,5,6] Working sometimes on the verge of psychophysiological opportunities and unfavorable production environment, one makes mistakes, the price of which in modern production suddenly increase. In most cases, operator actions prove incorrect not because low-skilled, but because of the inconsistency of the structural features of the technique with human capabilities. Studies show that up to 70% of failures are due to the human factor. All this shows that the optimum working conditions are essential for the selection of appropriate logistical machine reading system man-equipment- environment. [1,5,2]

According to [1,7], the first objective of ergonomics is to increase the effectiveness of human-engineering - environment (HEE), which means the ability of logistic equipment to perform their tasks with a certain quality at the lowest cost. Ergonomics is characterized by its impacts - internal (operator) and external (ambient staff).

The operator [1] carried out executive-operative activity at which the perception and processing information, making decisions and carrying out executive actions. The effectiveness of the system HEE however, is a function of time. It can not be permanently fixed, but varies throughout the day. Itself is multi task by

modeling on the process of change is also based on subjective information that is relevant model of Tanaka [8]. When analyzing HEE required subjective information be limited to a minimum. This is achieved through the use of standards and regulations.

Besides the literal "laws work," leading to ergonomics is the idea of coordinating the work of all professionals dealing with problems at work, so modern ergonomics is an area of knowledge that studies the employment rights in the systems "man-machine West Region "(HEE) in order to ensure safety, comfort and optimal information interaction between staff and technology.

It is known that HEE are manufacturing, information, transportation, military and systems maintenance and repair. According functioning - they are deterministic and non-deterministic. This work will be aktsentra logistical systems (LS) consisting of logistics machines and their operators support staff serving manufacturing and warehouse activities.

The man (operator) is a major subsystem Message regardless of the degree of automation. It manages, maintains and controls the entire process of operation and. Therefore his work is a starting point and a key priority of ergonomic analysis, synthesis and design message.

Requirements for logistics systems are strictly individual. They are different because of the different operating modes and not loaded on 100%, which affects the cost and efficiency of each machine. It is known [3] that the cost of the machine and involves additional costs for achieving the desired quality of the logistic machine. Their optimization is directly related to the ergonomic qualities of the machine. It is therefore necessary to study the impact of standards on logistics equipment. In this work deliberately omitted hygiene standards.

The purpose of this work is to analyze the current legislation - ergonomic standards affecting the internal effects of logistics technology and serve as a basis for study and optimization of this technique.

2.THEORETICAL BASES AND ASSUMPTIONS FOR DEVELOPMENT

2.1.Ergonomic parameters

There are various ergonomic parameters that must obey logistics machines. The work will focus on those that are directly related to the productivity of the operator (support staff), ie those affecting the cab of the machine or logistics environment in the absence of cabin.

2.1.1.Human body dimensions

Before describing the various ergonomic parameters for logistic equipment necessary to clarify the dimensions of the human body and the current standard for them. (See BS EN 547-1,2 and 3). Due to the nature of work one part of the logistics machines have

cabins with difficult access. Therefore object and scope of the standard - determines the size of open access to whole body to machines. This standard was developed initially for stationary machines to mobile machinery may have additional specific requirements.

The dimensions of access passages are based on the values of the 95 th or 99 th percentile of the expected set of users. The values for the 99th percentile apply for emergency exit routes. Anthropometric data given in EN-547-3, are derived based on static measurements of nude and do not account for body movements, clothing and equipment, and working conditions of machinery or environmental conditions.

Standard shows how to anthropometric data corrected with appropriate additives so as to take into account these factors. Situations in which people should be protected from the impact of risk are dealt with in EN 294.

2.1.2. Surface's Temperatures to which it is possible touch

In logistic machine operator has access to surfaces which become hot during operation and are sources of risk of burns. So this parameter is not of interest for consideration for the operator. But support staff involved in the uptake and release of cargo it is essential.

2.1.3. Noise

In logistic machinery noise mostly comes out of the cab ie the medium and the machine itself. Emissions of noise created during the performance of work equipment must be minimized to avoid health hazards and safety and to ensure operator comfort. The noise from the environment determines the soundproofing of the cabin.

Methods of analysis and design should be directed to the management of emissions from the source to the extent that the values of the final broadcast are low entering the area defined by the standards, and to create the necessary insulation. Apply standard ISO 4871: 1996.

2.1.4. Thermal radiation

Logistics equipment is catering equipment and is characterized by processes of working and waiting. In both cases, the thermal emissions are directly dependent on the processes they serve. Basic requirement is that thermal radiation can be minimized through design methods, in order to avoid health hazards and to ensure the comfort of the operator (see EN 563). In particular, it must be taken as follows:

- a) exercise of the operator (when it performs operations gripping the load;
- b) the thermal properties of the necessary clothing;
- c) the expected heat load on the operator (when the car is opened or closed).

2.1.5. Lighting

The lighting in the logistics technique is general and cabin. It must meet the requirements necessary for the performance of work by the operator. In the case that the analysis of the work task indicates that the total (ambient) light is not enough, it must be ensured mixed light, for example, which can be set and regulated. The lighting must be designed so as not to force the operator to take an awkward posture. According to DIN EN12464, where it must be done dimming, the means of regulation must be placed properly and should not present a danger to the operator. In particular must be taken as follow:

- a) to avoid flickers;
- b) to avoid glare or shine;
- c) to avoid distracting shadows;
- d) to avoid stroboscopic effects;
- e) contrasts the lights must conform to the task;
- f) must be reserved transmission of color.

2.1.6. Hazardous materials and radiation

The cabin and the trunk must be designed in such a way that any hazardous materials and hazardous radiation present during operation to be identified and treated with appropriate devices in order to avoid exposing the operator to danger to his health.

2.1.7. Vibrations

The vibrations generated in a logistics machine, dependent on the

operating situation, in which the appliance is used. Impact of vibrations on the operator depends on additional factors such as level of comfort, appearance and condition of the machine and its accessories, process and duration of the impact itself. The magnitude of the measured vibrations as much as possible, it is realistic to measure their intensity under normal operating conditions.

It is known that vibration control is a measure that allows to significantly reduce any transmission of periodic, percussion or random forces of the logistics machine to peripheral structures that surround or protect people, machines, equipment, buildings, by their environment (isolation of sites, protection against radiation). In both cases, the use of vibration isolation creates an elastic system whose dynamic response significantly affects the characteristics of the source of vibration, the dynamic characteristics of the machine, the structure on which the machine is installed, and the characteristics of resilient and damping elements. The optimization of the system to meet the requirements for protection against vibrations associated with detailed knowledge of all the factors influencing design and efficient application of vibration control of plant or equipment. The exchange of information between the machine manufacturer, the supplier of insulation and the user has a leading role in achieving this [12].

The purpose of the insulation of the source is to protect the environment through measures vibration when installing the source.

3.METODOLOGY

3.1. Collecting data methodology

Primary article builds on existing applicable standards - BS, EN, ISO, DaTech. Removed are the main parameters and criteria for analyzing their related logistics process.

The ergonomic design of logistics systems increases safety, efficiency and productivity, improved working conditions and human life and preventing adverse effects on the health and performance of humans. The application of ergonomics in the design of operating systems required in the process of studying the interaction between people, technology and the working environment to take into account human capabilities, skills, limitations and needs.

It is known that in the design of the work equipment using the system model can be described as a methodological process. Basic tasks such as setting goals, defining requirements and evaluation are included in this process. With equal importance taking into account the basic engineering and human factors.

The practice of designing logistics systems offers four main stages:

- 1.Placing a target and developing a job.
- 2.Preparation of conceptual design.
- 3.Preparation of work design.
- 4.Realization

In the first stage the specified system requirements are developed and clarified in order to draw up a list of requirements that must be met. In the second stage designer consistently refine initial ideas to a situation that can make a choice (or more) for further development. In the third stage designer developed the sketches of the project to the selection of a preliminary design and can be made requirements for detailed design. In the final stage designer graduated details of the project and made the final draft. Consultations with representatives of operators should be made as soon as possible early in the design process.

3.2. Data analysis and hypotheses validation data

The following subsections provide information about some ergonomic factors that should be taken into account in the design of machines. To achieve effective, healthy and safe interaction of operators working facilities required during the design process to be respected as ergonomic principles and technical safety requirements.

This work will show some highlights from those standards that serve as a framework and define the field of design and

operational decisions of logistics systems and equipment. Typical of such systems is that they are built not only by machines, but by auxiliary equipment such as garage-charging stations and more. All this determines the application of standards on the whole system.

Logistics systems in compliance with ergonomic principles should be applied not only in the use of working and auxiliary facilities, but also in their design, installation, tuning, energizing, maintenance, cleaning, repair or transportation. The projected parts may affect each other, so in the design process should take account of any interaction between them. Therefore essential when designing the interaction between the operator and operating facilities and therefore the allocation of functions and work between the operator and working facilities. The goal is to design a system which corresponds to the human capabilities, capabilities, limitations and needs. So in the design process is necessary to analyze the problem.

The design can be classified as follows:

Design, reporting anthropometry and biomechanics - dimensions of the human body posture, body movement, physical exertion (exercise) design, reporting mental capabilities (psycho-sensor voltage). Designing visual and signal displays and controls.

Interaction with the physical parameters of the working environment - noise and vibration, thermal radiation, lighting, hazardous materials and radiation interactions in the process.

3.2.1. Human body dimensions and anthropometric data

The European standard defines the minimum and not the optimal size for holes for the operator. This calls wherever possible, in terms of safety, the size should be increased. Moreover, open access must be sufficiently wide to allow quick exit in case of danger. Added in the amounts specified in EN 547-3 and EN 547-1: 1996. These requirements particularly important for logistics machinery moving space.

Anthropometric data are in accordance with standard BS EN 547-3. Table 1 shows the best approximation of data that can be obtained at present of European Studies of logistics equipment. The data give an estimate of the values for the 5th, 95th and 99th percentile for combined collection of men and women.

Each anthropometric value in the table is formed according to one of the following two methods:

I. National studies totals for a set of men and women: use the appropriate value for the 5th, 95th and 99th percentile.

II. National studies with individual values of percentiles for men and women. Although this method is statistically inaccurate, he has a good practical approximation. For value 5th percentile is elected for a European value, the lower value calculated in this way. For values of the 95th and 99th percentile is chosen accordingly highest value.

3.2.2. Temperatures of surfaces to which it is possible touch

Ergonomic data to determine the temperature limits for hot surfaces. (Standard BDS EN 563+A1+AC)

This standard is needed when handling loads in casting, welding and others. workshops and contains data for assessing the risk of burns, where possible to such of skin to hot surface. Where necessary, these data can also be used in other standards or rules for determining the limits of temperatures of hot surfaces. They are based on research results and present, as far as is known, the behavior of human skin on contact with a hot surface. Data still burning at very short touch of 0,5 s not based on direct research, and displayed by extrapolation of curves thresholds burning for long lasting touch. Taking into account the response time of a person and their distribution among the population, 0,5 s is the shortest appropriate time to touch for a healthy adult at an acceptable level of safety.

Classification of burns - burns are classified into three levels depending on their weight:

a) superficial burns - in almost all superficial burns epidermis is completely destroyed, but the hair follicles and sebaceous glands and sweat glands, survived.

b) deep burning - most of all epidermis and sebaceous glands are destroyed and only the deeper parts of the hair follicles or sweat glands survived.

c) complete combustion - When the skin throughout its thickness was destroyed and there are no survivors epithelial elements.

Burns may have different surfaces.

Threshold burning - surface temperature defining the boundary between the absence of burns and superficial burns caused by skin contact with a hot surface for a certain length of contact. Threshold values are to be measured and recorded depending on the type of material - metal uncoated, coated metal, materials of ceramics, glass, stone, plastics, wood. (See BS EN 563 + A1 + AC).

3.2.3. Vibrations

The purpose of the insulation of the source is to protect the environment through measures vibration when installing the source. A system for the isolation of the source may be needed:

a) safety of operators of vibration machines;

b) the safety of persons located near vibrating machines;

c) safety structures or buildings that are vibrating equipment (eg elevators);

d) the safety of persons present in buildings that may be the subject of intense vibrational excitations;

e) when vibration limits set by law exceeded.

A system for the isolation of the source should be used in addition to measures in the design, enabling a reduction in vibration. The system must not replace such measures and may apply:

a) during the design or the installation of vibrating machines;

b) during the design or modification of buildings that are vibration machines.

It is necessary to make a preliminary analysis of the vibratory phenomena of vibrations in the environment. It is important to monitor the changes in vibration depending on time and to analyze relative frequencies for each operating cycle of the machine for a long enough period.

An analysis of the frequency response of structures that transmit and receive vibrations facilitates optimal choice of structures and avoiding the coincidence between the dominant frequency of the source and own frequencies of these structures.

The vibrations in the environment should be established in order to know the level of own vibrations under which usually do not need any insulation.

In case of a correction of an existing situation vibrations (displacement, velocity or acceleration) must be measured simultaneously:

- at the points of attachment of the machine and in the immediate vicinity;

- the place occupied by the operator or by a person located in the immediate vicinity.

Measurements should be made in terms of environment in accordance with the location of the machine. Measurements and analysis should help them to understand the origin of the problem and to provide information in as possible for possible solutions. Measurements should be made in terms of environment in accordance with the location of the machine.

Таблица 1 - Антропометрични данни от европейски изследвания

Означение	Наименование	Стойност mm
h_1	Височина на тялото (ръст) P95	1881
h_1	Височина на тялото (ръст) P99	1944
h_8	Височина на глезена	96
a_1	Широчина на нивото на лактите P95	545
a_1	Широчина на нивото на лактите P99	576
a_3	Широчина на дланта с палеца P95	120
a_4	Широчина на дланта (метакарпална) P95	97
a_5	Широчина на показалеца (проксимална) P95	23
a_6	Широчина на ходилото P95	113
b_1	Предно-заден размер на тялото P95	342
b_2	Досегаемост напред (до оста на хващане) P5	615
b_2	Досегаемост напред (до оста на хващане) P95	820
b_2	Досегаемост напред (до оста на хващане) P99	845
b_3	Дебелина на дланта P95	30
b_4	Дебелина на дланта с палеца P95	35
c_1	Дължина на бедрото (от седалището до коляното) P95	687
c_1	Дължина на бедрото (от седалището до коляното) P99	725
c_2	Дължина на ходилото P5	211
c_2	Дължина на ходилото P95	285
c_2	Дължина на ходилото P99	295
c_3	Дължина на главата от върха на носа P95	240
d_1	Диаметър на мишницата P95	121
d_2	Диаметър на предмишницата P95	120
d_3	Диаметър на юмрука P95	120
t_1	Функционална дължина на ръката P5	340
t_2	Досегаемост с предмишницата P5	170
t_3	Досегаемост на ръката встрани P5	495
t_4	Дължина на дланта с пръсти P5	152
t_5	Дължина на дланта от върха на пръстите до основата на палеца P5	88
t_6	Дължина на показалеца P5	59

The points of attachment of transducers and vibration directions of the measurements should be recorded in the minutes. It is recommended that in complex cases where insulation system

used to require the opinion of an expert. The situation is especially complex when the machine and / or supporting structure have their own frequencies (modes of vibration) that are

considered frequency range [12].

There are many dynamic models for various logistical equipment. To solve each case it is necessary to present accurate information. In order to choose appropriate insulators and be properly installed insulation of the source is necessary exchange of information between the machine manufacturer, the supplier of isolation and use machines. The information required for optimal isolation of the machine is:

Information provided by the manufacturer of the machine - physical data on the machine - drawing machine excitation of vibrations, concrete prescriptions electrical characteristics specific regulations on mechanical resistance.

Information provided by the isolation - physical data system isolation - dynamic behavior, service life, environmental conditions, data maintenance.

Information provided by the isolation - physical data system isolation - dynamic behavior, service life, environmental conditions, data maintenance.

4.CONCLUSIONS

The analysis can draw the following conclusions:

1. The standards seek to create convenience for operators to increase their productivity.
2. There are no dependencies to determine the required ergonomics in various logistics systems.
3. Activities where access is required through the small access openings are less effective, less safe and less favorable to health than working with unrestricted access. Therefore, before making open access, you should consider other options such as the possibility to open the machine to remove parts for repair. This is particularly important where it is needed more frequent access.
4. A major drawback is that all standards have been paid, the interpretation of the directives is severe, they are written in different languages and are feasible in all countries. Problem is

some inaccuracies in the translation of standards into Bulgarian.

LITERATURE:

1. Gradinarov N and etc. Manual ergonomics. Sofia, Technics, 1973.
2. Эргономика. Учеб. пособие для вузов. Под ред. В.В. Адамчука. М.:ЮНИТИ-ДАНА, 1999.
3. Nickolova I, Kazakov N., Quality management in logistics systems. Sofia, Standards-European Integration – users – 2001, October 2001,97-99.
4. Ballou R. Business Logistics Management. Prentice-Hall Inter. 1992
5. A. Mital, Å. Kilbom, S. Kumar. Ergonomics Guidelines and Problem Solving. Elsevier, 2000, ISBN 13: 978-0-08-043643-2
6. Salvendy G. Handbook of Human Factors and Ergonomics. Wiley, 2012, ISBN-10: 0470528389e
7. Tochihara Y, T. Ohnaka. Environmental Ergonomics - The Ergonomics of Human Comfort, Health, and Performance in the Thermal Environment. Elsevier, 2005, ISBN13: 978-0-08-044466-6.
8. Nonaka, I., R. Toyama, N. Konno, SECI, Ba and leadership: A unified model of dynamic knowledge creation, Long Range Planning, 33 (1), 2000, pp. 5-34.
9. BS EN 547-1, 2 и 3
10. BS EN 563+A1+AC
11. BS EN 614-1
12. BS EN 1299-2001
13. BS EN ISO 15535:2012
14. BS EN ISO 15743:2009
15. BS EN ISO 9241-410:2008/A1:2012
16. BS EN 1005-4:2005+A1:2009
17. BS 15371:1981
18. BS 15263:1981
19. BS 14876:1979

ROLE OF THE HUMAN FACTOR IN THE FOURTH INDUSTRIAL REVOLUTION

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Abstract: Due to increasingly competitive is required the companies to provide personalized products and services. This contributes not only to ensure customer satisfaction, but also to require application of modern technical solutions like digitized solutions, specialized software, automation of production and services. All these changes are the foundation and the specificities of the fourth industrial revolution ("Industry 4.0)." This article performs the key features and principles of Industry 4.0, just like and the role and the requirements to the human factor. In this connection there are different scenarios applicable to companies in the light of the fourth technological revolution.

KEYWORDS: INDUSTRY 4.0, CPS, INTERNET OF THINGS, INTERNET SERVICES

1. Introduction

The development of the industrial revolution has passed through various stages. At the end of the XVIII century during the first industrial revolution was discussed the impact of the labor market and the role of the human factor. After three eras of mechanization, electricity and information technology in the early 21st century began the fourth industrial revolution. The term "Industry 4.0" (fourth industrial revolution) was first used in 2011 at the fair in Hanover [1]. Initiated in 2012 by the German government strategic initiative Roadmap for the fourth industrial revolution.

"Industry 4.0" became a top priority for many research centers, universities and companies within the last four years with numerous contributions by scholars and practitioners. As a part of this strategic initiative aims is the leading role of industrial information technology. The aim is to create "smart factory" (Smart Factory), which is characterized with resource efficiency, ergonomic design, flexibility and integration of customers and partners in the business processes and value-added [2]. Its elements are CPS and the internet of things and services [7].

The Cyber - physical systems are "intelligent systems, covering hardware and software, and effectively integrated physical components that interact closely with each other to reflect the changes of physical objects, defined by the American Institute of Standards and Technology (NIST) [8].

In literature is viewed the technical aspects and the issue of staff and society. With the increasing digitalization is expected to impact not only on plant and businesses, but expect placing specific requirements on personnel, which will lead to impact not only on the labor market, but also on opportunities for social innovation and social progress.

This was and is a major theme of the World Economic Forum in Davos in January 2016 regarding the specifics of the "Industry 4.0". It is predicted that until 2020, 5 million work places are going to disappear. [7].

2. Scenarios

Based on studies in the context of "Industry 4.0" the role of the human factor explore the relationship between men and machine are viewed various scenarios [2], [3]:

- **Scenario of specialization:** With increasing automation and digitization of manufacturing processes, it

is considered that the human factor will play a role of an expert.

- **Hybrid scenario:** monitoring and control tasks are carried out cooperatively and interactively through technologies related facilities and personnel in network.

- **Scenario of automation:** CPS to monitor and to control processes on line, based on the collection of information and data, their aggregation with additional interpretation by the human factor.fig.1[6].

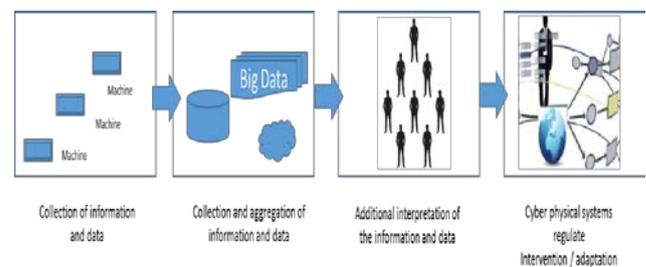


Fig.1: Scenario automation

On this basis, the role of humans is different in different scenarios regarding the management of processes, information and data. The basic requirements for the tasks of work, (Table 1).

Table 1. Basic requirements

	Scenario specialisation "The man used systems"	Scenario automation "The systems use the Man"
Content of work	Interestingly distribution of tasks with the possibility of distribution of shaping and objectives	Closely division of tasks with a high level of standardization/ external management
Organization of work	Opportunities for collaboration with agreed objectives and participation	High responsibility in a small degree of impact
Network creating	Impact of standards and interoperability in a transparent link	Availability of standards without transparency in terms of network and use of knowledge
Automatisation	Exemption from loading and unattractive work	Time for automation; factories without staff
Qualification / Competency	Linking training with a broad competence development	Only qualified job
Data	Access to information and knowledge in problem solving, data partitioning for staff and technology	Use of data to control the behavior and achievements

The exchange of information on line and networking devices is a prerequisite for the development and transformation of traditional jobs with mobile monitoring, management and taking decisions

This increases the role of humans in smart factories to increase its responsibility and impact. This human factor is expected to be the most flexible part of CPS production systems and traditional relations with machine-machine receives new man-machine such as virtual reality using multimodal interfaces, is shown on Fig.2

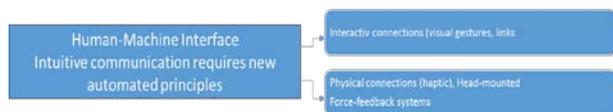


Fig.2: Man-machine interface

A radical change in the interaction between man and technology and human environment is going to happen. The introduction of "Industry 4.0" as a strategy should be enshrined in the managerial approach of the fact that the organization should be oriented to better meet the needs and desires of consumers.

In this respect there are the following questions :

- What are the opportunities for introduction?
- Which of these scenarios is most suitable ?

3. Concept for the selection of the scenario

In the special literature there is not definition for "Industries 4.", but it could be viewed as identification of objectives, analysis, selection of scenarios and measuring achievements in this regard, is shown on Fig.3.

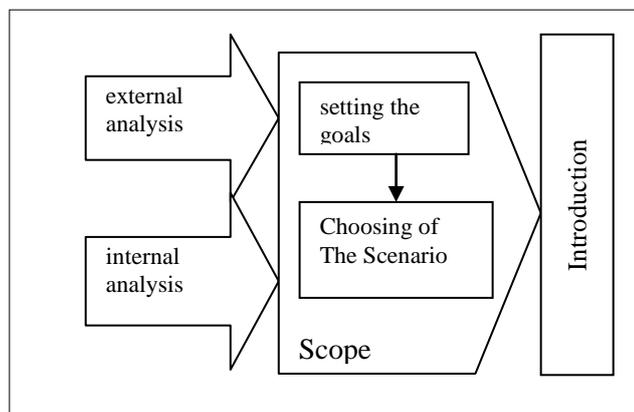


Fig. 3: Elements of concept for the selection of the scenario

Due to the rapidly developing digital technologies in industry and especially in the sectors of business services constantly new forms of work organization and employment and skills are updated.

A study in 2015 of the Bulgarian Chamber of Commerce and Industry (BCCI) about 500 companies expect to increase their export revenues. Like any other company had forecast growth of exports in 2015, but only 37% actually did it. Only 23% of them said that during 2016 are planned investments in new capacity and 27% in new products and innovation. The focus of investment

firms is placed on the development of human potential. About 25% of them plan to hire new staff, while the share for 2015 was around 30%. With respect to the scenarios would be appropriate scenario specialization.

Industrial companies in the country do not know the essence of "Industry 4.0" not currently intend to finance in this direction. However, they participate in European projects of the program Horizon 20/20, which essentially is an initiative of "Industry 4.0" .In 2015 all of the Bulgarian projects were rejected (unconfirmed data they are over a thousand) of the EU.

Unlike in Germany, where in 2015 a study was done in 235 companies of the German Chamber of Commerce, who for five years are going to invest 3.3% of its annual turnover in "Industries 4.0" technical solutions. This represents 50% of investments in new facilities or amounted to 40 billion euros and thus meet the requirements, principles and selection of appropriate scenarios "Industries 4.0."

These transformations should be monitored carefully. We need a robust framework for social dialogue and active participation, also in view of innovation centers for education and training at firm, sectoral, national and European level which takes into account the frequent restructuring of companies in the rapidly changing service sector [6].

This proves that "Industry 4.0" is not only a technological project and a specific effort to increase the competitiveness of the manufacturing sector in the future.

4. Conclusions

The problem of chuman factor und choosing of optimal scenario is analyzed and its characteristic special features are defined. Industry 4.0 is not only a technology project but also a way to increase the competitiveness of the firms in the manufacturing sector for the future.

The key of Industries 4.0 is to pay more attention to the social aspects of this new development. It affects not only the management and employees of the firms, but also the whole society.

References

- [1] Kagermann, et al, (2011) Mit dem Internet der Dinge auf dem Weg zur 4. Industriellen Revolution, VDI-Nachrichten
- [2] Gorecky, D., (2014) Innovative Factory Published in: Industrial Informatics (INDIN), 2014 12th IEEE International Conference
- [3] Roth, A. (2016) Einfuehrung um Umsetzung von Industrie 4.0, Springer
- [4] Spath, D.and Weisbecker, A.(2013) Potenziale der Mensch-Technik Interaktion für die effiziente und vernetzte Produktion von Morgen, Stuttgart.
- [5] Nikolova, I. Quality Management (2014), King, Sofia.
- [6] Statement of the European Economic and Social Committee on the "Impact of the business services industry" (2014), Brussels.
- [7] Report of the World Economic Forum in Davos (2016)
- [8] <http://www.bmw.de/DE/Themen/Industrie/Industriepolitik/moderne-industriepolitik.html>

THE TECHNICAL DEVELOPMENT AND INDUSTRIAL LOGISTICS

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Abstract: *The rapid development of innovative industry started to impose so-called service-oriented platform of product development, which means intelligent monitoring, or that the product will be monitored throughout its life cycle - from concept to recycling it. These intelligent products (Smart Products) have informational knowledge of their production processes, logistics and future applications. They actively support the production processes (when they will be produced, with what parameters, what materials should be produced, where it should be delivered, when, what modifications, etc.). In this environment and these conditions the logistical component has a qualitatively new dimension adapted to meet these new requirements imposed by the innovative development - namely, to be in constant optimal contact with the production cyber system.*

KEYWORDS: INNOVATION, INTELLIGENT PRODUCTS, INDUSTRIAL LOGISTICS, CYBER-SYSTEM

1. Innovative Development of Industry and Logistics

The innovations in the development of the industry are the main engine for its development. They are characterized by their stages of development or the so-called industrial revolutions. The First industrial revolution is related to mechanization, which is operated by water and steam. The Second industrial revolution characterized by mass production, built the division of labor (Ford, Taylor and others) using assembly lines and use of electricity. The Third industrial revolution is called digital revolution, characterized by the use of electronics and information technology to further automate of the manufacturing activities.

With the increasing complexity of products placed new demands on production. Factors that impose these changes are: increasing requirements in terms of flexibility, efficient use of resources and individualized products; Integration of customers and suppliers in the design and manufacture; the reorganization of the value chain and logistics and production processes in a globalized market. Begin to form new integration concepts that aim to qualitatively change the future production and logistics processes. In this context of development take shape and purpose of the Fourth industrial revolution. This suggests a new level of organization and management of the entire value chain, which is oriented towards individualized user desires. The value chain in the entire life cycle of products is expanding - the idea, the contract for the development, production, supply of a product, recycling, including related logistics services. Companies are starting to use their equipment and systems such as cyber-systems in the network world. In this way connect embedded system manufacturing technologies and intelligent manufacturing processes on the way to a new technological level. Intelligent industry refers to the technological evolution of embedded systems to cyber-physical systems or she represents the path to the "Internet of things (components) and services" (Fig.1.)

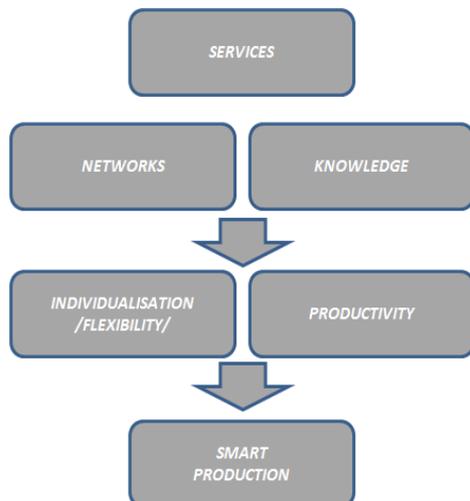


Fig.1.Characteristics of the Fourth Technological Revolution

This radically changed the manufacturing and business models by creating conditions for greater flexibility and resource efficiency. For the first time there is an industrial revolution, which predicted a priori, not to monitor its consequences. This provides various opportunities for companies and research institutes to active participation and impact on production. Of the other part, creates an opportunity to develop completely new technological models, services and products. The Fourth technical revolution is not only a technical challenge - the technological change, which will have lasting organizational consequences and creating opportunities for new production models and corporate concepts, but also a new concept of the network world, including all components including and logistics. In "one intelligent world" Internet is to serve all needs which leads to changes in electricity of smart grids (Smart Grids), to sustainable mobility concepts (Smart Mobility, Smart Logistics), social welfare (Smart Health) and new technological solutions.[2,4] In the production this leads to increased intelligence products and systems, their vertical network connected to engineering and horizontal integration through the value chain of the product. The work focuses on the manufacture of intelligent products, processes, methods, individual customer requirements and even profitable to produce single items; manufacturing, logistics and engineering processes can dynamically be designed so that the industry can change quickly and flexibly and respond to interference; It creates an opportunity to increase the efficiency of start (star-up) small businesses as well as to develop new services; the digital network allows direct involvement of customer requirements and inexpensive customization of products and services; There is huge potential for new products, services and solutions; global competition in the technology of production increases. The Logistics connection or logistics acquires a qualitatively new dimension. The Logistics chain will be under constant optimum connection with the manufacture of the product so that the material, information and financial flows will be a cyber-system built by both physically real objects and the virtual ones operating at optimum levels in the production network system.

2. Intelligent Factory (Smart Factory) and the role of Logistics

Structure of Smart Factory. An important element of this technical development is the intelligent factory (Smart Factory). There Smart Logistics is an important component of future intelligent infrastructure.[1] Smart Factory is defined as one factory in which are context-oriented (context-aware assists) and communicate people, machines and resources independently in the integration network for implementation of production tasks. These systems perform their tasks based on information coming from the physical and virtual world via the Internet of Things (components) and Internet of the services.[5] The information about the physical world is real position or state as opposed to information in the virtual world as electronic documents, drawings, simulations and more. In the intelligent factory physical objects such as manufacturing facilities, logistical components, information systems and staff must interact in real time. In Figure 2 it shows the structure of the smart factory.

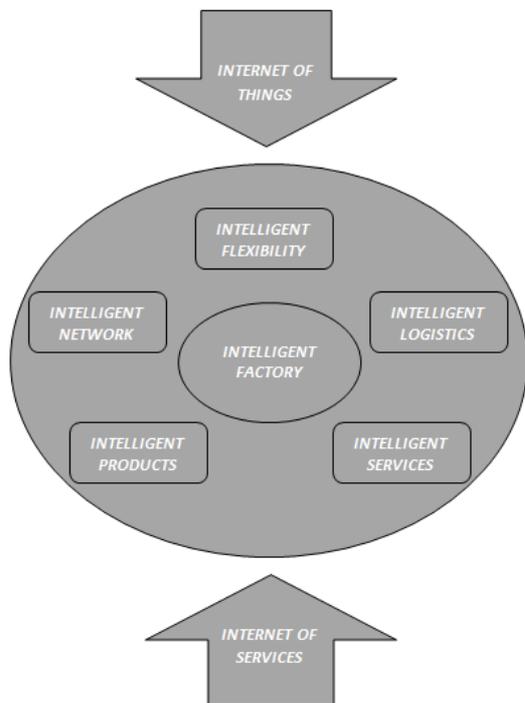


Fig.2. Intelligent Factory

Horizontal and vertical integration in Smart Factory. The horizontal integration defines continuous integration of various information technology systems in different stages of the production process and planning. This is integration process between material, energy and information flows both inside the company (input logistics, manufacturing, logistics output) and with other companies to find a continuously optimal solution. The vertical integration defines continuous integration of information technology at different hierarchical levels in the production system. Such as levels are: level actuator, level sensors, level management technique level production management, level management firm to find a continuous the best solutions at Smart Factory.

The vertical and horizontal interaction between machine - Internet machine - man and machine - a machine along the value chain in real time, forms the basis of the production cyber-physical system. They will be linked together in the integration network.

Logistics system of Smart Factory. It can be seen as separate from cyber-physical system (CPS), but must be connected to it by connecting models that perform the functions of coordination and management processes.[3] These models should be able to use integration data and real-time services. However, only material flow will have physical nature of dimension and its copy will be virtually or it is a virtual component. This system will regulate itself and participates in the optimization of the materials making up the product details. The physical component of the material flow includes smart flow of materials, vehicles and equipment and other logistics operations. Moreover, the logistics system is radically amended and qualitatively different from existing now as IT components (flow) will be entirely virtual to cloud borders capitalizing only logistical information allowing free communication in real time with cyber-systems of Smart production. It will use logistics data and services. The second component (flow) is the financial, which is also entirely virtual, using data integration and services, and is directed only to the financial changes as a result of logistical changes. Both components will operate in real-time cloud limits imposed by the intelligence of the Smart logistics system. This service-oriented platform, including features of Smart Mobility, Smart Logistics and Smart Grid, formed the requirements for intelligent factory producing intelligent products and representing an important component of future smart production infrastructures.

Conclusion

Based on the above, it can draw the following conclusions:

1. The logistical components acquired a qualitatively new dimension adapted to meet new requirements imposed by the innovative development.
2. The logistical components must be in constant optimum connection with production cyber-physical system.
3. Logistics chains will be under constant optimum connection with the manufacture of the product so that the material, information and financial flows will be one cyber system built by both physically real objects and the virtual ones operating at optimum levels in the production network system.
4. logistics system is radically amended and qualitatively different from existing now, as IT components (flow) will be entirely virtual in cloud borders capitalizing only logistical information allowing free communication in real time with cyber-systems of Smart production.

Literature:

1. Bauernhansl T., Industrie 4.0 in Produktion, Automatisierung und Logistik. Anwendung, Technologien und Migration. Wiesbaden: Springer Vieweg, 2014
2. Blanchet M., et al., "Industry 4.0: The New Industrial Revolution. How Europe Will Succeed, Roland Berger Strategy Consultants, Mar. 2014
3. Industrie 4.0 – Cyber Physical Systems in der Produktion – Nordrhein-Westfalen auf dem Weg zum digitalen Industrieland – Studie, Wuppertal, 2013
4. Kagermann, H.W., D. Lukas, and W. Wahlster., Industrie 4.0: Mit dem Internet der Dinge auf dem Weg zur 4. industriellen Revolution, VDI Nachrichten, (13) 2011
5. Turber S., Smiela, Christoph. A., Business Model Type For The Internet Of Things – Research in Progress, Twenty Second European Conference on Information Systems, Tel Aviv, 2014

AN ADDITION OF FUNCTIONALITIES IN AN INTEGRATED ROBOT COMPLEX FOR ASSEMBLING ELECTRONIC PRODUCTS

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Abstract: Robot assembling is flexible and it enables a stable and high-quality assembly. It enables a constant improvement and an easy multiplication. This report represents an idea for adding functionalities in a robot complex for assembling flame detectors in the firm “UniPOS” and it analyses the benefits of this. The main aims for a development of the existing robot complex for assembling are: decreasing the production prime cost; reducing the manual labor that is connected to loading components; increasing the use of the robot complex; reducing the cycle time and increasing the productivity of the robot complex; increasing the quality of the manufactured products. The additional functionalities are accomplished in parallel with the main ones in assembling and they are at the expense of running all robots in the complex and their use only for assembling (not for loading the components).

KEYWORDS: ROBOT, ASSEMBLY, REWORK, CYCLE TIME, PRODUCTIVITY

1. Introduction

In the course of one year by observation, analysis and using Lean Manufacturing [1] we came to a conclusion that loading the robot complex with components for assembling for producing flame detectors can be changed, as the trays with components are replaced by stacks of components on the analogy of the line with machinery conveyor assembling [2]. Additionally built conveyors will put the component for assembling at a certain place. The component will be taken from the stack by an isolated gate driver. This will enable the robots to work efficiently [3], as they will only assemble and there will be no need of a change of the trays which carry the components. The robots will work simplified because they will always take a component from one and the same place. This will lead to a stabler and faster work. It will lead to a simplified programming of the robots, too.

On fig. 1 it is shown the scheme of the complex with the described change.

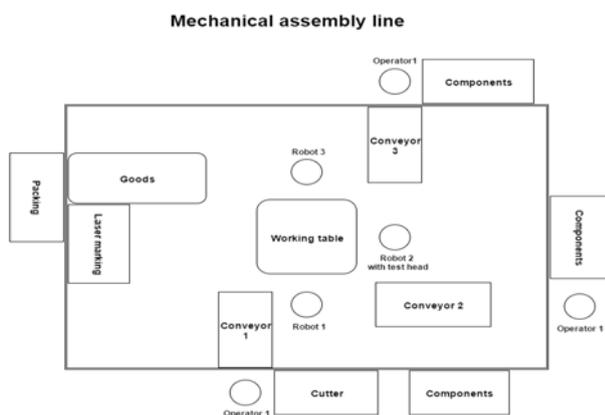


Fig.1. Robot complex with stacks

The operator will load a few stacks with components, which will enable a decrease in its work. In the production of the components (they are usually plastic details which are produced by syringing) their package will be able to be automated by introducing robots which will load stacks. In this way the production of the components will be able to be automated flexibly. The stacks have high density. They are easily transported and the process of separating the components for assembling is simplified and assured by isolated gate drivers.

2. Robot complex

On fig. 2 it is shown the robot complex which works with trays with components.

Fig.2. Robot complex with trays

The robot complex currently works with trays with components which are loaded by an operator. The components are in panels or in bulk.

On fig. 3,4,5 trays which are loaded with different components are shown.



Fig.3. Trays with corpses



Fig.4. Trays with bottoms



Fig.5. Trays with PCBA

3. Robot complex with additional functionalities

The idea is a replacement of these trays with large space and little density with components by appropriate stacks which will be loaded out of the dimensions of the robot complex. They will be firmed strongly with components. By an isolated gate driver they will pass a component by component through a small conveyor to a certain place (with a stopper) where the corresponding robot will take it for assembling.

This whole automation works in parallel with the robot complex and has enough time to accomplish the process. The synchronization in time is easy because it only depends on starting the assembly of the robots.

The use of stacks enables automation of the production and the package of the components. This type of packing has high density.

Passing the components will be safer and less risky. Then the possibility of stopping the complex is minimal.

4. Results

The results of the described additional functionalities are:

- direct – reducing the cycle time and the productivity of the robot complex for assembling due to a lack of work in changing the trays with components by the robots and a lack of pauses because of wrongly positioned components;
- indirect, connected to the reduced labor in production and package of the components, their transport and loading the robot complex;
- reduced rework because of the better quality of the components and their excellent positioning.

On fig. 6 it is shown a table with the results.

Production line	Cycle time, s	Productivity, pcs/shift	Man power, min	Rework, %
Manual assembly	18	1600	3,6	11,8
Conveyor	12	2400	1,8	5,2
Tact conveyor	11	2600	0,73	0,57
Machine conveyor	10	2880	0,67	0,42
Robot complex	10	2880	0,33	0,1
Robot complex with extra functionalities	8	3600	0,04	0,02

Fig.6. Table with results

5. Conclusions

The conclusions of the additional functionalities in the robot complex for assembling are:

- The cycle time reduces and the productivity of the robot complex increases;
- The labor considerably reduces directly and indirectly, which considerably decreases the prime cost of the product;
- The rework rate considerably decreases, which guarantees a lack of refusals among the clients;
- By the stacks conditions for POKA YOE are created (there is no possibility that the error will become a defect) regarding the quality of the components because the stacks appear as gauges that are used for packing the components (the component will not be able to be put in the stack if there is a diversion from the shape and the dimensions);
- The possibility of stopping the work of the robot complex decreases.

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References

- [1] James P. Womack, Daniel T. Jones и Daniel Roos, "The Machine That Changed the World: The Story of Lean", Production(1991).
- [2] V.Tsenev, " Lean manufacturing applying for increasing the efficiency of conveyor machine electronic production in the condition of Total Quality Managing ", Proceedings international symposium INNOVATIONS IN ENGINEERING", pp. 67-71, 2015.
- [3] FANUC robot M-10iA 10S (2013)

INNOVATION ACTIVITIES – PARADIGM OF LONG-TERM DEVELOPMENT OF SMALL AND MEDIUM ENTERPRISES

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SUMMARY: *The aim of this work is a reflection of the impact of innovation activities in the development of small and medium enterprises, especially in the long run. Innovation activities the trend of modern business, but at the same time is a prerequisite for sustainable long-term development.*

On the basis of small and medium enterprises is instability, which is the result of inadequate business. Under inadequate shall be deemed to be a business that is unable to meet the demands of the business environment. Given these shortcomings, this paper will demonstrate the impact of innovation activities to increase the profitability of small and medium-sized enterprises in the long term.

The application of innovation activities in small and medium-sized enterprises includes organizational changes, starting with the method of management that will promote culture and climate that will encourage the adoption of new knowledge, skills, tools and all other's requesting to be placed in front of the business.

KEY WORDS: INNOVATION, SMALL AND MEDIUM ENTERPRISES, LONG-TERM DEVELOPMENT

INTRODUCTION

SMEs are considered the engine of growth and employment thanks to innovation activities. The development of innovation SMEs ensure long-term development. In developed countries, innovation policy has been recognized as a complex problem. This approach confirms that innovation is recognized as a factor in long-term development. As a good example of the perception of innovation has been recognized Slovenia, although they observed that certain deficiencies which are planned to eliminate by 2020. Croatia can boast for the application of innovation, but there are certain preconditions for the development of innovation. This refers to measures at national level.

What is the focus of attention as Bosnia and Herzegovina, which has a low level of competitiveness. The reasons are manifold. First of all rates by economic growth, which does not allow spending for research and development that directly reflects the innovation segment. We can say that it was one of the reasons for the focus of this work and the situation in Bosnia and Herzegovina which is characterized by low levels of economic growth, low competitiveness, a slight separation of research and development, which directly reflects on the lack of innovation that the sector of small and medium enterprises, which is a lever for economic development in countries such as Bosnia and Herzegovina.

What is the focus of attention as Bosnia and Herzegovina, which has a low level of competitiveness. The reasons are manifold. First of all rates by economic growth, which does not allow spending for research and development that directly reflects the innovation segment. We can say that it was one of the reasons for the focus of this work and the situation in Bosnia and Herzegovina which is characterized by low levels of economic growth, low competitiveness, a slight separation of research and development, which directly reflects on the lack of innovation that the sector of small and medium enterprises, which is a lever for economic development in countries such as Bosnia and Herzegovina.

For all these reasons, opens space for reflection on innovation and their contribution to the development of SMEs.

Theoretical aspects of innovation

The process of development of the theory of innovation associated with Schumpeter, who is a very significant figure in the development of the theory of entrepreneurship. Schumpeter's innovations introduced as a basic factor of technological progress and economic development. Introduces the concept of creative destruction by which I considered replacing old technology with new.

Regarding the classification of innovation, Schumpeter already mentioned proposed five types of innovation:¹

- introduction of new production methods

- The opening of a new market
- The conquest of a new source of raw materials or semi-finished
- Reorganization of the industry ations.

From this survey it can be concluded that the key innovation product / service innovation and process innovation.

The key innovations related to product / service innovation and process innovation. According to the OECD classification into these innovations include:

- innovation of products / services:
- The use of new materials,
- The use of new intermediates,
- The new functional components, and
- Fully new features.
- Innovation process:
- New production techniques
- A higher degree of automation, and
- The new organization (with regard to new technologies).

The most important aspects of innovation is the creation of new markets and acceptance of new products / services by customers, which means that sophisticated consumer demand should be an important guide for innovative products and services. Since the company realizes the economic usefulness of the successful implementation of innovations that the company follows the center of the innovation process. Privacy becomes important as innovation and pricing policy as a result of competitive pressure. Innovation is a crucial means to create competitive advantage and superior buyer's value. The focus is on innovative ways to enhance its market position. Speed and diffusion of innovation is the key to productivity growth and the economy in general. Enterprises must become better at adapting and exploiting change, regularly renewing and directing their own activities, and showing a stronger entrepreneurial orientation.

Innovation policy in the EU

The main driver behind the development of the EU, as one of the most prosperous economic areas, knowledge, technology and innovation. In 2000 signed the Treaty of Lisbon, according to which the EU should become the most dynamic economy in the world, and one of the key determinants of achieving this goal is innovation.

The document is complementary to current challenges specific to the EU and recognizes the problems related to innovation. The importance of this issue given the fact that innovation activity is lower in the EU compared with the US and Japan.

It can be said that the EU generally recognized the importance of innovation policy. It is also closely linked with other EU policies, such as employment policy, competition, environment, industry and energy. The role of innovation is to modify the results of research into new and better services and products with the objective of maintaining competitiveness in the global market, and improve the quality of life of European citizens.

¹ OECD, Directorate for Science Technology for Competitive Advantage, Prentice Hall, New Jersey, 2001, pp. 23.

In order to become an everyday business innovation, the EU has developed a concept of "Innovation Union" aimed to:²

- in Europe to achieve world-class scientific results
- remove obstacles to innovation, such as expensive patenting, market fragmented, slow determination norms and lack of skills, which are currently preventing the rapid transfer of ideas to the market, and
- implementation of innovative partnerships between European institutions, national and regional authorities, as well-sized enterprises to revolutionize the way in which the public and private sectors to work together.

Innovation policy in the United States, Japan and Canada

In the US system that supports innovative process has become one of the most important national resources for development. Business in the United States has shown a significant ability to innovate and innovation in the market capitalization. The elements of the national innovation system, positioned in the center of the private sector, have a significant effect, where stands.³

- industry responds to new technologies and new ideas to the market,
 - Private companies are flexible and adaptive, definitely more than the government or the academic sector and can not accept the changes much easier,
 - Efficiency, so that industry access to the product life cycle, is also a strength of the business sector,
 - market access, as well as the factors involved in defining new products or business is also well stimulated by the industry.
- Japan has made the following changes, which have contributed to improved innovation policy:⁴
- Administrative reform, which included the reduction of a number of ministries and agencies; The biggest change was reflected in the merger of the Agency for Science and Technology with the Ministry of Education in the Ministry of Education, Culture, Sports, Science and Technology, which now controls about two thirds of government investment in research and development,
 - The transformation of national research institutes an independent administrative agency, which allowed greater flexibility in terms of personnel and financial management, as well as the impact on the future allocation of government resources.

Innovative policy has become one of the priority areas of the Canadian government, which resulted in the creation of innovative policies and strategies, which define the conditions to support the sustainable growth of small business, and efficient use of public R & # 38; D funds.

Innovation policy of Canada is clearly demonstrated knowledge that productivity is the major weakness of Canada. EU countries have been considered in terms of R & D and innovation system. Commercial use of research result is presented as the bad, so that investing in R & D has become a key issue of the national government. In this regard, Canada has done a number of things from 1997, in order to create conditions for greater innovation. Improved market environment, reducing taxes on capital, and constantly improved legal framework. Then, increase investment in R & D in universities and business in order to support new programs and activities aimed amplifiers increase the availability of highly qualified people through the support of university studies.⁵

Innovation policy in neighboring countries - Slovenia and Croatia

² www.europa.ba

³ Žuljević, A. Innovation as a factor in the creation of new business opportunities, the growth of SMEs, and help economic integration into the EU, doctoral dissertation, Faculty of Business Management Mostar, 2008, p. 96.

⁴ Isto., str. 101-104.

⁵ www.innovation.gc.ca/gol/innovation.

In relation to the overall innovation index, countries are divided into four main groups: (1) innovation leaders, (2) innovation followers, (3) moderate innovators, and (4) other countries followers. Slovenia in 2007 and 2008 contained in the group of moderate innovators, while in the period from 2009 to 2011 took the group of innovation followers. This is a big leap for Slovenia since it is located in the same group as well as Austria, Belgium, Cyprus, Estonia, France, Ireland, Luxembourg, the Netherlands and the United Kingdom.

However, it is still marked as a follower of innovation just below the average for EU-27. Slovenia is among the countries of the EU-27 as a follower of innovation in 2011 was on the 12th place.⁶

Although Slovenia recorded a relative advantage in human resources and innovation activities of those companies which are associated with the public I & # 38; R institutions, research indicates a very weak link in the protection of intellectual property (other brands) in the development of innovations in the field of services and processing and organizational innovation.

Innovation policy of the Republic of Slovenia is much clearer than it is the case with the Republic of Croatia. The main reason for this is the existence of an umbrella strategic and more active document: Resolution of research and development strategy of the Republic of Slovenia for the period from 2011 to 2020. Year. The foundations on which it rested preparation Resolution recognized several years ago, and external evaluation of previous results is primarily left to the OECD, whose conclusions are incorporated in the resolution. Awareness of the Republic of Slovenia on the importance of investing in research and development activities by the fact that even during the most difficult period of economic crisis, Slovenia has not decreased expenditure on research and development activities in 2009 amounted to 1.83% of GDP compared to 1:38% in 2000, in the framework of resolution expected an increase of 1.5% in 2020. In addition, one of the main missions of the Resolution is to establish a model that will streamline and harmonize all existing measures in the area of innovation, and long-term follow the expected effects, including effects on the economy.

Based on the above, it can be concluded that the Republic of Slovenia has worked out a system and rounded innovation policy for many years, and timely detect flaws that will try to return to the period up to 2020.

A comparative analysis of the innovation potential according to the methodology developed by the European Commission, weakness recorded in Croatia are:

- innovative products and processes (which might be attributed to the insufficient protection of intellectual property rights),
- lack of a clear vision of management (which challenges the innovation activities).

A review of existing (available) measures and opportunity to encourage research and development activities at the national level can be concluded that most measures in accordance with the actual needs of the development of SMEs in the direction of strengthening their innovative potential. However, most of these measures could not be implemented within the planned scope and the planned time, and no systematic evaluation of the effects did not result in the implementation of measures aimed at their timely changes and improvements. A potential cause for this is the lack of clear innovation strategy in the form of umbrella document at the national level.

Condition of innovation and SMEs in BiH

Economic Competitiveness in Bosnia and Herzegovina (BiH) is low, and its innovation system is underdeveloped: allocation for research and development are among the lowest in the Western Balkan region, business sophistication in research is low and universities have little ability and resources for research. in BiH there are many obstacles to the development of innovation, particularly in SMEs. They can be grouped:

- economic and financial,

⁶ www.europa.eu/innovation, Innovation Union Scoreboard 2011.

- regulatory and institutional, and
- modest scientific research infrastructure.

Among the economic financial dominate the lack of resources, and low domestic public budget allocations for R &D activities adversely innovative SMEs lending by international financial organizations and domestic commercial banks and microcredit organizations. As the internal obstacles may be cited lack of equity, lack of ability to assess business ideas, business ideas neglect, insufficient knowledge of financial management and marketing, and insufficient awareness of the importance of training. As far as the regulatory and institutional barriers to the development of innovative SMEs, they can diversify the political, legal, administrative, etc. As a general limiting factor that, so and economic progress of the country, there is a lack of a defined political will in terms of training. Also, business administration, especially in the process of business registration and ownership is inefficient, including loading the phenomenon of corruption. Furthermore, the judiciary is slow, are not built adequate institutions type management and financing of scientific and technological policies and the development of SMEs. Modest necessarily research infrastructure includes universities, without pronounced research activities, a small number of independent R &D institutions, libraries not connected to the eminent international, scientific journals, etc.

CONCLUSION

Innovation is the process of converting ideas into practical application, which is one of the simplest and most popular definition of innovation.

Developed country in the world, such as the EU, Japan, USA and Canada, have recognized the importance of innovation policy. The EU has created a number of documents that can be brought under the framework of innovation policy, and the most important protocol of innovation policy and the development of the concept of "Innovation Union", whose goal is to achieve world-class scientific results, remove barriers to innovation and to implement innovative partnerships between institutions, authorities and companies. In the US system that supports innovative process has become one of the most important national resources for development. Business in the United States has shown a significant ability to innovate and innovation in the market capitalization. The elements of the national

innovation system, positioned in the center of the private sector, have a significant effect. Japan has made certain changes in the form of administrative reform, transformation of national research institutes, and the reform of the implementation of the new Law on Science and Technology which have contributed to improved innovation policy. Canada is in the field of innovation policy improved market environment, reducing taxes on capital, and constantly improved legal framework, then, increase investment in R & D in universities and business in order to support new programs, and increase activities aimed at increasing the availability of highly qualified people through the support of university studies. Innovation system in BiH is underdeveloped: allocation for research and development are among the lowest in the Western Balkans In BiH there are many obstacles to the development of innovation, particularly for developing innovative SMEs. They can be grouped as economic and financial, regulatory and institutional modest scientific research infrastructure. BiH has no strategy for the development of innovation and SMEs, and therefore not necessary stimulus measures.

REFERENCES

1. Bowen, A., Ricketts, M., An internally developed solution human resource management, Volume 39, 2000.
2. Hamel, G., Bringing Silicon Valley inside, Harvard Business Review, October 1999.
3. Hender, J., Innovation Leadership – Roles and key imperatives, 2003.
4. OECD, Directorate for Science Technology for Competitive Advantage, Prentice Hall, New Jersey, 2001
5. Markides, K., All the Right Moves, Boston, Harvard Business School Press, 2000.
6. Saren, M., Determinants, Processes and Strategies of Technological Innovation: Toward an Interactive Paradigm, The Strategic Management of Technological Innovation, 1992.
7. SEC 1349, The European innovation scoreboard, Commission, Lisbon EU Council, 2002
8. Stošić, B., Management of innovation, Fakultet organizacionih nauka, Beograd, 2007.
9. Švarc, Račić, ERAWATCH Country Reports/Croatia, 2011. (objavljeno 2013., Evropska Komisija).

TOWARDS A NEW INDUSTRIAL ORGANIZATION: A GLANCE AT THE POLITICAL ECONOMY OF CLAUDE HENRI DE ROUVROY, COMTE DE SAINT-SIMON

КЪМ НОВА ИНДУСТРИАЛНА ОРГАНИЗАЦИЯ – ПОГЛЕД ВЪРХУ ПОЛИТИЧЕСКАТА ИКОНОМИЯ НА КЛЮД-ЕНРИ ДЪО СЕН СИМОН

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Abstract: Often referred to as Henri de Saint-Simon, the Comte (1760-1825) offered a new and contemporary organization of ideas and practices. He said it was necessary to put an end to the critical phase of feudalism, the 18th and 19th century revolutions, the wars, the intolerance and egotism of the old regime. This transformation, he said, could be achieved by industrialism. Saint-Simon established the doctrine of industrial progress. He was the first to create the doctrine of industrial progress, the first theoretician of industrial society and technocratic political reform.

KEYWORDS: INDUSTRIALISM, POLITICAL ECONOMY, SAINT-SIMON

If I have seen farther than others, it is because I have stood on the shoulders of giants.
Sir Isaac Newton (1676)

1. Introduction

French economist, engineer and entrepreneur Claude Henri de Rouvroy, Comte de Saint-Simon (1760-1825) is a founder of the doctrine of industrial progress, the first theoretician of industrial society and technocratic political reform. He remained forgotten by historians of economics, whether due to his influence on Karl Marx, or due to some already existing more modern industrial theories. Nevertheless, our interest in Saint-Simon is evidence of profound consciousness of the significance of the question of industry in the economic development of the state.

Saint-Simon came from an aristocratic family and received excellent education under the guidance of D'Alembert and Rousseau. He was only 17 when he left for America as part of the French Lafayette military service to participate in the American Revolutionary War. Over the time he spent there (1779-1783), he was extremely impressed by the enthusiasm and the freedom of the newly-formed states, and by the new industrial organization developing on the basis of individual freedom and political equality. Upon his return to Europe, he undertook a variety of initiatives: in Spain (1787) he worked on a project for the construction of a canal connecting Madrid and the Atlantic Ocean, while he also managed to accumulate some riches through speculative transactions. The well-known "Dictionnaire de l'économie politique" of Charles Coquelin of 1853 we can read about his new ambitions:

"I would only keep the riches... as a means of widespread establishment of industry, of creating a research centre for improvement, in other words, to contribute to the enlightened progress and improvement of the human race" (1: 566).

This mission of the reformer and his plan for industrial reorganization of society completely overruled his interest in the French Revolution. Consequently, Saint-Simon consecutively published his better-known works in the period 1817-1822, including the better-known *L'Industrie*, *Le Politique*, *Du système industriel* and *Catéchisme des industriels*.

His "parable" in *L'Organisateur* appeared in 1819, asking what if France suddenly lost her 3,000 leading scientists, artists, manufacturers, bankers, farmers and skilled craftsmen (the entire industrial and productive class), what would be the effect? The answer to this question was that overnight the nation would become a lifeless corpse. It would become inferior to the nations that are its rivals and it would remain so for at least a generation, until it had replaced the people it had lost. The second question was, suppose France lost all the king's family, the King's Ministers of State and councillors, his civil servants and all the local government officials,

her judges, her army officers and her leading churchmen (the entire unproductive but consuming class) France would grieve, but not suffer. The country would easily find other people to do their jobs (2: 71-78).

Saint-Simon's socio-political views are part of classical political economy whose main subject concerns the teaching about classes and society. His interest in political economy was sparked in 1813 when he attended the courses of Jean-Baptiste Say, also called the first professor of political economy in France, at the Athenee Royal. He was inspired by Say's *Traité d'économie politique* and underscored his contribution to clarifying the influence of the economy on social organization.

"Of all who have written, I think that those who have written about political economy have created the most beneficial works. I also think that Say's *Traité d'économie politique* is the book in which one can find the largest number of positively connected ideas... His work contains everything political economy has generated and shown so far. This is the best thing produced by this science in Europe to date" (3: 79-82).

The two share common features in respect to the old feudal system, positive knowledge and the importance of industrial classes. However, while Say's *Traité d'économie politique* reveals the principles that form the science of production, Saint-Simon outlined the classical theory relevant to industrialization.

This paper will discuss the political economy of Saint-Simon, more specifically its capacity to reveal a new, more progressive organization of society that implements the industrial system.

2. Results and discussions

Saint-Simon's entire work was influenced by the onset of a new organizational system, that of industrialization. His thought can be summarized in the maxim "Everything through industry, everything for it" (3: 4). He studied this question through an analysis of the historical past, realizing that this is a process of constant progress.

Industrialization is a product of the evolution of human history, of a constant improvement of practices and knowledge at every single stage to achieving its new perfect form.

In spite of that, an extreme division between the separate stages in the evolution of western civilization emerges. All systems proceeding the age of the Renaissance were guided by the "military and theological principle" to a various degree, while the "industrial and scientific principle" acted as a force intended to govern civilized society. We can take as an example medieval society as an

organic entity based on two fundamental principles: on the one hand, the wars, which were leading for feudalism, and on the other, religion and morals in the face of the clergy. According to Saint-Simon, the transformation of the new system passed through the choice of scientific and industrial capacity to the detriment of military, theological and metaphysical power.

"In the age when all our knowledge was mostly assumed and metaphysical, it was quite natural to govern society, or its spiritual affairs, to be in the hands of a theological authority as theologians were the principal metaphysicians. And vice versa, when all our knowledge is formed only on the basis of observations, the management of spiritual affairs should be put in the hands of scientific positive capacity, as it is obviously above theology and metaphysics... Temporary power in the old military force requires more passive submission on the part of the nation. Industrial capacity, by contrast, designed to be the power behind the temporary affairs of the public, will impose itself at random, as every thing has been decided according to a plan compiled for general success, on the one hand, and on the other, the implementation of this plan may require a very small degree of command between people" (4: 80).

His study on the philosophy of history also shows that the French Revolution did not achieve its main historical objective: the much desired transformation to liberty, equality and progress. At the end of the 18th and the beginning of the 19th century industrialists did not have any active role in politics, governance and administration and sustained considerable financial losses, once from the Law of the Maximum¹ and again by the Berlin Decree², which brought into effect a large-scale embargo against British trade.

That was why Saint-Simon declared that it was extremely exaggerated to say that the French Revolution destroyed the theological and feudal powers. It did not abolish them but only lost a considerable portion of the confidence vested in its fundamental principles in such a way that today its authority does not have enough power and credit to serve society... in industrial ideas. It is there and there alone that salvation and the end of the Revolution should be sought (3: 56).

In fact, in "the progress of civilization" the manners of social transformation (reforms and revolutions) were less important than the quality indicator of the system (industrial ideas). This also leads to uselessness of major revolutions leading to anarchy and subsequently to despotism.

The new organizational system suggested by Saint-Simon relates to industrial ideas and knowledge. This evolution is characterized by the constant progress of thought, the expansion of industrial technologies, as well as the progress of exact sciences. In France, the best type of governance in the form of constitutional monarchy was discussed during the Bourbon Restoration (1814-1830). To Saint-Simon, this was industrial monarchy and he openly said that "the best way is to give the heads of industrial enterprises the task of drafting the budget and subsequently to manage public administration, because it follows from the nature of things that the heads of industrial enterprises (who are the true governors of the people because they are those that manage them in their daily affairs) tend, always in the name of their own interests, to develop their enterprises as much as possible, and as a result of their efforts in this direction there will be the largest possible increase of the total number of activities carried out by the people" (5: 266).

¹ In 1793 France passed the Law of the Maximum affixing maximum prices on staple goods. Strict measures were taken against anyone who violated it.

² In 1806 Napoleon issued the Berlin Decree which brought into effect a large-scale embargo against British trade. Any trade with Britain was absolutely forbidden, any goods coming from Britain or its colonies were confiscated not only in the ports but also in the interior of the country, any letters coming from Britain were withheld and every Briton remained a prisoner in France.

He hailed the dynamics of production activity and the new industrial society based on action or labour. To him "work is a source of all virtues" (4: 134).

Production is a social organization because society and its participants are in symbiosis. The production of useful things for all people is the most important economic goal of the incumbent. In this way economic interests are integrated in social life. Work of any kind is the most adequate expression of every individual effort as simulated by social reality. "... [T]he most favourable organization lies in industry, industry most generally encompasses all types of beneficial activities, both the theory and practice, the activities of the mind and those of the hand" (3: 56, 57).

Saint-Simon sees bankers, scientists, actors and others as the part of industrial society related to its intellectual development. This conjunction of functions of production, credit and communication is a result of the economic, technical and intellectual education of the ruling elite.

The progressive organization of industrialists has its history, organically related to the "banker corporation" since the 17th century. According to Saint-Simon, bankers are the ruling elite and the main figures in industry. Banque de France is the institution that heads the banking sector and should have radical functions in industrial management. Saint-Simon interprets it as a fact or of political organization in the industrial class, which conditions the functioning of a dynamic system. "Industrialists are organised by the establishment of the bank which connects all branches in industry and manages the political usage of their capital" (6: 66).

Saint-Simon distinguished the connections of the new industrial organization through the prism of political science.

"As a fundamental part of industry, bankers should have direct contacts with the mass of the most remarkable scientists and artists" (6: 197).

Saint-Simon suggested that governance based on competence and academic capacity should ensure the transition to the new industrial system.

"Scientists have elements of the necessary theoretical activity to form the industrial doctrine and the intellectual requirements for that (4: 116).

Just as scientists, artists are people of imagination who stand at the head of the army of industrialists. Saint-Simon lent a poetic tinge to the task of artists: "artists transfer the earthly Eden to the future and present it as a result of the establishment of the new system, believing that this system will be established immediately" (4: 97).

3. Conclusion

In his political economy Saint-Simon suggested a new, contemporary organization of ideas and practices. It was necessary to put an end to the critical phase of feudalism, the 18th and 19th century revolutions, the wars, the intolerance and egotism of the old regime. This transformation could be achieved by means of industrialism.

A new social structure of European society emerged after the end of the 19th century, conditioned by the upsurge of engineers and their industrial organization. Since the beginning of the 20th century, this governing power, legitimized by science, has destroyed the rent bourgeoisie holding the capital. With his ideas Saint-Simon conditioned the contemporary world of governance and the main doctrine of French industrial society. These reflected in the scientific organization of labour, formalized in the works of Henry Fayol (1916) and the managerial revolution of James Burnham (1947).

The practical value of his industrial project is best measured by his followers, the Saint-Simonians. They were all convinced that the ideas of Saint-Simon, his industrialism as a social doctrine, provide the elements of a contemporary faith that can efficiently replace the

old Catholic moral and utilitarian ideals.

These include Augustin Thierry and Auguste Comte, Prosper Enfantin, Saint-Armand Bazard, Emile Pereire and we can also add Olindeand Eugène Rodrigues, among others.

Enfantin, Francois Barthélemy and Ferdinand de Lesseps initiated the construction of the Suez Canal. The first passenger railway in Eastern France, built by Compagnie du chemin de fer de Paris à Saint-Germain, was also headed by Saint-Simonian Emile Pereire. Others were the cause for the inception of various projects during the Industrial Revolution: banks funding industrial and commercial development like Crédit Lyonnais, the establishment of educational institutions (Ecole Centrale de Lyon, Ecole Centrale Paris, Societé d'enseignement professionnel du Rhone), to mention but a few.

The movement reached its apogee in 1852, when Napoleon III surrounded himself with industrialists like Michel Chevalier, Prosper Duvergier, Jean-Martial Bineau, Hippolyte Fourtoul, and Emile Barrault, who became his ministers. Thus Saint-Simon's industrial doctrine was established mainly at the core of the French state.

4. References

1. Dictionnaire de l'économie politique, Charles Coquelin, Gilbert Urbain Guillaumin, Paris Librairie de Guillaumin et Cie, 1853, p.566. Available at:
<http://gallica.bnf.fr/ark:/12148/bpt6k224108/f572.item.zoom>
2. Compte de Saint-Simon, Oeuvres de Saint-Simon, Capelle, Paris, 1841, p.71-78. Available at:
<http://www.philisto.fr/doc-75-la-parabole-de-saint-simon-1819.html>
3. Saint-Simon, L'industrie ou discussions politiques, morales et philosophiques, Paris, 1817, p.4-82. Available at:
<http://gallica.bnf.fr/ark:/12148/bpt6k5427151b/f4.image>
4. Claude-Henri de Saint-Simon, La physiologie sociale. Oeuvres choisies par Georges Gurvitch (professeur à la Sorbonne), Paris, Presses universitaires de France, 1965, p.80-134. Available at:
http://classiques.uqac.ca/classiques/saint_simon_Claude_henri/physiologie_sociale/st_simon_physio_sociale.pdf
5. Henry Saint-Simon, Du système industriel, Paris, Chez Antoine-Augustin Renouard, 1821, p. 266. Available at:
<http://gallica.bnf.fr/ark:/12148/bpt6k829388/f291.image>
6. Henry compte de Saint-Simon, Opinions littéraires, philosophiques et industrielles, Paris, Galerie de Bossange père, Libraire, 1825, p. 66- 197. Available at:
<https://go.gl/tM3ccw>