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ACTA TECHNICA CORVINIENSIS – BULLETIN of ENGINEERING

Tome IX [2016]
Fascicule 2
[April – June]

INDEXES & DATABASES

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We are very pleased to inform that our international scientific journal ACTA TECHNICA CORVINIENSIS ~ Bulletin of Engineering completed its eight years of publication successfully [2008–2015, Tome I–VIII].
In a very short period the ACTA TECHNICA CORVINIENSIS ~ Bulletin of Engineering has acquired global presence and scholars from all over the world have taken it with great enthusiasm.
We are extremely grateful and heartily acknowledge the kind of support and encouragement from all contributors and all collaborators!

ACTA TECHNICA CORVINIENSIS
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AIMS, MISSION & SCOPE

General Aims

ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering has been published since 2008, as an online supplement of the **ANNALS OF FACULTY ENGINEERING HUNEDOARA – International Journal Of Engineering**. Now, the **ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering** is a free-access, online, international and multidisciplinary publication of the Faculty of Engineering Hunedoara. **ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING** exchange similar publications with similar institutions of our country and from abroad.

ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering is an international and interdisciplinary journal which reports on scientific and technical contributions. Every year, in four online issues (fascicules 1 – 4), **ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering [e-ISSN: 2067-3809]** publishes a series of reviews covering the most exciting and developing areas of engineering. Each issue contains papers reviewed by international researchers who are experts in their fields. The result is a journal that gives the scientists and engineers the opportunity to keep informed of all the current developments in their own, and related, areas of research, ensuring the new ideas across an increasingly the interdisciplinary field. Topical reviews in materials science and engineering, each including:

- ✓ surveys of work accomplished to date
- ✓ current trends in research and applications
- ✓ future prospects.

As an open-access journal **ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering** will serve the whole engineering research community, offering a stimulating combination of the following:

- ✓ Research Papers – concise, high impact original research articles,
- ✓ Scientific Papers – concise, high impact original theoretical articles,
- ✓ Perspectives – commissioned commentaries highlighting the impact and wider implications of research appearing in the journal.

ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering encourages the submission of comments on papers published particularly in our journal. The journal publishes articles focused on topics of current interest within the scope of the journal and coordinated by invited guest editors. Interested authors are invited to contact one of the Editors for further details.

Mission

ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering is an international and interdisciplinary journal which reports on scientific and technical contributions. The **ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering** advances the understanding of both the fundamentals of engineering science and its application to the solution of challenges and problems in engineering and management, dedicated to the publication of high quality papers on all aspects of the engineering sciences and the management.

You are invited to contribute review or research papers as well as opinion in the fields of science and technology including engineering. We accept contributions (full papers) in the fields of applied sciences and technology including all branches of engineering and management. Submission of a paper implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis) that it is not under consideration for publication elsewhere. It is not accepted to submit materials which in any way violate copyrights of third persons or law rights. An author is fully responsible ethically and legally for breaking given conditions or misleading the Editor or the Publisher.

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We strongly believe that the open access model will spur research across the world especially as researchers gain unrestricted access to high quality research articles. Being an Open Access Publisher, Academic Journals does not receive payment for subscription as the journals are freely accessible over the internet.

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- ✓ Mechanical Engineering
- ✓ Metallurgical Engineering
- ✓ Agricultural Engineering
- ✓ Control Engineering
- ✓ Electrical Engineering
- ✓ Civil Engineering
- ✓ Biomedical Engineering
- ✓ Transport Engineering
- ✓ Nanoengineering

CHEMISTRY
- ✓ General Chemistry
- ✓ Analytical Chemistry
- ✓ Inorganic Chemistry
- ✓ Materials Science & Metallography
- ✓ Polymer Chemistry
- ✓ Spectroscopy
- ✓ Thermo-chemistry

ECONOMICS
- ✓ Agricultural Economics
- ✓ Development Economics
- ✓ Environmental Economics
- ✓ Industrial Organization
- ✓ Mathematical Economics
- ✓ Monetary Economics
- ✓ Resource Economics
- ✓ Transport Economics
- ✓ General Management
- ✓ Managerial Economics
- ✓ Logistics

AGRICULTURE
- ✓ Agricultural & Biological Engineering
- ✓ Food Science & Engineering
- ✓ Horticulture

INFORMATION SCIENCES
- ✓ Computer Science
- ✓ Information Science

EARTH SCIENCES
- ✓ Geodesy
- ✓ Geology
- ✓ Hydrology
- ✓ Seismology
- ✓ Soil science

ENVIRONMENTAL
- ✓ Environmental Chemistry
- ✓ Environmental Science & Ecology
- ✓ Environmental Soil Science
- ✓ Environmental Health

BIOTECHNOLOGY
- ✓ Biomechanics
- ✓ Biotechnology
- ✓ Biomaterials

MATHEMATICS
- ✓ Applied mathematics
- ✓ Modeling & Optimization
- ✓ Foundations & methods

Invitation

We are looking forward to a fruitful collaboration and we welcome you to publish in our **ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering**. You are invited to contribute review or research papers as well as opinion in the fields of science and technology including engineering. We accept contributions (full papers) in the fields of applied sciences and technology including all branches of engineering and management.

ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering publishes invited review papers covering the full spectrum of engineering and management. The reviews, both experimental and theoretical, provide general background information as well as a critical assessment on topics in a state of flux. We are primarily interested in those contributions which bring new insights, and papers will be selected on the basis of the importance of the new knowledge they provide.

Submission of a paper implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis) that it is not under consideration for publication elsewhere. It is not accepted to submit materials which in any way violate copyrights of third persons or law rights. An author is fully responsible ethically and legally for breaking given conditions or misleading the Editor or the Publisher.

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ASSOCIATE EDITORS & REGIONAL COLLABORATORS

We are very pleased to inform that our journal **ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering** is going to complete its eight years of publication successfully. In a very short period it has acquired global presence and scholars from all over the world have taken it with great enthusiasm. We are extremely grateful and heartily acknowledge the kind of support and encouragement from you.

ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering seeking qualified researchers as members of the editorial team. Like our other journals, **ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering** will serve as a great resource for researchers and students across the globe. We ask you to support this initiative by joining our editorial team. If you are interested in serving as a member of the editorial team, kindly send us your resume to redactie@fih.upt.ro.

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INTERNATIONAL SCIENTIFIC COMMITTEE & SCIENTIFIC REVIEWERS

ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering is dedicated to publishing material of the highest engineering interest, and to this end we have assembled a distinguished Editorial Board and Scientific Committee of academics, professors and researchers. **ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering** publishes invited review papers covering the full spectrum of engineering. The reviews, both experimental and theoretical, provide general background information as well as a critical assessment on topics in a state of flux. We are primarily interested in those contributions which bring new insights, and papers will be selected on the basis of the importance of the new knowledge they provide.
ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering encourages the submission of comments on papers published particularly in our journal. The journal publishes articles focused on topics of current interest within the scope of the journal and coordinated by invited guest editors. Interested authors are invited to contact one of the Editors for further details.
ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering accept for publication unpublished manuscripts on the understanding that the same manuscript is not under simultaneous consideration of other journals. Publication of a part of the data as the abstract of conference proceedings is exempted.
Manuscripts submitted (original articles, technical notes, brief communications and case studies) will be subject to peer review by the members of the Editorial Board or by qualified outside reviewers. Only papers of high scientific quality will be accepted for publication. Manuscripts are accepted for review only when they report unpublished work that is not being considered for publication elsewhere. The evaluated paper may be recommended for:

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The manuscript accepted for publication will be published in the next issue of **ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering** after the acceptance date.

All the authors and the corresponding author in particular take the responsibility to ensure that the text of the article does not contain portions copied from any other published material which amounts to plagiarism. We also request the authors to familiarize themselves with the good publication ethics principles before finalizing their manuscripts.

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Abstract: Preparation of drinking water is a very complex area in which is engaged a significant part of scientific and technical potentials in the world. The paper presents the results of treatment of raw drinking water, loaded with organic substances (COD = 94.68 mg/ l) and high concentration of As (up to 38.66 mg/ l). The treatment of raw water was carried out by in situ electrochemically synthesized ferrate(VI) in a pilot plant with a flow-through electrochemical cell. For the treatment of water the pilot plant batch type with three reaction columns was formed. The developed method was applied to the treatment of raw water from four different sources. The results showed the removal of up to 97% As, and permanganate index close to the statutory limit value (12 mg/ l of $KMnO_4$).
Keywords: Arsenic, ferrate(VI), electrochemical synthesis, oxidation, coagulation, pilot plant

Abstract: This paper shows discretized model of main spindle working unit module obtained by ANSYS software. Based on the conducted modal analysis for first ten bending modes within frequency range from 0 to 10 kHz, main shapes and natural frequency (eigenfrequency) have been determined, and modal matrix was formed. Obtained results were afterwards used to determine model dynamic behavior in the state space using MATLAB. State space model was further used as reference one for modal reduction whereby balanced reduction method was applied. Frequency response of full model (all oscillatory modes) and reduced model for direct FRF and cross FRF are presented through Bode diagram. Reliability of the model is verified by comparing the impulse response of full model and reduced model in time domain.
Keywords: natural frequencies, model order reduction, modal reduction, balanced reduction, state space

Abstract: During exploitation technical systems leads to irreversible changes in the system caused by various processes: friction, wear, corrosion, deformation, effects of the environment and the like. The development of rotating machines with ball bearings goes very quickly and improvements are focused on increasing the reliability of machines and their versatility. Improved reliability of ball bearings is to operate in special environments such as corrosive environments, high temperatures, high speed, and high vacuum environments, have become very important. Gliding of the balls is a function of lubrication, tolerance of balls in the cage, the angular rotation and lateral forces, surface quality, as well as speed and load. Lubrication has a dominant influence on the gliding of the ball. The main goal of the research presented in this paper is an analysis of the ball bearings 6206 piston compressors. Ball bearings, that transmit the load are very critical for the safe and efficient operation of rotating machines. In this paper presents analysis of through testing of wear of ball bearing of elements, wear the inner track, the outer tracks and balls, and the final goal was to present the resulting tribological processes. Purpose of monitoring the the state of wear balls was used the micrometer. Other place of testing performed of implemented measures were visual control.
Keywords: reliability, ball bearing clearance, wear, temperature

Abstract: Nowadays tabletting of powders in the pharmaceutical industry is, among other agglomeration processes, most widely used method of finalizing solid products. From a procedural point of view, stress fields of the tablet have the dominant importance because they directly determine its quality. This paper focuses on the experimental detection of the primary stresses during the compression of the pharmaceutical powdered substance AVICELL. Measurements will be performed on the KISTLER programmable electromechanical press in a die with a circular cross-section. Evaluation of the obtained data of the stress fields will be carried out by means of Mohr's circle.
Keywords: uniaxial compression, pharmaceutical powder, stress state, Mohr´s circle

Abstract: Processing numerical model high velocity oxygen fuel (HVOF) coating. Thermal spraying technology, principle and basic characteristics of each method of application of coatings. Literature search, mapping the current trends in the numerical simulation process. Choosing approach numerical simulation, processing and evaluation of the results of the pilot study. There is described a method of modeling by the finite element method the residual stresses induced during thermal deposition of coatings. The simulation was performed in two stages. The first dynamic stage simulated the impacts of the individual particles of the coating material onto the substrate, and the next static stage included a non-linear thermo-mechanical analysis intended for simulating the process of layer-by-layer deposition of the coating, with a specified thickness, and then cooling the entire system to the ambient temperature. During high velocity oxy-fuel (HVOF) thermal spraying, most powder particles remain in solid state prior to the formation of coating. A finite element (FE) model is developed to study the impact of thermally sprayed solid particles on substrates and to establish the critical particle impact parameters needed for adequate bonding. The particles are given the properties of widely used WC-Co powder for HVOF thermally sprayed coatings. The numerical results indicate that in HVOF process the kinetic energy of the particle prior to impact plays the most dominant role on particle stress localization and melting of the particle/substrate interfacial region. Both the shear-instability theory and an energy-based method are used to establish the critical impact parameters for HVOF sprayed particles, and it is found that only WC-Co particles smaller than 40 μm have sufficient kinetic and thermal energy for successful bonding.
Keywords: HVOF, finite elements method, residual stress, technology

Abstract: Subject of this work is focused to developing computation procedure for residual fatigue life estimation of cracked structural componentsunder load spectrum. Finite element method is used for determination of the stress intensity factors (SIF`s) of structural element with surface cracks. These discrete values of the stress intensity factors of cracked structural componentsare used for derivation of analytic function for SIF that is necessary in crack growth analyses. To demonstrate efficient computation procedure in residual fatigue life estimation of damaged structural elements here numerical examples are included. For residual life estimation of cracked structural elements here Forman and Mettumethod is used. In this approach a low cyclic fatigue material properties are used. Computation procedure to strength analyze with respects to fracture mechanic and residual life estimations is applied to aircraft structural elements with surface cracks under load spectrum. Computation results are compared with correspond analytic experimental results.
Keywords: Fatigue, stress intensity factors, surface cracks, singular finite elements, fatigue life prediction

Abstract: Under modern processes of 3D veneer plywood bending we consider creation and using of new technologies. This work emphasizing the importance of technological change of processes and products made from plywood panels, in order to ensure competitiveness in the domestic and foreign market. 3D plywood was created as a response to the increased demand for products that can be moulded into complex 3D forms, like metal or plastic. However, in this case appears well-known problem of anisotropy of wood. This problem is solved by patented mechanical modification of wood. 3D plywood panels opening up new possibilities in the design of chairs, curved fronts for furniture in three dimensions, as well as veneer interior for luxury cars or yachts.
Keywords: modern processes, 3D plywood panels, bending

Abstract: Electrochromic materials are able to reversibly change their colour when placed in a different electronic state. Such materials have a broad range of commercial applications. The most desired application are smart windows - windows with electrochromic thin film coatings that allow them to darken and lighten upon the application of a very small electric voltage and are the next significant advance in window technology for energy efficiency and comfort enhancement.Semiconducting copper(I) oxide, Cu_2O, films were prepared by electrodeposition method onto transparent conductive glass substrates. Those films revealed significant difference in transmittance in their coloured and bleached state, with an average relative modulation of about 53%, so they could be a candidatefor windowcoatings to control the inlet of sun light and heat.
Keywords: electrochromism, copper(I) oxide, electrodeposition, smart window

Abstract: The need for compact heat exchangers has led to the development of many types of surfaces that enhance the rate of heat transfer, among them and perforated plate heat exchangers. The perforated plate heat exchangers consist of a series of perforated plates, that are separated by a series of spacers. The present study investigates the local heat transfer characteristics of flow through a perforated plate with 2 mm in diameter, hole length to diameter ratio of 1 and porosity of 25.6%. For the determination of the local heat transfer, numerical simulations were performed. Reynolds numbers based on the perforated plate pitch were in the range from 80 to 300. The results of average Nusselt number prediction were compared with the related experimental correlations. The experimental results agreed on qualitatively with the results obtained using a CFD.
Keywords: local heat transfer, perforated plate, CFD

Abstract: The damage tolerance design of aerospace structures can be achieved if bearing loads are transferred through the lug-type joint. Such connection between the pin and lug represents potential zone where high stress concentration, fretting, corrosion and material defects could cause the crack growth and even sudden failure. To ensure operational safety of a structure under cyclic loading, it is essentially important to develop the reliable computational models. A computational models for the strength estimation of cracked aircraft lug are formulated. The crack growth propagation is investigated through the stress analysis and fatigue life calculation. The stress field around the crack tip and the stress intensity factor are evaluated by applying analytical approach. The fatigue life up to failure is simulated by employing two different crack growth laws.The estimations are compared with avaiable experimental data, and good correlation between different results are obtained.
Keywords: fatigue, crack growth, aircraft lug, strength evaluation

Abstract: For the correct design of a fluid bed granulator whose output may be granules with the required form and properties, it is necessary to know the process parameters, such as the amount and type of binder, the flow parameters, air distribution and the rate of rotation of the disc. This paper deals with the detection of the kinetics of growth of the granules, specifically their distribution characteristics depending on the binder concentration in the liquid phase. The experiments will be carried out in a fluidized bed granulator with a rotating disc, which was designed at the Institute of Chemical and Hydraulic Machines and Equipment's at the Faculty of Mechanical Engineering of the Slovak University of Technology in Bratislava. The output of the experiments will be the determination of the distribution characteristics of the resulting final granulate.
Keywords: granulate, binder, distribution characteristics

Abstract: The work describes the kinematic structure of production machinery. I compare the serial and parallel kinematic structures, which are the main carriers of industrial robots and manipulators. I show possibilities, advantages and disadvantages of both structures, the basic distribution and kinematics motion. Parallel mechanisms are characterized by their kinematic structure presented a closed kinematic chain. The end effector mechanism is coupled to the base of more than one arm. This design provides an advantage particularly high rigidity mechanism and other related properties. The disadvantage of such a construction is limited workspace.

In terms of positioning and management of this structure because of its complexity rather problematic. It is a structure that allows quick positioning of the tool with three degrees of freedom. Control system with a mechanical part is actually built on the Faculty of Mechanical Engineering. The work focuses on testing the parallel kinematic structure. Finally, the tests are evaluated. Results of experiments to serve in the design of telescoping steering rods and positioning parallel kinematic structure type Tricept in workspace.
Keywords: repeatability and accuracy of the distance position overshoot, paralel kinematic structure, pull-rodof

Abstract: The energy consumption of the world is keep on growing nowadays. Due to the continous development of the machine and electronics industry the average energy demand per person has increased fivefold in the last century. Accordingly the utilization of the non-renewable energy sources has extended. It has become more and more important to exploit our renewable energy sources, because of the sustainable development. The topic of our research is the energy-conversation from renewable energy sources moreover it includes the design procedure of a Photovoltaic Solar Water Heater System (PV-SWHS) and its comparison with a Solar Thermal Collector System (STCS).
Keywords: renewable energy, solar energy, domestic hot water, solar panel

Abstract: The present paper is concerned with the mechanical and mathematical modelling of the spoke wheel lateral truing. A finite element model of the wheel which consists of truss and beam elements is created in ADINA software. The warp in the wheel is embedded in the model geometry. This geometric shape imperfection is straightened by altering the spoke tension. A mathematical software is used to find the optimal values of the spoke tension. Results are presented for various truing strategies.
Keywords: spoke wheel, truing, finite element analysis, optimization

Abstract: This paper considers and describes possibilities for server system virtualization, methods of virtualization and performance of virtualized server systems. A special accent is given to the use of Microsoft Hyper-V hypervisor as a server virtualization technology, its architecture and practical implementation of server system virtualization using that technology. Performance of implemented virtualized server system is analyzed in details and compared with non-virtualized server system solution. Advantages of this type of virtualization are shown and listed in details. Disadvantages, with emphasis on usual performance decrease of virtualized server systems, are also pointed out. Results of detailed analysis and comparison of performance of virtualized and standard server systems are shown in the paper.
Keywords: Server Virtualization; Virtualization tools; Hyper-V hypervisor; Server performance

Abstract: An investigation of the influence of the maximal cutting force on the stresses and strain distribution in a milling spindle with two bearing supports from five-operating woodworking machine KP400 with lower position and console V-belt pulley is carried out by the method of finite elements (FEM) with a CAD/CAE system. The real-acting maximal cutting force on the spindle P^{max} is the maximum cutting force acting on the most laded bit of the cutter and it is 2 times greater than theoretically calculated moment maximal cutting force P_{max}, namely $P^{max} = 2P_{max}$. The 3D milling spindle model was generated section by section with all elements of the real spindle and a static analysis of the spindle 3D model is performed with Autodesk Inventor Professional. 1-st principal, 3-rd principal and Von Misses stresses, equivalent strains, resultant displacement and factor of safety distribution in the 3D spindle model are obtained and visualized. The results are compared with these for spindle loading with the theoretically calculated moment maximal cutting force P_{max}. Spindle loading with 2 times greater than theoretically calculated moment maximal cutting force causes increase of the stresses, strains and displacements values and reduction of the safety factor – as a result a danger of spindle failure exists. The finite element analysis results must be taken into account in designing of new milling machines with lower position of the spindle. It is recommended increasing of the spindle diameter in the place of the milling cutter location or lower location of the milling cutter and in this case the technological height can be adjusted by the lifting mechanism of the slide.
Keywords: cutting force, spindle, milling woodworking machine, static strength, FEM, CAD/CAE

Abstract: There are several technologies and methods for the security related design, management and maintenance of computer laboratories of educational institutions. In order to ensure the continuous availability and the proper maintainability it is crucial to protect the operating systems of the workstations as well as the whole network against internal and external attacks. Thus some kind of control and limitation of the internet based communication and network usage becomes inevitable. Besides, a well-structured, transparent, and secure system management can be obtained only through a central management approach. In this paper, we present some best practice methods and options applicable in case of computer laboratories; and thereafter we examine the current situation by analyzing the results of a comprehensive survey conducted in secondary schools of Kecskemét.
Keywords: IT security, computer laboratory, operating system protection, domain control, firewall

Abstract: Learning Management System can be defined in various manner and perspectives. Learning Management System is defined as a global term for a computer system specifically developed for managing online courses, distributing course materials and allowing collaboration between students and teachers. This paper discusses the development of a model for a customized learning management system in a Nigerian Tertiary Institution. It reveals the effects, benefits and challenges in the relationship between information and communication technology and modern education system. The E-learning portal was specifically developed and tested on Personal Computer systems and handsets in line with its set goals which are to ensure flexibility and collaborative efforts.
Keywords: Learning Management System (LMS), E-learning, Information and Communication Technology

Abstract: The acoustic properties of the products or characteristic sounds become important factor for customers. Aim of this article is to describe term psychoacoustics as well as more closely specify used equipment for an evaluation of acoustics parameters of products. Results of the psychoacoustic analysis show characteristics similar to human hearing and offers possibilities for objective valuation of sound quality. The most effective tool for psychoacoustic measurement and analysis is binaural measurement technique – artificial head. Artificial head have two ears that are positioned at about equal height at the two sides of the head.
Keywords: psychoacoustic, binaural measurement, sound, noise

Abstract: The solar panels which produce electric energy directly from the solar radiation are widely used in residential applications. The principle of operation of these is quite simple, and there is no need for expensive and complex auxiliary equipments. Alongside its advantages, its biggest disadvantage should be mentioned as well: the relatively low efficiency, which is affected by several factors, for example the cell's temperature. Like most of semiconductor devices, the operating parameters of the solar cells are influenced by theirs temperature. In this workthese physical phenomenons were investigated in laboratory conditions. First of all we had to create the measurement equipment. In this paper the investigation of the effects of temperature is presented.
Keywords: solar energy, photovoltaic cells, efficiency, effects of temperature

Abstract: This paper considers and describes possibilities for server system virtualization, methods of virtualization and performance of virtualized server systems. A special accent is given to the use of Microsoft Hyper-V hypervisor as a server virtualization technology, its architecture and practical implementation of server system virtualization using that technology. Performance of implemented virtualized server system is analyzed in details and compared with non-virtualized server system solution. Advantages of this type of virtualization are shown and listed in details. Disadvantages, with emphasis on usual performance decrease of virtualized server systems, are also pointed out. Results of detailed analysis and comparison of performance of virtualized and standard server systems are shown in the paper.
Keywords: Server Virtualization; Virtualization tools; Hyper-V hypervisor; Server performance

Abstract: In recent years IoT (Internet of Things) is gaining interest among researchers and many IoT development platforms, SDK's have been proposed. There are lots of low powered, efficient devices available in market which can be used to create IoT solutions. The main drawbacks of IoT is that every manufacture proposed it owns protocol and provide their own API's to work with it. You need to be an avid programmer to implement, understand, customized and use this API's. Since lots of these libraries are open source not much information can be gathered online. To solve this protocol agnostic problem in IoT many researchers are now focusing on WoT i.e. Web of Things. The main advantage of implementing WoT is that we can use familiar Web protocols to build up our solutions. In this paper we will discuss SOA architecture, proposing a high level WoT network implementation at home-using embedded devices and Web protocols like REST web services and JavaScript to achieve interoperability. We will also discuss security concerns in WoT and best practices to avoid vulnerabilities.
Keywords: WoT, Web of Things, IoT, Internet of Things, REST, SOA

Abstract: Proper behavior of multivariable process isn't guaranteed only through the disabling influence of its mutual coupling (interaction), but also compensation of disturbance has very important role. Investigation of disturbance that can be rejected by previously decoupled 2×2 process has been presented in this paper. Considered flow tank, as a multivariable process, was controlled using PI controllers. The aim was to determine limit of disturbance intensity under whose influence system can operate correctly, and in that way additionally check validity of designed decoupler, i.e. chosen non-conventional control. General expression for periodic rising signal that can be introduced into process in order to present array of disturbances has been derived, too.Investigation was supported by simulations. Here will be considered four cases of disturbance, that should serve to determine limits of its intensity which system can compensate.
Keywords: disturbance, non-conventional control, PI controller, flow tank

Abstract: Pre-tensioned point supported glass walls are widely used in modern architecture today. This paper deals with the stability of glass support structure to predict the collapse behavior of the same. All windows in their corners are connected to spider arm thus transferring the wind force on the bowstring structure. The results of the analysis provide load-displacement relationship and influence of the pretension forces as well as temperature effect on the stability of support structure. Physical and mechanical properties of elements are given at nominal temperature. Above and below this temperature properties have different values. In summer, temperature is higher than the nominal and steel elements extent causing pre-tension stress to decrease. Opposite to this case, in winter the elements are shrinking and add additional tension to the original pre-tension stress.
Keywords: FEM analysis; point supported glass walls; stability; pre-tension system, temperature effects

Abstract: Pneumatic servosystems are widely used in industrial applications because of the favourable performances/price ratio. However, high accuracy control of such systems is difficult due to their complex physical nature. In order to solve the problem of design and control of such systems, it is necessary to have better understanding of their nonlinear characteristics. Flapper-nozzle type valves are frequently used in pneumatic systems because of their simple structure, high precision, sensitivity and a broad bandwidth. They are usually used in control devices or measurement instruments. Flapper-nozzle type valve is commonly used for precision, flow control in pneumatic systems. For the purpose of analysis and design the paper is concerned with nonlinear mass flow rate of the valve taking into account different flow regimes. Flow rate is static, nonlinear function and could not be solved in analytical form. In this paper Particle Swarm Optimization method is used for numerical solution. Depending on supply pressure and flow area ratio along the static characteristic different segment can be observed. The paper analyzes the mass flow rate nonlinearity of the pneumatic flapper-nozzle type valve with high supply pressure. Various flow regimes are analyzed because when the supply pressure is higher than 0.15 [MPa], the air compressibility must be taken into consideration.
Keywords: flapper-nozzle valve, mass flow rate characteristic, PSO optimization method

Abstract: Great energy consumption and costs incurred by data centres are a huge incentive to find ways to reduce them. In a typical data centre, nearly one half of the energy consumed goes to supporting data-com equipment, and the other half is used by support systems. Hence, increasing the energy efficiency of data centres is a challenge. This paper discusses the possibilities for improving the energy efficiency of air conditioning systems and ventilation by integrating best tested devices, with special emphasis on the management and control system for air conditioning and ventilation.
Keywords: data centre, control system, energy efficiency, conditioning and ventilation

Abstract: Model-based predictive control is a very modern powerful control strategy that uses a model of the plant to predict its future behaviourand has been in focus of researchers in the area of buildings energy management. The aim of this paper is to develop and analyze NARX (Nonlinear AutoRegressive with eXogenous inputs) structure for the modeling of the building thermal behavior. A database was generated using simulation in EnergyPlus software. The NARX identification model was designed using the MATLAB System Identification Toolbox. The input variables analyzed in this paper are: outdoor temperature, heating or cooling power, and direct solar radiation. Simulation results demonstrate that the proposed nonlinear structure can be effective identificationtool for development of nonlinear buildings predictive control.
Keywords: building, NARX, identification, thermal behaviour

Abstract: Portal is a web site that is the starting point or access point for multiple web sites and online services. Portals combine a variety of information from multiple sources, providing consistent data and access to numerous applications that would otherwise pose a separate unit. The personal portal provides opportunities, especially tailored to each user, with the possibility of visiting and moving on to the page with different content. Designed for use with distributed applications, different numbers of software that act between applications and networks to integrate various services from numerous other sources. Portals provide users logging on a variety of activities, a directory service and information pertaining to a certain level of subject or organization. There are three types of portals: vertical portal for special activities, occupations and interests, private intranet portals - for employees, customers, partners, and a manufacturer, extranet portals include public and private information.
Keywords: portals, applications, service, information

Abstract: This paper presents a generative engineering method and the opportunities of applying it in the design of the structural components of heavy machines. The generative engineering method is a further development of the engineering methods currently used, which enables automatic generation of some parts or entire assemblies to the given requirements, thus saving time and avoiding errors during the design stages of a product life cycle. Generative engineering uses Knowledge-Based Engineering (KBE) to capture and reuse knowledge about the product and its design processes, various algorithms to create suitable geometrical models, and it enables Multi-Disciplinary Optimization (MDO) to be used effectively. The main model is based on parametric and associative geometric models created in CAD software, which are further enhanced with parametric design requirements. Discipline-specific analysis models are automatically derived from the main model, and they are used to verify if the requirements are met, or for further design optimization. The paper gives a theoretical description of a generative model and its constituent parts and it explains the differences between the engineering methods currently used and the generative engineering method, with a focus on the application of this method in the design of heavy machines' structural components. The proof-of-concept generative model is implemented in CATIA. It relies on standard modelling tools to create the initial definition model, and it uses VBA scripts to implement extended functionality required for generative model and to perform additional advanced operations on generative model.
Keywords: generative engineering, generative model, CATIA, heavy machine

Abstract: Today, is very often, especially where there is no indented city water supply network, on smaller agricultural areas, farms and the like. for irrigation use solar pumps. The paper deals with the problem of dimensioning of solar pumps in irrigation. For irrigation needs, the paper analyzed the solar pump of smaller capacity which are intended for watering of small agricultural areas, such as those in greenhouses, etc.
Keywords: The solar panel, the sun, irrigation, agriculture

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- **The Vth International Conference Industrial Engineering and Environmental Protection 2015 – IIZS 2015**, organized by the University of Novi Sad, Technical Faculty "Mihajlo Pupin", in Zrenjanin, SERBIA (October 15–16th, 2015). The IIZS 2015 is organized in cooperation with the partners: University of Agriculture, Faculty of Agricultural Engineering, Krakow (POLAND), University "St. Kliment Ohridski", Technical Faculty, Bitola (MACEDONIA), "Aurel Vlaicu" University of Arad, Faculty of Engineering, Arad (ROMANIA), Technical University-Sofia, Plovdiv branch, Faculty of Mechanical Engineering, Plovdiv (BULGARIA), University of East Sarajevo, Faculty of Mechanical Engineering East Sarajevo, (BOSNIA & HERZEGOVINA), University Politehnica Timisoara, Faculty of Engineering, Hunedoara (ROMANIA) and University of Niš, Faculty of Mechanical Engineering, Niš (SERBIA). The current identification numbers of the papers are # 1–3 and # 30, according to the present contents list.
- **The 12th International Conference on Accomplishmants in Electrical and Mechanical Engineering and Information Technology – DEMI 2015**, organized by the University of Banja Luka, Faculty of Mechanical Engineering and Faculty of Electrical Engineering, in Banja Luka, BOSNIA & HERZEGOVINA (29th – 30th of May, 2015). The current identification numbers of the papers are # 6–10, # 23–28, according to the present contents list.
- **The 9th International Conference for Young Researchers and PhD students – Education, Research, INnovation – ERIN 2015**, organized by the Czech Technical University in Prague, Faculty of Mechanical Engineering and the Vienna University of Technology, Faculty of Technical Chemistry, in Monínec, CZECH REPUBLIC (May 4–6, 2015). The current identification numbers of the papers are # 4–5, # 11–12 and # 29, according to the present contents list.

Also, the ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Tome IX/2016, Fascicule 2 [April – June/2016], includes original papers submitted to the Editorial Board, directly by authors or by the regional collaborators of the Journal.

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PILOT PLANT FOR TREATMENT OF RAW DRINKING WATER WITH HIGH CONTENT OF ARSENIC USING FERRATE (VI)

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Abstract: The paper presents the results of treatment of raw drinking water, loaded with organic substances (COD = 94.68 mg / l) and high concentration of As (up to 38.66 mg / l). The treatment of raw water was carried out by *in situ* electrochemically synthesized ferrate(VI) in a pilot plant with a flow-through electrochemical cell. For the treatment of water the pilot plant batch type with three reaction columns was formed. The developed method was applied to the treatment of raw water from four different sources. The results showed the removal of up to 97% As, and permanganate index close to the statutory limit value (12 mg / l of $KMnO_4$).
Keywords: Arsenic, ferrate(VI), electrochemical synthesis, oxidation, coagulation, pilot plant

INTRODUCTION

Preparation of drinking water is a very complex area in which is engaged a significant part of scientific and technical potentials in the world. Increasing demands in terms of quality and quantity of drinking water and, on the other side, increasingly polluted water resources result in intensive researches in this area.

Very serious difficulties in the process of preparing high-quality drinking water is the increased amount of natural organic matter in water resources, or the formation of a large number of by-products of disinfection and coagulation. In addition to organic matter in water resources a large number of inorganic pollutants, including arsenic, as one of the most widespread, can be found. Based on the UN Synthesis Report arsenic poisoning is the second major health risk related to drinking water [1]. The World Health Organization in 2001 estimated that about 130 million people are exposed to a concentration of 50 μg / l of arsenic in drinking water. The European Directive has defined maximum allowable concentration of arsenic in drinking water of 10 μg / l [2]. Arsenic in drinking water has never been a subject of interest in most European countries because the maximum allowable concentration of 10 μg / l of arsenic in drinking water have been rarely exceeded. However, in countries such as Hungary, Serbia, Croatia, Greece, Italy and Spain elevated arsenic content in drinking water was confirmed and additional efforts are needed in the treatment of raw water with the aim of achieving the maximum allowable As concentration of 10 μg / l [3,4].

Groundwater in the territory of the Republic of Serbia is the basic resource of water supply system and in the territory of AP Vojvodina water supply is exclusively oriented to groundwater. Much of the groundwater contains unacceptably high levels of arsenic. According to the Regulation on hygienic quality of drinking water [5] maximum allowable concentration of arsenic in drinking water is 10 μg / l. More than 40% of the population of AP Vojvodina is supplied with water containing a higher concentration of arsenic than allowed [1]. In most cases, the concentration of arsenic in drinking water ranges from 50 to 100 μg / l, but there are also municipalities, such as Zrenjanin, where the concentration of arsenic in drinking water ranges from 150 to 250 μg / l [6]. Content of the natural organic matters in these waters expressed through the consumption of potassium permanganate is from 20 to 150 mg / l, and in extreme cases up to 200 mg / l [1]. There are many harmful effects of arsenic on human health - cardiovascular diseases, diseases of the respiratory system, nervous system, various skin lesions, and cancer [7]. Most of the water supply systems in Vojvodina, except the system in Subotica do not own the technology for arsenic removal from groundwater. Efficient removal of organic matter

and arsenic from drinking water resources is still one of the greatest challenges in modern production of safe drinking water. A number of different techniques for reducing the content of organic substances in water are being applied, of which the most applied are conventional physic-chemical methods, such as coagulation-flocculation processes or improved treatment of coagulation. This is a multiphase technique that requires a considerable area of land, continuous supply of chemicals, and generates a significant amount of sludge. Literature indicates that cost-friendly treatment of wastewater and drinking water resources with minimal use of chemicals, which allows the sustainable management of water resources, is necessary. One alternative could be a potential treatment of raw water by ferrate(VI), which at the same time oxidizes the organic material and converts arsenic(III) is to As(V), which is far more mobile and removes from the solution as a slurry in the process of coagulation by generated $Fe(OH)_3$.

MATERIAL AND METHODS

The Na_2FeO_4 solution, concentration of 3,5 g/l used for the treatment was synthesized electrochemically. The process of electrochemical synthesis of the alkaline solution of ferrate(VI) was carried out in a laboratory facility, Figure 1, for electrochemical synthesis of ferrate(VI) composed of a two-part flow-through electrochemical cell and based on the transpassive anodic dissolution of iron alloys in a 10 M NaOH solution, in accordance with previous studies [8,9]. The concentration of synthesized ferrate(VI) was controlled by the titrimetric chromite method at a temperature of 25 °C. Freshly synthesized ferrate(VI) was used for the treatment of the solution.

Figure 1. Pilot plant for the electrochemical synthesis of ferrate(VI)

Within these activities the laboratory pilot device for the removal of As(III) from raw drinking water loaded with organic substances is formed.

Pilot plant for the treatment of raw drinking water by ferrate (VI) is composed of three reaction columns:

- Reaction column for the treatment of water by ferrate(VI),
- Reaction column for coagulation,
- Filtration column.

Between the reaction column are: transport pump for fluids, compressor for aeration, receiving tank, sedimentation tank, dozers for ferrate(VI) and $AlCl_3$, tanks for acid and hydroxide and tank for treated water.

Figure 2. Pilot plant for the treatment of raw drinking water by ferrate(VI) ferrate(VI)

Figure 3. Reaction column for the treatment of raw water by ferrate(VI) with aeration

Formed pilot plant is a batch-type with capacity of 10 liters and batch exchanges on every 30 minutes. In the formed pilot plant for the treatment of raw drinking water with high content of As, Figure 2, raw water from four different sources is treated. The procedure consist of: the treatment of raw water in the first reaction column by ferrate(VI) added from the doser, with aeration by air compressor, Figure 3, wherein the oxidation of As(III) to As(V) and the partial coagulation occur. After pH adjustment to the value pH = 6 by H_2SO_4, the treated water is transported by pumps and system of pipes and control valves, to the reaction column for coagulation, Figure 4.

Figure 4. The reaction column for coagulation

Figure 5. Sedimentation tank

Figure 6. Filtration column with filtration sand of different granulite

In second reaction column is carried out the process of coagulation by some of the common coagulants ($AlCl_3$, $FeCl_3$, $Al(OH)_3$) at pH = 8, with pH adjustment by NaOH. From the second reaction column the treated water is discharged into the sedimentation tank, Figure 5. From the sedimentation tank clear solution is transported by pump into the filtration column, Figure 6, with pH adjustment to neutral value of pH = 6 - 7 by H_2SO_4.

Filtration column contains sand filters with various granulation after which the purified water in the receiving tank has satisfactory characteristics, necessary for drinking water.

RESULTS AND DISCUSSION

Pilot plant is applied for the treatment of raw drinking water from 4 different locations from the theritory of Banat (locations known to the authors) with initial characteristics given in Table 1.

Table 1. Initial content of As and permanganate index of raw drinking water from various locations

Location 1		Location 2	
As, mg/l	$KMnO_4$, mg/l	As, mg/l	$KMnO_4$, mg/l
38,66	94,82	1,62	13,91
Location 3		Location 4	
As, mg/l	$KMnO_4$, mg/l	As, mg/l	$KMnO_4$, mg/l
1,1	38,56	3,57	16,44

The samples of raw water from all locations were treated with two different concentration of ferrate(VI) of 71 μM and 142 μM in the ratio (As : Fe(VI)) = 1 : 5 and 1 : 10. After ferrate(VI) treatment, in each sample was added a coagulant, $AlCl_3$ in a molar ratio ($AlCl_3$: Fe(VI)) = 1 : 1. After filtration and pH adjustment to 6-7 As concentration and the presence of organic matter (permanganate consumption) are analyzed.

Table 2. As content in untreated drinking water from the territory of Banat after treatment by ferrate(VI)

Location 1		Location 2	
Reduction of As,%		Reduction of As,%	
71 μM, Fe(VI)	142 μM Fe(VI)	71 μM Fe(VI)	142 μM Fe(VI)
		93	97
Location 3		Location 4	
Reduction of As,%		Reduction of As,%	
71 μM Fe(VI)	142 μM Fe(VI)	71 μM Fe(VI)	142 μM Fe(VI)
84,5	96,4	90	95

Table 3. Percentage of reduction of permanganate index in raw drinking water from the territory of Banat after treatment by ferrate(VI)

Location 1		Location 2	
Reduction of permanganate index		Reduction of permanganate index	
71 μM, Fe(VI)	142 μM Fe(VI)	71 μM Fe(VI)	142 μM Fe(VI)
		30,4	47
Location 3		Location 4	
Reduction of permanganate index		Reduction of permanganate index	
71 μM Fe(VI)	142 μM Fe(VI)	71 μM Fe(VI)	142 μM Fe(VI)
41	50,5	39	51

Results of the treatment and analysis of As and permanganate index are shown in Tables 2 and 3, in percentage of reduction compared to initial values.

CONCLUSIONS

Aim of the work to define the procedure for As removal from the raw drinking water by ferrate(VI) is reached. As removal is up to 97%, while permanganate index is close to the statutory limit values (12 mg / l $KMnO_4$) [5]. Further optimization of the process would reach the concentration of total As below 10 μg / l which is, according to the Regulations on Hygienic Quality of Drinking Water of the Republic of Serbia, the limit value of arsenic concentration in drinking water.

The application of ferrate(VI) in the treatment of raw drinking water is possible and desirable, due to the high environmental performances of ferrate(VI) in comparison to the oxidants based on oxygen, ozone or hydrogen peroxide and aluminum-based and chlorine-based coagulants. Alternative or pre-treatment to conventional methods, can potentially be the treatment of raw water by ferrate(VI), which at the same time oxidizes the organic material, and As(III) to As(V), which is far more mobile than As(III) and can be removed from the solution by coagulation and flocculation with the resultant $Fe(OH)_3$ as a slurry.

The created pilot plant for the purification of raw drinking water has proved very effective application of ferrate(VI) in both, primary and secondary treatment process for raw drinking water. However, the treatment of fresh drinking water need to be specifically optimized depending on the initial values of As and permanganate index. In the presented pilot plant the treatment of raw drinking water by some other oxidizing and coagulation agents is also possible.

Note

This paper is based on the paper presented at The Vth International Conference Industrial Engineering and Environmental Protection 2015 – IIZS 2015, University of Novi Sad, Technical Faculty „Mihajlo Pupin", Zrenjanin, SERBIA, October 15-16th, 2015, referred here as[10].

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STATE SPACE MODELING FROM FEM MODEL USING BALANCED REDUCTION

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Abstract: This paper shows discretized model of main spindle working unit module obtained by ANSYS software. Based on the conducted modal analysis for first ten bending modes within frequency range from 0 to 10 kHz, main shapes and natural frequency (eigenfrequency) have been determined, and modal matrix was formed. Obtained results were afterwards used to determine model dynamic behavior in the state space using MATLAB. State space model was further used as reference one for modal reduction whereby balanced reduction method was applied. Frequency response of full model (all oscillatory modes) and reduced model for direct FRF and cross FRF are presented through Bode diagram. Reliability of the model is verified by comparing the impulse response of full model and reduced model in time domain.
Keywords: natural frequencies, model order reduction, modal reduction, balanced reduction, state space

INTRODUCTION

Considering that finite element models may have high degree of freedom, MKE analysis may require more time, especially causing problems when analysis are often repeated during the designing process. Therefore, methods simplifying finite elements models are developed in the manner that the most important characteristics of the original dynamic system are included.

Model reduction is a method used to decrease the time required for simulation when finite element model are used and to obtain simplified model preserving at the same time wanted dynamic characteristics of original system. The task of the model reduction is to replace mathematical model of the system or of the process with the one (model) that is far smaller from the original one but still provides input/output relationships of the system or of the process. This paper is the sequel of the research presented in [4] which showed modal analysis by FEM on the working unit module main spindle, where based on the first ten bending vibration modes modal matrix was determined through analyzing displacement in ten measuring points. Afterwards, modal reduction was conducted whereby two methods of ranking of individual mode contribution to the overall frequency response were used, as follows: dc gain and peak gain. Which one, out of two, will be used, depends entirely whether damping ratio ζ has unique value or different value for individual modes. This paper presents SISO model (Single Input Single Output) wherein, for mode ranking, dc gain and peak gain might be used, but also other methods, such as balanced reduction. Hereby concepts of controllability and observability will be used for modes ranking. The method of reducing models "balanced reduction" is applied, using both ranking concepts simultaneously. In this paper FEM modal analysis results and balanced reduction technique were used to obtain a low order state space model of main spindle. Response of the main spindle due to excitation will be obtained using reduced number of vibration modes.

Equivalent dynamic model of main spindle with measurement points analyzed in this paper, is shown in figure 1, while discretized model of main spindle is shown in figure 2.

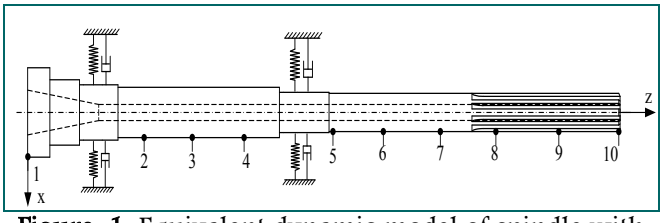

Figure. 1. Equivalent dynamic model of spindle with measurement points [4]

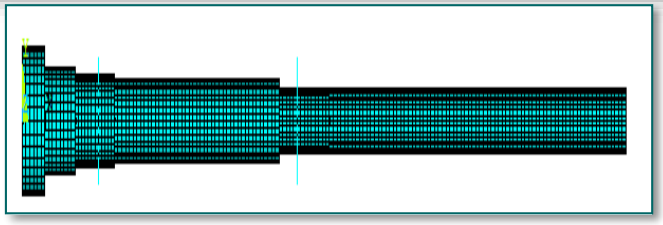

Figure 2. Discretized model of main spindle [4]

Main spindle is supported by the two sets of angular contact ceramic ball bearings in front, SKF S7011 CD/HCP4A and two sets of angular contact ceramic ball bearings in rear SKF 7008 CD/HCP4A, installed back to back [5], [6]. SOLID186 a higher order 3-D 20-node solid element is used to simulate main spindle, and spring damper element COMBIN 14 is applied to simulate the elastic support of the two set of bearings. Eighteen elements were set along the circumferential direction of the spindle on each set of bearing, simulating rolling elements. Since the inertial force and the thermal expansion of bearing elements affects the balls, an uneven distribution of contact forces appears and an uneven contact angle change occurs. The consequence of the aforementioned is the uneven distribution in bearing stiffness, depending on the position of the ball [6]. Values of bearing stiffness depending on the preload and main spindle dimension in are provided in [4], [5]. The first ten eigenvalues for bending motion of main spindle extracted using Block-Lanczos method are shown in Table 1.

Table 1. Eigenvalues for bending motion of main spindle, Hz

f_1	f_2	f_3	f_4	f_5
154,37	926,92	1641	2351,8	2538,1
f_6	f_7	f_8	f_9	f_{10}
4533,1	5687,4	6972,7	8228,9	9637,4

CONTROLABILITY AND OBSERVABILITY CRITERIA

There are different definitions of controllability and observability for state space system, described by equation (1).

$$\begin{aligned} \dot{x} &= Ax + Bu \\ y &= Cx \end{aligned} \tag{1}$$

According to [3] system is controllable if there is an input „u“ that can move the system from some arbitrary state x_1 to another arbitrary state x_2 in a finite time. Similar, the system is observable if the initial state x_0 of a system can be inferred from knowledge of the input u and the output y over a finite time (0,t).

Controllability as a measure of interaction between the input and the states involves the system matrix A and the input matrix B. Observability, as a measure of interaction between the states and the output involves the system matrix A and the output matrix C.

There are several criteria that determine whether a system is controllable and observable. A linear time-invariant system (A,B,C), with s inputs is completely controllable if and only if the NxsN matrix

$$\left[B \; AB \; A^2B \; \cdots A^{n-1}B \right] \tag{2}$$

has rank N. A linear time-invariant system (A,B,C) with r outputs is completely observable if and only if the rNxN matrix of has rank N.

$$\begin{bmatrix} C \\ CA \\ CA^2 \\ \cdots \\ CA^{n-1} \end{bmatrix} \tag{3}$$

There are two disadvantages of this criterion. The first one is that the criteria is suitable for operating with a small dimensions system only. In fact, it is to answer the question whether a system of controllable or observable A^{n-1} should be found, which is obviously a problem from the standpoint of numerical data processing with a larger system.

Another disadvantage is that the answer to the question of whether the system is controllable or observable, is only a "yes" or "no", which may not be the case if the application of other criteria.

Another criterion in determining the controllability and observability uses gramians to determine system properties.

Gramians controllability and observability can be determined from differential equations

$$\begin{aligned} \dot{W}_c &= AW_c + W_cA^T + BB^T \\ \dot{W}_o &= A^TW_o + W_oA + C^TC \end{aligned} \tag{4}$$

whose solutions is a time-dependent matrix. For a stable system, stationary solutions are obtained assuming $\dot{W}_c = \dot{W}_o = 0$ whereby differential equations become equations, known as Lyapunov's equations

$$\begin{aligned} AW_c + W_cA^T + BB^T &= 0 \\ A^TW_o + W_oA + C^TC &= 0 \end{aligned} \tag{5}$$

where W_c is controllability Gramian, and W_o observability Gramian.

Another definition of controllability and observability involves gramians W_c and W_o, the solutions to the Lyapunov equation (5) defined as

$$\begin{aligned} W_c &= \int_0^\infty e^{A\tau}BB^Te^{A^T\tau}d\tau \\ W_o &= \int_0^\infty e^{A^T\tau}C^TCe^{A\tau}d\tau \end{aligned} \tag{6}$$

If the solutions $W_c(t)$ and $W_o(t)$ are non – singular, then system is controllable, i.e. observable.

In modal coordinates the diagonal entries of the controllability and observability gramians are as follows [2], [3]:

$$w_{ci} = \frac{\|B_i\|_2^2}{4\varsigma_i\omega_i} = \frac{\left\|\begin{bmatrix} 0 \\ F_k z_{nki} \end{bmatrix}\right\|_2^2}{4\varsigma_i\omega_i} = \frac{F_k^2 z_{nki}^2}{4\varsigma_i\omega_i} \quad (7)$$

$$w_{oi} = \frac{\|C_i\|_2^2}{4\varsigma_i\omega_i} = \frac{\left\|\begin{bmatrix} z_{nji} & 0 \end{bmatrix}\right\|_2^2}{4\varsigma_i\omega_i} = \frac{z_{nji}^2}{4\varsigma_i\omega_i}$$

while Hankel singular values are obtained from

$$\gamma_i \cong \frac{\|B_i\|_2 \|C_i\|_2}{4\varsigma_i\omega_i} \quad (8)$$

For systems that have relatively small values of the damping ratio ζ, gram matrix is diagonal dominant, which means that the element outside the main diagonal have significantly lower values than elements which belong to the main diagonal.

The syntax for the MATLAB function *balreal* which produces a balanced realization of the linear time-invariant model with equal and diagonal controllability and observability gramians is:

$$[sysb, g, T, Ti] = balreal(sys) \quad (9)$$

where *sysb* is new balanced system, and *g* is diagonal of the joint gramian. Diagonal entries of the joint gramian g are squares of the Hankel singular values of the system. After the balanced gramian diagonal terms are sorted in descending order, *modred* function, option *mdc* or *del* can be applied to eliminate states with the lowest joint controllability/observability.

RESULTS AND DISCUSSION

Figure 3 and 4 shows direct FRF (X1/F1) and cross FRF (X10/F1), where all ten modes were included. Modes are sorted based on the dc gain whereby damping ratio has a uniform value ζ = 0.001. Individual modes contribution was shown on both figures also.

FRF shown in figure 3 does not contain first two natural frequencies (154,37 Hz and 926,92 Hz) i.e. modal contribution of the first two modes is smaller than contribution of modes three, four, five and nine. Explanation how to calculate modal contribution and preform ranking of all modes for this case is provided in [4]. Reasons for this can be found in figure 5 and figure 6, where it can be seen that the main spindle tip displacement on the first two natural frequencies is negligible. On the other hand, figure 4 represents cross FRF, i.e. displacement of measurement point 10 (figure 1), where first two natural frequencies are present. From figures 5 and 6 it can be noticed that point 10 has maximum displacement. Also, figures 7 and 8 show that at third and fourth natural frequencies (1641 Hz and 2351,8 Hz) both measurement points (1 and 10) have significant displacement. As a result both frequencies are present in direct and cross FRF, as can be seen from figures 3 and 4.

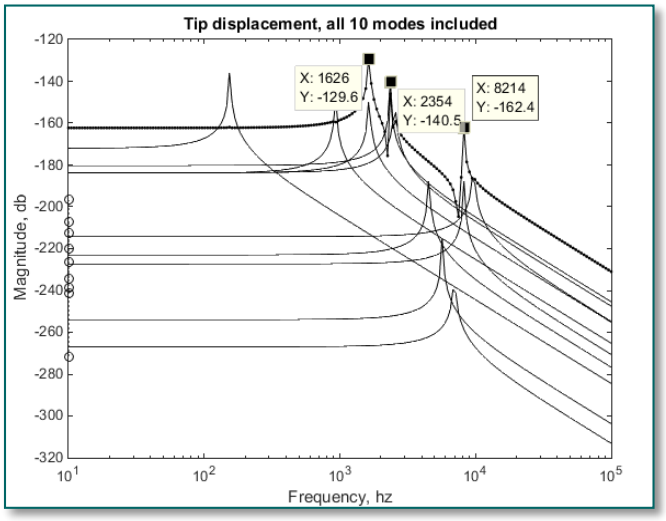

Figure 3. Direct FRF, all 10 modes included

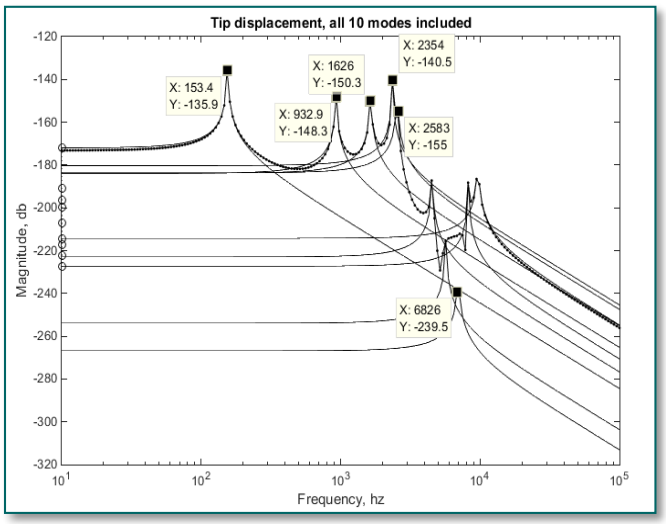

Figure 4. Cross FRF (X10/F1)– all ten modes include

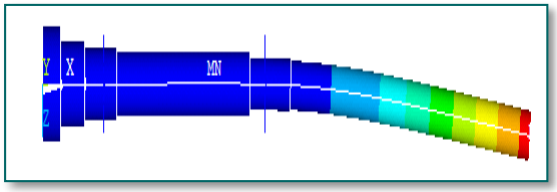

Figure 5. First bending mode 154,37 Hz

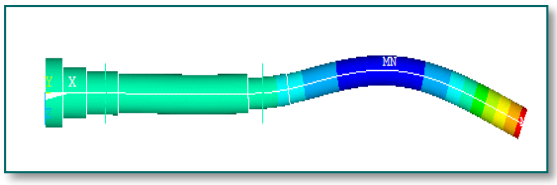

Figure 6. Second bending mode 926,92 Hz

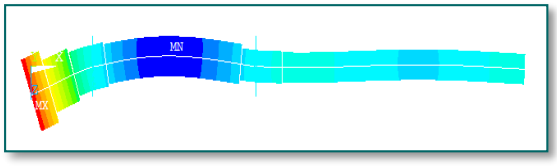

Figure 7. Third bending mode 1641 Hz

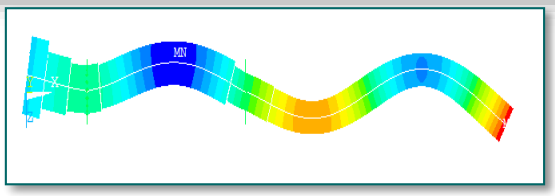

Figure 8. Fourth bending mode 2351,83 Hz

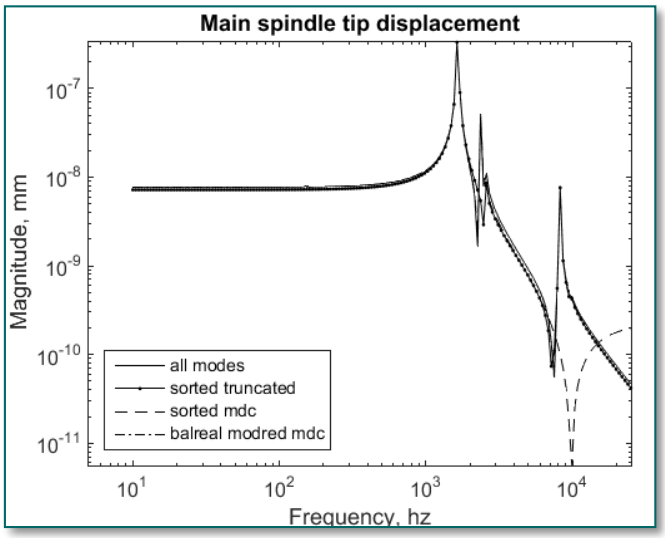

Figure 9. FRF for full model and four modes included, *balreal modred mdc* option used

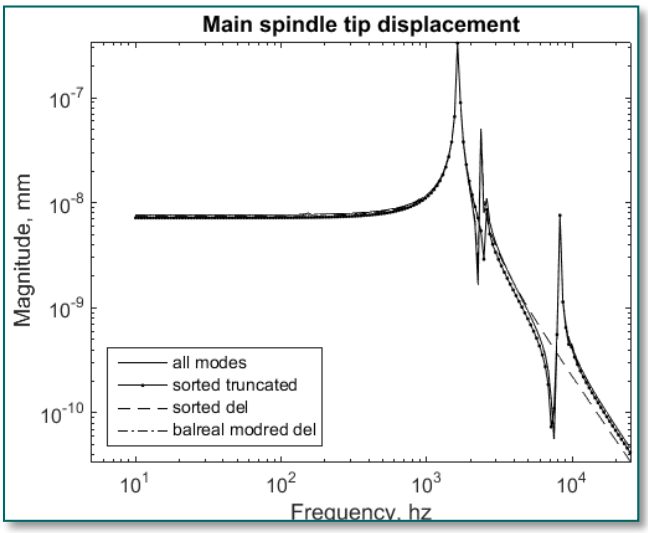

Figure 10. FRF for full model and four modes included, *balreal modred del* option used

Figures 9 and 10 show direct FRF where full model and first four modes were included, with different reductions technique used. Frequency response plot in figure 9 shows:

- Full model (all oscillatory modes)
- Sorted truncated, where dc gain was used for mode ranking, after that least significant modes were deleted
- Sorted mdc where dc gain was used for mode ranking and MATLAB function modred with mdc option to reduce
- Balreal modred mdc, where MATLAB function modred was used with mdc option to eliminate states with the lowest joint controllability /observability,

while frequency response plots in figure 10 shows:

- Full model (all oscillatory modes)
- Sorted truncated, where dc gain was used for mode ranking, after that least significant modes were deleted
- Sorted del, where dc gain was used for mode ranking and MATLAB function modred with del option to reduce
- Balreal modred del, where MATLAB function modred was used with del option to eliminate states with the lowest joint controllability/observability.

It can be noticed that in the high frequency portion, magnitude is rising when *modred* function *mdc* option is used which is not a case with *del* option. But, when modes are sorted using balanced system controllability and observability gramians there is no rising magnitude regardless which option was used. Comparison of the impulse responses in time domain is shown in figure 11.

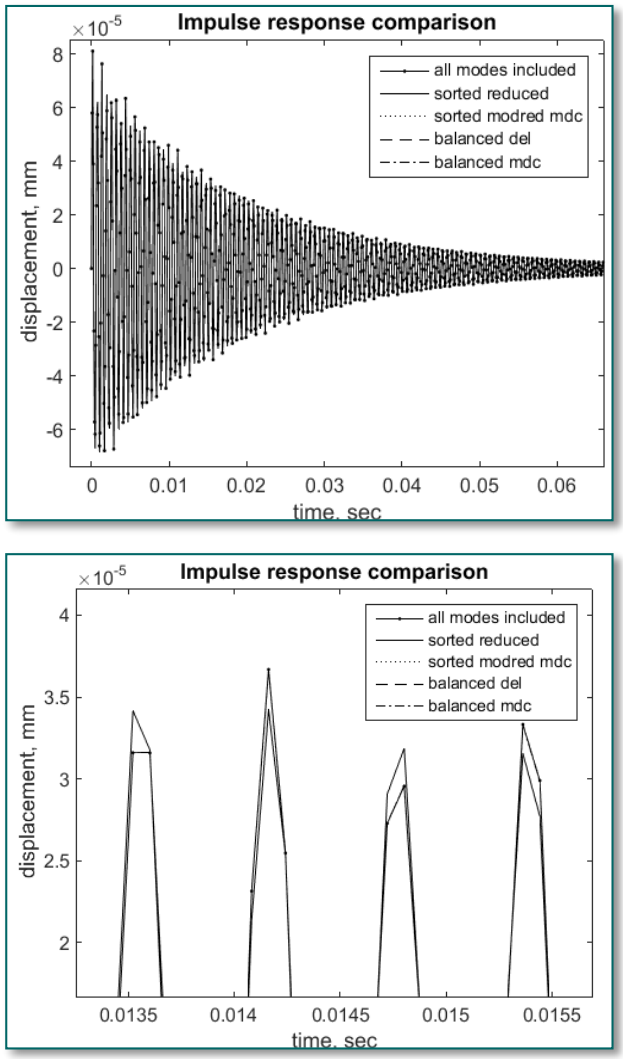

Figure 11. Impulse response comparison, full model and four modes included

Impulse response contains full model and four modes included with different reduction options used. It can be seen that there are no significant differences in the time domain response.

CONCLUSIONS

This paper shows, on the main spindle example, how the model can be transformed from finite elements into state space representation i.e. how to take the results of FEM and reduce the model size extracting lower order state space model in MATLAB (model reduction). Therefore, the goal is not only to obtain reliable dynamic model, since such a model is FEM model.

In the sense of the written, working on the subject above resulted in the following:

- Convert a large finite element model ("large model" assumes model with thousands of hundreds of DOF) to a smaller MATLAB model which still provides correct response for the forcing input, i.e. still maintaining the input / output relationship.
- Modal reduction was made by using balanced reduction technique.
- A reduced solution provides very reliable dynamic of the model with a significant reduction in number of states. Reduced mode can be further inserted into a more complex control system model and used to find system dynamics.

Note

This paper is based on the paper presented at The Vth International Conference Industrial Engineering and Environmental Protection 2015 – IIZS 2015, University of Novi Sad, Technical Faculty „Mihajlo Pupin", Zrenjanin, SERBIA, October 15-16th, 2015, referred here as[7].

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THE GEOMETRIC ANALYZES OF SIZED BEARING IN EXPLOITATION

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Abstract: The main goal of the research presented in this paper is an analysis of the ball bearings 6206 piston compressors. Ball bearings, that transmit the load are very critical for the safe and efficient operation of rotating machines. In this paper presents analysis of through testing of wear of ball bearing of elements, wear the inner track, the outer tracks and balls, and the final goal was to present the resulting tribological processes. Purpose of monitoring the the state of wear balls was used the micrometer. Other place of testing performed of implemented measures were visual control.
Keywords: reliability, ball bearing clearance, wear, temperature

INTRODUCTION

During exploitation technical systems leads to irreversible changes in the system caused by various processes: friction, wear, corrosion, deformation, effects of the environment and the like. [1]. Deviation of system characteristics of the projected value is considered a cancellation of the system, the most common case of such cancellation elements are balls on of rolling bearings, the inner tracks and outer tracks. Cancellation system is manifested by the appearance of temperature, noise and vibration systems.Gliding of the balls is a function of lubrication, tolerance of balls in the cage, the angular rotation and lateral forces, surface quality, as well as speed and load. Lubrication has a dominant influence on the gliding of the ball. Glide occurs due to the resistance forces on the ball, which was created by the viscous resistance force of lubricant, and is greater than the slip moment to point contacts. This attempt was aimed at easier access to obtain the theoretical model to study the effect of defect size, load and speed of the bearing vibration and predict spectral components. To preserve the production process and avoid minimum failures in the process, it is necessary to maintain the equipment and critical machine parts. The development of rotating machines with ball bearings goes very quickly and improvements are focused on increasing the reliability of machines and their versatility. Improved reliability of ball bearings is to operate in special environments such as corrosive environments, high temperatures, high speed, and high vacuum environments, have become very important [2].
It can be said that the performance bearings affect key functions, such as durability, noise and vibration behavior of the compressor. In a study conducted by Kim and Han [3] an analytical model the behavior of dynamic coupling of the piston and crankshaft was developed and compared to the model of terminal bearing. Same study presents a numerical procedure which combines the Newton-Raphson method and pattern of repeated excessive burden.
Having in mind the above mentioned, this study aims to investigate the tribological behavior of ball bearing 6206 with emphasis on the occurrence of temperature, wear, deformation in terms of lubrication and provide new information and knowledge. The influence of load, movement speed and the friction and gliding, on the tribological behavior of bearing wear intensity was analyzed with the exploitation of research.

MATERIAL AND METHODS

Changes of geometric sizes of the bearing in exploitation

The paper presents justification of monitoring characteristics of piston compressors, which are used to suck gas from a tank, pipe or the environment and suppress them (with the more significant increase of of pressure) to the second tank, piping, or generally to some of consumers [4].

Piston compressors applies clips that run directly via the piston mechanism pretending rotary motion of the rotor in the oscillatory linear motion [5]. The exploitation of the system was limited to a visual assessment of behavior of the system as well dynamic measurements of geometrical the process parameters [6].

In order to study bearings in a piston compressor included the effects of a particular damage to ball bearings SKF 6206, are shown in individual damage on the inner ring, outer ring, and balls that occurred during exploitation, established after the dismantling of bearings on the desk (Figure 1). Important geometric characteristics of ball (roll) bearing are diameters of rolling slopes, and the mid diameter of the bearing. They can be expressed by the geometric characteristics of the rolling tracks. On the geometry of the bearing, influencing factors are, material quality of the balls and tracks, surface quality balls and tracks, the way of maintenance, lubricant type, the conditions under which bearing exploits, etc..

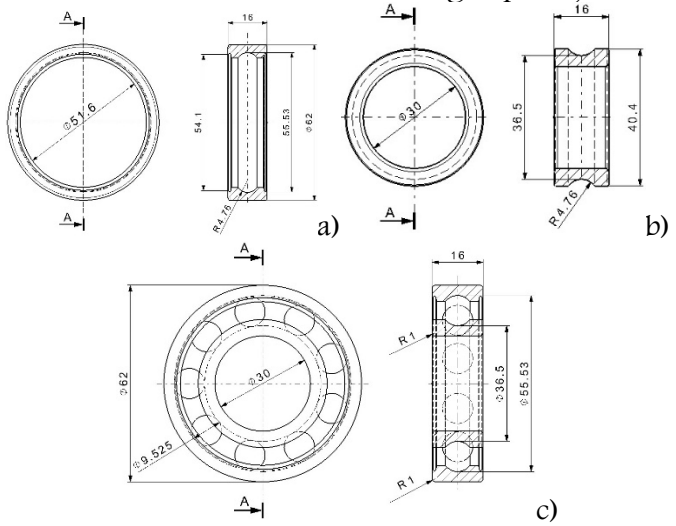

Figure 1. Geometrical size rolling ball bearing SKF 6206
a) The outer bearing ring, b) The inner bearing ring,
c) Damage to the outer and inner ring

The outer ring of the physical new beds 55.53 is measured at the beginning with a tolerance of ± 0.010μm, while the ring physical defective bearing extended to 55.56 mm. The inner ring of the new bearing is 36.5 ± 0.010μm, measured at the beginning, before exploitation 36.49 mm after exploitation-defective to 36.46 mm. From the above analysis it can be seen that the inner ring is worn out (Table 1).

Also track ball represents a measure of geometrical conformity of runs and balls in a plane passing through the (time) axis bearing (also called the center line or rotational axis), which line passes through the center bearing normal to the plane and transverse to the track.

In Figure 2 are presented the dimensions of single row of ball bearing, diametrical diameter balls, and tolerance obtained after of measurements [7].

Table 1. Shows the values of the new geometry of the bearing, as the deformed bearing

Geometry the bearing according to SKF	Values after defect	
Bearing outside diameter -D	62 mm	61.995
Bearing bore diameter -d	30 mm	29.998
Bearing width- B	16 mm	16.01
Ball diameter - d_k	9.525 mm	9.441
Contact angle - β	0°	0.8′
Number of balls - n	9	9
Weight balls - G	3.55 gr	3.48 gr
The inner diameter of the outer ring track - $D_{a\,max}$	55.53 mm	55.56
The diameter of the bearing outer track opening - $d_{a\,min}$	36.5 mm	36.46
Mass-bearing weight - G_1	200 gr	195gr
Basic static load rating, radial - C_0	11.2kN = 11200 N	
Basic dynamic load rating, radial - C	20.3 kN= 20300 N	
Limiting speed - n_G	15000 r/min	
Reference speed - n_B	24000 r/min	
The radius of curvature r_{min} = $r_{a\,max}$	1 mm	
Fatigue limit load, radial - C_{ur}	0.475kN= 475 N	
Modulus of elasticity bearing of materials	E=2.06.10 ^{11} Pa	
Poisson coefficient	μ=0.3	

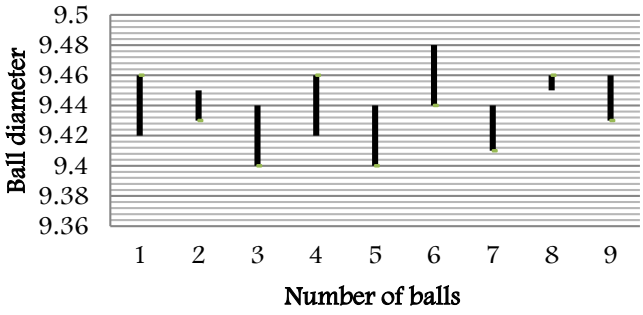

Figure 2. Changes in size balls after dismantling the bearing

Radial ball bearings have some effect from axial effect because they are designed to have a diameter tolerance. Also figure 2 shows that the radial bearing with the touch due to axial movement of the inner and outer rings is applied when it is not measurable force. Measurement of the balls was performed after dismantling bearings on test bench of examination of bearings, using a micrometer with an accuracy of 0.025 mm. By measuring the balls we determined deviation dimensions of balls compared to the standard value of 9.525 mm, which can be seen in Figure 2 „Diagram of ball dimensions".

RESULTS AND DISCUSSION

Types of damage in ball bearing is certainly the contact between the rolling elements and the ring or rings in the unloaded condition in point or line [8,

9]. Under load leads to elastic deformation at the contact point, so that the load transfer is realized by the small contact surfaces. Therefore, in spite of very high strength and hardness of the material parts of the bearing, as well as careful preparation, installation and maintenance, after a period of time leads to fatigue and damage to the contact surfaces [10]. The damage is the result of local contact overload and manifested first appearance of micro cracks just beneath the surface. In the future work of micro-cracks extending to the surface, which creates small holes and fissures. This damage is called pitting. Damage during work flow rapidly, and then leads to the separation of large metal parts, which is particularly acute in the inner ring of the bearing. The damage caused by unstable operation of bearing is followed with impacts and increased noise, which eventually leads to the violent rupture of the ring.

Due to variations in shape and dimensions of the bearing parts, in addition to rolling in bearing there and to a lesser extent gliding. It has the effect of abrasive wear of the bearing, in combination with further pitting damages desktop beds. Given that this damage ultimately lead to failure of the bearing, to perform tests in order to determine the operating time to the appearance of fatigue. The test consists in setting up a large number of bearing on the same test tables, and their work under the same conditions relating to the load, frequency of rotation and lubrication.

As the analysis of the results can be seen, the elements tribomechanical system of roller bearings can be caused by different types of wear and damage. On one bearing can occur at the same time several kinds of wear and tear, but, as a rule, one of the resulting species is dominant and it will fundamentally determine the future direction of development of tribological processes and finally the life of the bearing.

Which forms of wear occur, and which will be the dominant form, depends on many factors. Fatigue wear (pitting) is one of the most common and also the most typical kind of bearing wear. It is characterized by the appearance of wells in the initial stage and the destruction of the contact surfaces in the final stage of the process. Fatigue wear are exposed to all the elements of bearing: rolling elements, racks, the backrests of the inner ring.

Depending on a number of influencing factors, pitting may howl in different places on elements of tribomechanical bearing systems. Figure 3 shows the appearance of pitting on the inside of the track rolling bearings. It is obvious that pitting was not affecting the whole rolling surface but only a part, however, wear analysis shows that it is a devastating pitting.

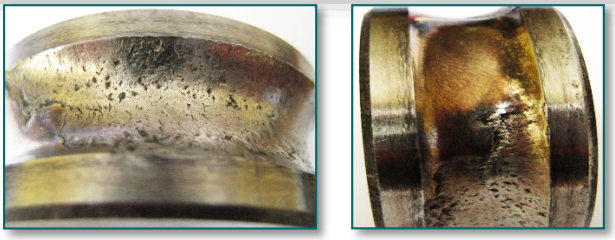

Figure 3. Fatigue wear (pitting) on the outer surface of the bearing inner track

Fatigue abrasion damage from fatigue cracks that occur below the surface are very rare. Damage caused by fatigue, occur more often on the surface of the components inside the rolling contact, as a result of inadequate lubrication or contamination. The causes of damage can not be recognized for a long time, until the damage advances. Fatigue can be recognized as spot damage in the material inside the rolling track ball bearing. Fatigue wear occurs on the outer rolling track and on the ball (Figure 4).

Fretting corrosion is the type of wear that occurs at low oscillatory displacements of one surface over another in terms of action corrosive environments. The conditions in which they arise are: small amplitudes of composite elements (within a few tens of micrometers) and in connection with the aggravated taking of wear debris from the zone of contact; low speed, relative displacement of coupled elements (a few millimeters per second); the presence of oxidation external environment (eg, oxygen, air) chemical reactions that causes oxidization of the contact surface with the consequences of their destruction.

Figure 4. Pitting on the outside rolling track ball bearing and the ball

Figure 5. Fretting corrosion on the outside rolling track of ball bearing [11]

Wear at fretting-corrosion differs from fretting wear - wear that occurs most often in small oscillatory relative movements. The main difference is that fretting occurs in the absence of oxidizing environments in the development of chemical reactions without material contact surfaces and

wear debris with oxygen. In addition to the fatigue wear on certain parts beds it is evident fretting corrosion. In Figure 5, the case of fretting corrosion.
Tracking of features mentioned mechanical systems amounted to a visual assessment of the behavior of the system as well as the measurement of vibration and temperature of the system in operation with the use of the projected dynamic process parameters [12, 13].
The outer ring of the physical new bearing 55.53 is measured at the beginning with a tolerance of ± 0.010μm, while the ring physical defective bearing extended to 55.56 mm. The inner ring of the new bearing is 36.5 ± 0.010μm, measured at the beginning, before mining 36.49 mm after exploitation-defective to 36.46 mm. So the inner ring is worn out.
Results of diagnostic research during the test of bearings on a laboratory table have pointed to the very complex conditions that have resulted in a variety of mid-functioning mechanical systems. The reasons why the bearing life of bearings in exploiting condition results differs from test results obtained in laboratory conditions and why the level of exploitation bearings assemblies of mechanical systems is more complex, should be sought in the following assertions: insufficient level of technical maintenance (primarily in the lubrication performance which has to be carried out in accordance with the manufacturer's bearings, which are all the same and performed periodically).

CONCLUSION

Diagnostics of the ball bearings of piston compressors for the given conditions of use and indicated primarily on all the shortcomings of the said assembly of mechanical systems in the process of exploitation, on basis of which the proposed measures are the possibilities for further exploitation (through a lifetime of ball bearings) in order to increase the reliability of piston compressors. The damage can occur in rolling elements of bearings due to defects in material, crack on the contact surfaces due to material fatigue, or defects or cracks on the rolling elements. The changes in the geometry of the bearing cause impulses when there is contact between the damaged area.

Note

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STRESS STATE OF PHARMACEUTICAL POWDER DURING UNIAXIAL COMPRESSION

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Abstract: Nowadays tabletting of powders in the pharmaceutical industry is, among other agglomeration processes, most widely used method of finalizing solid products. From a procedural point of view, stress fields of the tablet have the dominant importance because they directly determine its quality. This paper focuses on the experimental detection of the primary stresses during the compression of the pharmaceutical powdered substance AVICELL. Measurements will be performed on the KISTLER programmable electromechanical press in a die with a circular cross-section. Evaluation of the obtained data of the stress fields will be carried out by means of Mohr's circle.
Keywords: uniaxial compression, pharmaceutical powder, stress state, Mohr´s circle

INTRODUCTION

Tablet production by means of uniaxial compression is the dominant processing technology of powder materials. Among the areas of application of the technology belong powder metallurgy, filters, magnets and electrical contacts. Uniaxial compression plays an irreplaceable role in the pharmaceutical industry. The advantages of this technology are cost-efficiency, high productivity and low waste production.

THEORY

Analysis of the mechanical properties of the powder during compressing

The analysis of mechanical properties is focused on monitoring force action inducing change in the bulk density of the powder. These parameters are most often expressed as stresses and strains and their relation to the particular materials is a frequent subject of investigation. Based on the mechanics of solids, the principles of this investigation are implemented into the theory of compaction of powder materials.

Distribution of stresses during compression

During compression, the piston acts on the powder by compression force and creates a stress state in the powder. Due to fact that the powder is not a continuum, axial stress is not constant, but decreases with increasing distance from the pressing piston. Part of the axial load is converted to a radial which acts on the die wall, creating friction between the wall and the powder. The situation is shown in Figure 1, when the powder is compressed in a cylindrical die diameter D. Consider a cylindrical tablet of diameter D and height H and an elemental slice dz situated at distance z from the bottom of the tablet. Neglecting the weight of the powder, the force balance equation is:

$$\frac{\pi D^2}{4} d\sigma_z = \tau_z \pi D dz \quad (1)$$

where $d\sigma_z$ is the elementary increase of axial stress, τ_z is shear stress, dz is elementary increase of axial position. The radial stress at the given height z can be written as:

$$\sigma_r = K\sigma_z \quad (2)$$

where σ_r is radial stress at axial position z, σ_z is axial stress at axial position z and K is radial-to-axial stress ratio. The shear stress due to the friction acting on the elemental slice can be expressed according to Coulomb's law of friction:

$$\tau_z = \mu\sigma_r \quad (3)$$

where μ is the friction coefficient. Combining equations (2) and (3), the equilibrium equation becomes:

$$\frac{d\sigma_z}{\sigma_z} = \frac{4K\mu}{D} dz \quad (4)$$

If it is assumed that the product Kμ is independent of position z, equation (4) can be integrated using the appropriate boundary conditions:

$$\ln\frac{\sigma_z}{\sigma_B} = \frac{4K\mu}{D}z \quad (5)$$

or

$$\ln\frac{\sigma_T}{\sigma_B} = \frac{4K\mu}{D}H \quad (6)$$

Equations (5) and (6) imply the exponential distribution of the axial stress at a given height in the tablet:

$$\sigma_z = \sigma_B \exp\left(\frac{4K\mu}{D}z\right) \quad (7)$$

or

$$\sigma_z = \sigma_T^{\frac{z}{H}}\sigma_B^{\left(1-\frac{z}{H}\right)} \quad (8)$$

If the values of the stresses acting on the top and bottom piston are known, it is possible to determine the value of the axial stress at each point of the tablet on the basis of equation (8). If the radial stress is measured at one position along the tablet height, equation (8) determines the axial stress at the given position. Then it is possible to determine the stress state in the powder using a pair of principal stresses σ_1 and σ_2, where:

$$\sigma_1 = \sigma_z \quad (9)$$

and

$$\sigma_2 = \sigma_r \quad (10)$$

These stresses can be evaluated using Mohr's circle in τ - σ diagram. The diagram expresses the dependence between first and second principal stress and shear stress τ:

$$\tau = \frac{(\sigma_2 - \sigma_1)}{2} \quad (11)$$

The tangent line for each Mohr's circle is called the yield limit and expresses the flowabillity of a particulate material during compaction.

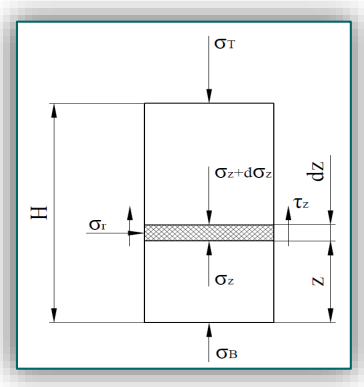

Figure 1: Stresses applied to a powder slice

EXPERIMENTAL STATION

Measurement was carried out on the electromechanical press KISTLER (Figure 2). The press contains a force sensor and a piston rod position sensor. The maximum compression force is 60 kN and the stroke of the piston rod is 200 mm. Pressure control and evaluation of the measured data is carried out by means of the NC module DMF-P A310, thus enabling evaluation of the force in dependence on position.

Figure 2: Electromechanical press KISTLER

EXPERIMENTAL MATERIAL

The material used in measurements was Avicel PH 102. This material is one of the oldest types of microcellulose and one of the most widely used pharmaceutical excipients. Cellulose is used in the powder, and MMC in the microcrystalline form. Its properties make it ideal for the formulation of pharmaceutical forms with a controlled release of the drug, ensuring a prolonged, delayed or pulsed effect of the drug substance in a living organism.

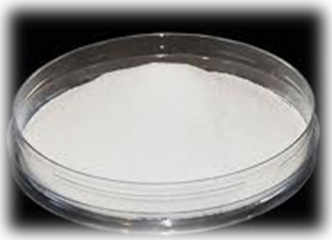

Figure 3: Avicel PH 102

Table 2: Mechanical and physical properties of Avicel

Particle size [μm]	180
Bulk density [kg/m³]	300
Density of solid particles [kg/m³]	1590
Angle of internal friction [°]	34,5
Young's modulus [MPa]	1209
Poisson's ratio [1]	0,148

EXPERIMENTAL MEASUREMENT

The measurement carried out on the equipment allows recording the axial force on the bottom piston and the radial force on the die wall. The bottom piston was static and compression was carried out through the movement of the top piston, which was pushed by an electromechanical press. The press recorded the compression force and piston position. The range of the compression forces was from 10 kN to 50 kN, and the compression speed was 1 mm/s. Force values were converted to stresses with respect to the piston cross-section. The current relative

density was calculated on the basis of the measured values of absolute heights of the tablet and known powder mass. The relative density of the tablet is defined as the ratio between bulk density of powder ρ_B and density of particles ρ_T:

$$RD = \frac{\rho_B}{\rho_T} \quad (12)$$

where the bulk density of the powder is defined by dividing the mass of the powder m and its volume V_B:

$$\rho_B = \frac{m}{V_B} \quad (13)$$

THE VALUES OF STRESSES DURING UNIAXIAL COMPRESSION OF THE POWDER

The measured values express the axial stresses acting on the top and bottom pistons, the radial stress acting on the die wall and the relative density of the tablets during compression. With respect to equation (8), the value of the axial stress at the point at which the radial stress is measured is calculated. In Figure 4 the evolution of the axial and radial stresses during compaction is shown as a function of the relative density. Pairs of the principal stresses at the radial sensor position are shown in τ - σ diagram as Mohr's circles and appropriate yield limit.

Table 2: Table of measured and calculated values of stresses and relative densities

Relative density RD [1]	Axial stress (top) σ_T [MPa]	Axial stress (bottom) σ_B [MPa]	Axial stress (sensor) σ_z [MPa]	Radial stress (sensor) σ_r [MPa]
0,270	0,000	0,000	0,000	0,000
0,607	31,545	23,344	25,401	1,165
0,713	57,361	43,182	47,415	1,474
0,774	80,726	58,808	65,863	1,993
0,835	115,900	76,862	90,047	4,970
0,910	159,096	102,644	123,398	11,105

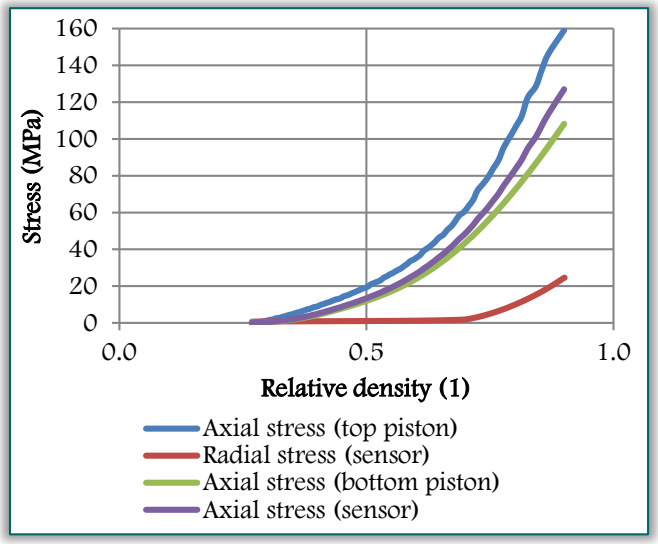

Figure 4: Evolution of the axial and radial stresses during compaction

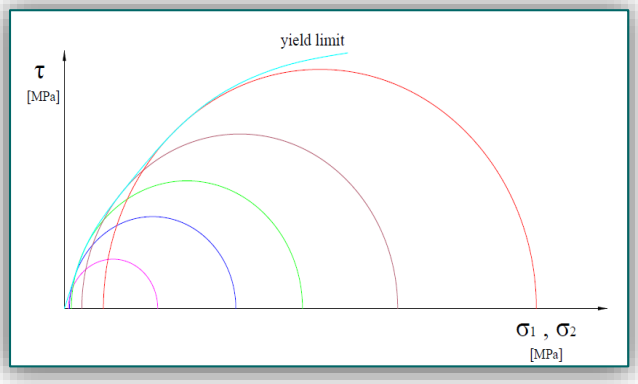

Figure 5: Mohr's circles and yield limit

CONCLUSION

The paper is focused on testing a new measuring procedure for obtaining the data needed to assess the mechanical properties of powders during uniaxial compression. The measurement was carried out on a single-action electromechanical press designed to obtain the laboratory data applicable to production equipment. The stress state arising during powder compaction affects the final quality parameters of the tablet. This data is also important for the design of pressing equipment and tools in industry.

Nowadays the pharmaceutical industry often uses computer simulations to describe and to create the possibility of improving the compression process. In order to carry out such a simulation, it is necessary to first input the mechanical properties of the powder into the simulation program. By the procedure described in this paper can be obtained the development of the axial and radial stresses during compression of the powder, which is also required as input data in the computer simulations.

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Note

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NUMERICAL MODELING THE BONDING MECHANISM OF HIGH VELOCITY OXYGEN FUEL (HVOF) SPRAYED PARTICLES

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Abstract: Processing numerical model high velocity oxygen fuel (HVOF) coating. Thermal spraying technology, principle and basic characteristics of each method of application of coatings. Literature search, mapping the current trends in the numerical simulation process. Choosing approach numerical simulation, processing and evaluation of the results of the pilot study. There is described a method of modeling by the finite element method the residual stresses induced during thermal deposition of coatings. The simulation was performed in two stages. The first dynamic stage simulated the impacts of the individual particles of the coating material onto the substrate, and the next static stage included a non-linear thermo-mechanical analysis intended for simulating the process of layer-by-layer deposition of the coating, with a specified thickness, and then cooling the entire system to the ambient temperature. During high velocity oxy-fuel (HVOF) thermal spraying, most powder particles remain in solid state prior to the formation of coating. A finite element (FE) model is developed to study the impact of thermally sprayed solid particles on substrates and to establish the critical particle impact parameters needed for adequate bonding. The particles are given the properties of widely used WC-Co powder for HVOF thermally sprayed coatings. The numerical results indicate that in HVOF process the kinetic energy of the particle prior to impact plays the most dominant role on particle stress localization and melting of the particle/substrate interfacial region. Both the shear-instability theory and an energy-based method are used to establish the critical impact parameters for HVOF sprayed particles, and it is found that only WC-Co particles smaller than 40 μm have sufficient kinetic and thermal energy for successful bonding.
Keywords: HVOF, finite elements method, residual stress, technology

INTRODUCTION

Thermal spraying is a promising technology, which is formed by coating the surface of the parts used in various industries. Using this flexible, high quality and economical technology can be optimally adapted to the surface properties of components with different requirements under operational conditions. The beneficial effect of the surface layers contributes significantly to extend the life, increase the reliability and safety as well as the economic benefit of the operational or production process [1].
The aim of the solution is to map the current state of the numerical simulation of thermal spraying process [2]. The solution has the character of the initial study, the main objectives of the resolution were as follows:

- Overview of the most commonly used methods of thermal spraying technology and selection methods, which currently appears to be the most promising.
- The literature search, processing of current trends and approaches in numerical simulation of surface coating layers,
- The choice of the appropriate approach and the development of numerical simulation example - a pilot study.

PRINCIPLE OF TECHNOLOGY

Thermal spraying technology can be generally characterized as a process for coating thicknesses of the order of 0.01 to 0.1 mm by melting the additive material, the particles are accelerated and applied on a properly prepared surface of the base material. Following each of the base material, a partial or complete deformation of the individual incident particles, which are rapidly cooled to form a coating of lamellar structure.
In view of the thin deposited layer does not occur during the process of coating technology, thermal spraying or heat of the base material at 100 ° C to 150 ° C. It follows that, during application of the coating material, there is no deformation of the

coated member and by or in degradation of the structure due to thermal effect on the base material [3].

The technology of thermally sprayed coatings can be formed on all common structural materials. When applying the material technology Thermal spraying is not essential chemical composition of the base material and the component or its condition. The coatings cannot be created only on the nitrided surface or already treated surfaces such chrome plating [4].

METHODS OF COATING

The most widely used method of coating application technology of thermal spraying are as follows:

1. thermal spraying flame,
2. The electric arc thermal spraying,
3. The plasma thermal spraying,
4. The thermal spraying high-speed continuous application [5].

NUMERICAL SIMULATION

During the coating process generated residual stresses, which determine the order finite elements. The simulation will be performed in two steps.

- First (dynamic) phase: simulation of the impact of individual particles of coating material on the substrate,
- The second (static) phase: includes non-linear thermo - mechanical analysis.

The process of coating so layer on the layer of the system is cooled to ambient temperature. In the calculations, we assume that the sample will have a cylindrical shape and composed of the substrate and the coating (on three different thicknesses). The accuracy of the numerical model is appropriate to experimentally verify the actual deformation of the coating [6].

In numerical simulations below were used following simplifying assumptions:

- The particles hit the substrate, which has resulted in a transformation in a relatively short period of time. Their kinetic energy is converted into thermal energy. In fact, the particles are flattened and form a so-called lamellae, which connect to the thin plate (bedrock). Other layers are sequentially deposited on it in the next cycle.
- During the cycle all the particles incident on the substrate have the same initial temperature. The layers formed from the particles in one "passage" parallel to each other.
- Coating particles are in a softened state. Within the conflict zone, the time required for heating and cooling of the particles is less than the cycle time by at least two orders of magnitude. The problem of simulating fluid dynamics is appropriate to simplify the thermo-mechanical problem.
- Influence of phase transformations on the size of the residual stress is neglected.
- The substrate and subsequent layers are in an ideal contact.

MATERIAL MODEL

For a modelling quick storylines involving a large plastic deformations are used in most cases material model Johnson-Cook, describing stress as the product of stress, strain rate and temperature effects [7].

EFFECT OF INITIAL TEMPERATURE BALLS THE SIZE OF THE RESIDUAL STRESSES

As we mentioned above, the initial temperature of the balls have changed the interface T = 1540-1640 [K] a step dT = 10 [K]. During the simulation we consider a constant speed v_0 = 450 [m / s] balls on impact on the substrate. We did so because, in order to better traceability of the change in stress at a given temperature balls.

Table 1: The resulting values obtained by numerical simulation

Temperature WC-Co [K]	Residual stress von Mises [MPa]	Peeding stress [MPa]
1540	259	210
1550	290	220
1560	260	200
1570	270	200
1580	284	190
1590	228	175
1600	242	165
1610	200	170
1620	216	150
1630	193	200
1640	205	200

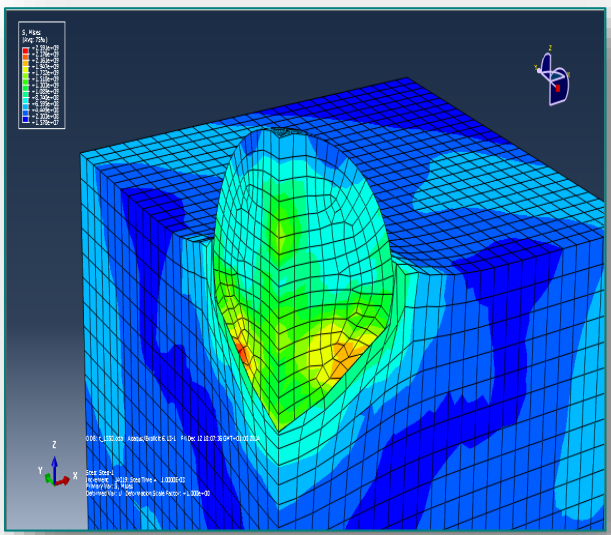

Figure 1: Residual stress at 1540 [K] by von Mises at an impact speed of 450 [m / s]

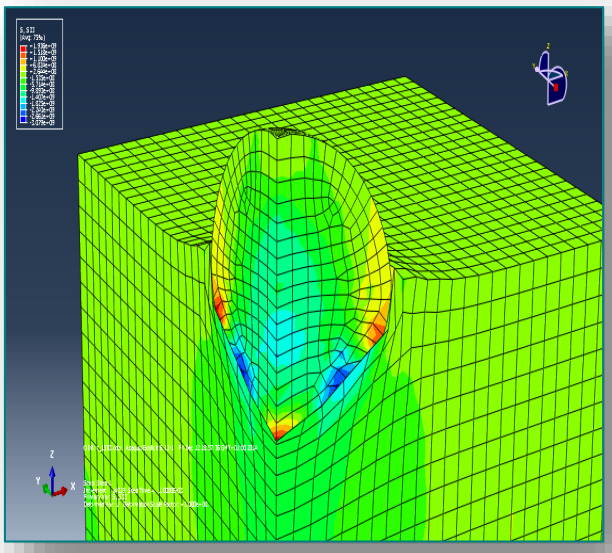

Figure 2: Peening stress at 1540 [K] at an impact speed of 450 [m / s]

The results of the simulation can be seen in the previous figures. The biggest plastic deformation originated in the place where the ball a maximum radius has changed with the connection to the substrate. In these places happened a max. stress.

CONCLUSION

To create a mathematical model of HVOF thermal spraying method, we used a quarter model of the incident particles to the base material St. program working with ABAQUS finite element, which we further evaluated. However, in this model were used for simplification of the model, which may distort the results, eg.:

- simulate only one particle,
- adiabatic process between the incident particle and the matrix,
- material properties,
- the impact of discretization model for the calculation.

Therefore, we can say that from constructing a mathematical model becomes rather complex matter in which it would be necessary to engage in a number of experts in various technical fields. Since it is necessary to determine the behavior of the material due to changes in the material constants during the process of thermal spraying. We argue that this model is only illustrative and for more reliable results it is better to do a technological test on a sample. Thanks to this knowledge would recommend experimentally determine these constants with the help of metallurgy, making the task has become trivial with the multidisciplinary. In view of this, it is necessary to do a comparison of the correlation mathematical model with measurements such as strain gauges or with X-ray or neutron diffraction.

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FATIGUE LIFE ESTIMATION OF AIRCRAFT STRUCTURAL COMPONENTS WITH SURFACE CRACKS UNDER LOAD SPECTRUM

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Abstract: Subject of this work is focused to developing computation procedure for residual fatigue life estimation of cracked structural componentsunder load spectrum. Finite element method is used for determination of the stress intensity factors (SIF`s) of structural element with surface cracks. These discrete values of the stress intensity factors of cracked structural componentsare used for derivation of analytic function for SIF that is necessary in crack growth analyses. To demonstrate efficient computation procedure in residual fatigue life estimation of damaged structural elements here numerical examples are included. For residual life estimation of cracked structural elements here Forman and Mettumethod is used. In this approach a low cyclic fatigue material properties are used. Computation procedure to strength analyze with respects to fracture mechanic and residual life estimations is applied to aircraft structural elements with surface cracks under load spectrum. Computation results are compared with correspond analytic experimental results.
Keywords: Fatigue, stress intensity factors, surface cracks, singular finite elements, fatigue life prediction

INTRODUCTION

Throughout their service life, aircraft are subjected to the combination of environmental attack and varying loads. The structural integrity of the vehicle can be impaired by surface degradation due to corrosive action or when crack damage is developed or aggravated by the environment. The requirement for lightweight aerospace structures leads to high design stresses [1]. High stresses can produce cracks early in the fatigue life of these structural components.Surface and corner cracks are encountered in engineering structures at locations where high stresses.Such cracks are present during a large percentage of the useful life of these components. Accurate stress intensity factors for such cracks are necessary for reliable prediction of fatigue crack growth rates or fracture. Three-dimensional (3-D) stress analysis of crack configurations have received considerable attention in the literature in the last three decades [2-4]. Various methods have been used to obtain stress-intensity factors for surface and corner cracks in plates: the alternating method [1,2], the finite-element method (FEM) with singularity elements [6], the finite element method with displacement hybrid elements and finite element alternating method. The slice synthesis method has also proved to be an accurate an inexpensive method to compute 3D stress intensity factor solutions [4-6]. The most accepted stress intensity factor solutions for surface cracks in finite thickness plates are obtained using FEM [3,4]; other methods are usually compared with FEM solutions to confirm their accuracy and convergence.

The methodology used here involves use the slice synthesis method that utilizes weight function technique.

STRESS INTENSITY FACTORS OF SEMI-ELIPTIC SURFACE CRACK

The slice synthesis approach used herein to computation of surface flaw stress intensities. The three dimensional surface flaw is idealized as a system of slices in the x-y plane, each containing a center crack whose length is determined by locations thru the thickness at which the slice was taken, Figure 2. Each slice is considered to react independently to the applied stress, σ, but are coupled through the introduction of pressure distribution, p^*, acting on the faces of the cracks. The pressure p^*, is determined by second system of slices in the z-y plane. Each of the z-

y slices contains an edge crack of depth a(x) over which the pressure, p^*, acts in opposition to that applied to the center crack slices [5]. Thus there are two slice systems: center cracks, and edge cracks, Figure 2.

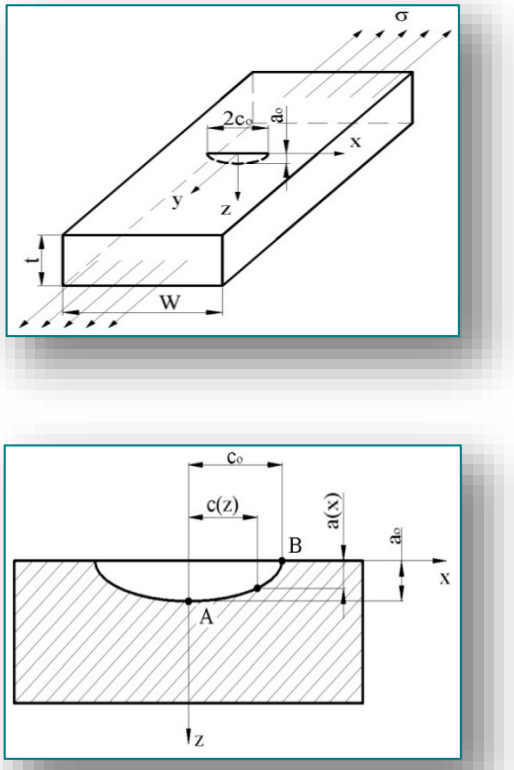

Figure 1. Surface crack idealization

The weight function in this case was formulated in the same manner as that of Fujimoto[5]. Using the crack face pressure distributions, stress intensity factors at A and B can be determined as

$$K_A = \sigma\sqrt{\pi a}\sum_{i=0}^{3}\sum_{j=0}^{3} A_{ij}\left(\frac{c}{a}\right)^{j/2}\left(\frac{a}{t}\right)^{i} \quad (1)$$

$$K_B = \sigma\sqrt{\pi a}\sum_{i=0}^{3}\sum_{j=0}^{3} B_{ij}\left(\frac{c}{a}\right)^{j/2}\left(\frac{a}{t}\right)^{i} \quad (2)$$

where: K_A is the stress intensity at depth; K_B is the stress intensity at surface, σ -applied stress,a - crack depth, c - half surface length, t -plate thicknes; A_{ij} and B_{ij} are the coefficients (represent the displacements over the entire crack face, the continuity expression is evaluated at 13 points).

To validate the analytic computation procedure, finite element method is used. Three-dimensional finite elements were used to model a plate containing a semi-elliptic surface crack. The finite element analyses were made using MSC/NASTRAN [8].

NUMERICAL EXAMPLES

Finite element analysis for surface cracks

To check validity of the above method for SIF evaluation by the semi-analytic slice synthesis approach, comparison between the calculated SIF results of surface cracks in plate and the solution obtained by finite elements are compared. For this purpose plate with semi-elliptic surface crack under tension σ=83.3 [N/mm²] is analyzed. Geometry properties of this plate are: w=60 mm, t=10 mm, c=10 mm, a=10 mm, Figure 2. Three-dimensional singular finite elements were used to model of a plate containing a semi-elliptic surface cracks under tensile load.

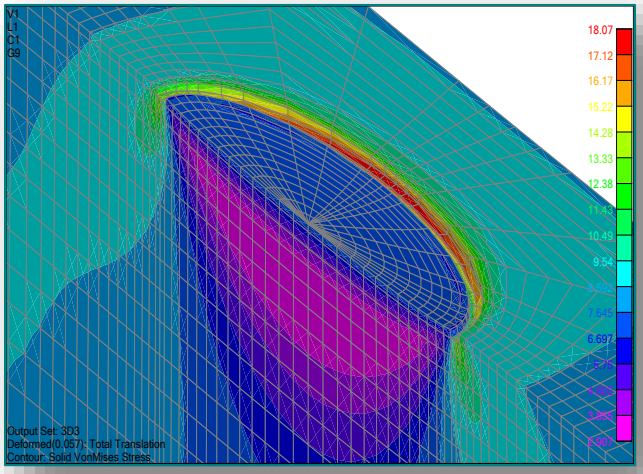

Figure 2. Detail finite element model of semi-elliptic crack

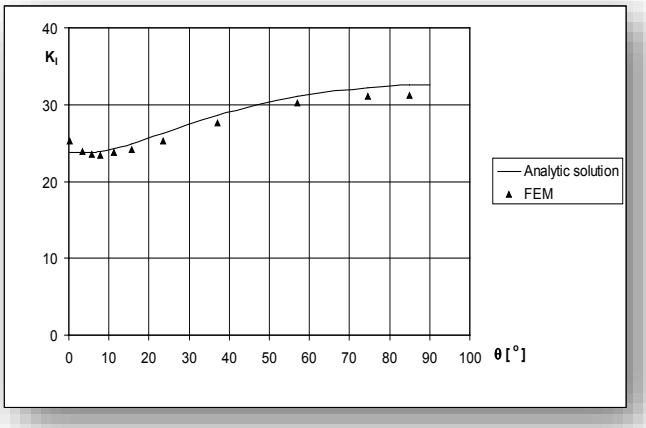

Figure 3. Comparisons between analytic and FE results for SIF calculations

Results presented in Figure 3 give good agreement between presented computation analytic and finite element results for the stress intensity factors. The difference was found to be less than 6%.

Fatigue crack growth

The stress-intensity factor equations (1) and (2) for surface cracks are used herein to predict fatigue-

crack-growth patterns under load spectra, Figure 2. For this purpose Forman and Mettu equation [7] is used.

$$\frac{da}{dN} = C\left[\left(\frac{1-f}{1-R}\right)\Delta K\right]^{n} \frac{\left(1-\frac{\Delta K_{th}}{\Delta K}\right)^{p}}{\left(1-\frac{K_{max}}{K_c}\right)^{q}} \qquad (3)$$

where N is the number of applied fatigue cycles, a is the crack length, R is the stress ratio, ΔK is the stress intensity range, C, n, p and q are empirically derived constants, f is the crack opening function, ΔK_{th} is the threshold stress intensity factor and K_c is the fracture toughness.

Numerical validation

Crack growth analysis for the next geometric and material properties of structural component with semi-elliptic surface crack, Figure 2, are illustrated in Figure 4.

- depth of surface crack, a = .100E-02 [m],half-length of surface crack c = .100E-02 [m]
- plate thickness, t = .200E-01 [m], width of cracked plate w = .200E-01 [m]
- crack growth coef., C = .300E-10, exponent n= .250E+01
- fracture toughness, K_{IC} = .500E+02

Table 1. Load spectra

N_i	S_{min} [MPa]	S_{max} [MPa]
6000	0	500
6000	100	400

Figure 4 shows results of crack growth analysis under load spectra. Curves denoted as Anal-A and Anal-B represent crack growths of points A and B (Figure 2) for semi-elliptic surface cracked structural element under tension load using analytic expressions for (1) and (2) stress intensity factor calculations with one side and Forman and Mettu equation (3).

Curve denoted with MKE-B represents crack growth at point B where SIF determined using approximate finite element results. Procedure for approximations of SIF from finite elements are presented in paper [4]. This procedure is based on determination of SIF using special 3-D finite elements for several successive crack length and defining analytic expression for SIF in polynomial form from these values. This method based on using 3-D special singular quarter-point singular finite elements for determination of SIF is very reliable method. If we compare crack growth in point B using analytic approach derived in previous considerations with finite element results (FEM-B) good agreement is evident.Good agreement between analytic computation method based on slice synthesis method with finite element approximations of SIF confirmatequality of presented analytic method in crack growth analyses.

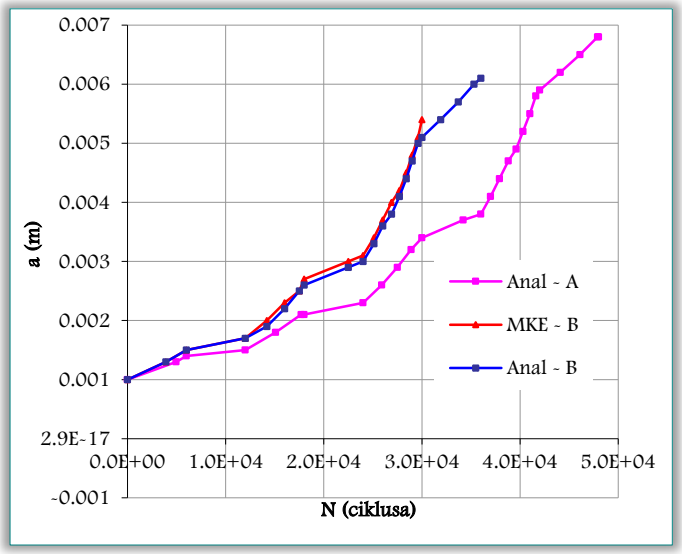

Figure 4. Surface crack growth under load spectra

4. CONCLUSION

Stress intensity factor solutions for semi-elliptical surface cracks were determined using analytic model and validation by comparisons with special singular finite element solutions. The slice synthesis approach is used herein to computation of surface flaw stress intensities. To validate the analytic derived stress intensity factors for semi-elliptic surface cracks, finite element method is used. The analytic results based on slice synthesis method were compared with finite element solutions and the difference was found to be less than 6% for surface points. Analytic model for the stress intensity factors, derived in this work, are used for crack growth analyses and fatigue life predictions.

Acknowledgments:

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Note

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1. Luka PANIĆ, 2. Atif HODŽIĆ, 3. Ekrem NEZIREVIĆ

MODERN AND SOPHISTICATED PROCESSES OF 3D VENEER PLYWOOD BENDING

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2-3. University of Bihać, Faculty of Technical Engineering, BOSNIA & HERZEGOVINA

Abstract: Under modern processes of 3D veneer plywood bending we consider creation and using of new technologies. This work emphasizing the importance of technological change of processes and products made from plywood panels, in order to ensure competitiveness in the domestic and foreign market. 3D plywood was created as a response to the increased demand for products that can be moulded into complex 3D forms, like metal or plastic. However, in this case appears well-known problem of anisotropy of wood. This problem is solved by patented mechanical modification of wood. 3D plywood panels opening up new possibilities in the design of chairs, curved fronts for furniture in three dimensions, as well as veneer interior for luxury cars or yachts.
Keywords: modern processes, 3D plywood panels, bending

INTRODUCTION

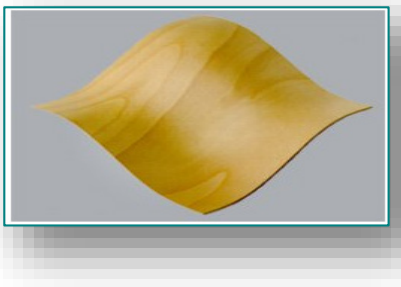
Survival, growth and development are the main goals the of which inevitably narrows the company producing furniture from plywood, in the dynamics of business processes. Development strategy and business policy, as instruments for the realization of these objectives, using known and acceptable modern production processes to stable operations, and thus the growth and development of companies in the domestic and foreign markets. [1]

We live in a time of three dimensions. In all spheres of life zhere is use of 3D technology: 3D movies, 3D movies, 3D animation, 3D ultrasound. Therefore felt need to produce 3D plywood, which would suppress plastic and metal from the production of furniture, that are dominant in the last decade compared to wood.

However, there is a question of the anisotropy of wood or dissimilar physical and mechanical properties of wood in different anatomical directions. Although the thickness of the veneer is small (typically 0.5 mm to 1.0 mm) they also behave differently when bending in the different anatomic directions. [2] For shallow forms such as filling in of frame construction veneers are relatively easy to bend. However, if we want to build a more complex three-dimensional form, veneers are the most frequently forced to break down. Same thing, but to a much greater extent, occurs with plywood.

This work examines and describes some conventional techniques of bending plywood that are common to the manufacturer in the region, but have their limitations. [3] Special attention was given to the mechanical bending modified veneers that have very similar behavior in all anatomic directions and can be bent into complex 3D shapes.

a)



b)

Figure 1. Three-dimensional (3D) veneer plywood produced by bending, from: a) peeled veneer b) mechanically modified veneer [5]

GOAL AND SUBJECT OF WORK

Radical changes in technology have accelerated the emergence of the so-called modern production technologies (processes), and caused the technological competitiveness become key determinants of business performance. Long-term profitability of the company assumes a successful strategic management of technology, the basis of which is exactly the technological changes, modern production processes.

The subject of this work is to improve production in bending plywood, adopting modern industrials and bending process 3D plywood.

The aim of this work is to analyze the modern production process of bending plywood, which contribute unlimited possibilities of designing and producing furniture from 3D veneer sheets.

BENDING OF PLYWOOD

Today, more and more there is a need for bending plywood. Methods plywood bending may be different, but they all have a common goal and that is to bend the plate with the desired radius and that they maintain the shape and not become damaged. On the market there are special plywood designed for bending.

CONVENTIONAL TECHNIQUES OF PLYWOOD BENDING

One of the most simple methods of plywood bending is steaming of panel in a closed vessel. The workpiece is placed in a chamber for holding the mating fixed time, which depends on the thickness of the plate and typically is calculated so that for each centimeter of thickness of plate takes 25-30 minutes. After steaming, the panel is folded over the template, attaches stage or in some other way, and so holds until dry. This method of bending largely depends on the quality of glue and gluing method, and there is always a risk of layering sheets of veneer.

Another method bent plywood is a method of plate threading. On the inner side that will be facing the molds, a series of parallel cuts of a certain depth by means of circular saw or a series of circular saw while cutting depth does not exceed two-thirds of the plate thickness. Adhesive is applied to the threaded side in an amount sufficient to fill the cuts to make stable structure. The plate is placed in a mold with the second threaded plate, so that thei threaded sides facing one another, and remain in the mold until the adhesive does not harden. [3]

MODERN TECHNOLOGIES OF 3D PLYWOOD BENDING

3D plywood panels were created in response to increased demand for products from wood which can be shaped in a mold in three dimensions, like metal or plastic. And in this case, appears well-known problem of the anisotropy of wood. This problem is solved by patented mechanical modifications veneer. This product opens up new possibilities in the design of chairs, curved fronts for furniture in three dimensions, as well as veneer interior luxury cars or yachts.

3D plywood panels can be found in unexpected places, such as in the interior of a luxury car, as the center console with the BMW X5, also used in the veneering of expensive medical equipment such as MRI Siemens and Loewe Opta TV whose body is veneered with exotic veneers.

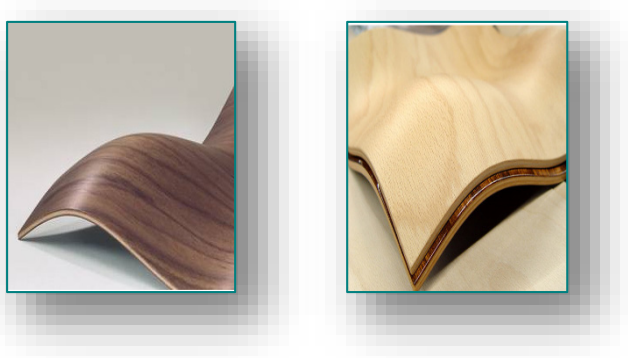


Figure 2. Trodimenzionalne (3D) furnirske ploče [7]

3D plywood panels are made with surface layers of peeled veneer beech, or sliced veneer beech, all kinds of walnut, oak or cherry, which were previously mechanically modified, so they texture remains unchanged. The inner layers are made of peeled beech veneer. The thickness of three-dimensional plywood range from 1.5 to 20mm. Veneers are glued to plywood (molding) in a mold (template) with male and female or in diaphragm presses by applying the UF glue for hot or cold bonding. [7]

By applying 3D plywood, designers opens a wide field for the realization of ergonomic design. The chair made of three-dimensional plywood weighs only 2 kilograms (Figure 4), indicating mpre efficient use of wood.

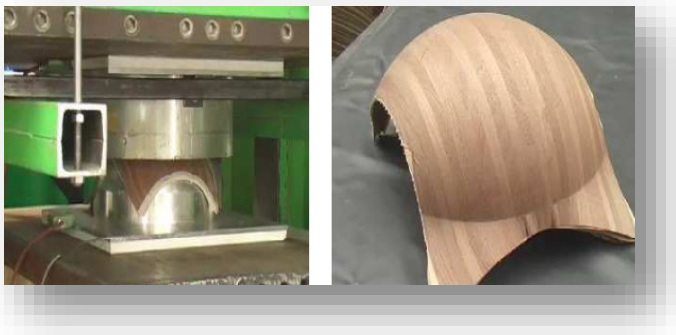


Figure 3. The process of making 3D plywood with male and female template[8]

Three-dimensional plywood can be combined with conventional, two-dimensional veneer sheets, so that only certain parts of products are made from plywood 3D (Figure 5).

Figure 4. Chair „Three skin“ [7]

Figure 5. One-piece plywood seat and back [5]

By using three-dimensional plywood we stepped into a new world and open the possibility of producing so far hardly imaginable product. Thus once again we return to the wood its rightful place as a warm, generous, environmentally clean and renewable material.

Figure 6. Stilica „Loop“ [6]

RESEARCH OF FUTURE USE 3D PLYWOOD

The research future applications of 3D plywood is in progress, and one of the main objectives is to increase the degree of possible deformation in order to obtain moldings with strong relief contours. On that way veneer would continuously follow the contours of the edges and corners of the boards.

By development and application of CAD/CAM software, it is possible, prior to construction, a software simulation of usage and analyze the behavior of the product that will be happening in the operation. Thus we are able to advance to make certain corrections - if it turns out that the original version does not meet the predicted requirements. Therefore the development of the product is significantly cheaper and the process of development is shortened because the prototype selects only product that meets the functional and aesthetic criteria.

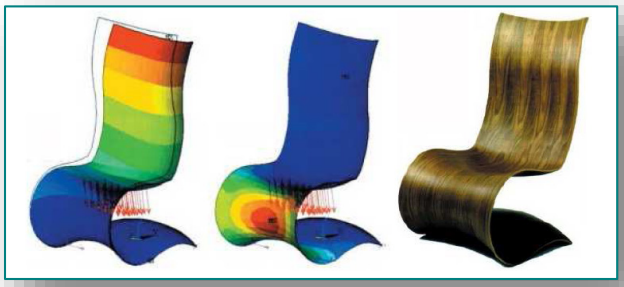


Figure 7. The software analyzes the load of the seat and backrest with chairs "XUS" (Designer: Peter Karpf, a Dane, Producer: iform, plugs) [7]

CONCLUSION

In modern conditions of competition, great risk is taken by the enterprises that do not adopt modern processes production and develop new products. Such companies will find that their products are victims of changing needs and tastes of consumers, shortened product life cycle and the increasing domestic and foreign competition. At the same time, new product development can be very risky, especially because of the high cost of the development process.

We live three time dimensions and all spheres of life resulting 3D technology. Therefore felt need to produce 3D plywood in response to increasing demand for products that can be formed in molds in 3D.

The modern process of 3D bending plywood is based on the application of veneers that are mechanically modified so that their texture is retained. 3D plywood panels are made with an external layer of peeled or sliced veneer beech, walnut, oak or cherry, while the inner layers are made from peeled beech veneer. Veneers are bonded (3D plywood) in a mold with a male and

female plate, with the use of special UV glue for hot or cold bonding.

Application of modern production processes in the furniture industry opens unlimited possibilities in the design of unusual furniture forms, by which we beautify the living space and once again we return to the wood its rightful place as a warm, generous, environmentally clean and renewable material.

Note

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1. Ratka NESHKOVSKA

ELECTROCHROMIC COPPER(I) OXIDE THIN FILM AS A CANDIDATE FOR SMART WINDOW

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Abstract: Electrochromic materials are able to reversibly change their colour when placed in a different electronic state. Such materials have a broad range of commercial applications. The most desired application are smart windows - windows with electrochromic thin film coatings that allow them to darken and lighten upon the application of a very small electric voltage and are the next significant advance in window technology for energy efficiency and comfort enhancement.Semiconducting copper(I) oxide, Cu_2O, films were prepared by electrodeposition method onto transparent conductive glass substrates. Those films revealed significant difference in transmittance in their coloured and bleached state, with an average relative modulation of about 53%, so they could be a candidatefor windowcoatings to control the inlet of sun light and heat.
Keywords: electrochromism, copper(I) oxide, electrodeposition, smart window

INTRODUCTION

Optically active (chromic) materials, such as thermochromic, photochromic and halochromic materials, change their colour reversibly when they are placed in a different environment (temperature, exposure to electromagnetic radiation, pH of the solution, respectively). One of the most useful form of chromism is electrochromism, discovered in 1969 by S. K. Deb. Electrochromic materialsare able to reversibly change their colour when voltage is applied across it. Electrochromic materials possess different colour in their reduced (when absorbing an electrons) and oxidized (electrons are ejected) state. They can be divided into two classes, depend on the potential where the colouration process occurs: cathodically and anodically colouring materials. Catodically colouring substances possess a reduced coloured state, i.e. they colour at the negative potential, while anodically colouring materials are those with an oxidized, coloured state, i.e. they colour when a positive potential is applied. Electrochromism is well known in numerous inorganic and organic substances [1]. Almost all of the interesting materials are oxides that are employed in the form of thin film. Electrochromism in different materials is strongly related to the method of preparation, i.e. it is affected by structure, stoichiometry, binding condition, and water content in the film.

The principle of monitoring the changes in color of selected materials by controlling their electrochemical reactions and its technological implications were first recognized in the early seventies and the route for their utilization for the fabrication of electrochemically driven optical displays was opened. There are many uses of materials whose optical properties can be varied reversibly and persistently by a low-voltage signal. The four main applications of electrochromic devices are:

- information display,
- electrochromic smart windows,
- variable emittance surface (infrared reflecting/absorbing surface, i.e., the thermal emittance is low/high) and
- mirror with variable specular reflectance.

Electrochromic (EC) smart windows are architectural or automotive windows with coatings that allow them to darken and lighten upon the application of a very small electric voltage, windows with variable transmittance so that a desired amount of visible light and/or solar energy is introduced. This application seems to be the most mature one. We all want the houses we live in and the buildings we work in more energy efficient, to the point where air conditioning isn't necessary. We can insulate the walls and the roof of a building easily, but windows are a problem area. We need

them to allow light into a building, so we can't insulate them with typical non-transparent insulation materials. Sunlight streaming through a window can really heat up a room. In thewinter we tend to welcome that extra warmth. But in thesummer, that heat increases cooling costs. Early studies at Berkeley Lab suggested EC smart windows could reduce a commercial building's annual energy use 15 to 25 percent [2]. According to computer simulations of building performance in the National Renewable Energy Laboratory of U.S. Department of Energy, the electrochromic windows [3]:

» reduce electricity consumption for cooling by up to 49 percent;
» lower peak electrical power demand by up to 16 percent; and
» decrease lighting costs by up to 51 percent.

As of today EC windows are still in an early stage of technological development. Only a few manufacturers offer commercial products. The technology is still expensive. The cost can be reduced using cheaperelectrochromic materials and by refining the manufacturing process. Today's thin film deposition equipment is the same one that's used to make flat panel displays and thin film solar panels and is much better than that used a few decades ago, when the electrochromic window concept emerged.

Electrochromiccopper(I) oxide thin filmsare appropriate for use in electrochromic smart windows because of the abundance of starting material and its cost. Copper(I)oxide (Cu_2O) thinfilms have been subject of numerous studies as a candidate for solar cell application. It has been recently found that these oxide thin films exhibit cathode electrochromism [4-8], i.e. they are transparent for visible light in their oxidized state, and almost black when switched to their reduced state.

Copper(I) oxide thin films could be made by different techniques: sputtering, chemical bath deposition, electro-deposition, sol-gel-like dip technique, thermal oxidation, anodic oxidation, etc.

The subject of this research were the electrochromic thin cuprous oxide films prepared by a electrodeposition method described by other authors [9], onto a fluorine doped tin oxide (SnO_2:F or FTO) pre-coated glass substrates.

EXPERIMENTAL DETAILS

A conductive and transparent fluorine doped tin oxide electrode was produced onto microscopic glass slides (25x75x1 mm) using the spray pyrolysis method [6]. The FTO deposition on glass requires previous degreasing of the glass slides in a mixture of chromic and sulphuric acid for 24 hours. The substrates were then rinsed with distilled water and wiped off with a cotton wool. The spraying of 300 ml 0.05 M aqueous solution $SnCl_2 \cdot 2H_2O$ was performed with a commercial BOSH paint sprayer. The fluorine doping was done by adding NH_4F to the solution, until neutrality was achieved. The spraying intervals were adjusted to about 1 s with pauses of about 5-6 s between. The spraying lasted about 20-30 min, until all the spraying solution was depleted. The substrate temperature was maintained constant at 400°C. Such prepared FTO was about 2 μm thick, 80% transparency for the visible light, with sheet resistance 18-38 Ω/sq [7].

The prepared FTO substrates were subjected to the electro deposition method of Cu_2O films. Besides the convenience of this method for obtaining thin films of copper(I) oxide on the transparent conductive glass, which is one of the conditions for examining the electro-chromic properties of thin films, the method of electrochemical deposition was selected because of its efficiency. The thickness and quality of the deposited film can be controlled during the electro-deposition. Deposition was performed with classical electrolysis, which makes this method simpler and more economical. The electrolysis container was placed in a large bowl with water (water bath) with a thermostat. The water bath provided a constant temperature for the electrolyte solution during electrolysis. The temperature of the electrolyte was an important requirement for the deposition of high-quality films. During the electrolysis, the temperature was maintained at 60°C. A copper clad for printed circuit board, with a thickness of 50μm, with dimensions 25x75 mm was used as the anode. The electrolysis solution was prepared from 64 g/l (0.4 M), anhydrous copper sulfate, $CuSO_4$, 242 g/l (2.7 M) lactic acid $C_3H_6O_3$, and about 125 g/l (or 3.1 M) sodium hydroxide, NaOH. The voltage between the cathode and the anode during operation was maintained in the range of 0.5 to 0.6 V, with a current density of 0.8 to 1 mA/cm^2.

Cleanliness of the surface of the anode and the cathode was very important for the quality of film formed as well as its adhesion to the substrate. Therefore, the anode was first cleaned mechanically and then chemically. Then the plate was cleaned with liquid detergent, washed with distilled water and dried. Prior to immersion in the electrolytic solution, the plates were cleaned with alcohol. Transparent conductive glass was used as the cathode. The process of cleaning it was the same as in other methods for deposition of thin films of copper(I) oxide, using chromosulfuric acid.

The thickness of the films obtained by this method, determined by gravimetric method, was about 200 nm.

The composition and crystal structure of the films were studied by X-ray diffraction (XRD) by Cu K_α radiation at wavelength $1.54 \cdot 10^{-10}$ m, with a Siemens D-500 diffractometer.

In order to examine the electrochemical behaviour of the electrodeposited Cu_2O films, an Electrochromic Test Device (ECTD) was designed (Fig. 1). It consisted of a transparent glass cuvette with a 0.1 M $LiClO_4$ aqueous solution electrolyte in which two electrodes were immersed. The working electrode represented the copper (I) oxide thin film onto FTO coated glass, whereas the counter electrode was FTO coated glass.

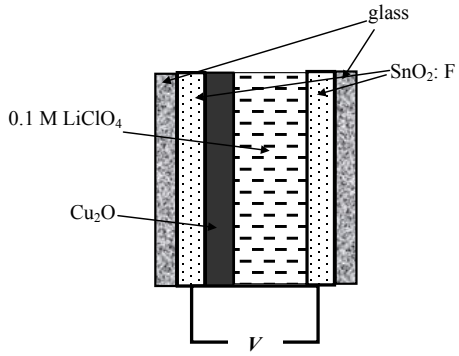

Figure 1. The cross-section of the so-designed ECTD

Devices are designed in such a way that they shuttle ions back and forth into the electrochromic layer with applied potential. When a voltage is applied between transparent electrical conductors ions are moved uniformly into and out of the electrochromic film. The charge-balancing counterflow of electrons through the external circuit then leads to a variation of the electron density in the electrochromic film and thereby a modulation of their optical properties, which remain stable for a long period of time.

The optical properties of the Cu_2O films were studied with a Varian CARY 50 Scan UV-Visible spectrophotometer, in the wavelength range from 300 to 800 nm. The visible transmission spectra were taken in-situ (the Cu_2O film incorporated as a working electrode into the ECTD) for the following film states: as prepared, coloured and bleached. The blank probe data were taken as the working electrode from the ECTD was replaced with FTO/glass electrode, so that the transmission spectrum could be normalized to 100%. The coloration and the bleaching of the cuprous oxide thin films were performed by application of a voltage - 1 V and + 1 V respectively.

RESULTS AND DISCUSSION

The films prepared by the electrodeposition method revealed cathode electrochromism, i.e. they showed coloration at a negative voltage, and bleaching at positive. The XRD pattern of the as deposited film onto the FTO substrate is presented in Fig. 2. The two most distinct detected peaks were found to originate from the SnO_2 substrate. The other four detectible wide peaks at $2.978 \cdot 10^{-10}$ m, $2.427 \cdot 10^{-10}$ m, $2.12 \cdot 10^{-10}$ m and $1.486 \cdot 10^{-10}$ m were crystalline Cu_2O [10]. The conversion from D values to 2Θ values for those four peaks is given in Table I. Hence, the XRD analysis showed that the composition of the as deposited films was Cu_2O.

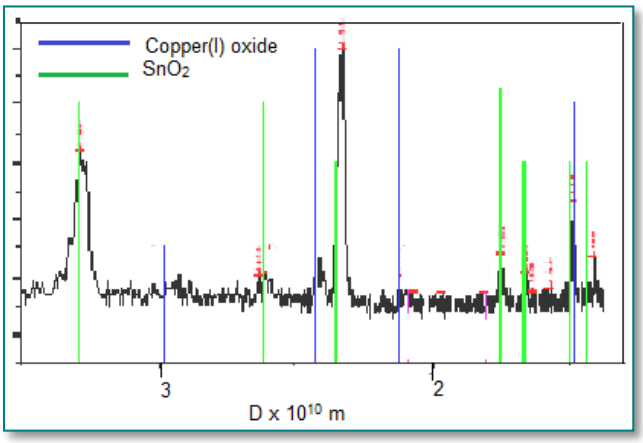

Figure 2. XRD spectrum of the 200 nm thin Cu_2O film.

Table 1. Cu_2O peak identification and D speacing to 2Θ conversion

Peak (JCPDS, 34-1354)	Dx10^{10} m	2Θ
1.	2.978	29.97
2.	2.427	37.00
3.	2.12	42.59
4.	1.486	62.42

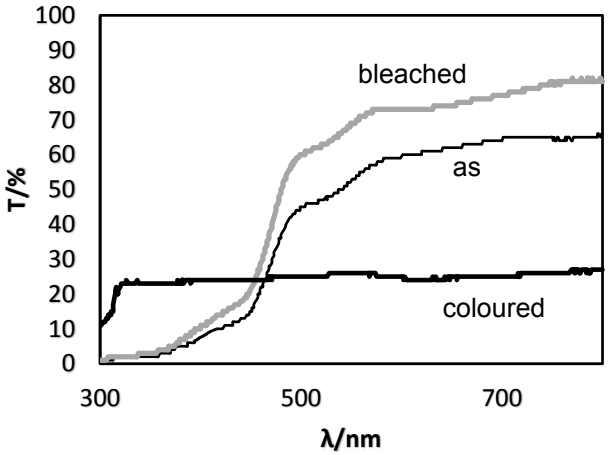

Figure 3. Transmittance spectra of the Cu_2O film.

The optical change is obvious on the visible transmittance spectra presented on Fig. 3 for: as prepared film, film in colored and film in bleached state taken in-situ: spectra were taken within the ECTD and then subtracted with a blank probe. A significant difference in the transmittance between the colored and bleached film is obvious throughout the whole spectral range. The relative

change in transmittance of film in bleached and colored state is around 53%:

$$\text{Modulation} \approx \frac{\sum T_{bleached} - \sum T_{coloured}}{\sum T_{bleached}} x\,100\,\% = \frac{51-24}{51} x\,100\,\% = 53\,\%$$

CONCLUSION

The fundamental property of an electrically activated chromogenic material is that it exhibits a large change in its optical properties upon a change in either electrical field or injected or ejected charge. The change in optical properties can be in the form of absorbance, reflectance or scattering. This optical change results in a transformation from a highly transmitting state to a partly reflecting or absorbing state. This change can be either totally or partly over the visible and solar spectrum. Typically it is over some portion of the spectra. Electrochromism can be used for the control and modification of incident daylight, solar energy and glare. Prepared EC thin copper(I) oxide films revealed about 53% modulation in transmittance in their bleached and coloured state. Because of this, EC window system coated with copper(I) oxide thin films could save energy. By controlling for daylight and glare it also provides occupants a more pleasant work environment, with year-round access to views and comfortable visibility of computer screens and work surfaces.

Note

This paper is based on the paper presented at The 12th International Conference on Accomplishments in Electrical and Mechanical Engineering and Information Technology – DEMI 2015, organized by the University of Banja Luka, Faculty of Mechanical Engineering and Faculty of Electrical Engineering, in Banja Luka, BOSNIA & HERZEGOVINA (29th – 30th of May, 2015), referred here as [11].

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A NUMERICAL STUDY OF PERFORATED PLATE LOCAL HEAT TRANSFER COEFFICIENT

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Abstract: The need for compact heat exchangers has led to the development of many types of surfaces that enhance the rate of heat transfer, among them and perforated plate heat exchangers. The perforated plate heat exchangers consist of a series of perforated plates, that are separated by a series of spacers. The present study investigates the local heat transfer characteristics of flow through a perforated plate with 2 mm in diameter, hole length to diameter ratio of 1 and porosity of 25.6%. For the determination of the local heat transfer, numerical simulations were performed. Reynolds numbers based on the perforated plate pitch were in the range from 80 to 300. The results of average Nusselt number prediction were compared with the related experimental correlations. The experimental results agreed on qualitatively with the results obtained using a CFD.
Keywords: local heat transfer, perforated plate, CFD

INTRODUCTION

One of the most important properties of heat exchangers, apart of having a high effectiveness is the need to be very compact, i.e. they must accommodate a large surface to volume ratio. This helps in controlling the heat exchanger exposure to the surroundings by reducing the exposed surface area. A small mass means also a smaller heat inertia. This requirement is particularly important for small refrigerators operating at liquid helium temperature.

The need of attaining high effectiveness and a high level of compactness together in one unit led to the invention of matrix heat exchangers (MHE) by McMation et al. [1]. Matrix heat exchanger consists of a package of perforated plates with a multitude of flow passages aligned in the direction of flow allowing high heat transfer in a proper design unit. This exchanger can have up to 6000 m^2/m^3 surface to volume ratio [2,3].

The convective heat transfer characteristics of any heat exchanger surface can be determined using steady state, periodic test and transient test techniques [2]. For a steady-state method, the temperatures of hot and cold fluids entering and leaving the heat exchanger, as well as flow rates are measured, and when steady state is achieved it is possible to determine heat flux, thus overall heat transfer coefficient. In the transient technique method, after the steady state is achieved the temperature of the fluid entering the heat exchanger is suddenly changed. The heat transfer coefficient can be determined from temperature-time history data. The periodic test techniques represents a variation of the transient method in which the temperature of the fluid entering the heat exchanger is continuously varied.

In the present study, a local heat transfer over a single perforated through which air is flowing is investigated using a Computational Fluid Dynamics (CFD) method. The research was conducted in order to understand the thermal process at the surface of the perforated plate. For the numerical experiment, a block of 2x2 holes with diameter of 2 mm and 3.5 mm pitch between holes was modeled (Figure 1).

MATHEMATICAL MODEL

The mathematical model is based on following governing equations:

» continuity equation

$$\frac{\partial \rho}{\partial t} + \frac{\partial (\rho u_i)}{\partial x_i} = 0 \qquad (1)$$

» momentum (Navier-Stokes) equations

$$\frac{\partial(\rho u_i)}{\partial t}+\frac{\partial(\rho u_i u_j)}{\partial x_j}=\frac{\partial(\tau_{ij})}{\partial x_j}-\frac{\partial p}{\partial x_i}+f_i \qquad (2)$$

» energy equation

$$\frac{\partial(\rho h)}{\partial t}+\frac{\partial(\rho u_i h)}{\partial x_j}=\frac{\partial(j_{ih})}{\partial x_j}+\mu\phi+S_h \qquad (3)$$

where ρ is the density, u_i – the three main velocity components, p – the pressure, f_i are the body forces and any other additional momentum sources, h is the enthalpy, and S_h represents the generation/ destruction rate of enthalpy. The τ_{ij} is the momentum shear stress tensor and the j_{ih} – the diffusion flux of energy transport. In the energy equation, the diffusion flux of energy transport term j_{ih} includes the energy transfer due to conduction:

$$j_{ih}=\Gamma_T\frac{\partial T}{\partial x_i}. \qquad (4)$$

where the factors Γ_T are the diffusion coefficients for the enthalpy – thermal conductivity coefficient. The second term on the right hand side in eq. (3) represents the energy transport by diffusion of species and the Soret-effect species diffusion transport, respectively. Finally, the term Φ is the viscous dissipation defined as:

$$\phi=\frac{1}{2}\left(\frac{\partial u_i}{\partial x_j}+\frac{\partial u_j}{\partial x_i}\right)^2-\frac{2}{3}\frac{\partial u_k}{\partial x_k}\frac{\partial u_l}{\partial x_l}. \qquad (5)$$

Numerical research

Three-dimensional steady-state turbulent flow is studied using commercial software ANSYS Fluent 14. The Reynolds Averaged Navier–Stokes equations (RANS) together with an eddy viscosity turbulence model are solved. The Shear Stress Transport (SST) k-ω turbulence model is chosen for its advantage in resolving flow separation and generally better performance than the standard k-ε model [4,5]. In order to model the local flow structure, a representative unit with 4x4 holes is defined (Figure 1). A uniform velocity is set at the inlet and a constant pressure boundary at the outlet. Turbulence quantities at the inlet are determined from the empirical correlations for turbulence intensity for internal pipe flows [6]. Symmetry planes were set on the side boundaries perpendicular to the flow direction (Figure 1). Domain is created as a sufficiently long (>20d), especially on the downstream side, to ensure the simulation results.

The computational mesh (Figure 1) uses continuously refined resolution near the solid wall boundaries, so that y^+ is less than 5 in order standard wall functions could be applied. The air velocity and the temperature on the inlet, as well as the constant temperature boundary conditions on the wall surface have been set according to the earlier experimental research conducted by Tomić et al. [7]. A typical convergence of the numerical research have been presented on the Figure 2.

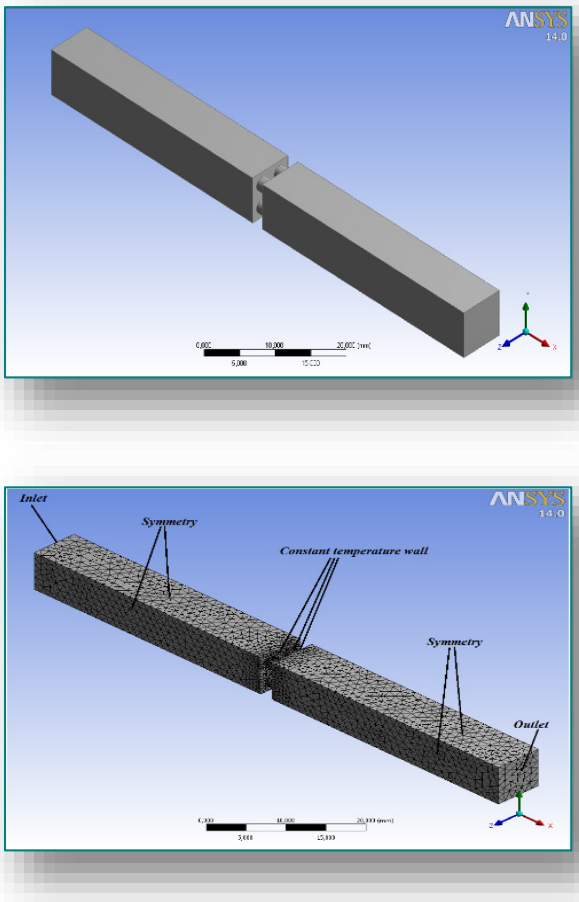

Figure 1. A 3D model and its numerical grid with boundary conditions

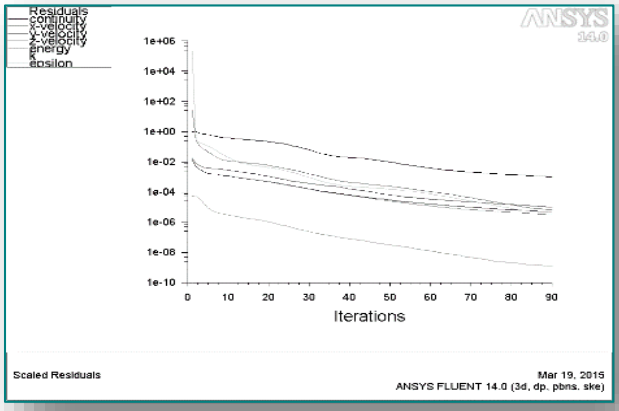

Figure 2. A typical convergence of the numerical model

2.2 Validation of the numerical model

The validation of the numerical experiment has been done by comparing with them with results of Tomić et al. [7]. On the Figs. 3-5 are presented comparison for the partial heat transfer coefficients, as well as overall heat transfer coefficient.

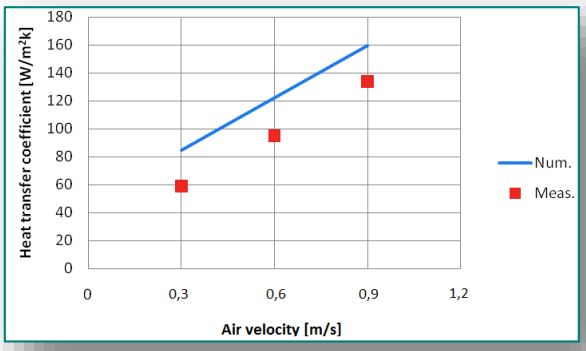

Figure 3. Comparison of the numerical model and experimental results for the heat transfer coefficient for the upwind side of the perforated plate

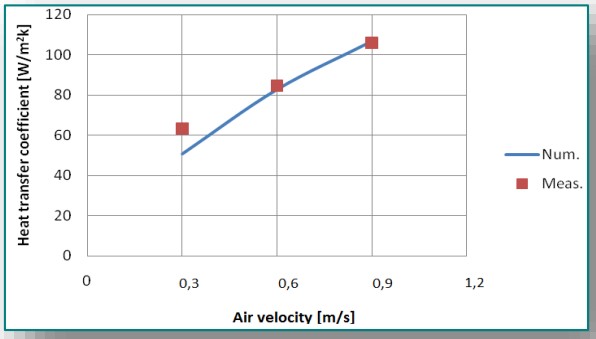

Figure 4. Comparison of the numerical model and experimental results for the heat transfer coefficient for the downwind side of the perforated plate

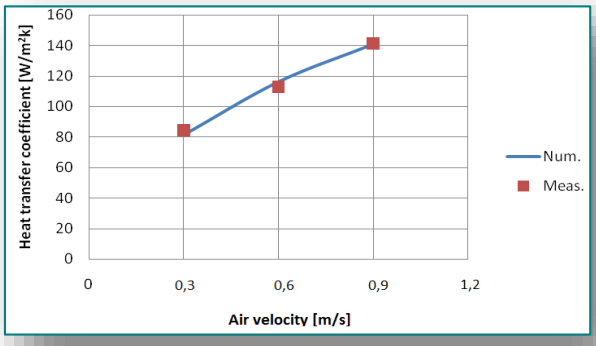

Figure 5. Comparison of the numerical model and experimental results for the overall heat transfer coefficient

RESULTS AND DISCUSION

Figure 6 and 7 shows the heat fluxes for the upwind and downwind side of the perforated plate along with velocity profile for the air velocity of 0,33 and 1,24 m/s, or in pitch based Reynolds numbers 80 to 300. As it cold be seen from the figures on the upwind side the difference between local heat transfer zones is the consequence of the flow separation and its acceleration through perforations, while on the downwind side, it is the consequence of the jet flow and surrounding recirculation zones. Each recirculation zone is located between diagonally neighbouring holes (Figure 6 and 7). Between the recirculation zones are „dead zones“ with low air velocity and thus low heat transfer.

Generally, the local differences in the heat transfer coefficients are upto 2 times and they are in the function of local air velocity. If the local heat transfer coefficient is assumed to be proportional to the local heat flux and according to the Nusselt criterial equation

$$\alpha_x \sim w_x^n . \quad (4)$$

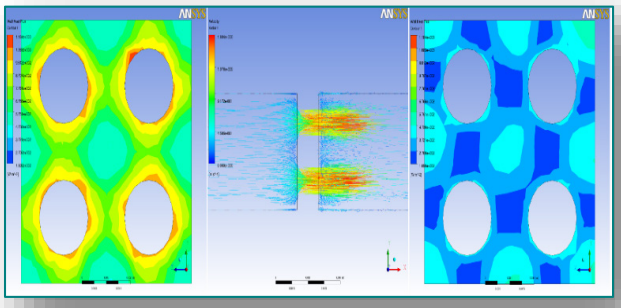

Figure 6 . Numerical results for the Reynolds number 80 - air velocity of 0,33 m/s

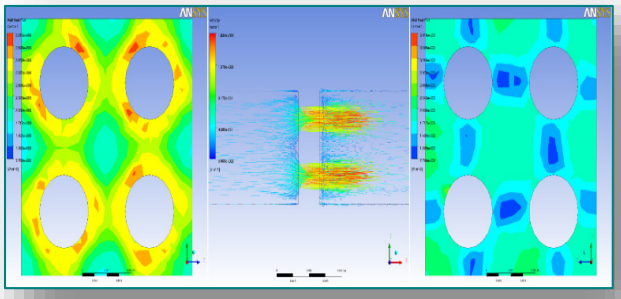

Figure 7. Numerical results for the Reynolds number 300 - air velocity of 1,24 m/s

At the upwind side, the heat transfer coefficient is proportional to

$$\alpha_x \sim w_x^{0,522}, \quad (5)$$

and on the downwind side

$$\alpha_x \sim w_x^{0,520} . \quad (6)$$

It could be assumed that power in the eqs. 5 and 6 has the mean value of 0.521.The results in the eqs. 5 and 6 are in good agreement with results of Tomić et al. for the overall heat transfer coefficient [7]

$$Nu = 1.055 Re^{0,524} . \quad (7)$$

CONCLUSION

The detailed gas flow and heat transfer through a single perforated plate is investigated using a Computational Fluid Dynamics method in order to

determine local heat transfer coeficients. The obtained results show good general trend and mutual agreement. The current work lays a foundation for the future research of the influence of geometric parameters and number of plates in a perforated plate heat exchanger on the local heat transfer.

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Note

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FATIGUE STRENGTH SIMULATION OF AIRCRAFT LUG

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Abstract: A computational models for the strength estimation of cracked aircraft lug are formulated. The crack growth propagation is investigated through the stress analysis and fatigue life calculation. The stress field around the crack tip and the stress intensity factor are evaluated by applying analytical approach. The fatigue life up to failure is simulated by employing two different crack growth laws.The estimations are compared with avaiable experimental data, and good correlation between different results are obtained.
Keywords: fatigue, crack growth, aircraft lug, strength evaluation

INTRODUCTION

The damage tolerance design of aerospace structures can be achieved if bearing loads are transferred through the lug-type joint. Such connection between the pin and lug represents potential zone where high stress concentration, fretting, corrosion and material defects could cause the crack growth and even sudden failure. To ensure operational safety of a structure under cyclic loading, it is essentially important to develop the reliable computational models.

Within the context of fracture mechanics, the complex propagation process has to be considered through adequate crack growth laws. Paris and Erdogan [1] found that the crack extension under cyclic loading can be described by crack growth rate as a function of the stress intensity factor. Elber [2] introduced crack closure concept and took into account the effective stress intensity factor instead of the stress intensity factor. Further, Erdogan and Roberts [3] proposed the maximum stress intensity factor and the stress intensity factor range for the crack growth analysis. Walker [4] and later, Huang and Moan [5] recognized that the stress ratio together with the stress intensity factor range can be used to describe the crack propagation.

From the engineering point of view, the complex stress field of pin-loaded lug configuration has to be considered through the stress intensity factor by applying different methods. Schijve and Hoemakers [6] proposed an empirical solutions for the stress intensity factor. Impellizeri and Rich [7] suggested to employ the weight function for analyzing through-the-thickness lug problems. Hsu [8] studied the same configurations by applying singular finite element method. Pian et al [9] suggested that the crack growth of through-the-thickness crack initiated in the lug can be investigated by using the hybrid finite element method.

In the present paper, the computational procedure for the fatigue life analysis of the pin-loaded lug with through-the-thickness crack emanating from a hole is developed. In the crack growth estimation, the stress analysis and the residual strength evaluation are considered. For the stress analysis analytical approach is employed. The predictive capability of proposed models is discussed through the adequate comparisons between crack growth evaluations and experimental data.

CRACK GROWTH SIMULATION UNDER CYCLIC LOADING

During exploitation of structural components, cyclic loadings with different levels cannot be avoided. Complex fatigue process can often lead to unexpected failures of components. From the engineering point of view, the main issue is the evaluation of the reliable computational models while including the adequate loading parameters. The crack propagation of structural components can be investigated through the crack growth rate calculation and the fatigue life estimation.

The strength assessment of components can be realized through the adequate crack growth laws.

The present authors theoretically investigated the propagation process of the lug with through-the-thickness crack(s) by employing two different relationships for crack growth rates, the first one proposed by Huang and Moan [5] i.e.

$$\frac{da}{dN}=C(M\Delta K_I)^m \quad (1)$$

where $M=(1-R)^{-\beta}$ for $0\le R<0.5$

and then, the following relationship introduced by Erdogan and Roberts [3]:

$$\frac{da}{dN}=C K_{I\max}^2\Delta K_I, \quad (2)$$

where K_{Imax} and ΔK_I are the maximum stress intensity factor and stress intensity factor range, respectively, R denotes stress ratio and C, m and βr represent constants experimentally obtained.

In the fatigue fracture analysis, the relationships for crack growth rates enable that the number of loading cycles up to failure can be computed. After integration Eqs.(1) and (2) the expressions for final number of loading cycles up to failure can be written as follows:

$$N=\int_{a_0}^{a_f}\frac{da}{C\left((1-R)^{-\beta}\Delta K_I\right)^m}, \quad (3)$$

$$N=\int_{a_0}^{a_f}\frac{da}{CK_{I\max}^2\Delta K_I}. \quad (4)$$

where a_0 and a_f denote initial and final crack length, respectively.

The number of loading cycles up to failure is here estimated for adequate crack increments by applying two different crack growth laws where service cyclic loading conditions are taken into account through either stress ratio R or the maximum stress intensity factor $K_{I\,max}$, respectively. Since the relationships for stress intensity factor are complex, relevant numerical methods related to the integration of complex functions are employed in developed computational model.

STRESS INTENSITY FACTOR EVALUATION

Under cyclic loading the service life of engineering structures often can be reduced by cracks initiated in the zones of stress concentration or manufacturing defects. In order to ensure the safety design and exploitation, the crack propagation process has to be investigated through the stress intensity factor calculation. Such fracture parameter includes external loading, geometry and material of the structural component, and for the lug with through-the-thickness crack(s) emanating from a hole (Figure1) it can be expressed as follows [10, 11]:

$$\Delta K=\Delta S\sqrt{\pi a}\,f_{wn}f_n\sqrt{\frac{1}{\cos\left(\frac{\pi D}{2w}\right)}}G_n \quad (5)$$

where ΔS is the stress range, a presents the crack length, D denotes diameter of the hole of the lug and w is width of the lug.

The Bowie correction can be expressed by f_n (n = 1 for single crack and n = 2 for two-symmetric cracks)on the following way [12]:

$$f_n=\begin{cases}0.707-0.18\lambda+6.55\lambda^2-10.54\lambda^3+6.85\lambda^4; & n=1\\ 1.0-0.15\lambda+3.46\lambda^2-4.47\lambda^3+3.52\lambda^4 & ; n=2\end{cases} \quad (6)$$

where

$$\lambda=\frac{1}{1+\frac{2a}{D}} \quad (7)$$

The pin-loaded effect is included through the correction factor G_n given by:

$$G_n=\begin{cases}\frac{1}{2}+\frac{w}{\pi(D+a)}\sqrt{\frac{D}{D+2a}}; & n=1\\ \frac{1}{2}+\frac{w}{\pi(D+2a)} & ; n=2\end{cases} \quad (8)$$

The finite-width correction factor f_{wn} can be calculated by employing the following relationship:

$$f_{wn}=\sqrt{\frac{1}{\cos\left(\frac{\pi}{2}\frac{D+na}{w-2b+na}\right)}} \quad (9)$$

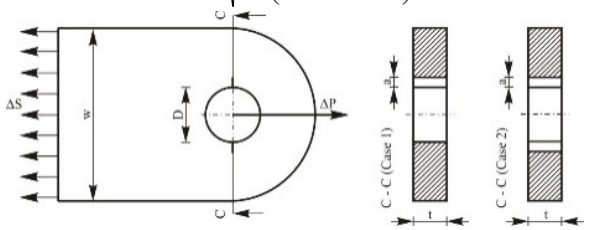


Figure 1. Geometry of the lug with through-the-thickness crack.

NUMERICAL RESULTS

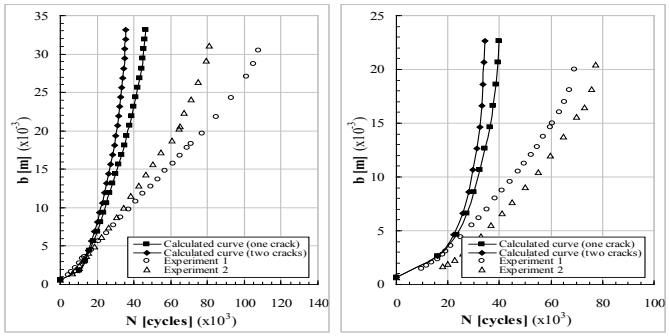
The efficiency of the proposed mathematical models for residual strength analysis of the lug with through-the-thickness crack(s) is considered through a few numerical examples. In such examples, the fatigue life up to failure is estimated by employing two different crack laws.

Example 1. The strength estimation of the lug with through-the-thickness crack(s)

The first example examines the residual life simulation of the lug with one crack and two-symmetric cracks emanating from a hole (Figure1). Geometry sizes of the lug, made of 7075 T6, are as follows: a_0=0.635 mm, t=12.7 mm D=38.1 mm [13]. The fatigue evaluations are performed for two different width of lug w (114.3 mm, 85.72 mm). The strength of considered lug configurations is investigated under axial cyclic loading with constant amplitude (a far field maximum gross stress S_{max}=41.38MPa, R=0.5), and the following

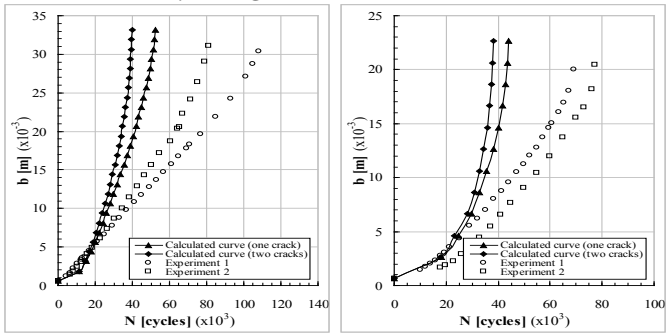
material parameters are assumed: $C_B=2.55*10^{-10}$, $m_B=3.06$ [14].

According to the mentioned geometries, material and loading parameters, the strength of lug is evaluated through the stress intensity factor calculation by applying appropriate relationships (Eqs (5)-(9)) for either single crack or two-symmetric cracks.



(a) (b)

Figure 2. Crack length versus number of loading cycles (by using Eqs.(3) and (5)-(9)).



(a) (b)

Figure 3. Crack length versus number of loading cycles (by using Eqs.(4) and (5)-(9)).

Experiment for the lug with one crack from Ref.[13]:

(a) w = 114.3 mm, 1- ABPLC84, 2-ABPLC91;

(b) w = 85.72 mm, 1 – ABPLC47, 2 – ABPLC94.

Since two different crack growth laws are considered, the residual life up to failure is computed using either Eq.(3) or Eq. (4) together with Eqs.(5)-(9). Obtained results for the number of loading cycles versus crack length by employing Huang and Moan, and Broek's crack growth laws are presented in Figure2 and Figure3, respectively.

At the same Figures, all computed results for fatigue life up to failure are compared with experimental data. The comparison between different results shows a good agreement. Additionally from Figure2 and Figure3 it can be also deducted that the crack growth law expressed by Eq.(3) is slightly conservative than that one presented by Eq.(4) when compared to experimental results.

Example 2. The residual life calculation of the lug under spectrum loading

This section considers the evaluation of the number of loading blocks up to failure. The considered lugs with either single crack or two-symmetric cracks (Figure1) have the following geometry parameters: $a_0=1.25$ mm, w=80 mm, D=35 mm, t=10 mm. External spectrum loading (Figure4) is axial with three different stress levels. The values of loading levels are shown in Table1. The considered plate is made of the same material as in the previous one.

Table 1. Maximum gross stress and appropriate number of loading cycles for considered load spectra.

Load level	I	II	III	IV	V	VI
Smax [MPa]	28.75	47.50	75.00	55.00	43.75	22.50
ni [cycles]	100	70	10	50	30	200

The strength of lug with through-the-thickness crack(s) under spectrum loading includes the stress intensity factor calculation and the crack growth rate simulation. Since the propagation process is investigated through two different crack growth laws, the number of loading blocks up to failure is estimated either by applying Eq. (3) or Eq. (4) together with Eqs (5)-(9). For both lug configurations, the computed number of loading blocks against the crack length is shown in Figure5a and Figure5b by using as a crack growth law, Eq. (3) or Eq. (4), respectively.

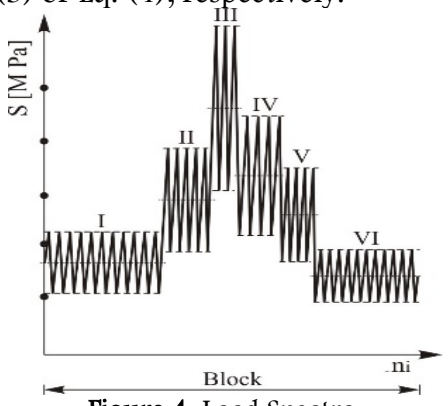
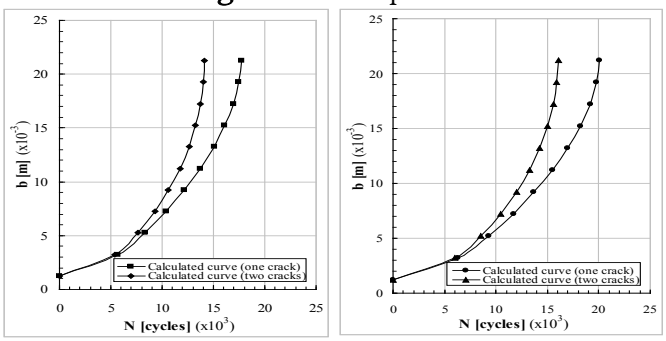


Figure 4. Load Spectra.



(a) (b)

Figure 5. Crack length versus number of loading blocks.

The comparison presented in Figure5 implies that developed computational model based on the crack growth law expressed by Eq.(1) gives slightly lower number of loading blocks up to failure than the one where Eq.(2) is employed.

CONCLUSION

The residual strength under cyclic loading of the lug with through-the-thickness crack is theoretically simulated. The crack propagation process is investigated through two different crack growth laws, and the stress intensity factor is calculated by employing analytical approach. The proposed models are verified by comparison with fatigue crack growth data. The implementation of Huang and Moan crack growth law gives slightly conservative fatigue evaluations than the one proposed by Erdogan and Roberts. Good agreement between computed results and experimental data shows that mathematical models are applicable in engineering practice for the reliable strength estimation of the lug with through-the-thickness cracks.

Acknowledgment

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Note

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THE INFLUENCE OF AGGLOMERATION BINDER ON KINETICS OF GRANULES

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Abstract: For the correct design of a fluid bed granulator whose output may be granules with the required form and properties, it is necessary to know the process parameters, such as the amount and type of binder, the flow parameters, air distribution and the rate of rotation of the disc. This paper deals with the detection of the kinetics of growth of the granules, specifically their distribution characteristics depending on the binder concentration in the liquid phase. The experiments will be carried out in a fluidized bed granulator with a rotating disc, which was designed at the Institute of Chemical and Hydraulic Machines and Equipment's at the Faculty of Mechanical Engineering of the Slovak University of Technology in Bratislava. The output of the experiments will be the determination of the distribution characteristics of the resulting final granulate.
Keywords: granulate, binder, distribution characteristics

INTRODUCTION

In the course of designing industrial granulation equipment it is nowadays not possible to proceed without examining by experiment the process parameters. It is often a requirement for the specific distribution characteristics of the final product and optimization of the granulation time. This paper deals with the detection of the growth kinetics of the granules in a fluid bed granulator, in dependence on the amount of granulation liquid and the concentration of granulation binder in the liquid phase.

THEORY

The agglomeration of the particles is currently achieved by a number of conventionally used methods. One such method is fluid bed granulation, wherein the enlargement of the particles takes place by spraying a liquid binder onto the aerated processed material. Inlet air enables the movement of the powder without auxiliary components such as a blade or a screw in other granulation technologies. Satisfactory fluid bed granulation ensures a balance between the hydrodynamic, gravitational and interparticle forces.

At the Institute of Chemical and Hydraulic Machines and Equipment of the Faculty of Mechanical Engineering a fluid bed granulator with a rotating disc was developed. Compressed air, ensuring the creation of a fluidized bed is obtained from a compressor and is fed into the apparatus from below. Using a perforated distributor, air is uniformly distributed under the rotating disk. Exhaust is carried out by means of suction through the top of the device. The liquid is injected into the system by a nozzle through a metering pump. The device is operated in batch, therefore the product created after each measurement must be removed from the chamber.

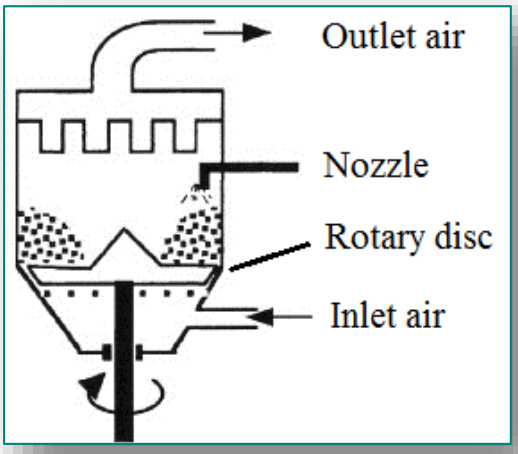


Figure 1: Diagram of experimental equipment

EXPERIMENTAL MATERIAL

The experimental material for the production of samples was finely ground limestone (Fig.2) with a microcrystalline structure. Selected properties of

ground limestone are seen on Table 1. A granulation liquid containing 10% rel. mass of liquid starch was used as a granulation binder, with the remainder being distilled water. Since ground limestone in the powder form is well wettable, it was not necessary to use further auxiliary additives. The distribution characteristic of the experimental material, (Figure 4), was measured by a Malvern Mastersizer 3000 particle size analyser.

Figure 2: Experimental material – finely ground limestone

Table 1: Properties of experimental material

Loose density	0,65	[g.cm^{-3}]
Tap density	0,78	[g.cm^{-3}]
Material density	2,71	[g.cm^{-3}]
Specific surface area	1037	[m^2.kg^{-1}]
Relative humidity	0,1	[%]

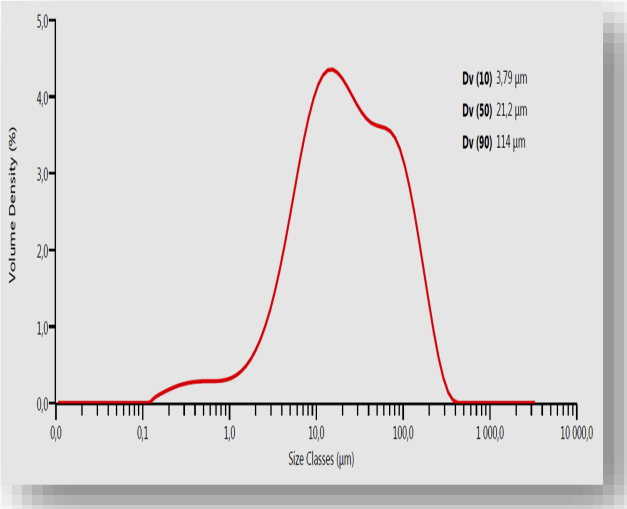


Figure 3: Distribution characteristic of experimental material

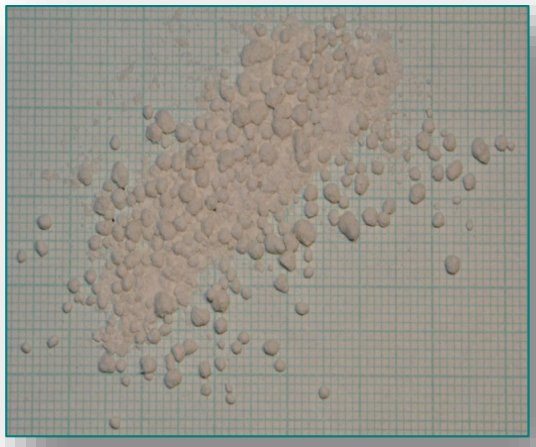
FLUID BED GRANULATION OF EXPERIMENTAL MATERIAL

Experimental measurements were made for the different amount of transported granulation liquid, with monitoring of the size reduction in dependence on the time of granulation. The same batch of fresh material was used for each measurement. The individual parameters of the granulation process are recorded in Table 2.

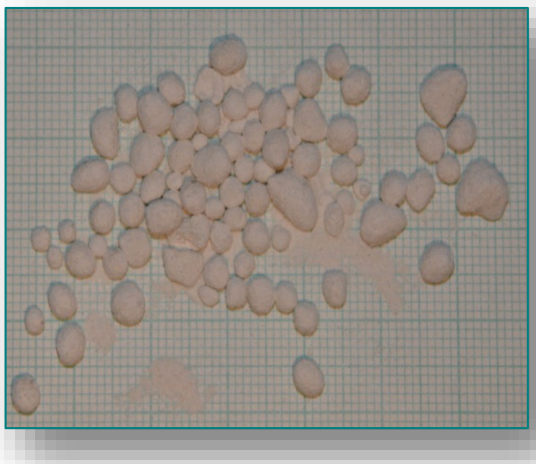
Table 2: Parameters of process

Speed of rotary disc	500	[s^{-1}]
Air flow in chamber	30	[m^3.h^{-1}]
Mass flow of liquid	10-30	[ml.min^{-1}]
Batch mass	200	[g]
Granulation time	30-150	[s]

The resulting granules (Figure 4) were dried in a dryer at 120°C for 2 hours. Subsequently, the dried product is subjected to sieve analysis, which is determined by the diameter of the largest numbers of particles (median) d_{50}.



a)



b)

Figure 4: Resulting granulates before sieve analysis
a) granulation time 30 s,
b) granulation time 150 s

Table 3: Table of measured data

Sample number	Granulation time [s]	Mass flow of granulation liquid [ml.min^{-1}]	Particle diameter d_{50} [mm]
A.1	30	10	1,5
A.2	60	10	2
A.3	90	10	3
A.4	120	10	3,5
A.5	150	10	4,5
B.1	30	20	1
B.2	60	20	2,5
B.3	90	20	4
B.4	120	20	5
B.5	150	20	6
C.1	30	30	1
C.2	60	30	3
C.3	90	30	4,5
C.4	120	30	5,5
C.5	150	30	7,5

RESULTS OF EXPERIMENT

Evaluation of the experiments was designed to determine the kinetics of agglomerate growth in dependence on the amount of granulation liquid used. Measured data of parameters d_{50} for all samples examined are recorded in Table 3. Graphical function of the size of the granules, dependent on the duration of process, is shown in Figure 5.

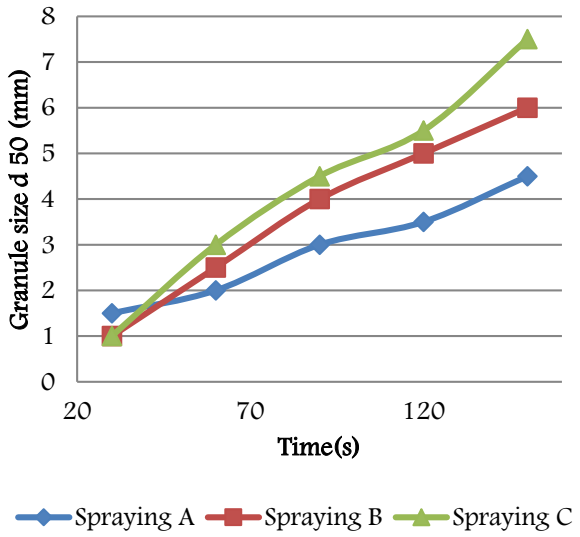


Figure 5: Kinetics of growth of granules

CONCLUSIONS

From the experimental measurements using a fluidized bed granulator with a rotating disc seems possible to evaluate the kinetics of growth of the granules in dependence on the amount of added agglomerating liquid. The results obtained suggest that the increase in median particle size is almost linear for the compositions with a lower and a higher content of liquid. Gradient of granular growth according to time of agglomeration was similar for all the examined liquid contents. The initial experiments proved the significant impact of added liquid on the growth of the granules. In following experiments it will be possible to observe the growth kinetics of the granules according to the process parameters that were constant in the initial measurements. These parameters include speed of rotation of the rotary disk, the amount of supplied air, and the filling of the charge chamber.

Acknowledgements

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Note

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TESTING PULL-RODOF OF THE PARALLEL KINEMATIC STRUCTURE

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Abstract: The work describes the kinematic structure of production machinery. I compare the serial and parallel kinematic structures, which are the main carriers of industrial robots and manipulators. I show possibilities, advantages and disadvantages of both structures, the basic distribution and kinematics motion. Parallel mechanisms are characterized by their kinematic structure presented a closed kinematic chain. The end effector mechanism is coupled to the base of more than one arm. This design provides an advantage particularly high rigidity mechanism and other related properties. The disadvantage of such a construction is limited workspace. In terms of positioning and management of this structure because of its complexity rather problematic. It is a structure that allows quick positioning of the tool with three degrees of freedom. Control system with a mechanical part is actually built on the Faculty of Mechanical Engineering. The work focuses on testing the parallel kinematic structure. Finally, the tests are evaluated. Results of experiments to serve in the design of telescoping steering rods and positioning parallel kinematic structure type Tricept in workspace.
Keywords: repeatability and accuracy of the distance position overshoot, paralel kinematic structure, pull-rodof

NOTE

The basic structure of the tricep developed at the SUT (Slovak University of Technology) FME (Faculty of Mechanical Engineering) can be represented by a parallel kinematic structure. The mechanism is based on a tripod structure with an added central shaft and is rigidly attached to the platform. It is connected to the frame by means of a spherical or universal joint.

Therefore, the tricep is constructed from a frame, three linear motors, central shaft, and a platform. Motion of the PKS (Parallel Kinematic Structure) is not a result of simple addition of partial movements, but a more complex calculation since moving members are configured parallel to each other. The goal of this contribution is to measure the unidirectional accuracy and position repeatability as well as the measurement of multidirectional accuracy of the end effectors position.

TRICEP PARAMETERS

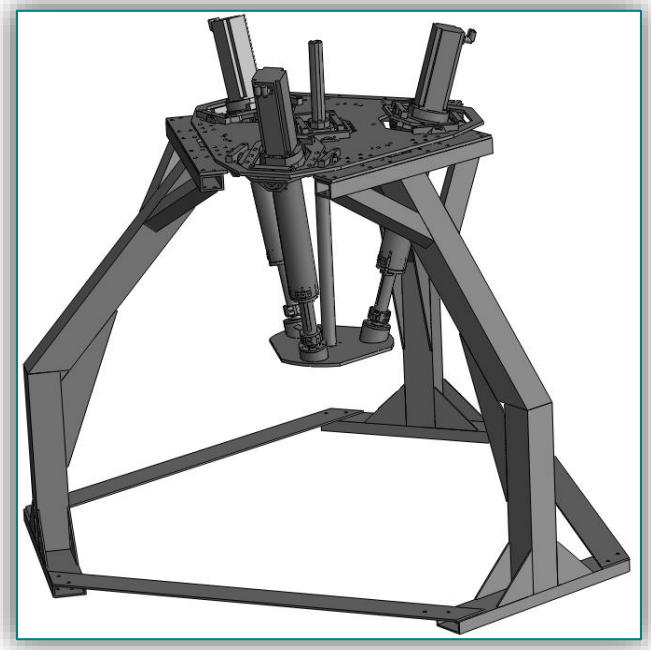
The tricep was tested at the institute of manufacturing systems, environmental technology and quality management at the SUT FME in Bratislava. The test parameters are as follows:

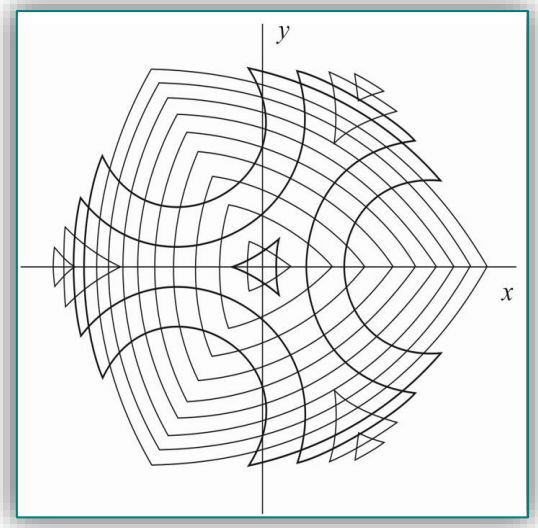
- maximum loading: 300N
- maximum telescoping length: 550mm
- maximum angle of rotation of the central shaft: 40°
- motor: Maxon EC 60, power: Pelm=400 [W], freq. Of rotation: n1 = 2900 [min-1],
- digital encoder: HP HEDL 9140
- transmission: Maxon GP 81, ratio: i = 3,7:1

The working area of the PKS does not have a simple path as opposed to mass produced devices. Its motion is given by the distances and position of the axes of rotation of the telescoping shaft. The size of the working area is given by the structures parameters. Its greatest limitation is the length of the telescoping shafts and their corresponding angles of rotation since collisions must be avoided with the fixed platform and main frame.

DESIGN AND IMPLEMENTATION OF THE EXPERIMENT

Measurements were performed utilizing systems from Leica Geosystems. The measuring apparatus consists of a measuring device, probes, PC with software for data acquisition and processing within polyworks software.





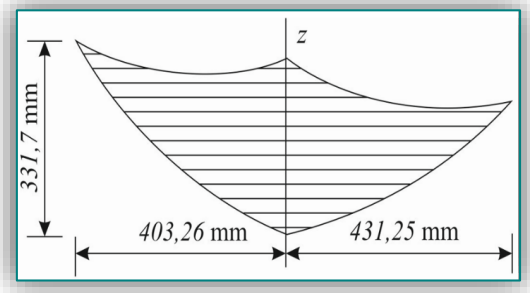


Figure 1. Design of the PKS and the working area of the PKS

MEASURING APPARATUS

Utilizing the laser tracker (Leica Absolut Tracker AT 901 – Basic) actual position of the mechanism end effector is recorded as it moved to the predefined "programmed" position. Technical documentation for the device is given in table 1.

Table 1: Leica parameters

Directing the beam	Pohyblivé zrkadlo
Source beam	pevný
Method of measurement	IFM+ADM+uhol
Range	160m
Rotate	360°
Maximum acceleration	360°/s²
The maximum speed	180°/s
The accuracy of the lines (IFM)	±0,4 μm
Angle accuracy	±15 μm

The laser tracker also allows for non-contact measurements but requires a probe which accurately reflects the emitted beam from the laser (Figure 2).

Figure 2. The laser tracker

EXPERIMENTAL PROCEADURE

The experiment was divided into two parts. In the first part, the unidirectional positional accuracy is measured. The second part measured the positional accuracy of multidirectional movement. For the sake of the experiment, it was necessary to include an imaginary cube within the working area of the mechanism. Its corners were defined by C_1 to C_8 and was positioned in order to fulfil the following conditions:

- Placed in a zone were most work was assumed to occur,
- Represents the largest permissible volume, where the edges are parallel to the general axis of the system.

In order to measure position, measurements had to be performed with respect to the planes in figure. 3.

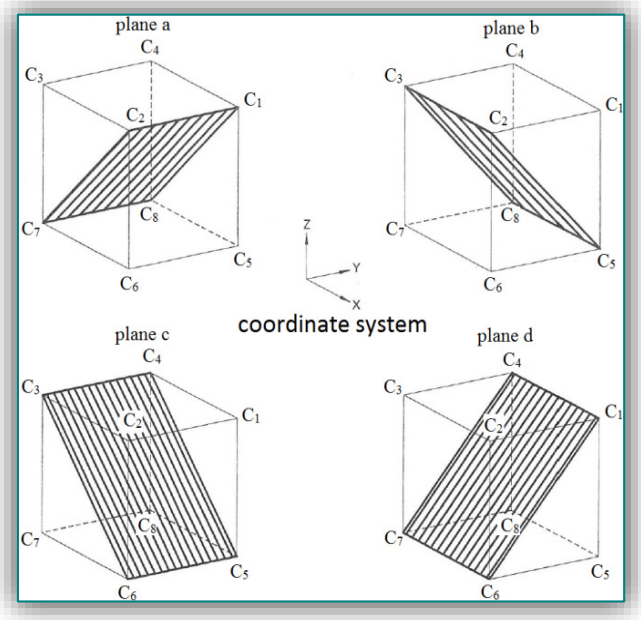


Figure 3. The positional accuracy of unidirectional movement

The positional accuracy of unidirectional movement was calculated as follows:

$$AP = \sqrt{(\overline{x} - xc)2 + (\overline{y} - yc)2 + (\overline{z} - Zc)2} \quad (1)$$

where:

$\overline{x}$, $\overline{y}, \overline{z}$ - average values of the coordinates after repeated movement to the same point

x_c, y_c, z_c - are the coordinates for the given position.

Unidirectional positional repeatability was calculated by the following method:

$$RP = \overline{l} + 3S_l \quad (2)$$

$$\overline{l} = \frac{1}{n} \sum_{j=1}^{n} lj \quad (3)$$

where

$$lj = \sqrt{(xj - \overline{x})2 + (yj - \overline{y})2 + (zj - \overline{z})2}$$

$$Sl = \sqrt{\frac{\sum_{j=1}^{n}(lj - \overline{l})2}{n-1}} \quad (4)$$

$\overline{x}$, $\overline{y}, \overline{z}$ - average values of the coordinates after repeated movement to the same point

x_j, y_j, z_j - are the coordinates for the given position

Measurement of the positional accuracy of multidirectional motion required at least three measurement points. Distance and motion paths were also necessary to determine (Figure 4).

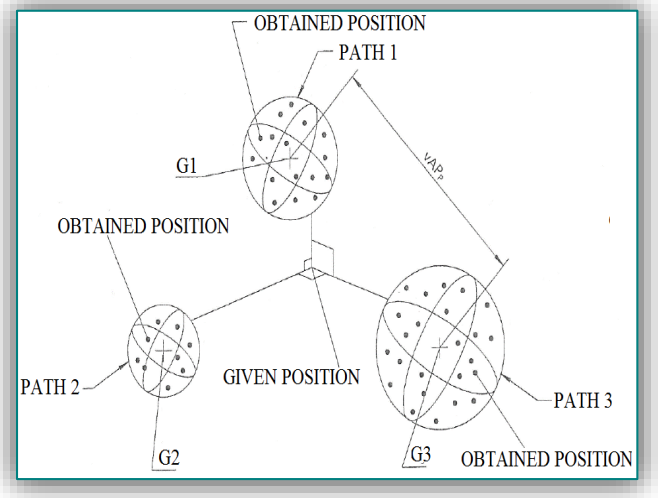


Figure 4. Measurement of the positional accuracy of multidirectional motion

The maximum deviation between the centres of cluster points, obtained at the end of individual paths, represents the multidirectional accuracy of the position (MAP), and was calculated as follows:

$$vAP_P = \max\sqrt{(xh - \overline{xk})2 + (yh - \overline{yk})2 + (zh - \overline{z}k)2} \quad (5)$$

h, k = 1,2,3

vAP_P defines the distance between point cluster centres (G1 and G3) measured for each axis individually. For each point, 3 MAP values were calculated

- distance between G1 and G2
- distance between G2 and G3
- distance between G1 and G3

From these values, the worst result is taken and is considered the maximum deviation for a specific point.

Standards do not specify any further procedures for the evaluation of the results. Therefore MAP results were obtained for points P1, P2, P3, and P4. The

experiment can be repeated with different loads and speeds.

IMPLENENTATION OF EXPERIMENT

Three types of measurement cycles were used (linear, pendulum, and wandering). Measurements were compensated for temperature changes in environment by a compensating apparatus. The program receives data about the thermal expansion of the guide screw material.

Process of the linear cycle:

Initial position > Measurement point 1 (negative direction),
> Measurement point 2 (negative direction),
> Measurement point n (negative direction),
> Measurement point 10 (negative direction),
> End position,
> Measurement point 10 (positive direction),
> Measurment point 9 (positive direction),
> Measurment point n (positive direction),
> Measurement point 1 (positive direction),

The horizontal axis (Figure 5) shows values of set coordinate points. The vertical axis shows the deviation from the set position. The zero line represents an imaginary value of the maximum allowable deviation, determined before measurements. The blue line represent connected points which were detected by the laser tracker in the negative direction (from absolute zero to highest value). The green line represents connected points in the positive direction. The red line represents the average measurement values in the negative and positive directions. From the curves of the graphed results it can be seen that an anomaly occurs between values obtained at the mid and end position values. At the time, this anomaly was not completely determined, therefore a further measurement was performed.

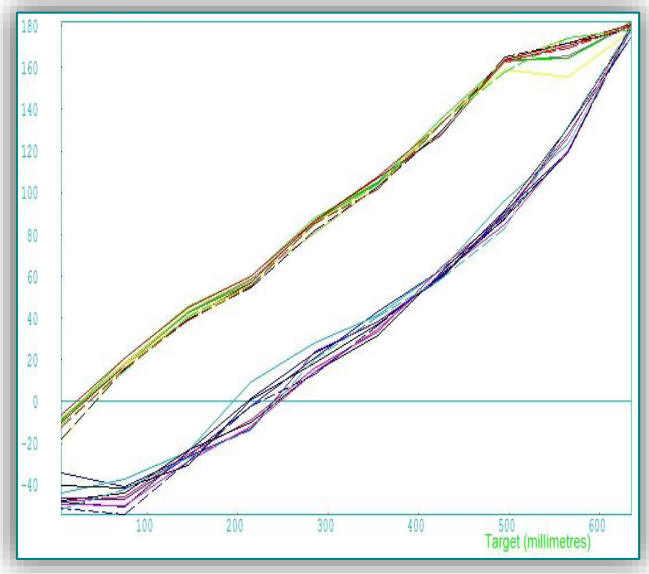


Figure 5. Process of the linear cycle

The measurement to determine the anomaly (fir. 6) was performed throughout the complete motion. In order to quickly diagnose, only one linear cycle was used. From the results it was found that there was not a direct correlation between the initial (absolute zero) and end points as can be seen in the graph. It was determined to perform another linear cycle with software correction at 50 µm which defines an imaginary clearance in the screw.

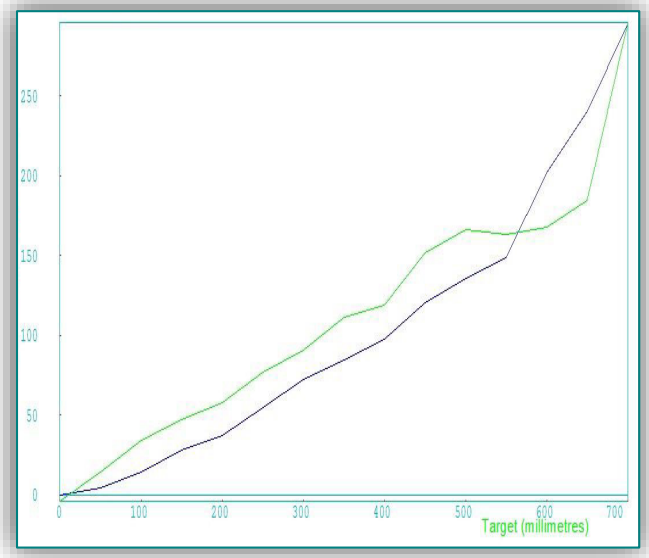


Figure 6. The measurement to determine the anomaly

From the resulting graph it was concluded that the measuring apparatus was not at fault, nor was the measurement procedure to blame for the anomaly, but rather the tolerances in the mechanism itself.

Process of the pendulum cycle: cycle was performed such that the initial "first" point from the negative and positive directions was measured 10 times. Afterward measurements of points 2, 3,..., n were performed.

Initial position > Measurement point 1 (negative direction)> +5mm
-5mm > Measurement point 1 (positive direction)> -5mm
+5mm > Measurement point 1 (negative direction) > +5mm
-5mm > Measurement point 1 (positive direction) > -5mm …
+5mm > Measurement point 1 (negative direction) > + hodnota kroku
+5mm > Measurement point 2 (negative direction) > +5mm
-5mm > Measurement point 2 (positive direction) > -5mm
+5mm > Measurement point 2 (negative direction) > +5mm …
-5mm > Measurement point n (positive direction) > -5mm

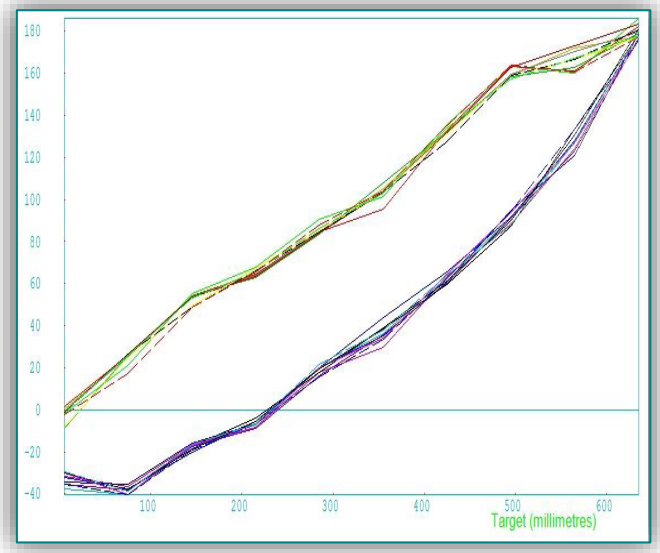


Figure 7. Process of the pendulum cycle

Process of the wandering cycle: performed such that the first point is measured 10 times in the negative direction. Then point 2 is measured in the negative direction while point 1 is measured 10 times in the positive direction, followed by point 3 in the negative direction and point 2 in the positive direction repeated up to point 10.

Initial position > Measurement point 1 (negative direction) > Initial position > Measurement point 1 (negative direction) > Initial position …
> Measurement point 1 (negative direction) > + step value (70mm)
> Measurement point 2 (negative direction) >
> Measurement point 1 (positive direction) >
> Measurement point 2 (negative direction) > …
> Measurement point 1 (positive direction) > + 140mm (step value x2)
> Measurement point 3 (negative direction)>
> Measurement point 2 (positive direction) > …

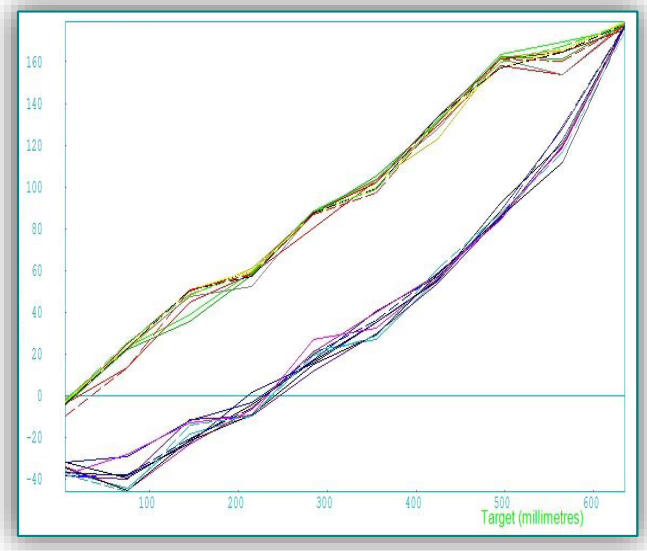


Figure 8. Process of the wandering cycle

CONCLUSION

Afore mentioned parameters (Table 2) were evaluated in RENISHAW software according to standard ISO 2302-2. From the curves on the graph, the pendulum cycle shows lowest values in terms of deviation or repeatability.

Table 2. The aforementioned parameters

	linear cycle [µm]	pendulum cycle [µm]	wandering cycle [µm]
AP	247,315	233,342	239,671
RP (forward)	45,445	25,550	38,752
RP (reverse)	34,815	28,561	32,127
vAPp	91,552	88,002	94,229

When defining the highest deviation, it was appropriate to utilize the linear cycle. However, the character for repeatability are not yet completely describable, therefore more cycle types are necessary to implement into the measurements.

Acknowledgment

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Note

This paper is based on the paper presented at The 9th International Conference for Young Researchers and PhD Students - ERIN 2015, May 4-6, 2015, Monínec, Czech Republic, referred here as[4].

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DESIGNING PROCEDURE OF INNOVATIVE PHOTOVOLTAIC SOLAR WATER HEATER SYSTEM

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Abstract: The energy consumption of the world is keep on growing nowadays. Due to the continous development of the machine and electronics industry the average energy demand per person has increased fivefold in the last century. Accordingly the utilization of the non-renewable energy sources has extended. It has become more and more important to exploit our renewable energy sources, because of the sustainable development. The topic of our research is the energy-conversation from renewable energy sources moreover it includes the design procedure of a Photovoltaic Solar Water Heater System (PV-SWHS) and its comparison with a Solar Thermal Collector System (STCS).
Keywords: renewable energy, solar energy, domestic hot water, solar panel

INTRODUCTION

The aim of our research project was to reveal an alternative solution for domestic hot water production beside the solar thermal collector systems. The complexity of the PV-SWHS is not up to the subtility of the STCS's, since several devices belong to STCS, e.g. the puffertank, pump, controller and heat-insulated tubes, etc. These decives enlarge the expenses and the return of the systems and require regular maintance and control.

MATERIALS AND EXPERIMENTAL DETAILS

The PV-SWHS's are composed of the PV-panels, solar cables, Maximum Power Point Tracking System (MPPT) and a hot water tank with an electrical heating element. These systems have larger maintenance intervallums, and are cost-effective.

DESIGNING PROCESS OF THE SOLAR THERMAL COLLECTOR SYSTEM (STCS)

First of all it was defined how much heat is needed to produce domestic hot water for a family of four people. Following the determination of the number of the collectors was performed by using Eq. 1:

$$Q = 0.9 \cdot N \cdot A \cdot Q_{annual} \cdot \eta \,, \qquad (1)$$

where N is the number of the collectors, A [m²] is the surface of one collector, Q_{year} $\left[\frac{kWh}{m^2 \cdot year}\right]$ is the annual energy production by unit area (1 m²) of one collector, and η is the collector-efficiency. The number 0.9 is a correction factor, defined by the angular offset of the rooftop and the orientation of the building.

The designing procedure of the STCS have been performed to produce the domestic hot water for a house of four people. The solar collector field, the pipelines, the storage tank, the expansion tank and the pump have been designed, as well. The amount of energy produced by thermal collectors have been calculated for each month of the year.

According to our calculation 2 collectors are needed if the production of domestic hot water is completely derived from solar energy. Nevertheless avoiding the stagnation behaviour of the STCS, only one collector should be chosen for the system. The STCS includes one flat plate collector with the absorber surface of 1.84 m², a hot water storage tank with capacity of 300 l, 18 l expansion tank and thermal insulated copper pipeline with length of 30 m.

Avoiding the stagnation behaviour and the over-heating conditions at summertime the following arrangements should be made:

≡ cooling down the water tank
- » at night, through the collectors
- » with cold water
- » controlled lowering
- » with thermo-ventilator

≡ partial or full shade (covering the absorber surface)
- » manually

» automatically

Figure 1. Automatic shading system

DESIGNING PROCESS OF THE PHOTOVOLTAIC SOLAR WATER HEATER SYSTEM (PV-SWHS)

Beside the high efficiency of the Solar Thermal Collector Systems, frequent maintenance and wear of the mechanisms can be occurred. A system was simulated, which produce the domestic hot water by applying solar panels. The panels are linked with a storage water tank by solar cables and with a water heater. The PV-SWHS have been sized for the same house of four people, as well as the Solar Thermal Collector System. The solar panel field, the storage tank, the water heater and the solar cable have been designed. The amount of energy produced by solar panels have been calculated as well. The PV-SWHS includes six polycrystalline solar panels with peak power of 250 W_p, solar storage tank with capacity of 80 l, 183 V / 1500 W water heater and 30 m of solar cable.

THE PROFITABILITY OF SOLAR POWER

In order to assess the potential return to a solar energy investment, the analization of the cost of constructing and operating a solar utility, and the forecast of the potential revenue provided by the system should be done.

There are numerous methods for energy production cost calculation - and the result depends on method to a large extent. The following costs were derived by the annuity method. The basis of this method is that annual income must cover annual expenditure throughout the full depreciation period. There is a distinction between the nominal annuity method which works out costs and income using appropriate inflation factors; and the real annuity method which uses current costs and income on an uninflated basis. Annual income is calculated from the product of the energy production costs to be calculated and annual energy production, which is estimated as a constant over the period under consideration.

RESULTS AND DISCUSSION

Table I. shows that the photovoltaic system possesses even less investment, maintenance, operation costs than the collector system and they possess nearly the same income. The photovoltaic system's payback period is shorter accordingly. We must admit that the PV-SHWS requires more surface on the rooftop than the STCS.

Table 1. Comparison of the PV and the Collector systems

Appellation	Solar Thermal Collector System	Photovoltaic Solar Water Heater System
Produced energy [kWh/year]	1 547	1 543
Surface [m2]	1.84	9.56
Investment [Ft]	768 100	523 800
Maintenance [Ft/year]	11 200	6 700
Operation [Ft/year]	9 200	3 900
Income [Ft/year]	65 200	65 000
Payback period [year]	17.36	10.21

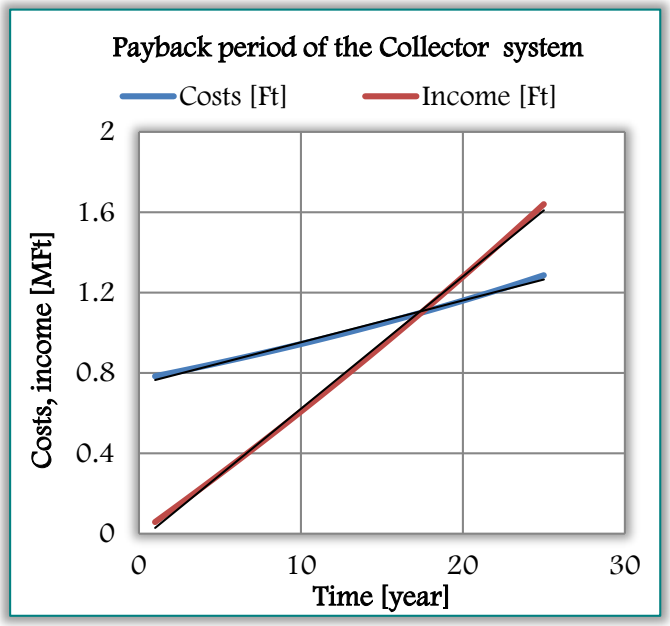

Figure 2. Functions of costs and income of the Collector System

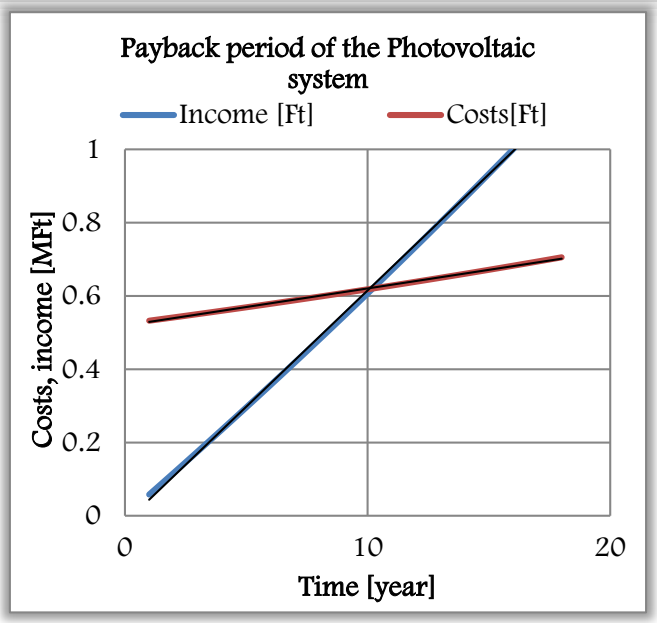

Figure 3. Functions of costs and income of the Photovoltaic System

CONCLUSION

In this paper it was shown that a photovoltaic system could eliminate several disadvantages of the solar collector system in terms of domestic hot water production. Our calculations pointed that the PV-SHWS is more cost-effective than the Solar Collector System. A small-scale Photovoltaic Water Heater System is going to be assembled in the departmental laboratory, so that measurements can be performed.

ACKNOWLEDGEMENTS

The described work was carried out as part of the TÁMOP-4.2.1.B-10/KONV-2010-0001 project in the framework of the New Hungarian Development Plan. The realization of this project is supported by the European Union, co-financed by the European Social Fund.

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FINITE ELEMENT MODELLING OF THE SPOKE WHEEL TRUING

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Abstract: The present paper is concerned with the mechanical and mathematical modelling of the spoke wheel lateral truing. A finite element model of the wheel which consists of truss and beam elements is created in ADINA software. The warp in the wheel is embedded in the model geometry. This geometric shape imperfection is straightened by altering the spoke tension. A mathematical software is used to find the optimal values of the spoke tension. Results are presented for various truing strategies.
Keywords: spoke wheel, truing, finite element analysis, optimization

INTRODUCTION

Spoke wheels are widely used on bicycles, motorcycles and wheelchairs because of their lightweight and stiff structure. A common failure type of these is the warping of the rim due to excessive load. This causes the wheel wobbling side to side, i.e. in axial direction. This should be avoided, because it leads to additional stresses and power losses in motion. If the warp is of slight degree than it can be repaired by truing the wheels. This process consists of tightening the spoke nipples which alters the spoke tension. Since the spokes are directed in axial and radial directions, the "rim run out" can be straightened.

As regards the mechanical analysis of spoke wheels the first studies appeared in the first half of the last century. Wheels with spokes subjected to compressive load were investigated by Pippard and Baker [10] who calculated the maximal stress. In the articles by Coker [3] and respectively Reynolds and Ehasz [14] have analysed the stress distribution with the use of photoelasticity. Pippard and Duncan have averaged the spokes and smeared it into an equivalent disc to analyse the load transmission between the rim and hub [11].

Pippard and Francis have first dealt with the modelling of tensioned spoke wheels [12] and in a later article Pippard and White compared it with experimental results [13]. Decades later Burgoyne and Dilmaghanian have compared experimental results with results carried out from a model, where a disc was substituted for the spokes [2]. Minguez and Vogwell developed an analytical model in which the rim and the spokes were considered and the effect of pretension was taken into account [7]. In the study by Gavin the stiffness of the wheel in terms of the arrangement of the spokes was determined by analytical, numerical and experimental results [4]. Petrone and Giubilato report on the measurement results about the behaviour of the spoke wheel in radial direction in their article [9].

With fast computers and effective numerical methods investigation of complex problems has become available. Finite element computations are presented by Brandt [1]. In addition to the numerical results, the cited book describes the structure and geometric properties of the spoke wheel and gives instructions how to repair them. Salamon and Oldham investigated the effect of the spoke arrangement using finite element method [15], while Hartz reports on numerical and experimental results [5]. In the study [8] the effect of the number of spokes on the radial stiffness was analysed with the finite element method.

The cited works model the wheel as a two-dimensional structure, therefore they are not able to describe the axial displacements and the response behaviour of the wheel to lateral load. Consequently none of them deal with the modelling of wheel truing.

The present paper deals with the finite element modelling of truing a damaged spoke wheel. The paper outlines the basic assumptions, the finite element model and the mathematical model of

wheel truing. Numerical results are also shown, which can be used as a basis for repair instructions.

MECHANICAL MODEL OF THE WHEEL

The object of our examinations is a spoke wheel consisting of a rim, 36 spokes and a hub. The other parts of the wheel are not taken into account. We consider the hub as a stationary and rigid part, consequently it will act as the ground in our investigations.

It is assumed that the displacements are small and the material law is linear, consequently we can use linear theory of elasticity.

The spokes are treated as beams under tension. At the ends of the spokes they connect to the rim and the hub with joint which allow small rotation in every direction. Thus they can be modelled with truss elements. The spokes have a circular cross section. There are many standard values for their diameter. In our investigation we use the common d=2 mm value which corresponds to the cross section area A=3.14 mm^2. The lay-out of the spoke arrangement follows a 3-cross pattern.

The rim is considered as a Bernoulli beam, with a cross section shown is Figure 1. The relevant second moments of area are calculated by the CAD tool in which the figure was drawn. Their values are I_x=6422.1 mm^4 and I_y=11217.8 mm^4 respectively.

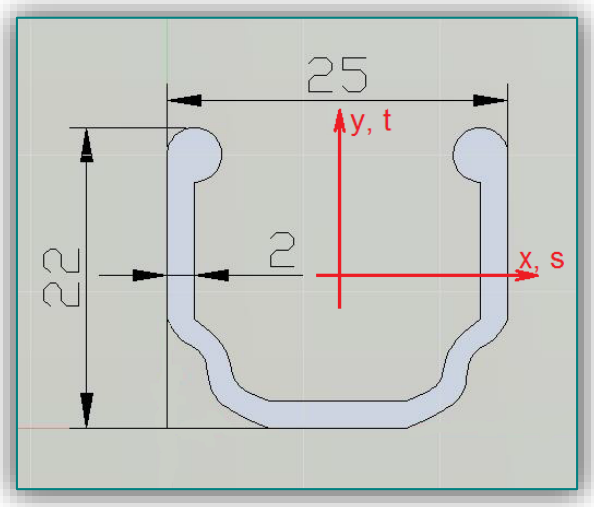

Figure 1. Cross section of the rim

The Saint-Venant torsional constant I_T is calculated by the formula valid for thin-walled open cross section [6]:

$$I_T = \frac{1}{3}\int_S t^3 ds \qquad (1)$$

where the S curve denotes the centreline of the section and t the thickness. The calculated value for the rim is I_T=144 mm^4. The section area of the rim is A=122.7 mm^2.

The rim and spokes is made of steel, which is regarded as homogeneous isotropic material with E=210 Gpa modulus of elasticity and ν=0.3 Poisson's ratio.

The finite element analysis is made with ADINA software. The model is built of truss and beam elements. The pretension of the spokes was considered as initial strains with the value ε_0=0.00076 which correspond to an initial stress of σ=159.6 Mpa. Using only the initial strains as load, the mesh on the rim was refined until the obtained results converged to a certain value. The finite element model of the rim is shown in Figure 2. It consists of 649 nodes.

The lateral warp of the rim is of 1 mm. This damage is considered as an initial geometric property. Consequently no residual stresses are taken into account. The form of the rim is originally a circle. This circle is drawn in the *xz* plane. In the deformed rim some points have a lateral displacement, i.e. they are taken off the plane in *y*-direction In the present model 1 mm warp is placed at one of the spoke connections to the rim, and 0.5 mm warp is at the neighbouring spoke connections. This is demonstrated in Figure 3 where the belonging node numbers are also marked.

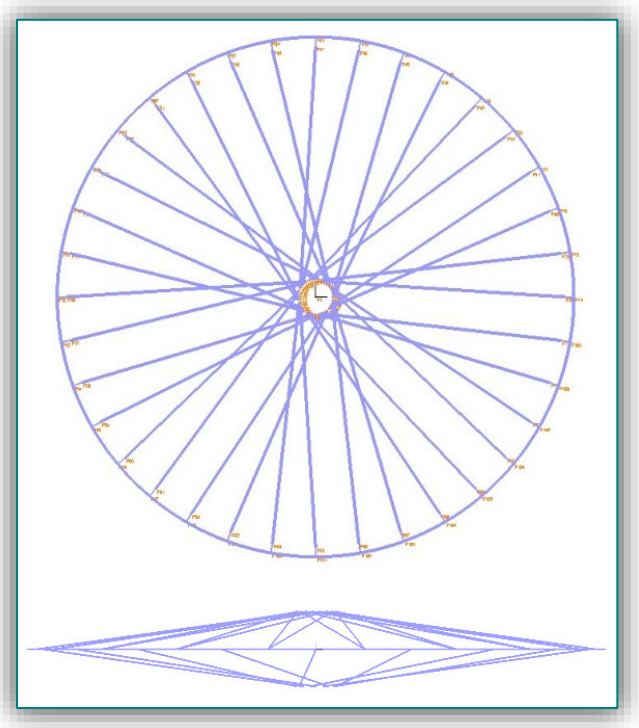

Figure 2. FEM Model

Together with the neighbouring spoke-rim connections, which have initially zero *y*-coordinates (they are not deformed), these points constitute the domain of the rim, which is regarded as the damaged domain of the wheel. In the following this domain will be examined. The node numbers of these points together with their initial *y*-coordinate is listed in Table 1. The placement of these nodes are shown in Figure 4.

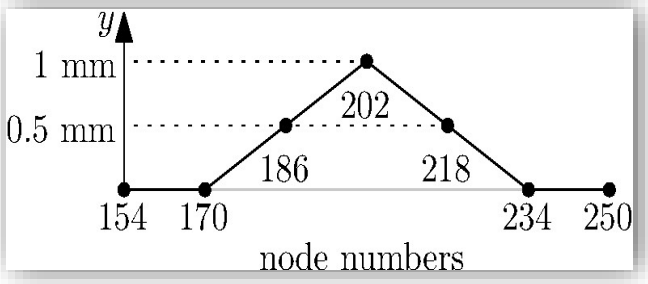

Figure 3. Initial y positions

Table 1. Initial *y*-position of the examined points

Node 170	0.00000E+00
Node 186	5.00000E-01
Node 202	1.00000E+00
Node 218	5.00000E-01
Node 234	0.00000E+00

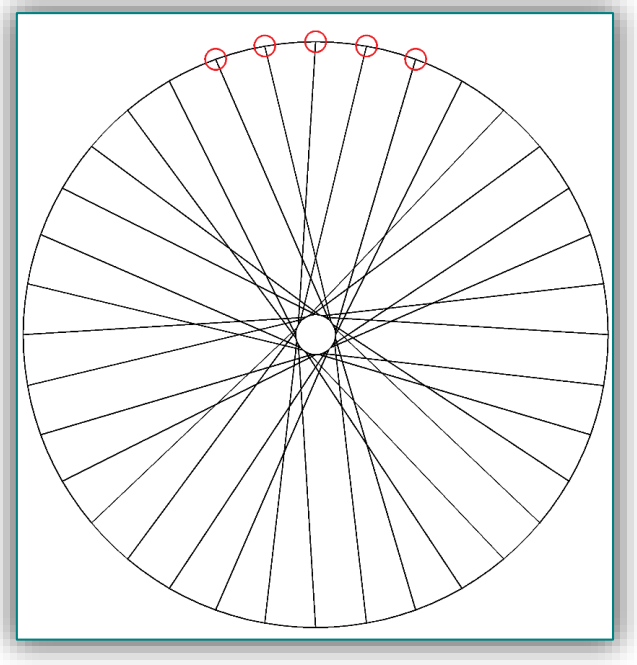

Figure 4. Placement of the examined nodes

MATHEMATICAL MODEL OF TRUING

The main goal of truing is straightening the described lateral warp. The original ideal form cannot be achieved, but the failure can be reduced in a satisfying measure which is within a given margin of error. The best result is achieved, if the warp of the rim is minimal. Therefore we have to solve an optimisation problem.

In order to solve the problem we define an objective function which we have to minimize. The input values are the initial strains of the spokes, consequently we have 36 input values. The function calls ADINA which does the finite element calculation with the given initial strains. Then the *y*-positions of the examined points are taken from the calculated results. The square sum of these *y*-positions is a good index of the magnitude of the warp. Consequently this number is taken as the value of the function that has to be minimized.

As a result of the truing process tightness of the spokes alter. Extremely loose and tight spokes should be avoided. Therefore we prescribe the inequality constrains

$$0.00038\varepsilon_{0,i} \quad 0.00114 \quad i = 1,\ldots 36 \qquad (2)$$

which mean that the initial strains should not exceed the original value by ±50%. The inequality constrains are handled by a penalty function.

The minimization is done by a computer program written in the GNU Octave mathematical software. We use a built-in function which uses the Nelder & Mead Simplex algorithm for minimization.

RESULTS

If the initial strains of all spokes are taken into account for minimization, i.e. every value is altered, then a minimum is found where the *y*-positions of the nodes in Table 1 become the values listed in Table 2.

Table 2. Results for all spokes altered

Node 170	-3.24500E-01
Node 186	5.05318E-02
Node 202	5.03589E-01
Node 218	4.33440E-02
Node 234	-3.35638E-01

The warp reduces overall, but the rim deforms largely at other locations far from the examined points. This circumstance is demonstrated in Figure 5 with scaled displacements. This is an undesired behaviour. In order to solve this problem, we take more points into account, when we evaluate square sum of the *y*-positions. In addition we select three more points on the rim whose placement is shown in Figure 6.

The results show that the magnitude of the warp is of the same order as in the previous calculations, but the rim is not affected by large deformations at other locations of the rim. Therefore this solution is a better as the previous one. The *y*-positions are listed in Table 3.

Table 3. Results with additional examined points

Node 170	-3.46355E-01
Node 186	6.74146E-02
Node 202	5.37462E-01
Node 218	7.04624E-02
Node 234	-3.41745E-01

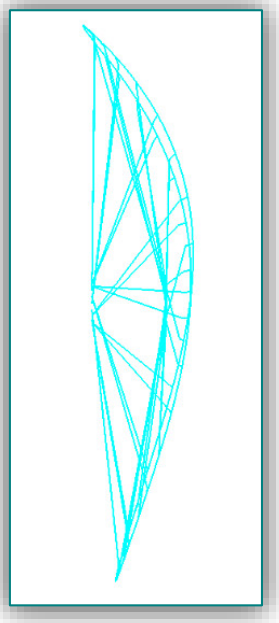

Figure 5. Deformed wheel

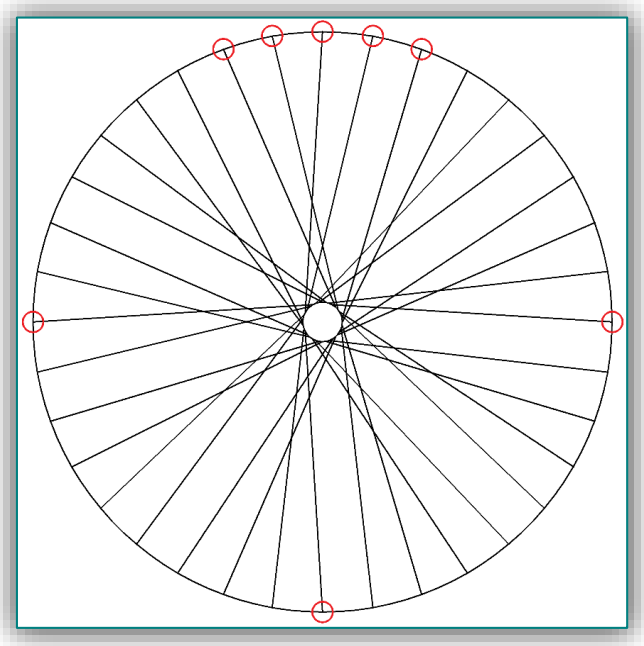

Figure 6. Additional examined points

Another approach comes from practical experience. Professional wheel builder only alter the spokes near the damaged domain in the truing process. Reducing the number of spokes whose initial strain is altered corresponds with this. Since the number of input variables reduces, this also causes less computation time.

The spokes with altered initial strains are marked in the Figures 7 and 8. The number of the altered spokes are 9 and 7 respectively. The results of the computations are listed in Table 4 and 5. According to the results it is enough to alter the initial strain of seven spokes in the damaged area.

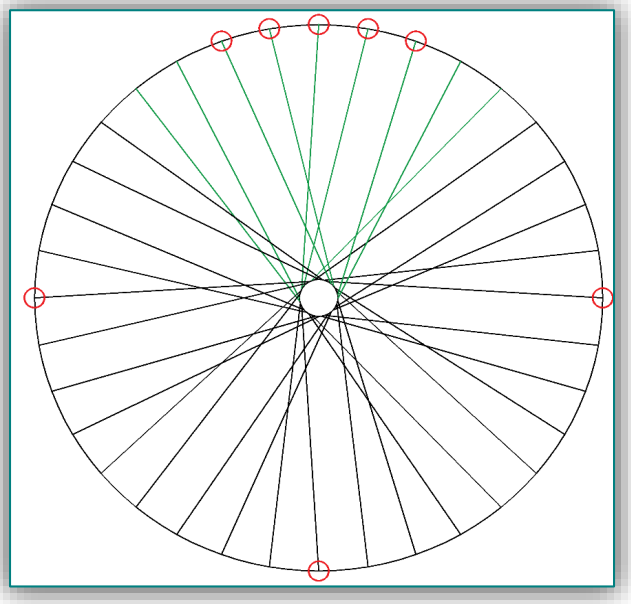

Figure 7. Nine altered spokes

Table 4. Results for 9 altered spokes

Node 170	-3.12930E-01
Node 186	1.16757E-01
Node 202	5.71028E-01
Node 218	5.82344E-02
Node 234	-4.19403E-01

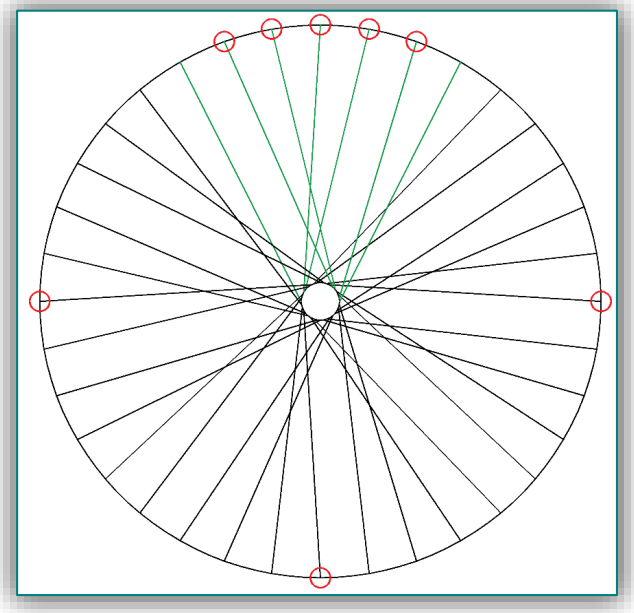

Figure 8. Seven altered spokes

Table 5. Results for 7 altered spokes

Node 170	-3.73946E-01
Node 186	7.39701E-02
Node 202	5.49029E-01
Node 218	5.53532E-02
Node 234	-4.07693E-01

Since the initial strains are only altered in a smaller range, it is not needed to consider the additional points when the square sum of the y-position is evaluated. Figure 9 presents the case if seven spoke strains are altered and only the five points in the damaged area are taken into account. The results for the y-positions of the selected points are presented in Table 6.

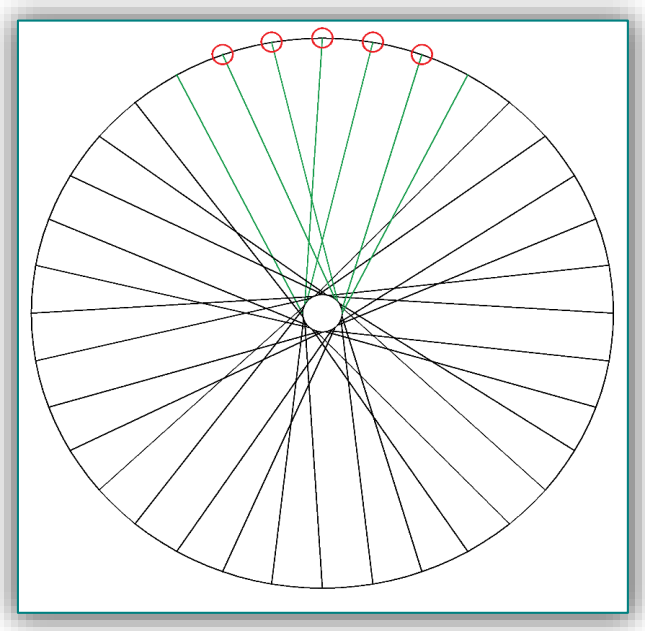

Figure 9. Seven altered spokes without additional examined points

Table 6. Results for 7 altered spokes without additional examined points

Node 170	-3.74249E-01
Node 186	7.17306E-02
Node 202	5.45161E-01
Node 218	5.05212E-02
Node 234	-4.12753E-01

Since the difference of the results between these and the previous ones is minimal this solution is considered satisfactory and it correspond to practical experience. The computational costs are also smaller in this case, therefore this case is considered as the preferred choice. Regarding to the results the warp is approximately reduced to half.

The values of initial strains where the minimum lies are also computed. If we have knowledge about these values together with the spoke length and pitch of the spoke nipple, repair instructions can be given about the necessary turns on the nipples.

CONCLUSION

The present paper has presented the finite element model of a spoke wheel which consists of a rim, 36 spokes and a rigid hub. A program was implemented in order to model the truing of a damaged wheel. According to the results altering the tension in the range around the failure leads to satisfactory melding, which corresponds to practical experience. The results for the optimal initial strains of the spokes is a good basis for repair instructions of the wheel.

ACKNOWLEDGEMENTS

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PERFORMANCE ANALYSIS OF SERVER SYSTEM VIRTUALIZATION IMPLEMENTED USING HYPER-V HYPERVISOR

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Abstract: This paper considers and describes possibilities for server system virtualization, methods of virtualization and performance of virtualized server systems. A special accent is given to the use of Microsoft Hyper-V hypervisor as a server virtualization technology, its architecture and practical implementation of server system virtualization using that technology. Performance of implemented virtualized server system is analyzed in details and compared with non-virtualized server system solution. Advantages of this type of virtualization are shown and listed in details. Disadvantages, with emphasis on usual performance decrease of virtualized server systems, are also pointed out. Results of detailed analysis and comparison of performance of virtualized and standard server systems are shown in the paper.
Keywords: Server Virtualization; Virtualization tools; Hyper-V hypervisor; Server performance

INTRODUCTION

The term server virtualization refers to the abstraction or masking of physical server resources that would logically look different than they are physically. It gives the ability to system administrators to relocate and adjust load of the machines. Briefly, the term abstraction of machines implies a set of technologies that perform abstraction of the entire physical system or server, and ensures that all its resources are integrated and shared. Such abstraction of machine performs a logical abstraction and isolation of the operating system and applications from the hardware [1].

There are several studies dedicated to the performance of virtualized systems. Most of those researches have been conducted in order to determine impact on I/O workload and networking performance [2-4], as well as general research of the impact of virtual machines and host configuration on performance [5-7]. In this paper, performance is analysed for CPU, RAM memory and HDD, for the operation of multiple virtual machines running on a single host server using a Microsoft operating system and hipervisor Hyper-V.

SERVER VIRTUALIZATION TECNOLOGIES

There are many software manufacturers who offer products for server virtualization. Tendency of increasing usage and the level of development of virtualization as a platform are constantly increasing. The products with the highest percentage of presence are of several virtualization software manufacturers, while the influence of others can almost be neglected. TechTarget's "2013 Data Center and Reader's Choice" survey may be cited to support that fact [8]. For years, as was confirmed by the study, the largest percentage of companies that are introduced into the server virtualization rely on VMware technologies. In addition to VMware Microsoft Windows Server 2012 R2 and Hyper-V have a significant percentage of practical participation. They are followed by Citrix Zen [8, 9].

However, in recent years with the new versions of Hyper-V technology, Microsoft has made significant progress and therefore it has become more present in companies that are introducing server virtualization. This can be confirmed by comparing the above research with data TechTarget's research from 2010 of „intent for purchase and introduction of virtualization software". According to that survey, at the time, VMware had 76% usage share and Microsoft had only 13% [10]. In addition to the fact that companies opted exactly for this technology, it is important to keep in mind specifications that are required to support hypervisor [10].

When it comes to the choice of technology which is being used for virtualization of server systems it is of highest importance to consider the hypervisor characteristics and simplicity of use. Hypervisor that takes up less space reduces the surface on which external attacks can happen, also being easier to maintain because it requires less software "patches", and therefore the security and stability of work of the data centers is increased [10]. Installation on the host hardware, configuration, management and upgrades are also less complicated. Any error or vulnerability of parent operating system directly affects the hypervisor, even if it is in a component that is not directly related to virtualization. Therefore, it is important that the security settings are installed directly on the hypervisor, which directly protects virtual machines and entire virtualization technology. It is important to choose the technology that provides the largest selection in terms of hardware and applicative components, technology that is not only vertically organized and which offers a choice and expansion, high availability, support for hardware and applications, and also provides a high level of utilization of hardware.

MICROSOFT HYPER-V HYPERVISOR

Hyper-V hypervisor is available in two versions: standalone free version called Microsoft Hyper-V Server which includes full Hyper-V functionality, and an optional feature installed with Windows Server. Hyper-V is free, but Windows Server must be paid for. System Center Virtual Machine Manager (SCVMM) can be purchased as an add-on. It supports the creation of large virtual data centers with multiple physical servers and a large number of virtual machines [10, 11].

The hypervisor for server virtualization Microsoft Hyper-V Server allows to consolidate loads helping organizations improve server utilization and reduce costs. Hyper-V is a dedicated, standalone product that contains hypervisor, Windows Server driver model and virtualization capabilities. Hyper-V Server leaves a small footprint, and requires minimal costs. Organizations that do not want a new license for Windows Server operating system or who only perform server consolidation using an alternative operating system also introduced Hyper-V server. In contrast, Windows Server is recommended for organizations whose required virtualization rights are flexible and cost-effective. Virtualization Rights for Windows Server are enabled by purchasing the required versions of the software. Windows Server Datacenter version provides unlimited virtual instances [12].

Figure 1 shows architecture of Hyper-V. The installation of Windows Server and other necessary drivers is required to enable Hyper-V. It is therefore thought that Hyper-V has to work on the operating system. When you enable the Hyper-V option, it is installed "under" operating system to run directly on the hardware, on the ring of the processor. At this point, Windows Server installation is known as the Management OS [13].

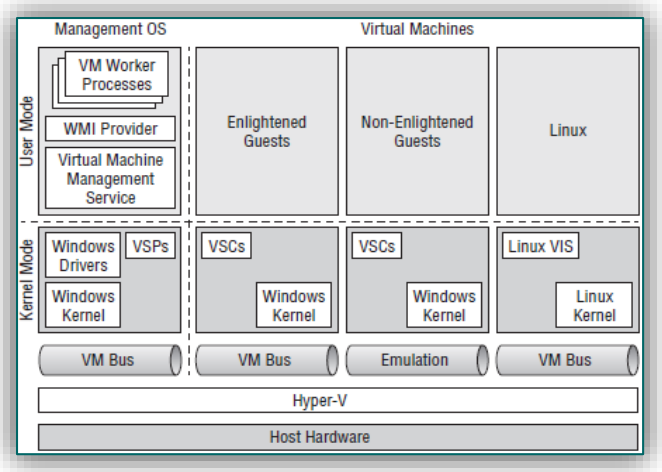

Figure 1. Hyper-V hypervisor architecture [13]

The current version of Hyper-V is included in Windows Server 2012R2, however Windows Server 2016 should be released by the end of the year 2016. Currently, Windows server 2016 is in a technical preview stage, but main capabilities of Hyper-V for Windows server 2016 are already available in Hyper-V for Windows 10 operating system. These features include many improvements of Virtual machines and Hyper-V manager, as well as the posibility of using a Hyper-V cluster with mixed Hyper-V version, nested virtualization and many other features [14].

SERVER VIRTUALIZATION ADVANTAGES AND DISADVANTAGES

Key benefits of this virtualized infrastructure can be divided as follows [1]: server consolidation (reducing the number of physical servers, reducing the power and cooling expenses for data center, reducing the complexity of entire IT infrastructure), business continuity and disaster recovery, development and test systems, dynamic data center. In addition to the above, the introduction of virtualization server system provides reliable and cost effective system for disaster recovery and provides a high resistance to failure of physical infrastructure, and thus the reliability of the entire IT infrastructure. With this approach, total cost can be reduced and the deployment speed (flexibility) can be increased significantly compared to non-virtualized systems.

There are also some disadvantages and potential problems in working with virtualized servers. Some of the disadvantages are [9]: single point of system failure; need for better hardware performance; system performance may decrease; additional

training for personnel to work with new tools. Potential problem with single point of system failure is connected with the possibility of system failure and it can be eliminated by using two servers functioning redundantly in a cluster. The need for better hardware performance as the second potential problem comes from running multiple virtual machines on a single server which needs hardware that has significantly better performance than individual servers. However, the fact that a single server attaches several machines, leads to reduction in the required number of physical machines. System performance may decrease since virtualizing hardware can cause severe performance degradation. Additional training for personnel is needed since virtualization adds a number of tools for system manipulation and it is necessary to train administrators to use these tools.

PERFORMANCE ANALYSIS AND COMPARISON OF VIRTUALIZED AND NON-VIRTUALIZED SERVER

Hyper-V is a technology which is rapidly evolving, and it comes as a part of the Windows operating system, both on the server and desktop versions. In this way, the cost of virtualization are reduced for small and medium companies whose business relies on information systems. In this paper, for practical implementation and for performance analysis of virtualization server systems were used Hyper-V virtualization tools. Guest operating system was Microsoft Windows 10.

Performance analysis of the host non-virtualized server and virtualized server machine virtualized using Microsoft Hyper-V Server was performed by performance monitor tool - PassMark Performance Test version 8.0. Server with the configuration shown in Table 1 was used for the practical implementation and performance testing.

In a real environment, several virtual machines operate on one host server. Any of them are not aware whether the other virtual machines are present or are they in a working state. In this case, four virtual machines were running. All of them are dedicated to the different purposes: application, database, backup, reporting. This means that they are executing specific jobs and they are not multipurpose machines. Virtual machine on which the performance is tested is a database virtual machine with Microsoft SQL server 2012 installed. The goal was that the configuration at the host has the approximate performance as the configuration of virtual machine. Virtual machine is on the host on which the performance is analyzed. The host has four CPU cores, and virtual machine has four virtual processors. Maximum RAM memory size that this virtual machine can take up is 8 GB. Disk space on same SSD disk is set to 60 GB.

Table 1. Host computer configuration

Component	Host	Database Virtual machine
CPU	CPU Intel Core i7-4790 @ 3.6 GHz, 8 MB Cache, 4 Cores	4 Virtual CPU
RAM memory	16GB SDRAM 1600MHz PC3-12800 DDR3 HyperX	4 GB Virtual memory, max memory 8 GB
Hard Drive	Samsung SSD 850 EVO 250GB	60 GB Virtual disc

Performance analysis results of the most important components of the system are shown in Figure 2. The blue color shows results for performance of host server and the red represents benchmark performance of virtual machine. The results are expressed in points and are given as average scores based on integration of all results by the test software. More points indicate better performance. Figure 2 presents results of a comparative test of the processor, RAM and hard disk drive performance on the host computer and the virtualized machine running on that host.

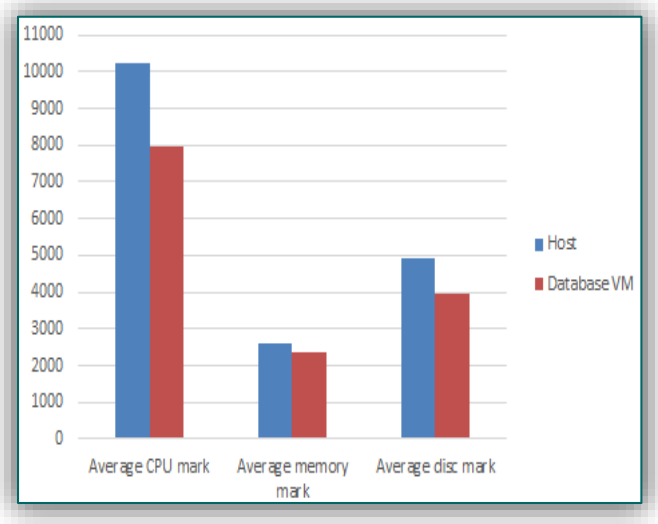

Figure 2. PassMark Performance Test overall results

Figure 3 shows compared processor performance achieved on host and virtual machine. During this testing performance measurement software ran various procedures performed by the CPU and measured execution speed of host and virtual machine. These procedures are related to speed of execution of individual processor instructions. This is primarily related to speed of mathematical instructions for prime, integer and decimal numbers, complex mathematical and physical formulas and instructions, data compression, encryption and sorting. In Figure 3 it is visible that there was a

reduction in CPU performance of virtual machine compared to non-virtualized server.

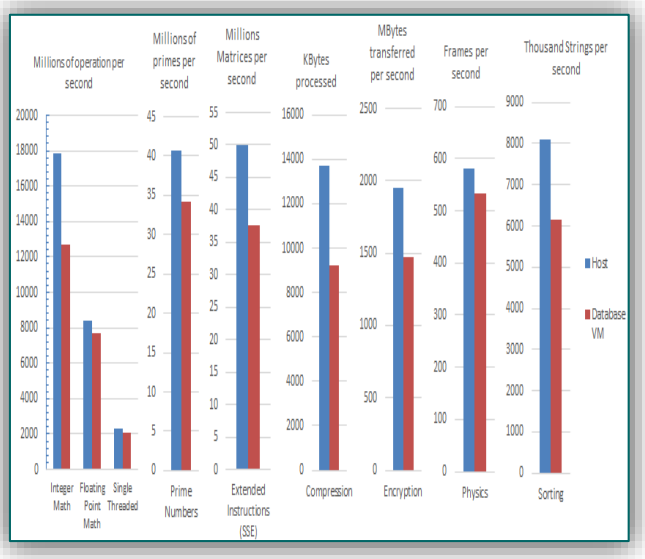

Figure 3. Results of comparative analysis of processor performance

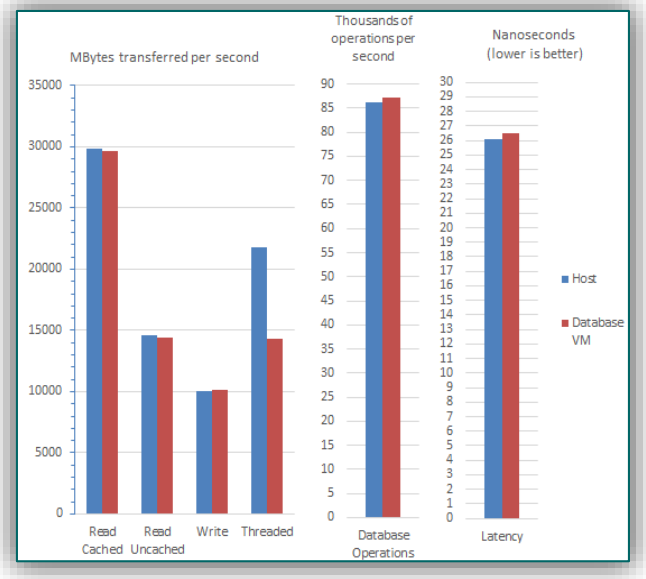

Figure 4. Results of comparative performance analysis for RAM memory

Figure 4 gives performance analysis of RAM memory operation on host computer and virtual machine.

All tests use a combination of 32-bit and 64-bit data when reading or writing from or to RAM. The test measures speed of large data arrays manipulation during manipulation of data from the database. Reading speed test was performed on smaller blocks of memory completely stored in the cache and speed of reading of large blocks of memory not stored in the cache is measured as well. After these tests, the test of speed of reading data from RAM memory was performed. These tests are performed on a single process and on the two at the same time, in order to get information how fast RAM memory manipulates multiple processes simultaneously. Special analysis refers to the latency of RAM memory and the time that it takes to transfer a byte from memory to the CPU for processing. The latency test was measured in nanoseconds, and in this case lower values are better. The Figure 3 shows that performance decrease on virtualized machines exists, but it is small. Testing the performance of memory in maintaining large structures of data showed that the performance of virtual machines when working with databases is even better than on the physical server.

The reason is that virtual RAM is a distributed software which has better usability with a large number of database operations. This means that RAM memory is better distributed with virtual machines.

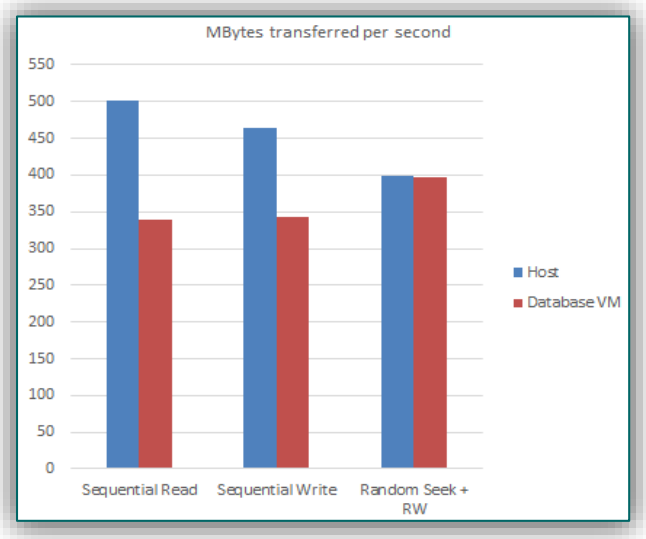

Figure 5. Results of comparative analysis of disk performance

It is also important to test disk performance of the entire system. The disk performance was tested on a disk with installed operating system in the host computer and in the virtual machine. In this system there is no separate virtual machine for shared storage by default. It uses memory of virtual machine on which operating system is located. Standard reading and writing to the disk test, created a temporary file in the root directory of the logged in user on the disk partition on which the operating system was installed. The size of this file is usually around 200 MB. Reading data from disk is tested first. Data was already generated in file fragments each measuring 20% in size and on those files sequential read from beginning to end of the file was performed. The same process was repeated to test sequential write to the disk. After that, parallel write and read was performed with randomly selected positions on the disk.

Comparative analysis of the disk performance of the host computer and the virtual machine is shown in Figure 5.

Considering all shown comparative analysis, it is evident that there has been some decrease of virtualized system performance in almost all observed segments. This decrease was approximately 22% for CPU performance, 9% for memory performance and 20% for disk performance.

In earlier versions of Hyper-V, after the installation of hypervisor, feature was hidden from virtual machines to prevent guest virtual machines from running Hyper-V server role among other hypervisors. [15]. When released, Windows Server 2016 will enable nested virtualization for Hyper-V, in contrast to Windows 10 in which it can be enabled now. Considering that nested virtualization is one of the newest features in Microsoft virtualization tools, performance testing on nested Hyper-V as a virtualized host was performed also. Nested virtualization is not enabled by default, and in this stage of development the only way to use this feature is to install the same version of Windows 10 operating system on host and virtual machine on which nested virtualization should be enabled. Both operating systems must have the latest updates installed for Pro or Enterprise editions. After that, nested virtualization needs to be enabled through Windows PowerShell tool, for every virtual machine separately. Hyper-V is then exposed to Windows guest operating system and it can be installed on a virtual machine. That virtual machine can act as a virtual host with virtual hardware virtualization on which is possible to install a virtual machine. Nested virtualization was enabled on the virtual machine used to conduct initial performance testing. Nested virtualization using Hyper-V on Windows 10 is shown in Figure 6.

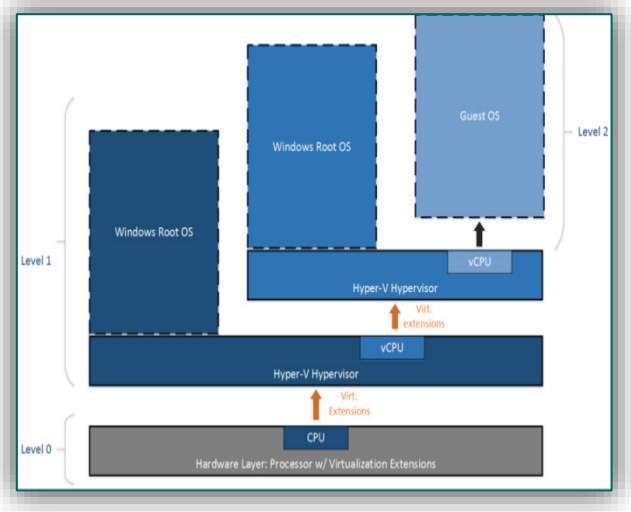

Figure 6. Nested virtualization [15]

The installed operating system on nested virtual machine was also Windows 10. Virtual hardware allocated to nested virtual machine was the same as virtual hardware of virtual machine on native Hyper-V. Performance testing was conducted using the same PassMark performance test tool of version 8.0, and in the same conditions as in previous tests.

Tests were performed for CPU, RAM memory and disk separately. Overall results considering all tests, as well as the performance of nested virtual machine compared to native Hyper-V and to physical host performance are shown in Figure 7. Blue color depicts performance of host, red color depicts native Hyper-V virtual machine, and green color depicts overall performance of nested virtual machine. It can be observed that the performance of nested virtualization were reduced by approximately 30% in CPU segment, 12% on memory and 2% on disk performance compared to native Hyper-V. This is no surprise considering that the nested Hyper-V was on virtualized host and it is not installed directly on the physical hardware. Although there is a significant drop in performance, especially in the CPU segment, this type of server virtualization may have significant usage in the server consolidation, administration and management of student laboratories, classrooms, etc.

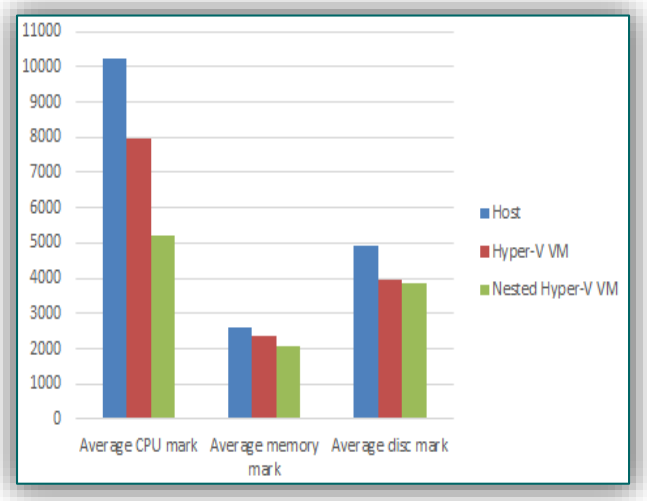

Figure 7. PassMark performance test compared overall results

However, when using virtualization, the attention should be paid to making a proper calculation of hardware resources needs and then perform the allocation of resources, taking into consideration needs of the individual virtual machine and available physical resources. That is a prerequisite in order to keep performance degradation at a minimal level. Also, it will not affect the working process in relation with system efficiency increase with virtualization. In the case that distribution of resources is not done correctly or has reached

maximum of hardware capabilities of the system, potential decrease in performance is possible, but these problems are the same for non-virtualized system.

CONCLUSION

Expansion and improvement of the hardware specifications in their production and use are permanent and all the leading companies engaged in the production of software have various virtualization tools. Although the virtualization can slightly decrease the performance of server systems, correct calculation of needs and correct selection of hardware, as well as correct assignment of resources to individual virtual machines can even increase performance in relation to non-virtualized system, with very significant lower overall cost. Hardware components are adapting for use in the virtual environment. Also, increasing number of IT service providers, as well as IT companies, and other growing companies have some form of server virtualization. Keeping all this in mind, as well as interest in virtualization technologies of all types of users, virtualization of server resources has a foreseeable future in the field of information technology. The continued expansion and improvement of virtualization tools for all IT platforms can be expected.

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INVESTIGATION OF THE INFLUENCE OF MAXIMAL CUTTING FORCE ON THE SHPINDLE STATIC STRENGTH OF A MILLING WOODWORKING MACHINE BY FEM

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Abstract: An investigation of the influence of the maximal cutting force on the stresses and strain distribution in a milling spindle with two bearing supports from five-operating woodworking machine KP400 with lower position and console V-belt pulley is carried out by the method of finite elements (FEM) with a CAD/CAE system. The real-acting maximal cutting force on the spindle F^{max} is the maximum cutting force acting on the most laded bit of the cutter and it is 2 times greater than theoretically calculated moment maximal cutting force P_{max}, namely $F^{max} = 2P_{max}$. The 3D milling spindle model was generated section by section with all elements of the real spindle and a static analysis of the spindle 3D model is performed with Autodesk Inventor Professional®. 1-st principal, 3-rd principal and Von Misses stresses, equivalent strains, resultant displacement and factor of safety distribution in the 3D spindle model are obtained and visualized. The results are compared with these for spindle loading with the theoretically calculated moment maximal cutting force P_{max}. Spindle loading with 2 times greater than theoretically calculated moment maximal cutting force causes increase of the stresses, strains and displacements values and reduction of the safety factor – as a result a danger of spindle failure exists. The finite element analysis results must be taken into account in designing of new milling machines with lower position of the spindle. It is recommended increasing of the spindle diameter in the place of the milling cutter location or lower location of the milling cutter and in this case the technological height can be adjusted by the lifting mechanism of the slide.

Keywords: cutting force, spindle, milling woodworking machine, static strength, FEM, CAD/CAE

INTRODUCTION

Primary influence on the strength dimensioning of the spindles of milling machines provide a cutting force acting on each of the bits of the cutting tool. This is the instantaneous maximum force calculated based on the average shear cutting, which is assumed to be the same for all bits (Grigorov, 1985).

In practice, the cutting force of the individual bits is different. The reason for this is the different radius of cutting for each of them. In a study of this force for two bits, the radius of one of which is greater by 0,01 mm has been found that it is two times greater for the one with the larger radius of cutting (Grigorov, 1985).

The reasons why you might get a difference in diameters of the cutting bits are: errors sharpening; radial run-out of the spindle, which according to BDS 3780:1985 is permitted to be within 0.02-0.04 mm; looseness in the fit between the spindle and cutting tool; precession movement of the cutting tool. The first three reasons listed above are geometric in nature and directly affect the radius of cutting the individual bits. Radial run-out of spindle, joint gap between the spindle and cutting tool and own unbalance of the cutting tool caused unbalance of the spindle unit (Vlasev, V., 2013), in consequence of which, in dynamic regime of idle and working stroke precession movement of the cutting tool is obtained. In this regard researches are known on the influence of unbalance of the cutting tool on the accuracy of processing with milling machines (Strenkovskii, 1967). It has been found that the machined surface in unbalance of the cutting tool larger than 17.10^{-5} kg.m is formed by one bit, wherein the location of the unbalance and the bit coincide. Opposite to him bit takes part in cutting but did not participate in the formation of the machined surface.

Other studies on the influence of the unbalance of the cutting tool on the cutting power show that, with its increase the cutting power decreases to 25%. It has been found that this is due to precession movement of the cutting tool. The trajectory, which

describes the geometrical centre of rotation is an ellipse, as a result of which the different bits have different radii of cutting (Vlasev, 1990). It follows that with the increase of imbalance the participation of bits in the cutting decreases, or some of them take smaller chips at the expense of others. The latter means that the cutting forces for them are different. The mentioned literature clearly shows that the strength dimensioning of the spindles of milling machines necessary cutting forces for individual bits are of different sizes corresponding to that in real cutting conditions. The precise determination of the magnitude of cutting forces on individual bits is not yet possible.

According to popular literature, hypothetically may be accepted following values for their size for cutter with four bits at the theoretically calculated moment maximal cutting force P_{max}, as follows: for the first cutter /side unbalance/ - $P_1 = 2P_{max}$; second - $P_2 = 0.5P_{max}$; the third - $P_3 = 0.2P_{max}$; and fourth - $P_4 = 1.3P_{max}$.

In determining the magnitude of the forces is according to their sum within a complete rotation of the cutting tool is constant, according to the formula $P_1+P_2+P_3+P_4=4P_{max}$. Each of these forces is of-phase compared to the previous of angle of $\pi/2$. According to the traditional modes of such dimensioning is necessary to select the maximal value, acting on the most loaded bit, namely $P_1 = 2P_{max}$.

The object of this study was to establish the influence of the maximum cutting force acting on the most laded bit of the cutter on the spindle static strength of 5-operating woodworking machine KP 400 with spindle lower position by the method of finite elements (FEM).

METHODS

Calculation scheme of the cutting spindle

A cutting spindle with two bearing supports (l=264 mm) from a 5-operating aggregate woodworking machine K5-400 with lower spindle position and console pulley is considered and 3D modeled. The 3D model of the cutting spindle is created with the modulus "Shaft Generator" of the program Autodesk Inventor® section by section with all elements of the real spindle – key slot, tread for fixing of the cutter, grooves for clip ring, wrench, chamfers, filets, center holes in both ends, etc. The sequence of creation of the 3D geometrical model of the cutting spindle is described in detail in our previous publication (Staneva and Vlasev, 2014).

The spindle is driven by an asynchronous motor with 3 kW power and revolutions of 2860 min^{-1} by a high-speed belt gear with gear ratio i=0.5. The cutting spindle is loaded with a torque and forces calculated according to Filipov, 1979 as pointed on the scheme of loading - Figure 1. The meaning and calculated values are given below in 2.2.

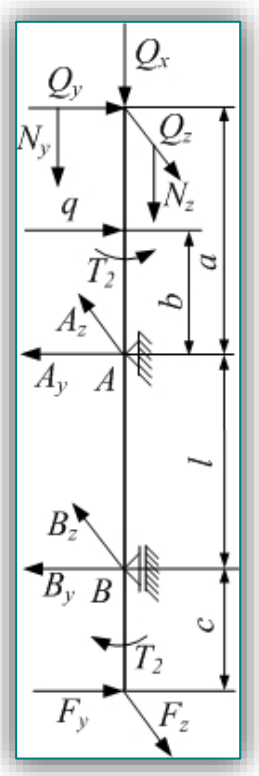

Figure 1. Scheme of loading of the cutting spindle

Static analysis

Recently, the modern CAD/CAE systems for 3D modeling and engineering analyses by finite element method (FEM) of the operating woodworking cutting mechanisms are widely applied (Chaitanya and Kaladhar, 2013; Gok et al, 2013; Marta and Corduta, 2010).

The static analysis of the cutting spindle 3D model is performed by the method of finite elements (FEM) with the CAD/CAE system Autodesk Inventor Professional® (student version) and it is described in detail in Staneva, Vlasev, 2014.

The material "Carbon Steel" was chosen with the following characteristics: yield strength $350 \cdot 10^6$ $N \cdot m^{-2}$; ultimate tensile strength $420 \cdot 10^6$ $N \cdot m^{-2}$; elastic modulus $2.0 \cdot 10^{11}$ $N \cdot m^{-2}$, shear modulus $7.75 \cdot 10^{10}$ $N \cdot m^{-2}$; Poisson's ratio 0.29; density 7870 $kg \cdot m^{-3}$. These characteristics are closest to the Bulgarian carbon steel brand 45 according BDS 2592:1971.

The fixing of the spindle in the 3D model was set: fixed.

The following loads according to the scheme of loads (Figure 1) were calculated and set for the simulations:

- torque, $T_2 = 5.01$ N·m;
- forces, initiating at cutting process, determined from maximal cutting force acting on the most

loaded bit of the cutter P^{max} and it is 2 times greater than theoretically calculated maximal moment force P_{max}: $P^{max} = 2P_{max} = 1368$ N and the maximum radial cutting force $R^{max} = 1368$ N (for milling cutter with 160 mm diameter and two cutters): $Q_x = 1963.62$ N – axial force along x-axis, sum of the components P_x, R_x and the mass of spindle and assembled parts; $Q_y = 632.46$ N – radial force directed along y-axis, sum of the components P_y, R_y and the centrifugal force from unbalanced moving masses; $Q_z = 1221.04$ N - radial force directed along z-axis, sum of the components P_z and R_z (a=73.5 mm); $N_y = 932.20$ N and $N_z = 932.20$ N – axial remote forces, received from the decomposition of forces P_x and R_x along the axes y and z and summation of corresponding components;

» force, with which the gauge is clamped to the guide roller: q = 616.82 N, radial force directed along the y-axis (b=50.0 mm);

» stretching forces from belt gear: $F_y = 31.5$ N – radial force directed along y-axis, which includes the centrifugal force from belt pulley unbalance because of fit inaccuracy; $F_z = 469.69$ N – radial force directed along z-axis (c = 38.0 mm).

Specified forces and torque are shown on Figure 2 in such a way as they are visualized by the system Autodesk Inventor Professional®.

Figure 2. Loading of the spindle

The following characteristics of the finite elements mesh were set: average element size 0.1; minimum element size 0.2; grading factor 1.5; maximum turn angle 60 deg; curved mesh elements; The created mesh for the model has 27184 numbers of nodes and 17618 numbers of finite elements. For the solver the following were set: maximum number of h refinements 3; stop criteria 10%; h refinements threshold 0.75.

RESULTS AND DISCUSION

Some of the results from the static analysis of the cutting spindle are represented on Figure 3 to Figure 8. In order to understand where deformation is occurring an exaggeration effect is provided with "Adjust Displacement Display" – Adjusted x 2 (Autodesk Inventor Professional®, Online User's Guide & Help Files).

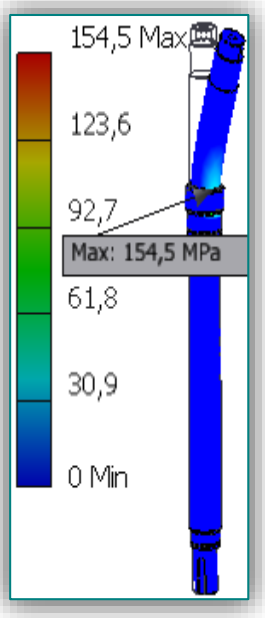

Figure 3. Distribution of the Von Mises stresses

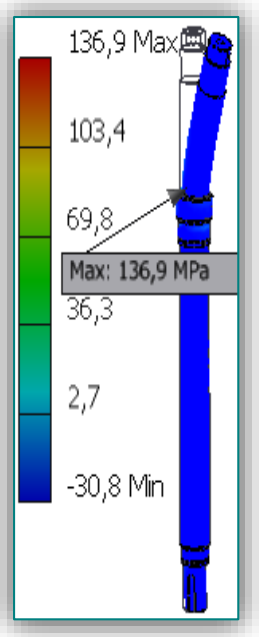

Figure 4. Distribution of the 1-st principle stresses

The distribution of equivalent Von Misses stresses in the cutting spindle 3D model is represented on Figure 3. The maximal value of $154.5 \cdot 10^6$ N·m^{-2} is received and localized near to the bearing shoulder "A" on the side of the cutter. In the same place the maximum $136.9 \cdot 10^6$ N·m^{-2} of the 1^{-st} principal stress (Figure 4) and maximal strain are received.

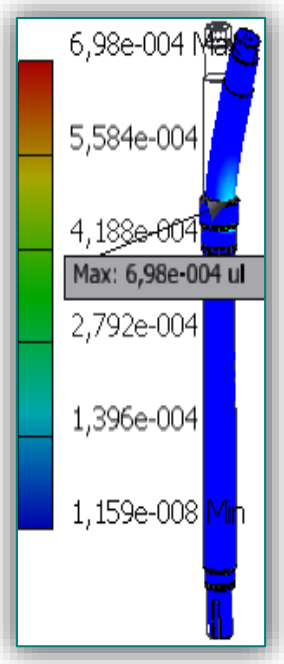

Figure 5. Distribution of equivalent strain

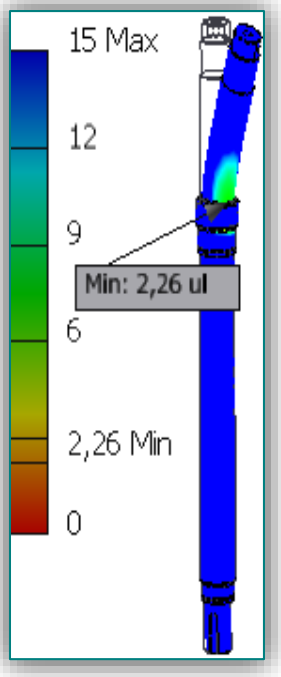

Figure 6. Distribution of factor of safety

The maximal equivalent strain 0,000698 (Figure 5) is higher than the allowable strain for shafts:

$$[f] / l \leq (0{,}0002 \div 0{,}0003).$$

A strength control for spindle failure was carried out. The program calculates the factor of safety as the ratio of the maximum allowable stress to the maximum von-Misses stress when using Yield Strength as a Yield Limit:

$$\text{Factor of safety (FOS)} = \sigma_{\text{limit}} / \sigma_{\text{vonMises}}$$

The distribution of safety factor (FOS) is shown on Figure 6. A minimal safety factor of 2.26 is received localized to the bearing support "A". The factor of safety is very close to 1, i.e. there is a potential danger of spindle failure.

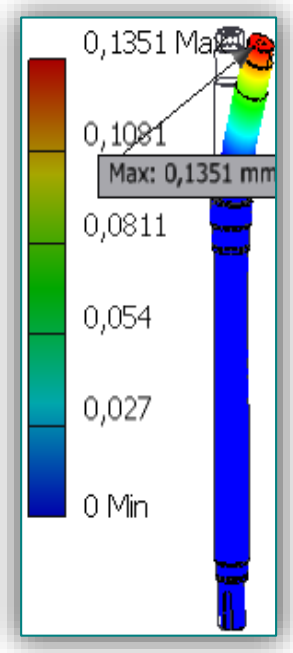

Figure 7. Distribution of resultant displacement

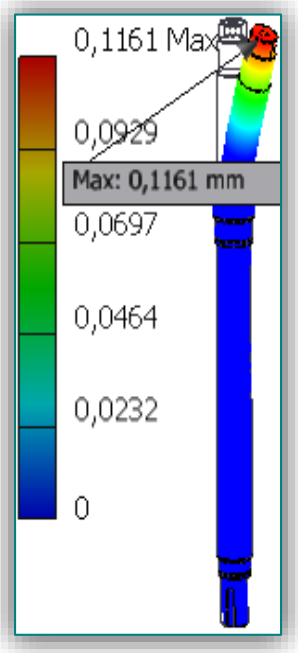

Figure 8. Distribution of *Z*-displacement

Table 1. Values of the maximal stresses, strains and displacements

Parameter	Max. values (for FOS – minimal)	
	I var.	II var.
Von Mises stress, $\cdot 10^{-6}$ N·m^{-2}	68.42	154.50
Ist principal stress, $\cdot 10^{-6}$ N·m^{-2}	67.42	136.90
3rd principal stress, $\cdot 10^{-6}$ N·m^{-2}	9.769	21.50
Equivalent strain, $.10^{-4}$	3.14	6.98
Factor of safety (FOS)	5.12	2.26
Resultant displacement, mm	0.05869	0.135
Z – displacement, mm	0.05816	0.116

Obviously, comparing the results of two variants of spindle loading, the doubled cutting force causes an increase of the stresses, strain and displacements values and reduction of the safety factor – as a result the spindle is threatened by a failure. The maximal values of the stresses, strain and displacements are localized in the same places as in the Ist loading variant.

With the help of modulus "Shaft Generator" of the program Autodesk Inventor® the distribution of "ideal diameter" along the spindle length was received setting the same material and loads – Figure 9. It is evident that in the place of cutter fixing (the most loaded section) a maximal spindle diameter of 30,4195 mm was calculated and offered by the program, that means the real spindle diameter of 30 mm in this location is lower and must be increased to avoid spindle failure in given loading conditions.

CONCLUSIONS

Received results from the static analysis by FEM of 3D model of cutting spindle loading with real-acting cutting force 2 times greater than theoretically calculated one causes increasing of the stresses, strains and displacements values and reduction of the safety factor. Having in mind that the dynamic loading was not involved in calculations shows that the spindle is at the limit of rupture. This must be taken into account in designing of new milling machines with lower spindle position and in the operation of existing ones. The received displacements at such loading of the spindle show that the roughness of the treated surfaces of parts will increase.

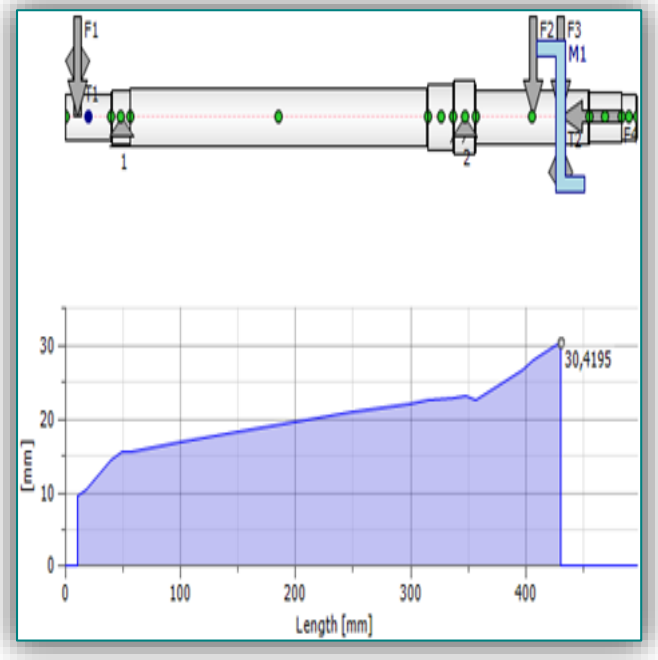

Figure 9. Distribution of "ideal diameter"

It is recommended for new woodworking milling machines with lower spindle position:

» To increase spindle diameter in the place of cutter fixing from 30 mm to 32 mm;

» The cutters to be fixed lower, near to the support and technological height can be adjusted by the lifting mechanism of the slide.

For existing woodworking milling machines is recommended not to load maximum to avoid any dangerous consequences.

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PROTECTION OF COMPUTER LABORATORIES IN EDUCATIONAL INSTITUTIONS

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Abstract: There are several technologies and methods for the security related design, management and maintenance of computer laboratories of educational institutions. In order to ensure the continuous availability and the proper maintainability it is crucial to protect the operating systems of the workstations as well as the whole network against internal and external attacks. Thus some kind of control and limitation of the internet based communication and network usage becomes inevitable. Besides, a well-structured, transparent, and secure system management can be obtained only through a central management approach. In this paper, we present some best practice methods and options applicable in case of computer laboratories; and thereafter we examine the current situation by analyzing the results of a comprehensive survey conducted in secondary schools of Kecskemét.
Keywords: IT security, computer laboratory, operating system protection, domain control, firewall

INTRODUCTION

Recently risk factors of computer laboratories of educational institutions have increased owing to the development of information technology and infrastructure [16]. A secondary school is a typical place where workstations, the interconnecting network, and other devices are exposed continuously to several threats. On a large scale, risks can be traced back to the students' malicious and random actions. However, external threats cannot be excluded either. In such situation it is important to interpret properly the need for protection on different fields of information technology, i.e. not only the hardware security has to be ensured but one should also cope with network communication and data security issues, as well as the vulnerabilities of the operating system have to be taken care of. Thus protection should be a priority in order to ensure the easy maintainability as well as the continuous availability of the workstations and the connected services.

There are several methods aiming the assessment of security risks, the reduction of the vulnerabilities resulting from configuration and management errors, and the avoidance of the possibilities of computer attacks. Cost is always an important factor that influences the procurement of tools and devices as well as the selection of applicable methods, especially in secondary schools. However, there are other aspects of security like the short and long time effects of a successful harmful activity that should be also taken into consideration before a decision. Besides, even when someone has a reduced budget there are always low-cost or even no-cost entry level options like introduction of a security focused attitude, definition of a proper computer laboratory usage policy, etc.

In this paper, we present the results of our research related to the available best practice solutions that could contribute to the implementation of a safe, secure, and well maintainable computer laboratory. In order to get a broader picture of the current situation a survey has been conducted in eleven secondary schools of Kecskemét. In the second part of our paper the results of this survey are analyzed in details.

The rest of this paper is organized as follows. Section 2 introduces the possible components of a multilevel security solution that can be considered as best practice. Section 3 gives a picture on the current situation by analyzing the results of the survey conducted in secondary schools.

COMPONENTS OF THE PROTECTION

Securing the physical access

Securing the physical access to the laboratories could serve as a first step towards the ideal

protection level of the laboratories. One can control the group of people entering a lab using possession based authentication like magnetic access cards, smart cards, key-fobs (Figure 1), etc. or knowledge based authentication such as a PIN number reader based solution (Rhodes, 2015)(Access, 2015)(Khosrow-Pour, 2014). The advantage of possession based authentication tools are that they are usually cheap and can be immediately disabled when they are stolen or lost.

Figure 1. Access control key fob (Proximity, 2016)

Access control systems (ACSs) make possible the screening of laboratory usage, easy automatic analysis of logs as well as restricting the access to specified time frames of a day (Bunyitai, 2011). Furthermore, these systems eliminate the need for easily duplicated keys. ACS management rights should be given to system administrators or the teachers supervising the laboratory. The physical access restriction based protection plays an important role in avoiding theft of hardware components like mice and memory chips as well as installation of unauthorized devices.

Protection of the workstations

The first and essential step towards securing the workstations of a computer laboratory is the password protection of the Basic Input Output System (BIOS) of the workstations. It is important because this is the place where the boot drive is configured and so it determines from which drive which operating system is started when the computer is switched on. Without a right protection anybody becomes able to modify the boot order and this can led to the possibility of booting from an external drive followed by an attempt on cracking the administrator password on the original system. When the workstation BIOS is protected by a strong password the attacker can be successfully hindered in modifying the BIOS setup. However, this protection can be evaded by removing the battery from the motherboard temporally that leads to the deactivation of the password. Therefore the password protection should be combined with physical protection of the chassis using stickers or more sophisticated tamper-evident technology (Tamper, 2016). Here usually a regular inspection is necessary in order to detect physical attacks against computers.

Figure 2. Tamper evident foil security sticker seals (Tamper, 2016)

Protection of the operating system

It is typical for school computer laboratories that students try to install a lot of applications, and modify the configuration in several ways partly led by curiosity partly thinking that it would make their work more comfortable, and of course malicious misconfiguration attempts are also possible. These activities result in a heterogeneously configured computer group and in slowing down the workstations. Both of these obstruct the effective teaching-learning process and therefore they should be avoided. The first step towards this goal is the proper user/group based sophisticated right and privilege allocation. Students should receive always only those (restricted) rights which are necessary for their learning activity. System configuration abilities should be given only to the staff responsible for system administration.

The only exception to the above mentioned rule is the case when the topic of the subject taught is the system administration itself. In this case an automatic mechanism is necessary, which ensures that after a system administration class everything is brought back to its normal (initial) state. The basic idea is that before starting the semester system administrators create the desired configuration and they define a so called restore point. After finishing the class that resulted in modifications of the configuration everything is returned to the state stored as restore point. It can be done by using the Windows built-in System Restore functionality (What, 2009) or using specialized software like Deep Freeze (Fig. 3) (Deep, 2016). In the first case the restoration effects only the system files and

settings and it has to be started manually, while in the case of the second solution after a reboot all changes are removed from the protected partition and the computer is returned to its original "frozen" state. In the latter case the students only need to shut down the computers at the end of each class.

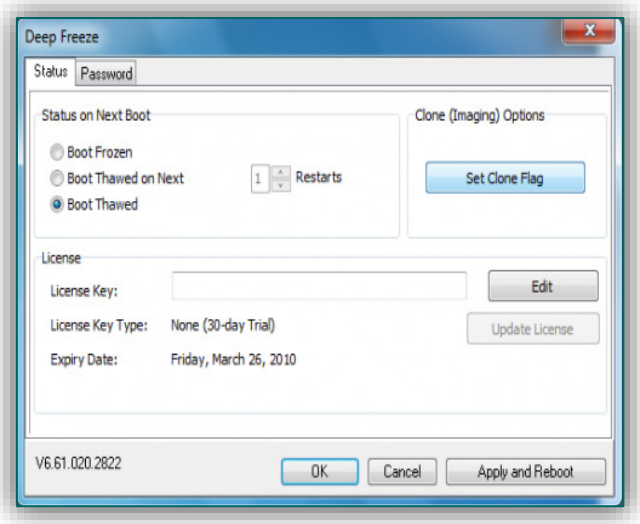

Figure 3. Deep Freeze configuration (Deep, 2016)

Centralized system

In case of a big number of users and workstations system administrators are not able any more to manage operating systems, user rights, and data security locally. These tasks can be solved efficiently only by applying some kind of centralized management that helps the simplification and automatization of several recurring tasks. A centralized management always has a hierarchical client-server structure. User accounts and different restrictions, like rules, policies, logon time limits, privileges, etc. are stored in a central database. In case of Windows based systems this database is called Active Directory (AC) (Thomas, 2014) while in case of Linux based systems OpenLDAP (OpenLDAP, 2015) and Samba 4 (Samba, 2016) based solutions are mostly used. Most of the secondary schools have computer laboratories equipped with workstations running Windows operating systems. Therefore, further on we will focus only on Windows based solutions and best practices. In this scenario the server machine hosting and maintaining the central database is called a Domain Controller (DC) and all the computers, which use the AC have to join the domain.

Thus most of the management task done by system administrators has to be carried out on a DC, and also a DC is responsible for the authentication of the users. Tools like Group Policy (GP) make possible for system administrators to control security settings of the operating systems of workstations in a centralized manner configuring it only once and applying it for all concerned machines automatically. For example one can deny all access to removable devices or media with only one GP setting (Thomas, 2014). Similarly one can control the appearance of the Windows Desktop and the availability of different software and Control Panel services as well.

File server and domain based centralized data storage is the key for an easy configurable and maintainable folder access permission system. Besides, it could also be very advantageous for computer laboratories because it facilitates the creation of failsafe storage as well while workstation based user folders can be backed up only in a complicated and more time consuming way. Moreover, if a partition protection based system restore solution is configured on workstations one should put the user folders on a separate partition anyway in order to avoid the deletion of user contents whose persistence is required. Furthermore, the implementation of a systematic backup scheme is also facilitated. The typical backup types are presented below (Backup, 2012).

» Full backup – all the selected files and folders will be backed up.
» Differential backup – all the files and folders that have been modified since the last full backup will be backed up.
» Incremental backup – all the files and folders that have been modified since the last backup will be backed up.

Protected network

Firewalls are standard components of the protection system of an IT infrastructure aiming the prevention of unauthorized access to or from a network. There are hardware, software, and combined implementations for this task. Firewalls control the type of incoming and outgoing traffic by filtering the transmitted data and blocking those data packets that do not meet the specified security criteria (Gattime, 2016). Usually only that incoming traffic is enabled to enter the protected (internal) network which is a response to a query sent from the internal network.

The filter functionality is based on the definition of Access Control Lists (ACLs) that specify which kind of traffic can be enabled or should be denied (CCNA, 2012). An ACL contains at least one command but it can comprise several hundreds of them as well. The commands are executed on the order they were specified. Basically there are three types of ACLs (Configuring, 2007):

» Standard – this is the simplest one, it does the filtering based on source IP address and they are applied to an interface (inbound or outbound).

» Extended – beside the source IP address it takes also into consideration the destination IP address, the protocol, and the port numbers.
» Named – it is a standard or extended ACL where a name can be used for the identification of the ACL instead of memorizing numbers.

For example it is important to avoid the overload of the school network due to unnecessary file swapping and downloads. A simple ACL can deny the FTP access of the students.

Here the whole FTP traffic (ports 20 and 21) is denied in the local network 192.168.1.0/24. Thus the existence of a firewall in case of a school network is an essential requirement from a security point of view. It can contribute to an efficient traffic filtering management and it can ensure the simple separation of the laboratory network from the staff network. Furthermore, the analysis of the network traffic logs created by firewalls can also give clues for the improvement of the applied protection measures.

Computer laboratory usage policy

A computer laboratory usage policy defines when, how and by whom laboratory resources can be used. Its positive effect is that it creates a clear situation by defining possibilities and boundaries. Usual elements of this rule collection are prohibitions of

» interfering with cables and laboratory equipment;
» illegal downloading, file swapping, and copying;
» usage of the equipment for non-scholarly purposes;
» software installation by students;

as well as the regulation of

» availability to students for drop-in use when classes are not in session;
» printing and the related billing;
» how a software installation can be requested by a teacher;
» responsibility disclaimer for lost, damage or theft of personal items left unattended in the labs.

SURVEY ON THE CURRENT PRACTICE

The main aim of our survey was to get a broad picture of the protection level of computer laboratories in secondary schools of Kecskemét. We were wondering which components of the above presented best practice measures are in fact used in everyday practice. The diagrams presented in Figures 4-15 show the results of the evaluation of the questionnaires representing the positive answers with blue and the negative ones by red, respectively. The responses given to the questions related to the physical protection and the protection of the workstations show that about one out of four or less school exploits the cheapest available security options like ACSs and password protection of the BIOS (see Figure 4 and Figure 5).

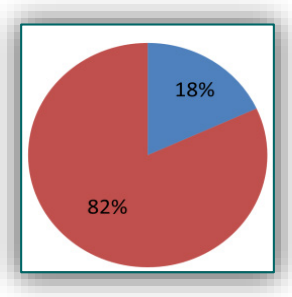

Figure 4. Do you use any kind of lab access control system?

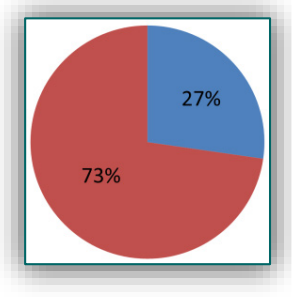

Figure 5. Is the BIOS of the workstations password protected?

However, one can clearly recognize the presence of the security awareness aiming the protection of the operating system and the stored data. The vast majority of schools utilize the built-in security services like authentication mechanisms and automatized partition/folder restore (see Figure 6 and Figure 7).

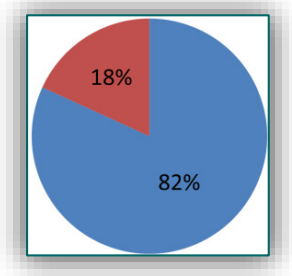

Figure 6. Do the users need login credentials in order to log into the workstations?

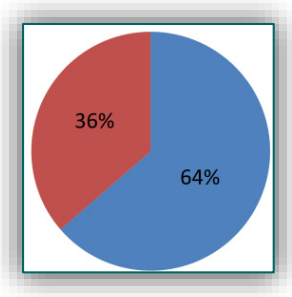

Figure 7. Did you configure a folder or partition based restore solution?

Surprisingly most of the institutions opted for a centralized management despite its significantly higher costs (see Figs. 8 and 9). These systems are mainly based on Microsoft's Windows OS family.

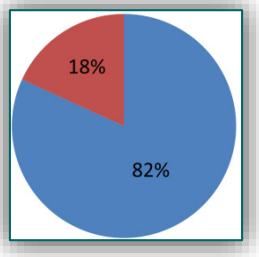

Figure 8. Do the workstations belong to a domain (DC supervised system)?

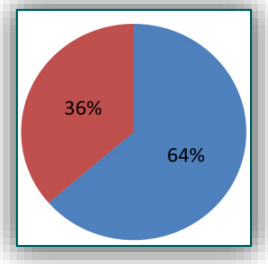

Figure 9. If there is a domain system implemented do you use group policies for workstations and users?

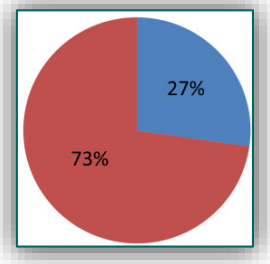

Figure 10. Is denied the access to any external hardware devices (e.g. USB disk)?

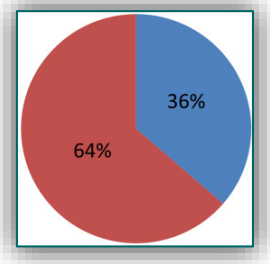

Figure 11. Do you have a backup scheme for the file server?

Although they offer a wide range of security strengthening service only a relatively small amount of them is applied in practice. For example useful and simple-to-configure services like the denial of access to external drives or file server backup schemes do not belong to the applied security measures in most of the cases.

Apparently network protection gets an increased attention, almost three out of four institutions created separate security zones for the laboratory networks and the institutional network. However, 27% of them do not even have a firewall which results in a high risk of cyber-attacks.

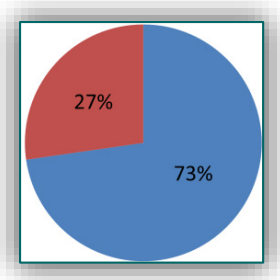

Figure 12. Is the institutional network separated from the network of the labs?

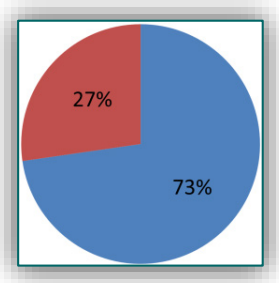

Figure 13. Does your LAN have a firewall?

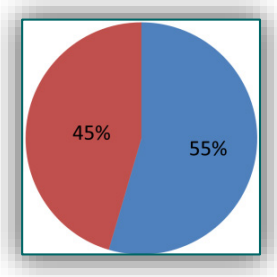

Figure 14. Is there any documentation about your institutional network and IT system?

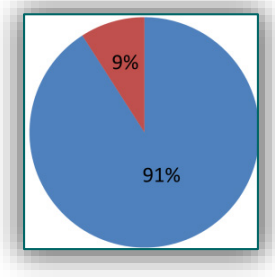

Figure 15. Do you have a usage policy for the computer labs?

More than half of the schools recognized that having a proper documentation of the administered network can significantly simplify the maintenance and troubleshooting activities. Although computer lab rules and policies usually are not very popular between students but almost all of the schools found

them to be an indispensable component of the security infrastructure.

CONCLUSIONS

Analyzing the results of the survey one can clearly recognize the existence of security awareness of the institutions in some fields. They strive for the protection of their IT systems but they do not embrace all the available options. Some examples supporting this conclusion are enlisted below.

- Applying group policies but not denying the access to external hardware devices.
- Creating centralized data storage but lacking in systematic backup.
- No emphasis on physical protection of the rooms and workstations despite the promise of the most cost-effective solution.
- Missing computer laboratory or IT system documentation.

Summarizing the experiences we can state that secondary schools should have an increased focus on information security in order to protect the infrastructure and the students as well. There are always reserves whose exploitation could lead to an improved level of security without significant cost increase.

Acknowledgements

We thank system administrators and teachers of secondary schools of Kecskemét for supporting our work by filling out the survey, which made us possible to get a picture about the current regional state of computer laboratory security.

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DEVELOPMENT OF LEARNING MANAGEMENT SYSTEM IN NIGERIAN TERTIARY INSTITUTIONS

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Abstract: This paper discusses the development of a model for a customized learning management system in a Nigerian Tertiary Institution. It reveals the effects, benefits and challenges in the relationship between information and communication technology and modern education system. The E-learning portal was specifically developed and tested on Personal Computer systems and handsets in line with its set goals which are to ensure flexibility and collaborative efforts.
Keywords: Learning Management System (LMS), E-learning, Information and Communication Technology

INTRODUCTION

Learning Management System (LMS) - The backbone of E-learning

Learning Management System can be defined in various manner and perspectives. According to Aboderin (2013), Learning Management System is defined as a global term for a computer system specifically developed for managing online courses, distributing course materials and allowing collaboration between students and teachers. E-learning is defined as the acquisition of knowledge and skill using electronic technologies such as computer or mobile devices and internet-based courseware. According to Microsoft Encarta Encyclopedia (2009), Distance Education, involves methods of instruction that utilize different communications technologies to carry teaching to learners in different places. A LMS allows the management of every aspect of a course, from the registration of students to the storing of test results, as well as allowing the teachers to accept assignments digitally and keep in touch with the students. In essence, the LMS is the backbone of most e-learning activities.

The Role of Information and Communication Technology in Nigerian Educational System

ICT in education implies the implementation of ICT equipment, strategies, techniques and tools in teaching and learning process as a media and methodology. The specific objective of ICT in education is to expose students and teachers to the use and operations of computers and internet infrastructures. Professor Ajayi, G. O. of OAU, Ile Ife, Nigeria, shared the multi-purpose application of ICT as he put it "ICT is now regarded as a Utility such as water and electricity and hence has become a major factor in socio-economic development of every nation". Tinio (2002) noted that ICTs are powerful enabling tools for educational change and reform. When used appropriately, helps expand access to education, strengthen the relevance of education to the workplace, and raise educational quality by creating an active process connected to real life.

SYSTEM DESIGN

Osun State College of Technology Electrical & Electronics Engineering E- Learning Portal was designed to deliver digital, reliable, seamless, time controlled exam and testing, collaborative learning Management System to the students and lecturers in the department. Apart from that, the E-Class has some features which are spelt out below. There are 20 pedagogical tools included in the E-Class as shown in Figure 1 below.

Registration

There are 9 predefined user profiles namely Students, Tutors, Teachers, Coaches, Session coaches, Session managers, HR director, Portal administrator and Global administrator. These features are available for easy and flexible online registration for different categories of users. We deliberately disabled these features owing to student's attitude using fictitious name and identity. We created login details and customized emails for both lecturers and students using some relevant identities like surnames and matriculation numbers.

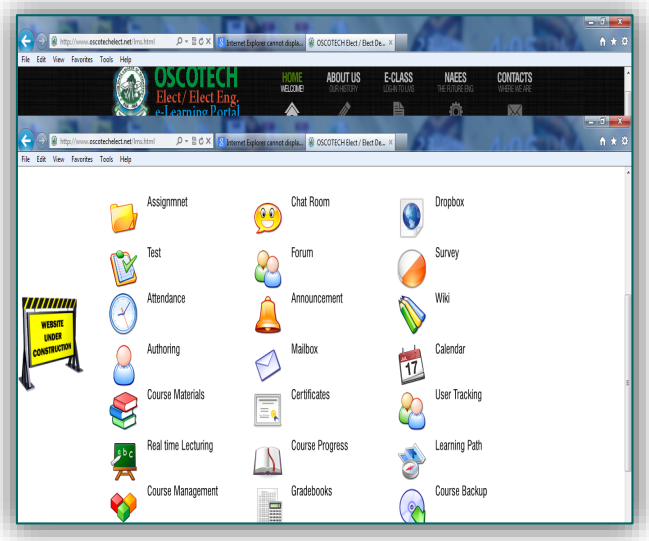

Figure 1: Screenshot of the E-Class tools

User management

Figure 2 below shows the page that is opened when the "E-CLASS" icon at the top of the webpage (http://oscotechelect.net) is clicked. This is the page where users can login with their username and password in order to access the portal.

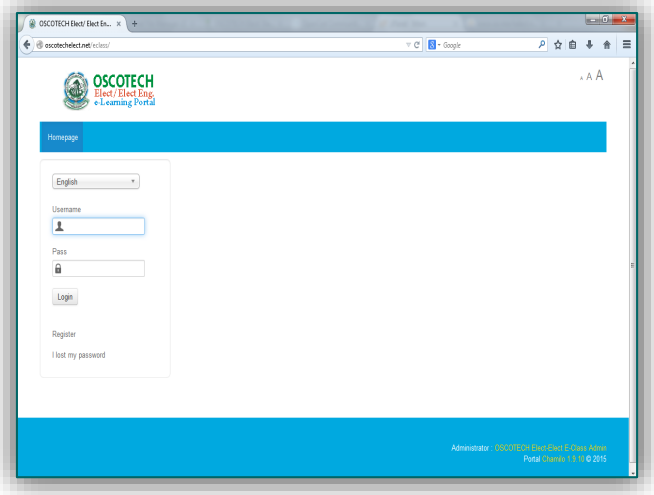

Figure 2: User login page

Courses management

Figure 3 below shows the page displayed when a user logs in. It displays the courses thought by the lecturer, manages courses and also gives him access to his department mailbox. Clicking on any course, Figure 4 which is the Lecturer's dashboard is displayed where he can produce course description/content, upload course materials, make announcements, set tests for students, take attendance, assess students' performance, chat, give assignments, take surveys, produce report on students' performance, set personal agenda, etc. Figure 5 displays the course description/content while Figure 6 displays the course materials or documents uploaded.

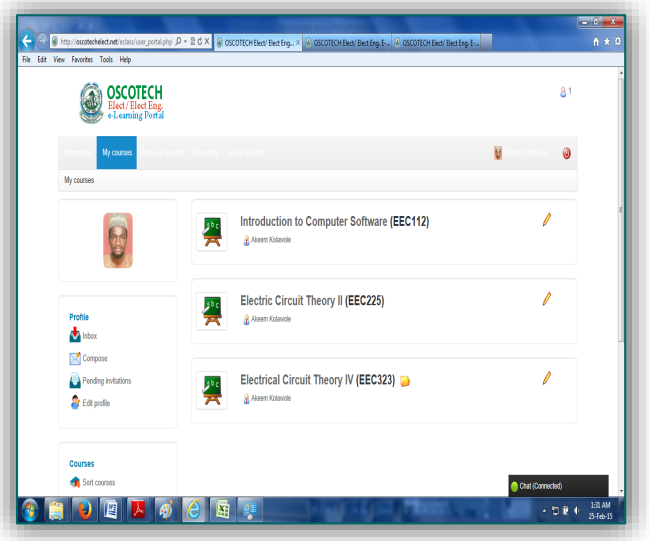

Figure 3: User homepage displaying courses thought

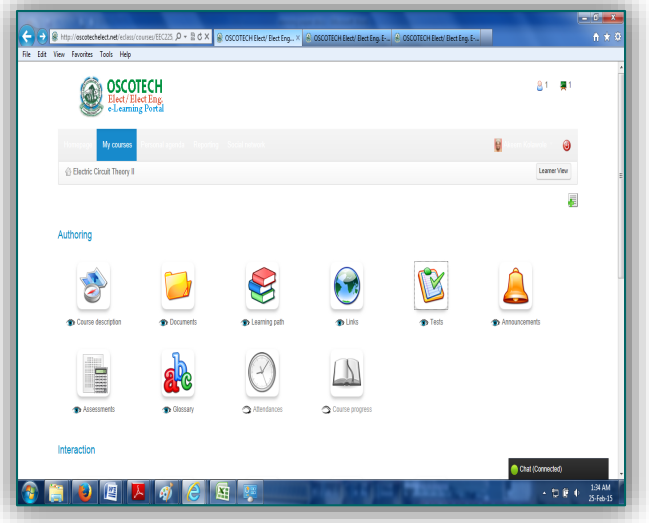

Figure 4: Lecturer's dashboard

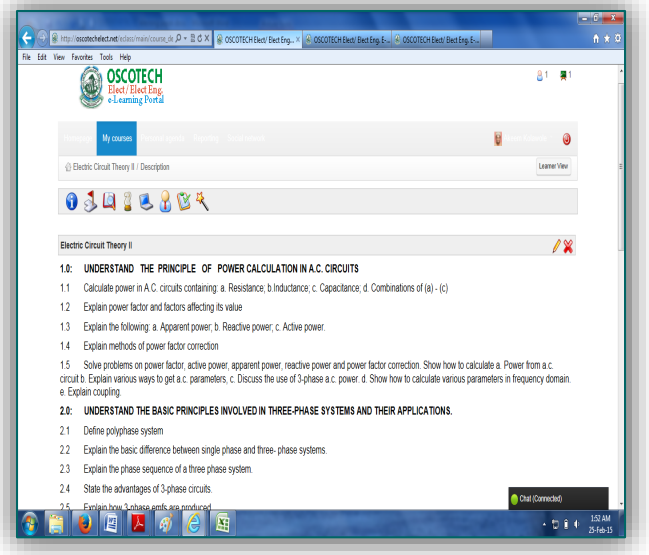

Figure 5: Course Description page

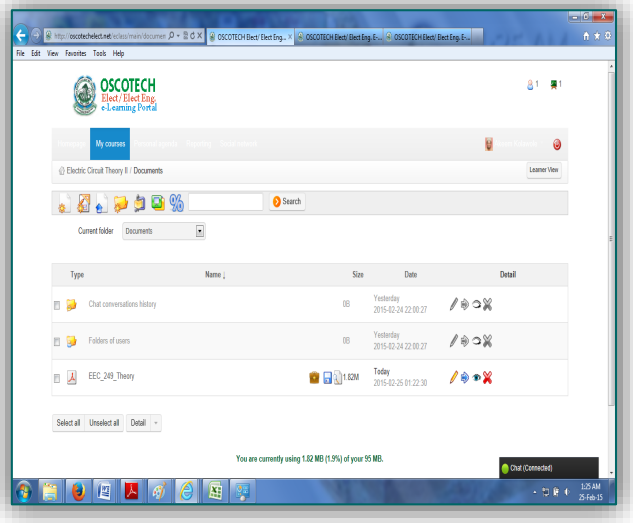

Figure 6: Course Materials/Document page.

Figure 7 shown below is the student's homepage displaying the list of courses offered by the student and also give access to his personal email and profile while Figure 8 shows the student's dashboard that displays all the tools that are available to the students like documents, assignment, announcements, tests, etc.

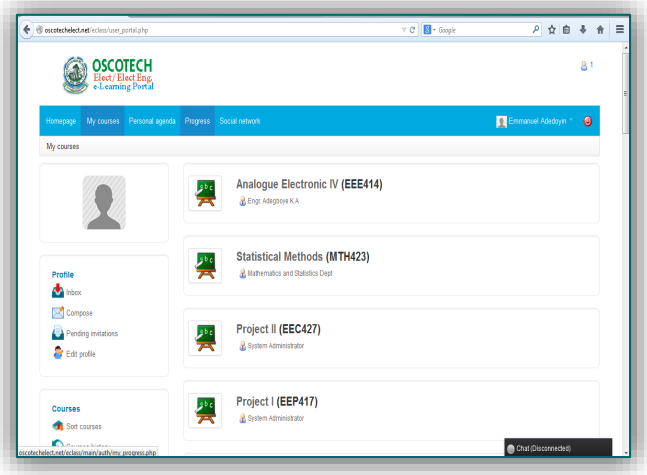

Figure 7: Student's Homepage

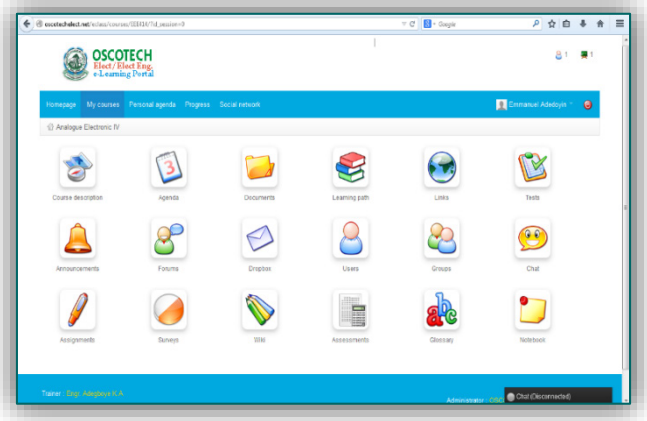

Figure 8: Student's Dashboard

ADVANTAGES OF LEARNING MANAGEMENT SYSTEM

Some pertinent advantages include Reduced overall time and cost, which is the single most influential factor in adopting e-learning. Also, Consistent delivery of content is possible with asynchronous, self-paced e-learning. Furthermore, Expert knowledge is communicated, but more importantly captured, with good e-learning and knowledge management systems. Self-pacing and On-demand availability enables students to complete training conveniently at off-hours or from home. Likewise proof of completion and certification can be automated.

THE CHALLENGES

There are lots of factors militating against the full implementation of Learning Management System in Nigerian Higher Institutions and these have affected the mode of delivery of knowledge and also, our curriculum is not yet ICT compliant and/or enhanced. Other factors are inadequate numbers of standard computers and its auxiliary devices, epileptic power supply, problems of internet network failure, lack of proper ICT knowledge/skills, difficulty in integrating ICT to instruction, scheduling computer time, inadequate software, insufficient teaching time, lack of qualified ICT and maintenance personnel and huge cost of equipment,

CONCLUSION AND RECOMMENDATIONS

The effect of integration of ICT into Nigerian Educational System is unquantifiable and it cuts across all tiers of the system, from primary school level to higher institution. It has greatly helped in the administration and instruction in line with Nigerian Educational System. Agbetuyi (2012) highlighted that the National Policy on Education (FRN) as revised in 1988 and 2004, re – emphasized the need for the integration of ICT in the Nigerian educational system. This is an acceptance of the need to go beyond computer to the level of ICT also the need for infrastructure.

Three major objectives, among others were emphasized in the Nigerian National policy for Information Technology (FRN, 2001). These are to empower youths with ICT skills to prepare them for competitiveness in a global environment, integrate ICT into the mainstream of education and training and establishment of multifaceted ICT institutions as centers of excellence of ICT. To achieve these objectives, nine major strategies were outlined. These include making ICT compulsory at all educational institutions, and developing ICT curricular for all levels of education. Furthermore, ICT companies should invest in education by giving study grant and scholarships on ICT. Government should organize 'Training the trainers' scheme for

youth corps members on ICT establish public dedicated ICT institutions. Working with international and domestic initiative to transfer ICT knowledge will facilitate the development of learning and E-Learning in our Higher Institutions.

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APPLICATION OF THE PSYCHOACOUSTICS AND BINAURAL MEASUREMENT FOR THE SOUND QUALITY VALUATION OF THE PRODUCTS

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Abstract: The acoustic properties of the products or characteristic sounds become important factor for customers. Aim of this article is to describe term psychoacoustics as well as more closely specify used equipment for an evaluation of acoustics parameters of products. Results of the psychoacoustic analysis show characteristics similar to human hearing and offers possibilities for objective valuation of sound quality. The most effective tool for psychoacoustic measurement and analysis is binaural measurement technique – artificial head. Artificial head have two ears that are positioned at about equal height at the two sides of the head.
Keywords: psychoacoustic, binaural measurement, sound, noise

INTRODUCTION

Humans, like most vertebrates, have two ears that are positioned at about equal height at the two sides of the head. Physically, the two ears and the head form an antenna system, mounted on a mobile base. This antenna system receives elasto-mechanical (acoustic) waves of the medium in which it is immersed, usually air. The two waves received and transmitted by the two ears are the physiologically adequate input to a specific sensory system, the auditory system.

Specifically, it is the biological role of hearing to gather information about the environment, particularly about the spatial positions and trajectories of sound sources and about their state of activity. Further, it should be recalled in this context that interindividual communication is predominantly performed acoustically, with brains deciphering meanings as encoded into acoustic signals by other brains.

BINAURAL MEASUREMENT TECHNOLOGY

The aim of the artificial head measuring technique is, to get apart from the conventional possibilities of the evaluation, acoustic data with which the actual situation at the item under test is at any time callable.

The noise analysis ability of the hearing is not attainable, respectively replaceable by any analysis. So that the noise analysis with the hearing functions, it needs a binaural input signal. This is made available with the help of the artificial head measuring technique.

In air with 20°C, the speed of sound amounts to 334 m/s. The human hearing is available to recognize very small time differences. If a sound event arrives somewhat earlier at the left as at the right ear, the event is noticed left.

The localization of an acoustic source is made possible particularly by binaural hearing. The human brain evaluates the differences between the signals at the left and at the right ear and determines the direction of the acoustic source. Relevant parameters for detecting the direction are run time differences and level differences between the ears.[4,6]

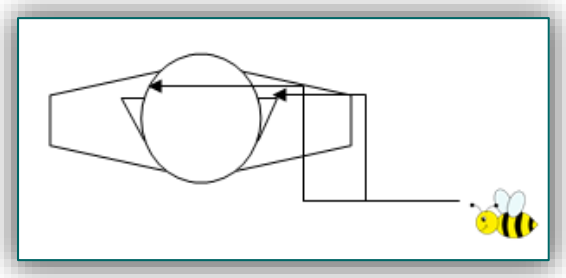

Figure 1. Human ear as analyzer (run time differences and level differences between the ears)

COMPARABILITY BETWEEN CONVENTIONAL AND BINAURAL MEASURING TECHNIQUE

The four important characteristics of the human hearing:

1. The external ear is an direction filter. The sound pressure will be influenced in the range +15 to 30 dB.
2. The human hearing has two entrances:
   ⇒ binaural signal processing,
   ⇒ sound localization, selectivity, squelch.
3. The psycho-acoustics of the hearing determines the noise impression: loudness, sharpness, roughness and tonality.
4. High resolution of the hearing in the amplitude, frequency and time interval.

Hardly anybody would evaluate a sound with closed ears. However, this is still common practice for conventional acoustic and vibration measurements. Recordings with conventional measurement microphones are not suited for an aurally - accurate evaluation of an acoustic scenario, because substantial acoustic information such as the spatial array of sound sources and the selectivity of sound perception gets lost. [2, 4]

Monaural technique (measuring with microphone figure 1):

» recording with a precision microphone,
» not all information are included,
» recording of the sound pressure on just one point.

Binaural hearing cannot be simulated by simply using two measurement microphones as "ear replacements". Only after having taken the acoustic filter characteristics of the head and ears into account, do aurally-accurate, unaltered recordings become possible. [2]

Binaural technique:

» recording with an artificial head (Figure 2),
» more close to the function of the human hearing,
» makes all information e.g. for the direction hearing available.

The binaural measurement system is a stand-alone, mobile measuring device that is ready to perform aurally accurate binaural recordings immediately after powering up. The patented artificial head geometry offers [4]:

» a mathematically describable reproduction of the human head and shoulder geometry,
» an accurate reproduction of all acoustically relevant parts of the human outer ear.

Meaning of the binaural signal recording:

» binaural hearing makes it possible to detect directions,
» reducing of disturbance noise and of reverberate,
» disturbance noise and utilizable sound can be separated more easily,
» selective hearing,
» binaurale loudness depends on the position of the acoustic sources,
» the human head changes the sound field; a sound source on the left or right side is louder than if it comes from the front.

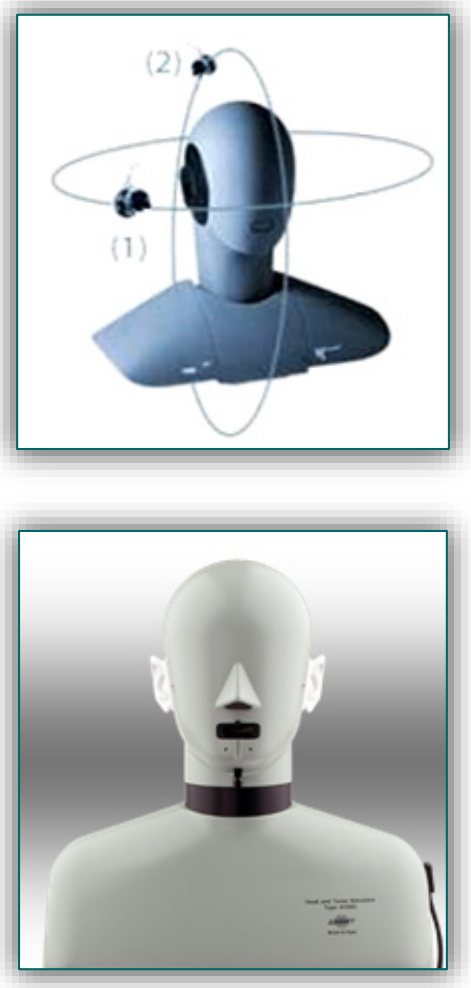

Figure 2. Binaural measurement system – artificial head (Head acoustics and Brüel & Kjær) [4, 5]

SOUND QUALITY AND PSYCHOACOUSTICS METRICS

Generally speaking most working definitions include the concept of the audible suitability of a product when compared with a user's expectation. Sound quality testing is an important design concept in the automobile and audio industries. Marketing studies in these areas can demonstrate a relationship between sound and non-auditory concepts e.g. luxury, power, speed, safety, expense [3] making the sound of a product an important design consideration. There are a large number of metrics, some of which are well defined and others which are not. Very few have been standardized and the usefulness of a particular metric is dependent on the nature of the sound being tested. he majority of sound quality metrics can be divided

into those that quantify some physical aspect of the sound (e.g. pressure level, frequency content) and those that try to quantify some physical effect taking place in the ear (e.g. impression of loudness, tone etc.)

Some frequently used metrics are: roughness, sharpness, loudness, fluctuation strength, tonality.

Figure 3. Binaural measurement of washing machine sound

CONCLUSION

Aurally accurate listening and simultaneous watching the analysis results, leads to detecting of certain noise components.

Characteristics of aurally-accurate measurement:

- recording of noise in the same way as the human hearing,
- analysis comparable to the human signal processing,
- subjective and comparative evaluation is possible,
- reproduction of the selectivity of the hearing,
- manipulation and synthesis from sound events can be used for forecast of modifications,
- documentation of original acoustic events,

Binaural measurement system is very good applicable in these sectors:

- Examination and optimization of the sound quality of technical products: motor vehicles and car components, domestic appliances, office machines and power tools,
- binaural measurements in product development and quality control,
- sound design and product optimization.

With the help of the binaural measurement and analysis the parameters of the noise can be detected (frequency, range, strength, etc.). With this information, with these data then e.g. activities can be seized to reduce unpleasant noise parts and all of these could be used for development of new products.

Acknowledgement

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TEMPERATURE DEPENDENCE OF SOLAR CELLS' EFFICIENCY

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Abstract: The solar panels which produce electric energy directly from the solar radiation are widely used in residential applications. The principle of operation of these is quite simple, and there is no need for expensive and complex auxiliary equipments. Alongside its advantages, its biggest disadvantage should be mentioned as well: the relatively low efficiency, which is affected by several factors, for example the cell's temperature. In this paper the investigation of the effects of temperature is presented.
Keywords: solar energy, photovoltaic cells, efficiency, effects of temperature

INTRODUCTIONS

Like most of semiconductor devices, the operating parameters of the solar cells are influenced by theirs temperature [1]. The regarding literature describes the relationship between the solar cell's electrical parameters and the temperature (1), (2), (3), (4), [2].

$$I_{SC} = K \cdot E \,, \tag{1}$$

$$V_{OC} = \frac{k \cdot T_{cell}}{e} \cdot \ln\left(\frac{I_{SC}}{I_s} + 1\right), \tag{2}$$

$$I_s = qN_D N_A \left(\frac{D_p}{L_p N_d} + \frac{D_n}{L_n N_a}\right) exp\left(-\frac{E_g}{kT_{cell}}\right), \tag{3}$$

where: I_{SC} – short-circuit current [A]; V_{oc} – open-circuit voltage [V]; T_{cell} - the solar cell's temperature [°C]; P - the solar cell's electrical power [W]; φ - fill factor [-]; I_s - the saturation amperage [A], E-solar radiation intensity $\left[\frac{W}{m^2}\right]$, K-proportional factor (the solar module's specific) [-].
We can see that the increase of the temperature causes a reduction in the voltage. The changes in the amperage are negligible.

$$P = V_{OC} \cdot I_{SC} \cdot \varphi \,, \tag{4}$$

$$\eta = \frac{A \cdot E}{P} \cdot 100\% \,, \tag{5}$$

where: P - the solar cell's electrical power [W]; φ - fill factor [-]; A - the solar modul's effective surface [m^2]; η - the solar module's efficiency [%].

Based on (2), (4), (5), formulas we can say that: at higher temperature the solar module produces less power so its efficiency decreases.

DETAILS OF MEASUREMENT

In this workthese physical phenomenons were investigated in laboratory conditions. First of all we had to create the measurement equipment.
The type of the investigated small scale polycristalline modul was Korax Solar KS-85. The solar radiation was substituted with eight pieces of halogen bulb reflectors, with electris power of 300W each. Figure 1 shows the dispersion of light intensity caused by the illuminance.

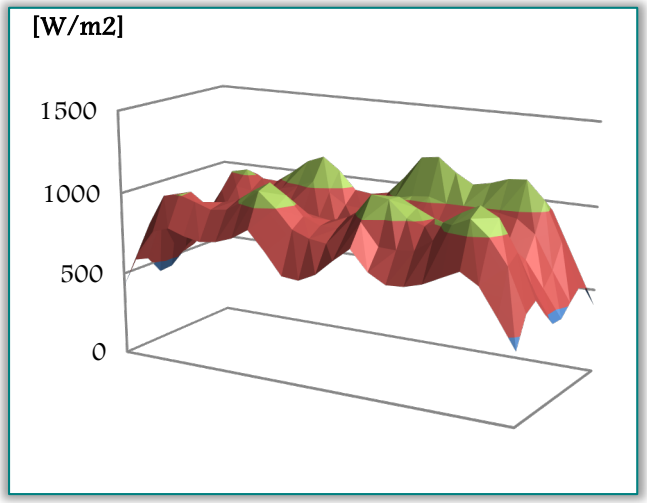


Figure 1. The dispersion of light intensity

The next important question was this: how can we influence the solar module's temperature? A channel was created below the solar panel, where cold air was then circulated. Over and above, the

solar surface of panel was cooled down with a fan. Without cooling, the temperature of the solar module has reached about 80°C. By combining the two cooling systems it was possible to stabilize three solar module's temperatures: 65°C, 40°C, 30°C. The surface temperature was measured by a YC-747D - type digital thermometer in four points. The measuring arrangement is presented in figure 2.

Figure 2. The illuminated PV module and the cooling system

RESULTS OF MEASUREMENT

First of all the „transient temperatures" measurements were performed, where we constantly modified the temperature while the open-circuit voltage and the short-circuit current were measured. We know that the theoratical electric power can be calculated by using the formula (6), [3].

$$P_{th} = V_{OC} \cdot I_{SC} \quad (6)$$

So the changes in the temperature and the electric power were followed, and were illustrated on a graph. (Figure 3)

This experiment demonstrated how the theoritical power changes due to the temperature changes. It can be observed if the solar radiation is constant, the warmer PV module produces less power.

Tests at constant temperatures

In this case, we stabilized the temperature of PV module and a variable electric resistance was connected to the output wires. The value of resistance was changed whilemeasurement of the voltage and the amperage was carried aut. Figure 4 shows the voltage-amperage characteristics in case of four constant temperatures.

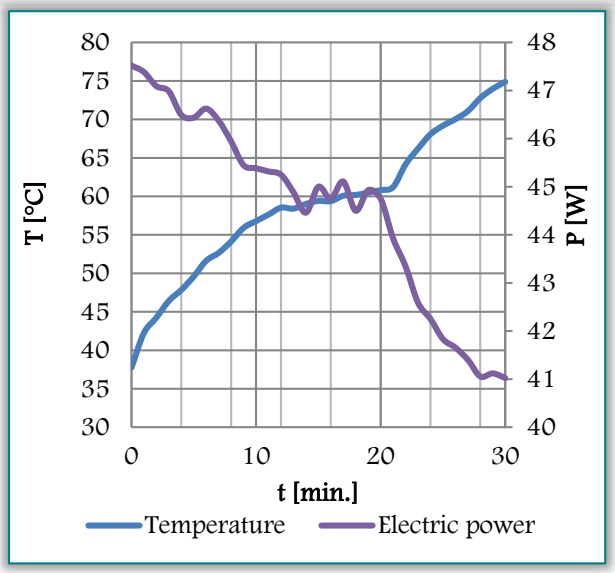


Figure 3. Relationship between the temperature and the power as a function of time

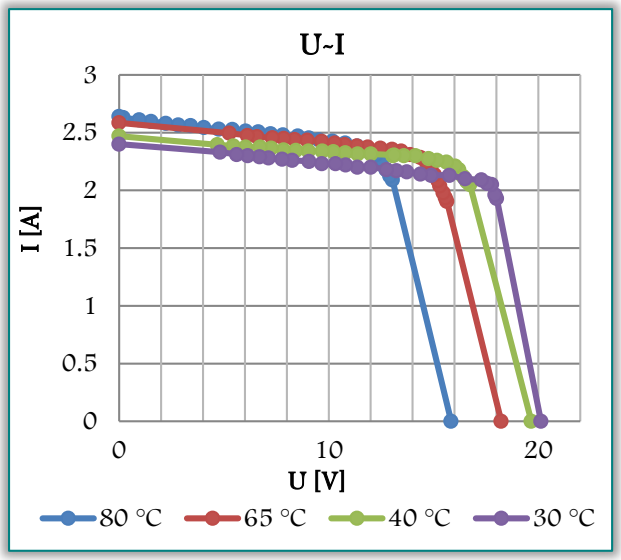


Figure 4. U-I characteristics in different temperatures

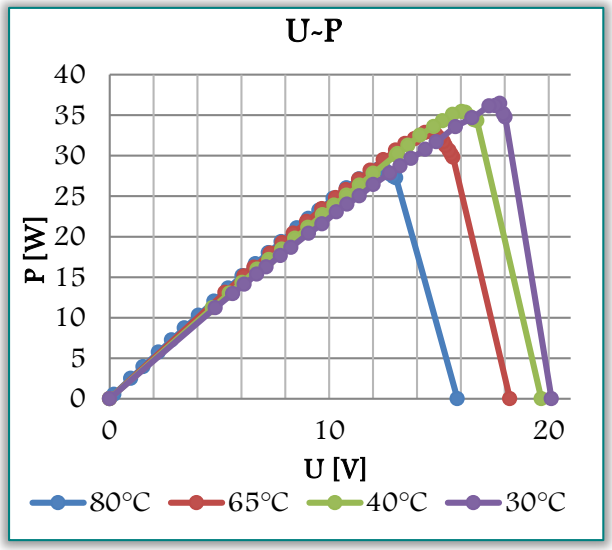
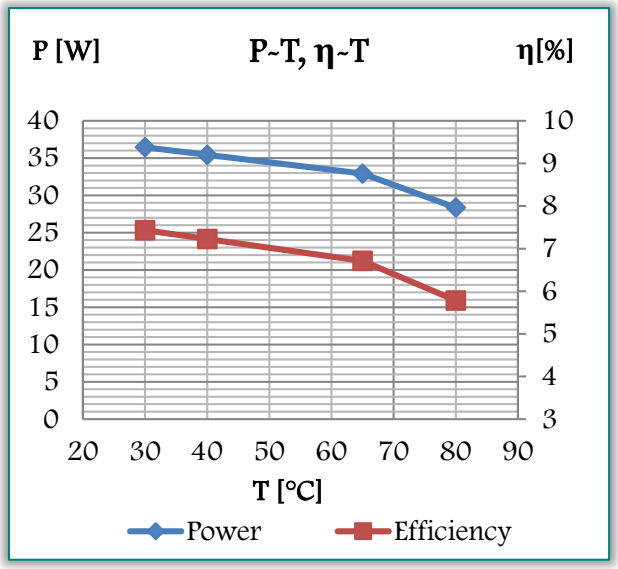


Figure 5. U-P characteristics in case of different temperatures

By increasing the resistance, the electric power was increased to a certain point, too. Following this point it began to decrease. This point is called the Maximum Power Point where the solar module produces the most electricity [4]. Figure 5 presents the voltage-electric power characteristic in different constant temperatures.

Solar panel temperature coefficients

Temperature coefficients show how the module's electric parameters change by the effects of temperature change [5]. Using the available data (from our measurements) it was possible to calculate these coefficients for voltage, amperage, electric power, efficiency, fill factor and ideal electric resistance (formula (7)). The electrical parameter (for example voltage) wich depends on the temperature was illustrated. After that the rise of the function had to be found. (Using linear regression a line was created from the measured curve.)



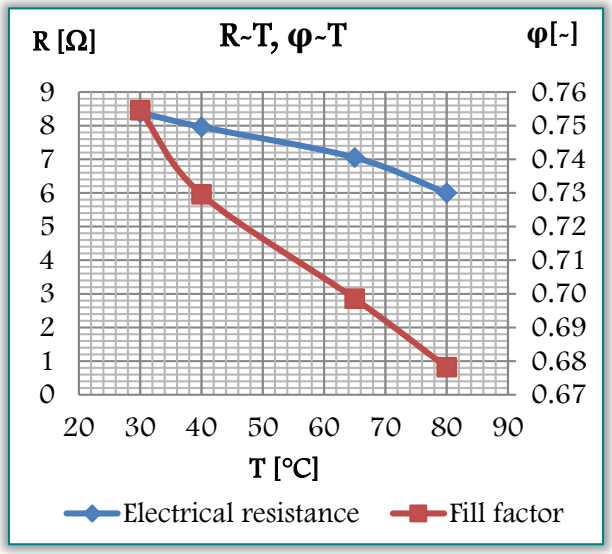


Figure 6. Functional relationship between the parameters and the temperature

$$A = \frac{x_{n+1}-x_n}{x_n} \cdot \frac{100}{T_{n+1}-T_n} = 100 \cdot \frac{m}{x_n}, \qquad (7)$$

where: A- temperature coefficient $\left[\frac{\%}{°C}\right]$; x_n – the chosen electrical parameter's value at a fixed temperature (for axample: amperage [A] at 40°C); m - rise of the line; T_n- the chosen temperature [°C].

Figure 6 shows the functional relationship between the parameters and the temperature. (In this case these parameters are the following: efficiency, power, fill factor and the ideal electrical resistance)

The calculated coeffitients (8)-(12) are:

$$A_p = A_\eta = (-0{,}459)\left[\frac{\%}{°C}\right], \qquad (8)$$

power and efficiency;

$$A_R = (-0{,}633)\left[\frac{\%}{°C}\right], \qquad (9)$$

ideal resistance;

$$A_\varphi = (-0{,}211)\left[\frac{\%}{°C}\right], \qquad (10)$$

fill factor;

$$Au=(-0{,}41)\left[\frac{\%}{°C}\right], \qquad (11)$$

voltage;

$$A_i = 0{,}11\left[\frac{\%}{°C}\right], \qquad (12)$$

amperage.

CONCLUSION

During our investigations it was possible to reproduce the phenomenons described in the regarding literature. In every cases the reduction of the solar cell's temperature caused the increase of the electric power output and the efficiency. In conclusion one way of increasing the solar cell's efficiency is to reduce its temperature. By the help of the temperature coefficients the solar cell's design and return calculations will be more accurate.

Note

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IMPROVEMENTS AND BENEFITS OF UPGRADING CNC MACHINE FOR ENGRAVING AND CLEANING METAL PARTS

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Abstract: The main goal of this research is to demonstrate a design solution of upgrading an existing CNC engraving machine for cleaning metal parts. With this improvement the time of finishing metal parts was reduced and higher quality of the finished products was obtained, with improving the safety usage standards. Special CNC engraving machine was designed, which is used for final processing of metal parts. Also improvements in the automatization of the whole process were implemented. The practical aspect was based on the improvements and adaptation of an existing CNC engraving machine with applying innovative measures, which increase the productivity by automating the process and reduction the risk of injuries of the operators.
Keywords: CNC machine, engraving, upgrading, cleaning, improvements

INTRODUCTION

Metal parts in the car industry for production of catalysts are not final products. Usually the customers have additional quality requirements, and for that reason final processing of the products is necessary.

The request is done on written form with an attached sketch. There is a statement regarding which part of the metal product need final processing, surface cleaning from the chemical coating.

The sketch often contains too little information and this is the main reason, why the best quality method of cleaning is applied in order to prevent complaints from customers. The chemical coating that remains on the metal parts after their production is a big problem in the welding process, because chemically reacts with the weld beam and changes its physical properties. The chemical coating contains very strong acids and bases, depending on the applied method of welding and reacts differently. In that case it is obviously that an additional welding process will be problematic in case of presence of remains of chemical coating.

Analyses were done in order to investigate how metal parts in similar industries currently have been cleaned. Analyses have shown that two methods are usually applied for cleaning metal parts: using a machine to clean the circular parts or applying a robotic arm [15]. In order to select the most appropriate method an analysis of the advantages and disadvantages of the previous methods was done. The advantages and disadvantages of the currently used cleaning methods are given in Table 1. From Table 1 it can be seen that the both applied methods have quite opposite advantages and disadvantages. Depending on the request from the client, an appropriate method which adequately responds to the client requests is used. To select the most appropriate method additional analysis of the order, has to be conducted. The obtained results are presented in Table 2.

Table 1. Advantages and disadvantages of the currently used cleaning methods

Machine for cleaning circular parts		Robot arm for cleaning metal parts	
Advantages	Disadvantages	Advantages	Disadvantages
Costs	Limited shape	Unlimited shape	Costs
Number of cleaned parts	Quality of cleaned parts	Quality of cleaned parts	Number of cleaned parts
Simple equipment			Complex equipment

From the analysis we can conclude that it is necessary to apply a method which can enable a greater range of geometric shapes of working parts. In this case it is necessary to apply a high precision method, which will be able to clean various types of geometrical shapes (elliptical, circular parts). Currently used cleaning methods, could not fully

respond to the customer requests. In order to respond to the customer demands, a new innovative cleaning method was applied, involving the usage of a CNC engraving machine.

Table 2. Analysis of customers requirements

Planned production on a monthly basis	Cleaning capacity	Possible solutions
Current production of elliptical metal parts is 40.000 pieces	Manual cleaning – 18.000 pieces. Monthly capacity of 2-3 operators	Bringing machine for cleaning with dry ice [11]
Planed additional 40.000 elliptical pieces that need to be cleaned in the current year	A cleaning machine with dry ice with a capacity of 60.000 pieces per month (the machine is located outside the country)	Designing a special CNC engraving machine for cleaning metal parts, which will also satisfy the capacity for cleaning the planned number of pieces
30.000 pieces other round parts	Total cleaning capacity of 78.000 pieces per month	Implementing this process in production with the appropriate quality standards [14]
Other forms of parts-8.000 pieces		
Total number of parts which need to be cleaned - almost 120.000 pieces		

UPGRADING OF CNC MACHINE FOR CLEANING METAL PARTS

The cleaning concept consists of using a CNC engraving machine, as a tool for cleaning metal parts with different shapes [2]. The basis of this idea consists of part A (whose shape and diameter can considerably vary), which needs to be cleaned and to be positioned and a CNC engraving machine where the spindle with a metal brush for cleaning B performs complex movements around the part where the cleaning process is necessary (Figure 1).

In order to confirm the concept of using an existing CNC [1] engraving machine as initial equipment, firstly the system for holding the parts which need cleaning, was constructed. Since different parts with different shapes [10] have to be cleaned, the biggest challenge was to make an universal system that can grip all forms of processing parts.

Figure 2 shows the concept of design of gripping mechanism [4] for the parts which need cleaning. This system consists of several elements which have specific role in gripping the parts which have to be cleaned and to be placed on the machine table.

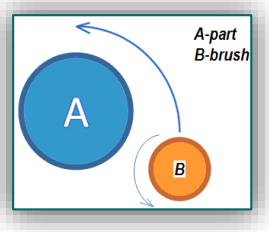

Figure 1. Movements of the metal brush around the piece [7]

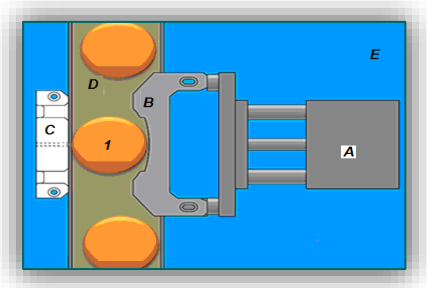

Figure 2. A conceptual design for gripping parts which need cleaning

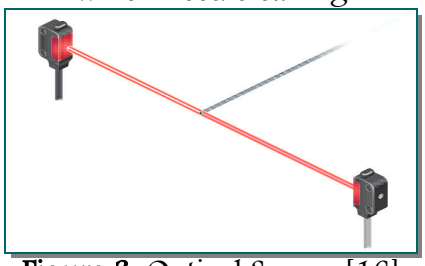

Figure 3. Optical Sensor [16]

A movable arm element B is attached to the air cylinder A. The mobile arm has the shape of the one side of the working part which needs cleaning. The working parts travel on a conveyor belt D, until the moment when the part comes to the center of the static element C. An optical sensor is positioned on that place, which operates using a transmitter-receiver (Figure 3).

When the sensor signal is interrupted, an optical sensor detects a piece [9] and the conveyor D stops, while the center section of the part is located just in the middle of the movable element B. The sensor sends a signal that there is a piece in front of it and also sends the information to the air cylinder A to move. The piece moves to the static element C and it acts on it with constant pressure from the air cylinder A. Figure 4 shows a 3D model of the proposed idea for gripping unit.

Because large amounts of metal parts need cleaning, it was decided this system for cleaning metal parts to be incorporated into the CNC engraving machine with multiple cleaning heads. According the size and needs for cleaning metal parts, the optimal solution was upgrading of a CNC engraving machine with 4 cleaning heads. Figure 5 shows a 3D model of an upgraded CNC engraving machine with 4 cleaning heads.

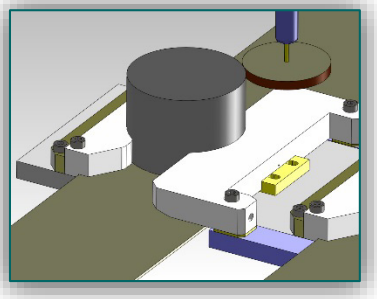

Figure 4. A 3D model of the proposed idea for gripping unit

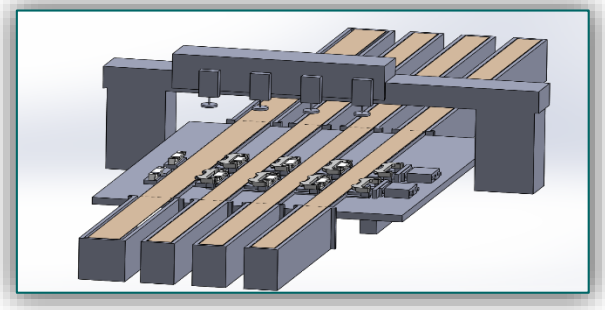

Figure 5. A 3D model of the implemented system for gripping parts on the engraving machine [6]

Figure 6. A photo of the upgraded CNC engraving machine [5]

All necessary simulations were done on the 3D model in order to check the functionality of the system [3]. All performed tests demonstrated positive results. After that, the next step was implementation of upgraded existing CNC engraving machine. Figure 6 shows a photo of the upgraded CNC engraving machine.

The real model justified the expectations and demonstrated that various forms of working parts can be cleaned at high speed. After the design, the process of complete cleaning with detailed overview of each step [12], was defined. For each step the necessary time was specified, and the total time for cleaning of a particular product was defined.

After the upgrading of CNC engraving machine, a significant step is also the optimization of the overall cleaning process, where all steps are discussed in details and additional improvements are introduced.

IMPROVEMENT OF THE PROCESS FOR CLEANING METAL PARTS

The metal parts should be cleaned from both sides. After the implementation of CNC engraving machine [13] and its daily use in the cleaning of metal parts, a logical step was a defining standard working procedures for each of the working positions, standard number of operators and jobs, standard time for the working cycle of the machine and finding a technical solution for elimination of the manual work [8].

It was necessary to examine the scope of tasks for each of the operators working on the CNC machine and at the tracks of the material flow.

In this analysis the number of pieces that passed through the operators hands were observed. Higher number of pieces, enable greater opportunities for making errors and omissions. Manipulation and catching the pieces are steps which operators do not notice during the operation. Therefore, the observation was made by another person from distance. The lean tool that was used for this analysis is called Yamazumi - line balancing. The role and involvement of operators who are the most familiar with their work is crucial. So their creativity it comes to the fore with this tool. A very important step that should not be forgotten before the start of the observation, is the communication with operators which will be involved in the measurement. An important part of this phase of the project was the involvement of operators as the best source of accurate information and experts in the relevant field. Data collection was conducted by two methods of measurement. Firstly, by observing of a video recording and secondly, by direct observation of the work of the operators on the workplace. Dual monitoring was done in order to obtain accurate confirmation of collected data. The calculation of the required number of operators on each of the working positions was done by dividing the total time required to perform all work steps at each working position with the time of one machine cycle (see Table 3). The required number of operators is rounded to the next integer value.

Table 3. Calculation of the required number of operators for each of the working positions

	Position 1	Position 2	Position 3	Position 4
Time of work steps (sec)	40	8	8	31,9
Machine cycle (sec)	18	18	18	18
Number of needed operators	2.22~3	0.44~1	0.44~1	1.77~2

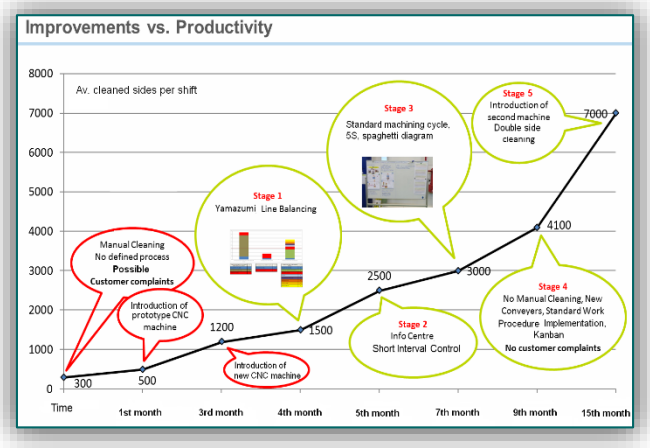

Figure 7. Influence of improvements on the productivity

Once the required time for each position was individually defined, the required number of operators for each of these positions, was also established. After the results of the measurements were obtained for each position, an analysis of the data was conducted. Using the collected data, several successive improvements in the cleaning process were made.

- First improvement - An analysis of the initial balance was conducted. A schedule for operators was made in order to get a more balanced work.
- Second improvement - An extension of the exit conveyors was made and tools for cleaning were defined.
- Third improvement - Analysis and standardization of the machine cycle for parts cleaning.
- Fourth improvement - extension of the conveyors front part in order to get more parts on stock. A Kanban system for inventory control was also introduced.
- Fifth improvement - Adding a second machine for cleaning parts from the both sides and definition of the overall process.

All these improvements were made subsequently, one after the other. So, after the each implemented improvement, an additional analysis of the overall cleaning process was made, in order to identify the weak points and to find ways to eliminate them. The relation how the improvements affected on the productivity is presented in Figure 7, where the improvements are presented by stages.

CONCLUSIONS

This innovation project is an excellent example how a simple CNC engraving machine can be upgraded and used for different purposes. Although the overall project, seems very simple, in fact it is a brand new concept for cleaning metal parts, which offers a new direction in the automotive industry. This concept has already been accepted in two factories and it is applied in the same manner. Modern production requires fully functional equipment. The fulfillment of these conditions is only possible if the specialization of the equipment is raised to a high level and the production time of products is drastically reduced, as it is the case with the above mentioned CNC engraving machine.

To achieve this goal, it is necessary to know the specific elements of the production process and the applied technical and technological solutions. Different design solutions in practice show different results in terms of quality and time of the finalization of the products under specific conditions of exploitation. But considering cost-effectiveness, it can be said that this design was the best solution. With upgrading the existing CNC engraving machine and optimization of the process of cleaning, the number of the cleaned parts increased from 300 to 7.000 pieces per day.

After this achievement in the process of finishing metal parts, it is expected overall process to be improved with more complex equipment, which can allow finalization of much larger and more complex parts.

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WEB OF THINGS – PRAGMATIC APPROACH

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Abstract: In recent years IoT (Internet of Things) is gaining interest among researchers and many IoT development platforms, SDK's have been proposed. There are lots of low powered, efficient devices available in market which can be used to create IoT solutions. The main drawbacks of IoT is that every manufacture proposed it owns protocol and provide their own API's to work with it. You need to be an avid programmer to implement, understand, customized and use this API's. Since lots of these libraries are open source not much information can be gathered online. To solve this protocol agnostic problem in IoT many researchers are now focusing on WoT i.e. Web of Things. The main advantage of implementing WoT is that we can use familiar Web protocols to build up our solutions. In this paper we will discuss SOA architecture, proposing a high level WoT network implementation at home-using embedded devices and Web protocols like REST web services and JavaScript to achieve interoperability. We will also discuss security concerns in WoT and best practices to avoid vulnerabilities.
Keywords: WoT, Web of Things, IoT, Internet of Things, REST, SOA

INTRODUCTION

With the popularity of IoT more and more devices manufactured by different vendors are coming to market. Each device has their own specification and protocols supported.

However, the central focus of IoT is to achieve interconnectivity among these devices and how to achieve interoperability while ensuring trust and security [1] [9] [10] [11]. Also, different operating system proposed in IoT for resource constraint devices [2]. In [19] author proposes to use cognitive radio with IoT and in [18] author discuss about secure communication in cognitive radio. To overcome this mismatch many researchers are moving to WoT which is a subset of IoT but here to communicate between devices they are using Web protocols [3]. WoT, unlike IoT which works on all layers of OSI, mainly works on OSI layer 1. Because of this high level of abstraction, it is easier to connect devices and send messages among them. Also, with the growing maturity of cloud computing, data can be easily stored, shared and retrieved. To implement physical mashup communication where physical devices communicate with virtual platforms web technologies like JavaScript, REST can be used. JavaScript has been tested and tried from last 10 years and is mostly used nowadays in both client side as well as server side scripting language in Web. It can become WoT programming language in near future with the increasing user base. Also, REST is well defined protocol which works with many different data format like XML, JSON and used pre-defined verbs like GET, POST, PATCH, and PUT. Using these well-defined protocols and programming languages in our system we can develop our solution without any worry of new protocol implementation. JSON data is preferable over XML data in WoT because unlike latter JSON data are much faster to parse and doesn't need strict validation. Today nearly every device can consume REST services and parse JSON data with ease. In [4]-[8] authors have applied REST to smart devices mainly considering interoperability, mash ability and complexity.

SERVICE ORIENTED ARCHITECTURE

Service Oriented Architecture (SOA) is collection of services which communicate with each other and pass data among them. In SOA the basic components are service and connection. A service is independent, fully functional, well defined function. To connect these services the most common connection we used is web service.

The two most popular Web Services approaches are:

WS-* Architecture: This is most commonly known as SOAP (Simple Object Access Protocol) initially builds by Microsoft which becomes standard by

W3C. SOAP implement various WS-* services. It basically woks with XML file for data transmission, WSDL for Service definition and UDDI for Service discovery. Before parties can communicate with SOAP they need to share the message structure, protocol use among themselves. Any deviation from accepted structure can result in message rejection in SOAP. SOAP is a protocol which implements WS*-Architecture.

a. REST architecture: REST (Representation State Transfer) is not a protocol but rather define some style on how to consume services using standard HTTP protocol. REST doesn't dependent on any single communication protocol but any protocol which supports URI can use REST. Also, unlike SOAP no prior knowledge of data is required. REST uses HATEOAS (Hypermedia as the Engine of Application State) constraint to achieve this functionality. It's a constraint in REST services where client communicate with services based on hypermedia provided dynamically by application servers.

In WoT, REST is considering to be the first class citizen to communicate data among devices over HTTP because of following reasons:

1. No prior knowledge of data required beyond media type which the resource can provide.
2. REST permits different data format but SOAP only works with XML.
3. REST can be used with different communication protocol.
4. REST supports JSON data which is lightweight than XML and can be easily parsed.
5. REST can use HTTP protocol security mechanism like SSL for secure communication.
6. SOAP messages are more secure than REST because it can implement WS-Security which offers confidentiality and integrity of data. But, these securities overhead consume lot of resources and many embedded devices are resource constraint. So, in spite of REST is not as secure as SOAP we can limit the security vulnerabilities by following some best practices.

In [4], the author uses REST API's which gets data from Bluetooth enable embedded devices and visualize data/functionality like power consumption, power on/off on web-page.

SECURITY CONCERNS

Security is a major concern for any communication nowadays. In paper [6], the author discuss about different security and privacy issue in IoT. There are ways to secure IoT communication [8] but again will extra overhead on embedded devices. In WoT, all the communications are REST API based. So, attacker can attack the API's and insert malicious data with techniques like script injection, SQL injection. The best way to avoid this is to follow some REST best practices [17] and limit the attack surface.

1. Since REST API are stateless authentication should not depend on cookies or sessions. Each request must come with authentication data like API key. API key can either be incorporated into URL or message header. The problem with API key in URL is anybody can copy the key and share it with others. So, it's better to have API key within header than URL.
2. The API key within header is still being traceable because the credentials are travelling through wire. So, it always better to signed request. For this, it's always better to use HTTPS over HTTP.
3. Avoid forwarding failure request to less secure API. Always better to send 404 errors in case of authorization failure with proper message.

Some best practices of JavaScript:

1. Reduce the use of global variables.
2. Reduce the possibility of undesirable re-declarations
3. Reduce the use of anonymous functions for better debugging experience and maintainability.
4. Avoid using Eval statement.
5. Always use HTTPS and avoid HTTP communication.

But still after following these best practices there are always room for well know network attacks like man-in-the-middle attack, DoS attack. The most useful technique to break secure communications which are using HTTPS is SSLStrip. SSLStrip acts as a proxy for HTTPS traffic and send the request as HTTP. Since the HTTP traffics are not secure attacker can use tcpdump to retrieve user credentials. To overcome SSLStrip attack the best way is to always host API using HTTPS and doesn't forward the request to HTTP in case of failure. In this paper we are discussing setting up home WoT network so chances of network attack are minimal.

TOPOLOGY USED

In this network topology Fig.1 we are using Raspberry Pi as a central point of communications which interacts with different devices to get data and forward it to cloud storage. Here, Arduino is used to sense room temperature/humidity with the help of sensor DHT11 and post message (interval can be set programmatically) to Raspberry pi by consuming REST API exposed by Raspberry Pi with the help of ESP8266 Wi-Fi module. End systems like smartphone/Laptop are request initiating devices which request data and get response from cloud storage. The data flows as follows:

1. Arduino sends sensor data to raspberry pi (within interval) to raspberry pi.

2. Raspberry pi in turn sends the data to cloud storage.
3. Request initiating devices like smartphone/ laptop request room temperature/humidity by consume API exposed by cloud service.
4. Once the cloud receives the request it sends the latest data got from Raspberry pi.
5. Request initiating devices like smartphone, laptop can then use these data for analytics purpose.

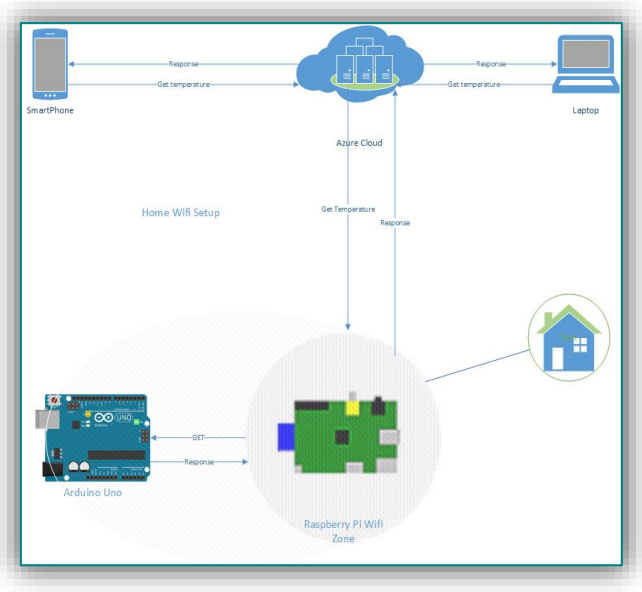

Figure 1. Network topology diagram of WoT devices

ALGORITHM

To implement below algorithm we have used JavaScript in Raspberry Pi and C language in Arduino. Today JavaScript become the language of Web and we can leverage its power in WoT. There are client side JavaScript modules available like angularjs [14] as well as server side JavaScript like Nodejs [16]. For, cross platform mobile application Ionic framework [15] is used which can be programmed using angularjs, HTML5 and CSS3 [12]. There are lots of open source JavaScript modules available which helps in fast development.
Arduino doesn't have built in Wi-Fi module. But for Wi-Fi communication Arduino Wi-Fi Shield is available. In this experiment we are using ESP8266 cheap, efficient Wi-Fi module for communication with Raspberry Pi.

Communication between Arduino and Raspberry Pi.

1. Initialize variables
2. Start initiating connection
3. We have introduced interval of 10 mins so that Raspberry Pi should not be flooded with data.
4. While(ESP8266 is available) {
   a. Configure header with registered Device id. The device registration should be done beforehand and must be unique for audit purpose
   b. POST data to Raspberry Pi Rest API using ESP8266 command.
   }
5. While(wait for response) {
   Log full response for audit purpose;
   }
6. Close connection

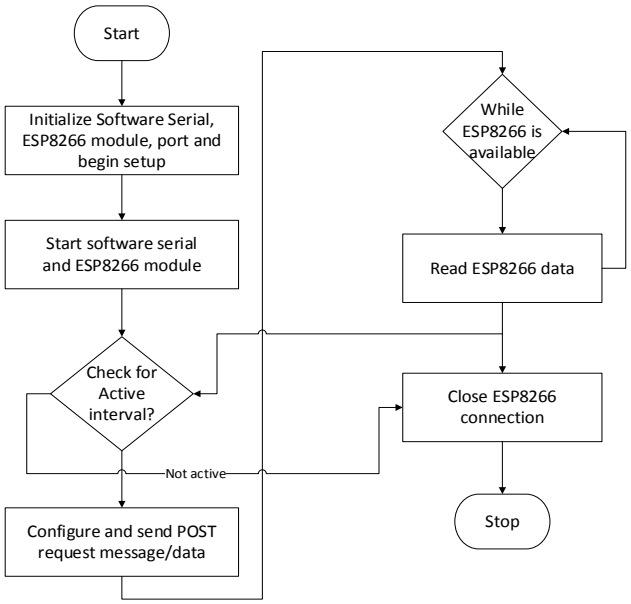

Figure 2. Arduino workflow

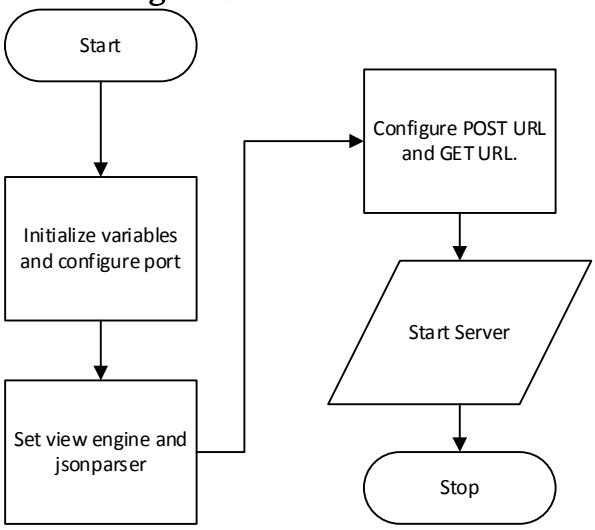

Figure 3. Node js workflow

Communication between Raspberry Pi and Cloud Service

1. Initialize variables and configure port
2. Start initiating connection
3. While(Listen for incoming messages)
   {
   a. Configure POST message using device name
   b. Configure request header
   c. Apply authorization key to header
   d. Send data to cloud storage
   }
4. While(wait for response)
   {
   Log full response for audit purpose;
   }

For complete code and configuration visit [13].

The communication between Arduino and Raspberry Pi is not secure and doesn't follow REST best practices. We keep it simple with the assumption that since devices are connected to LAN rather than WAN, they are more secure from outside attacks.

CONCLUSION

With the invent of WoT, more and more researchers are moving towards it because of its simplicity, interoperability and use of well-defined/tested web technologies But with the increasing number of devices security becomes more and more vulnerable. The way we can limit WoT vulnerabilities is by following Web technologies best practices. Also, the rises of web languages like JavaScript, HTML5 help WoT researchers and enthusiasts' jobs much easier. Now with vibrant open community available WoT can be the future of connected devices.

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ANALYSIS OF POSSIBILITIES FOR DISTURBANCE REJECTION IN THE DECOUPLED MULTIVARIABLE PROCESS

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Abstract: Proper behavior of multivariable process isn't guaranteed only through the disabling influence of its mutual coupling (interaction), but also compensation of disturbance has very important role. Investigation of disturbance that can be rejected by previously decoupled 2×2 process has been presented in this paper. Considered flow tank, as a multivariable process, was controlled using PI controllers. The aim was to determine limit of disturbance intensity under whose influence system can operate correctly, and in that way additionally check validity of designed decoupler, i.e. chosen non-conventional control. General expression for periodic rising signal that can be introduced into process in order to present array of disturbances has been derived, too.Investigation was supported by simulations.
Keywords: disturbance, non-conventional control, PI controller, flow tank

INTRODUCTION

Numerous researches have been presented the advantages of non-conventional control system containing decoupler in its controller over approach where mutual coupling wasn't taken into consideration. In one of them [1], control system of level and temperature in 2x2 flow tank has been investigated.Analysis of interaction among its inputs and outputs was carried out using theory given in [2] and decoupler has been designed like in [3]. Previously, process was modeled in [4] using physical laws and experiential data. Parameters of PI controller were determined based on principles given in [5] without need for repeating relay feedback test like in [6]. Beside reference tracking, researched and confirmed in [1], another very significant indicator of control quality is process ability to reject disturbances that occur during its operating. That is the main subject of this research. Here will be considered four cases of disturbance, that should serve to determine limits of its intensity which system can compensate.

PROCESS AND ITS MODEL

Various types of plants in the chemical, pharmaceutical, food and other industries contain some kind of flow tanks where two fluids are mixed in order to obtain their blend. Flow tank with water as a fluid that come through the two valves, 1 and 2, whose temperatures are t_1=15°C and t_2=70°C, respectively, was researched. Water is mixed on the constant number of revolutions. One or more properties of final fluid through the outlet valve 3 (on/off type,flow rate Q_3) can be controlled. Demand for temperature control comes from production technology. Level in the tank should be maintained on the specified value in order to provide proper mixing of components. Therefore, in present 2x2 process, inputs are flow rates (Q_1 or Q_2) through the valves 1 and 2. Outputs are level h and temperature t. Reference values are taken to be 1m for level, and 30°C for temperature. Mathematical model for this type of flow tank, derived in [4], is expressed with following transfer function matrix:

$$G(s)=\begin{bmatrix} g_{11}(s) & g_{12}(s) \\ g_{21}(s) & g_{22}(s) \end{bmatrix}=\begin{bmatrix} \dfrac{K}{Ts+1} & \dfrac{K}{Ts+1} \\ \dfrac{K_1}{T_1 s+1}e^{-L_1 s} & \dfrac{K_2}{T_2 s+1}e^{-L_2 s} \end{bmatrix} \quad (1)$$

where: $g_{ij}(s)$ – elements of transfer function matrix, K, K_1 and K_2 – gains, T, T_1 and T_2 – time constants, L_1 and L_2 – delay times.

ANALYSIS OF DISTURBANCE

Analysis of process behaviour in the presence of disturbance is extension in checking of control strategy for considered flow tank.Square shape of disturbance was taken and it is assumed that they appear in the steady state. To enhance efficiency of test, the disturbances were introduced sequentially with defined period and in rising order of their

intensity (more precisely, its absolute value). Whereas disturbances aren't measured, the feedback control is obvious here. General form of used disturbance is expressed by equation (2).

$$d=\begin{cases}0, & t\in(0,t_0)\ \bigcup_{j=1}^{n}\left(t_0+t_p(j-1)+{}_t\!\triangleleft\, t_0+t_pj\right)\cup\left(t_0+t_pn,+\infty\right)\\ [0,i], & t=t_0+t_p(i-1)\\ i, & t\in\left(t_0+t_p(i-1),\ t_0+t_p(i-1)+{}_t\!\triangleleft\right)\\ [i,0], & t=t_0+t_p(i-1)+{}_t\!\triangleleft\end{cases}$$
$$i=1,2,\ldots,n \qquad (2)$$

where are: t_0 – time of introducing of the first disturbance, t_p – period between starts of the adjacent disturbances, Δt – disturbance duration, i – disturbance intensity, d_i – ordinal number of disturbance, n – number of iterations. The meanings of values in equation (2) are shown in Figure 1.a). The part b) of this figure shows opposite direction of disturbance influence. Hence, this form can be used to determine limits of disturbance intensity. It offers opportunities for researching wide range of their intensity, but then they have to be scaled.

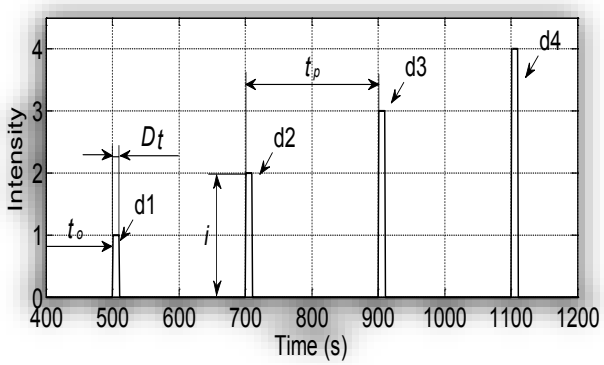

Figure 1. Array of square disturbance: a) positive direction, b) negative direction

In this survey following values have been chosen: t_0=500 s, t_p=200 s, Δt=10 s, n=4.Boundary for acceptable intensity are 10% of overshoot and undershoot. Analysis was performed through the considering process responses in presence of disturbance.

That was realised using simulations, which need block diagram of entire control system shown in Figure 2. This block diagram, except disturbance, was formed in [1,4], where I/P transducer is current-pneumatic transducer and U and X_i are manipulated and controlled variable, respectively.

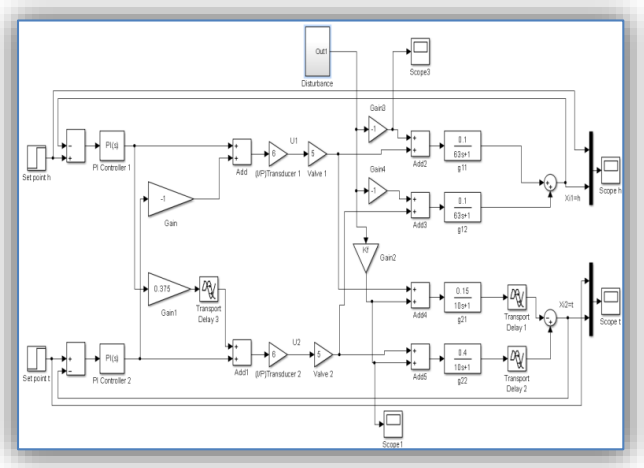

Figure 2. Block diagram of the control system of level and temperature in decoupled flow tank with introduced disturbance

≡ First case – increasing of level and temperature (h+,t+)

Hot water on temperature of 100°C is adding into tank with flow rate which scaled values is between (1–4). Exact ratio between disturbance and its scaled value can be determined experimentally. That implies its scheduling till equalization of process responses obtained from simulations with its real equivalent, where upon it can be related with certain value i in equation (2).

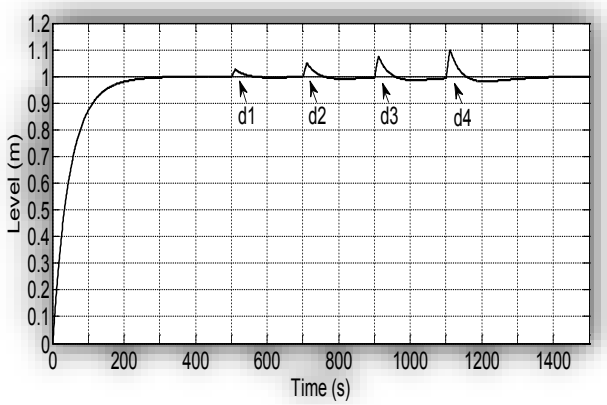

Figure 3. Level in flow tank under influence of disturbance (h+,t+)

Effects of disturbance on the process outputs depend on terms in transfer function matrix, too. But for completing definition of disturbance effect, relation between fluid volume and temperature should be calculated and it is presented through the correction factor K_f. This is carried out using law of conservation of energy, which for this flow tank is expresed by equation $t_{r+1}=(V_rt_r+V_dt_d)/(V_r+V_d)$, where t_{r+1} – temperature of blend after influence of disturbance, t_r – temperature of blend before

influence of disturbance, t_d – temperature of added water, V_r – volume in flow tank, V_d – volume of added water.Now correction factor is $K_f=[(t_{r+1}- t_r)/ t_r]\cdot 100$.

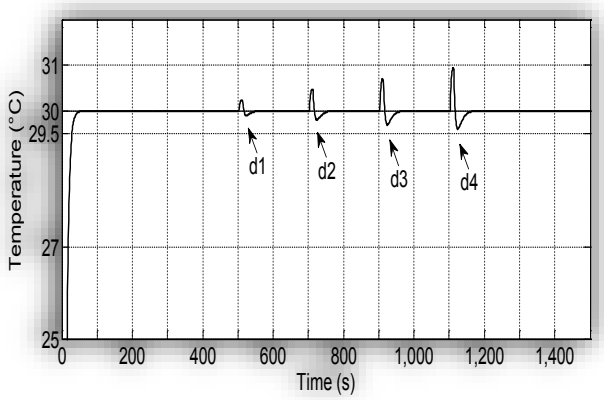

Figure 4. Enlarged view of temperature in flow tank under influence of disturbance (h+,t+)

In this first case K_f=2,3. Simulations of four values of disturbance intensity, without gains 3 and 4 in Figure 2, give level in flow tank in Figure 3, while Figure 4 contains enlarged view of temperature in this tank.

≡ **Second case - increasing of level and decreasing of temperature (h+,t-)**

Equal volumes of mixed water and ice as in first case,but here on temperature of 0°C are adding into tank. Therefore, level is the same like in first case (Figure 3) and temperature,obtained after simulations of four values of disturbance intensity, without gains 3 and 4 in Figure 2, is shown in Figure5. In this case correction factor is K_f=-1.

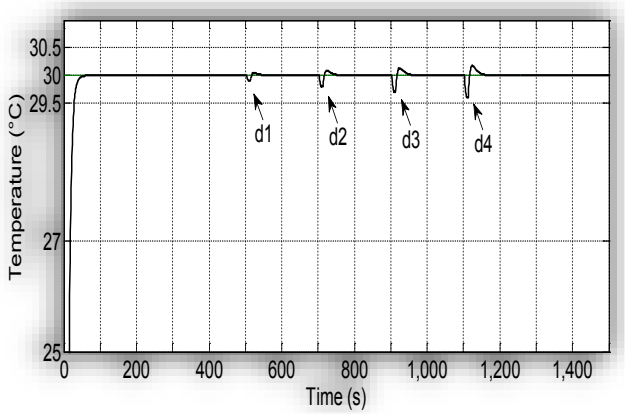

Figure 5. Enlarged view of temperature in flow tank under influence of disturbance (h+,t-)

≡ **Third case - decreasing of level and increasing of temperature (h-,t+)**

This case describes drop flow through the valve 1, and because of that, at the initial moment, more water come from valve 2. Temperatureof that water is 70°C and it increases temperature of blend t_r. In this case correction factor is K_f=1,3. Simulations carried out according block diagram in Figure 2 give level and temperature in flow tank shown in Figure 6 and 7, respectively.

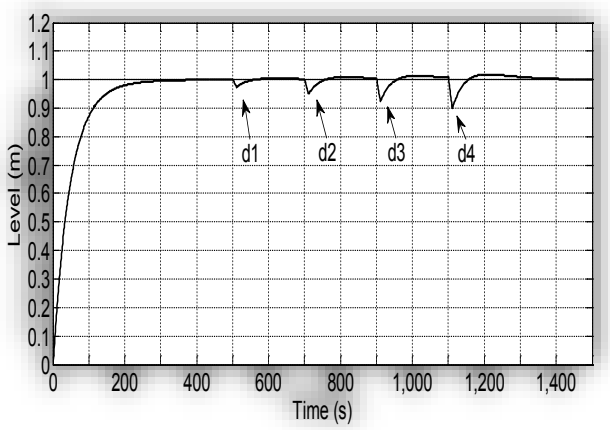

Figure 6. Level in flow tank under influence of disturbance (h-,t+)

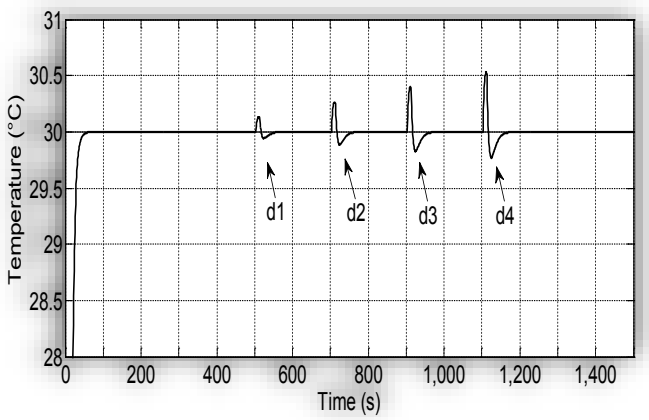

Figure 7. Enlarged view of temperature in flow tank under influence of disturbance (h-,t+)

≡ **Fourth case – decreasing of level and temperature (h-,t-)**

Drop flow (equal as in third case) through the valve 2 was simulated here, and because of that, at the initial moment, more water come from valve 1. Temperature of that water is 15°C and it decreases temperature of blend t_r. In this case correction factor is K_f=- 0,5.Level is the same like in third case (Figure6) and temperature is shown in Figure8.

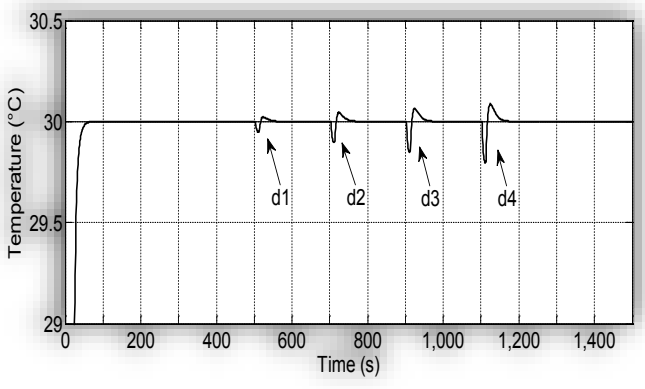

Figure 8. Enlarged view of temperature in flow tank under influence of disturbance (h-,t-)

DISCUSSION OF RESULTS

As stated, limits within which response can be taken as good are ±10%. Thus, for level limits are (0,9÷1,1)m and for temperature (27÷33)°C. To determine settling time after influence of disturbance T_s, steady state error was defined $\varepsilon s=\pm 2\%$. It is: for level $\varepsilon s=(0,98\div 1,02)$m and for temperature $\varepsilon s=(29,4\div 30,6)$°C. Taking into account these limits and simulated responses, it is noticeable that disturbance has larger influence to the level. Numerous values of disturbance intensity were varied and it was found that responses weren't overcome limits up to forth level of intensity, as it shown in Figure 3-8. Another favorable result is that responses which overcome steady state error have very short settling timefrom the start of disturbance (highest in the level in first case $T_s=39,5$ s). Based on this, after mentioned scaling, the real values of water volume and its temperature, that can be added into flow tank as disturbance without undermining the good work of process, can be determined.

CONCLUSION

This research supports efforts in forming general model for determining range forcertain kind of disturbance that can be compensated by the feedback control system. In this regard, general model of rising disturbance in square form that occur in equal intervals has been derived. Considering flow tank, rejection will be better with larger Q_{3max}, because for higher disturbance intensities drainage flow rate should be higher, too. Regarding temperature, larger flexibility of control system can be enabled with valves which satisfy ratio $Q_{3max}=2\cdot Q_{1max}=2\cdot Q_{2max}$.

Note:

This paper is based on the paper presented at The 12th International Conference on Accomplishments in Electrical and Mechanical Engineering and Information Technology – DEMI 2015, organized by the University of Banja Luka, Faculty of Mechanical Engineering and Faculty of Electrical Engineering, in Banja Luka, BOSNIA & HERZEGOVINA (29th – 30th of May, 2015), referred here as [7].

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ANALYSIS OF POINT SUPPORTED-GLASS WALL SYSTEM UNDER WIND LOAD

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Abstract: Pre-tensioned point supported glass walls are widely used in modern architecture today. This paper deals with the stability of glass support structure to predict the collapse behavior of the same. All windows in their corners are connected to spider arm thus transferring the wind force on the bowstring structure. The results of the analysis provide load-displacement relationship and influence of the pretension forces as well as temperature effect on the stability of support structure.
Keywords: FEM analysis; point supported glass walls; stability; pre-tension system, temperature effects

INTRODUCTION

Figure 1 represents the structure used for the stability analysis in this paper. The main components of the support structure are: TR-F (B) – Tension Rod-Front (Back), SP – Strut pipe, VR – Vertical Rod and HR – Horizontal Rod.

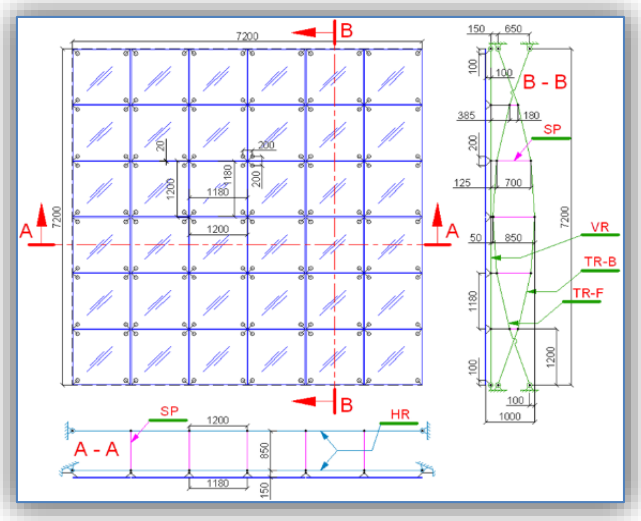

Figure 1. System used for the analysis

TR-F and TR-B form "front" and "back" arch of the so called "bow and arrow" system. The crossed bows are hold strained with the elements marked as SP on Figure1. They play the role of "arrow" in the system. TR-F and TR-B can only take tension forces, while SP can be exposed to compression forces.

Two arches crossed set take the pressure difference which exists between outside and inside of the window panels. The force from the windows is transferred through the "arrows" to one of the arches, front or back one.

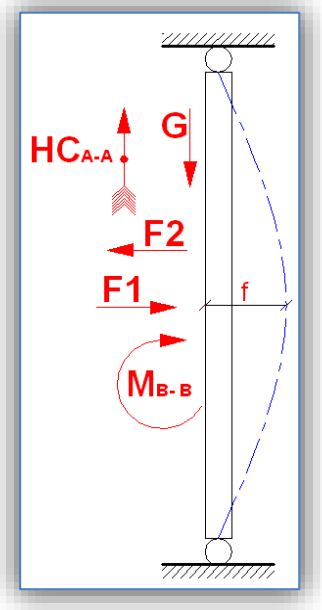

Figure 2. Functions of structure

VR or DLR – Dead Load Rod (element for receving dead load) is set vertically and close to the window panels. The reason why VR is set near the window panels is to eliminate the bending moment caused by dead load and the distance from the panels to the support points.

The elements on Figure 1 designated as HR are used to give stability of support structure in A-A plane. They do the role of "stabilizers" of the support structure in the horizontal plane.

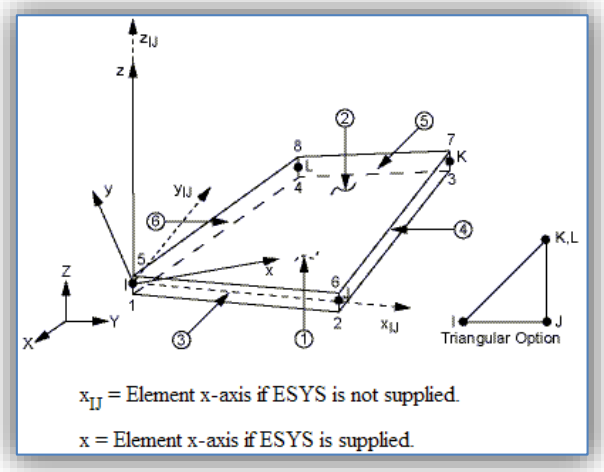

Figure 3. SHELL63

On Figure 2 are shown functions [1, 2, 3, 4] that support structure should perform. The structure needs to resist to transversal forces F1 or F2, axial forces marked as G, resists with bending stiffness $M_{B\text{-}B}$, resists with torsion stiffness $HC_{A\text{-}A}$.

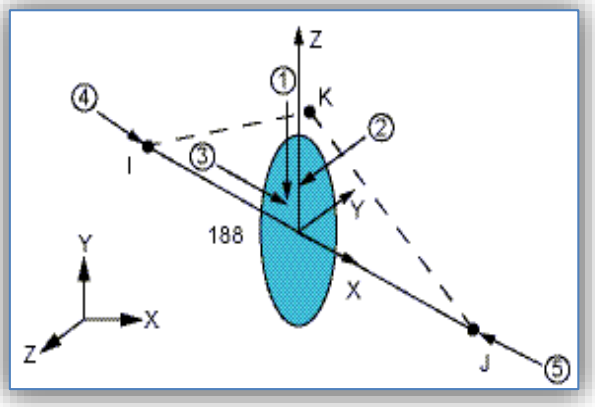

Figure 4. BEAM188

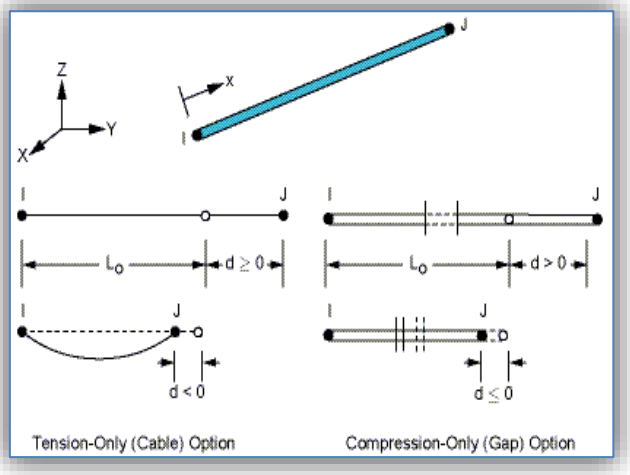

Figure 5. LINK10

Generally speaking, glass support system should perform the same way as simple beam with two point support providing transversal, axial, bending and torsion stiffness.

MODELING THE SYSTEM

In order to perform the FEM analysis it's necessary to select the material properties of the elements constituting the support structure. They are given in Table 1.

Next important step is defining the type of finite elements that will be used for building the model. It is very important because it will affect structure behavior. The elements which are selected are:

- SHELL63 – this element simulates glass panel behavior (Figure 3). Acts as membrane which can take bending. This element has six degrees of freedom at each node;
- BEAM188 – this element is suitable for analysis of slender to thin beam structures. It's linear element with two nodes (Figure 4) and it has six degrees of freedom at each node. It is used for modeling the spider and the arrow of the support structure;
- LINK10 – this element can perform only tension or compression (Figure 5). It is used for modeling the arches, front and back, as well as the horizontal stabilizers.

After material and physical properties are defined and finite elements are selected, support structure of the glass curtain wall is ready to be analysed. The whole support structure is modeled in Ansys (Figure 6a).

Table 1: Selected material and physical properties

Window Panel	E_{glass}=72 000 N/mm²; μ=0,3; α_T=0.6 x 10^{-5}/°C; δ=12 mm; ρ=2,52 x 10^{-6} kg/mm³; m=50 kg/panel; $R_{p0,2}$=R_m=80 N/mm²;
Strut Pipe	E_{steel}=200 000 N/mm²; μ=0,3; α_T=1.8 x 10^{-5}/°C; Ø=20 mm→A=314 mm²; I_{zz}=7853,98 mm⁴; ρ=7,83 x 10^{-6} kg/mm³; m=0,0025 kg/mm; $R_{p0,2}$≈300 N/mm²;
Tension Rod	E_{steel}=200 000 N/mm²; μ=0,3; α_T=1.8 x 10^{-5}/°C; Ø=13 mm→A=133 mm²; ρ=7,83 x 10^{-6} kg/mm³; m=0,001 kg/mm; $R_{p0,2}$≈300 N/mm²; $\sigma_{pre\text{-}stress}$ =10 N/mm²; ε=0,00005;
Vertical Rod	E_{steel}=200 000 N/mm²; μ=0,3; α_T=1.8 x 10^{-5}/°C; Ø=10 mm→A=78,5 mm²; ρ=7,83 x 10^{-6} kg/mm³; m=0,0006 kg/mm; $R_{p0,2}$≈300N/mm²; $\sigma_{pre\text{-}stress}$=10 N/mm²; ε=0,00005;
Horizontal Rod	E_{steel}=200 000 N/mm²; μ=0,3; α_T=1.8 x 10^{-5}/°C; Ø=6 mm→A=28 mm²; ρ=7,83 x 10^{-6} kg/mm³; m=0,00022 kg/mm; $R_{p0,2}$≈300N/mm²; $\sigma_{pre\text{-}stress}$ =10 N/mm²; ε=0,00005;

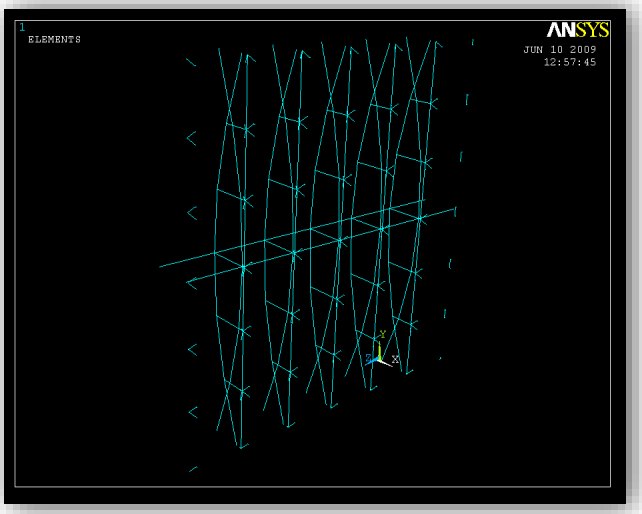

Figure 6a. Completed FEM model

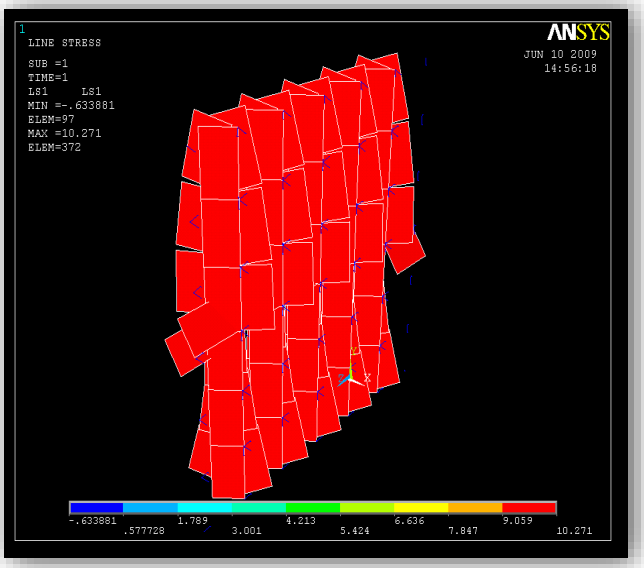

Figure 6b. Pre-tensioned struc. with 10MPa

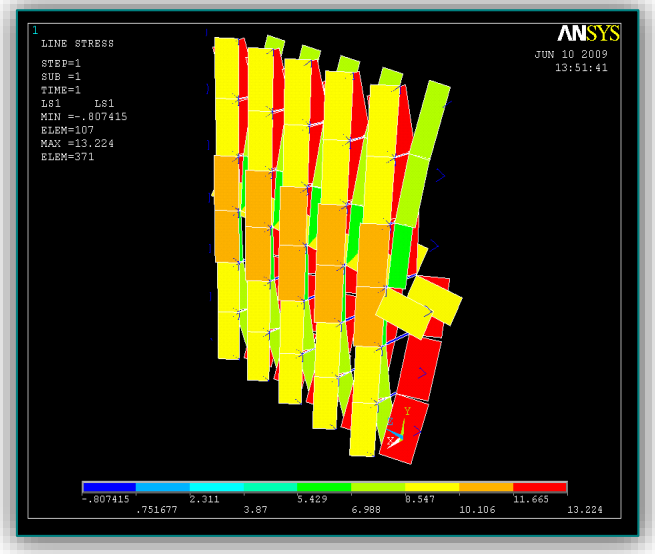

Figure 7. System with 100N at each arrow

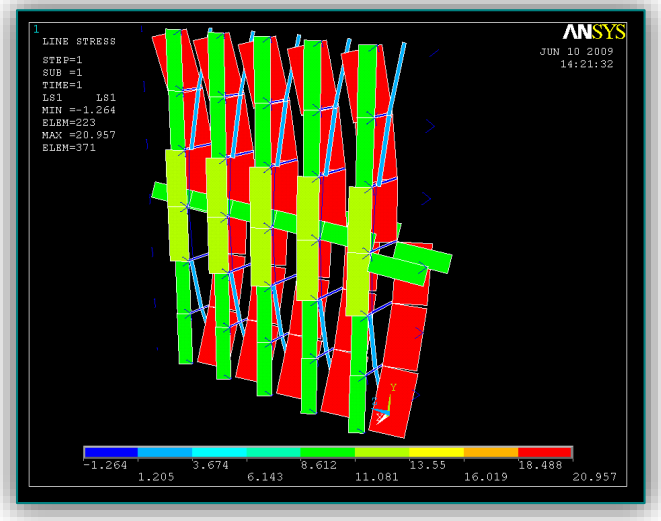

Figure 8. System with 330N at each arrow

ANALYSIS OF THE SYSTEM UNDER EXTERNAL FORCE

The goal of the analysis is determination of the capacity of the support structure with pre-tension of 10MPa (Figure 6b) to receive lateral load or maximal load that each "arrow" can take without causing loss of stability of the system. At the beginning each arrow is loaded with force of 100N. The force is increased step by step considering the condition $\sigma<R_{p0,2}$ until the system becomes unstable.

Figure 6b, 7 and 8 show that increasing the load from 100N till 330N causes TR-B to become additionally stressed, while TR-F is relaxing. When the force at each arrow reaches 350 or 360N the system losses stability and causes rigid body motion. The undefined motion of the support structure is explained on Figure 9.

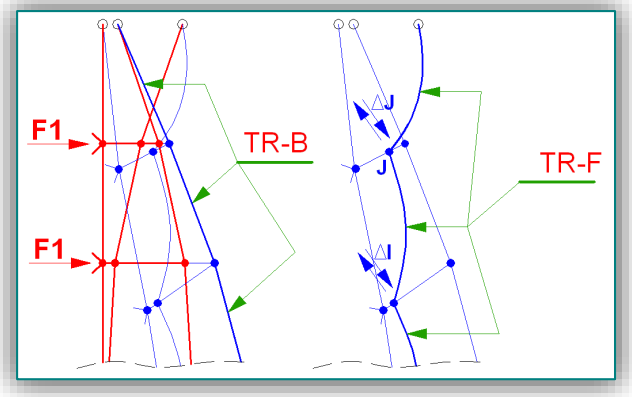

Figure 9. Support structure losing stability

Glass support structure (Figure 9) is losing stability when the nodes I and J become free to move. In this case, TR-F is completely relaxed from tension and practically doesn't participate in the support of the glass wall.

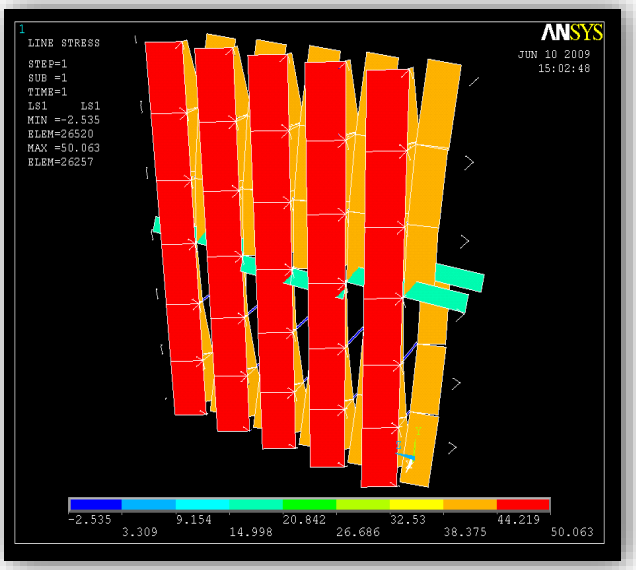

Figure 10. TR=40, VR=50, HR=20 MPa

ANALYSIS OF THE SYSTEM WITH MODIFICATIONS

The system on Figure 6 is modified in order to receive provisional wind load of 100 kg/m² [5]. The area of window panel is 1.2 m². The force that one arrow will take is approx. equal to 100 kg/m² x 1.2m² = 144 kg or 1440 N.

Considering that the analysis is linear, we can calculate the necessary pre-tension of the arches TR-F and TR-B, knowing that 350N is the boundary force which can be applied before system losses stability. Therefore, 1440/350 ≈ 4 meaning 4 times larger pre-tension than the one for the primary system with 10MPa. The first adopted modification is pre-tension of the arches equal to 40 MPa.

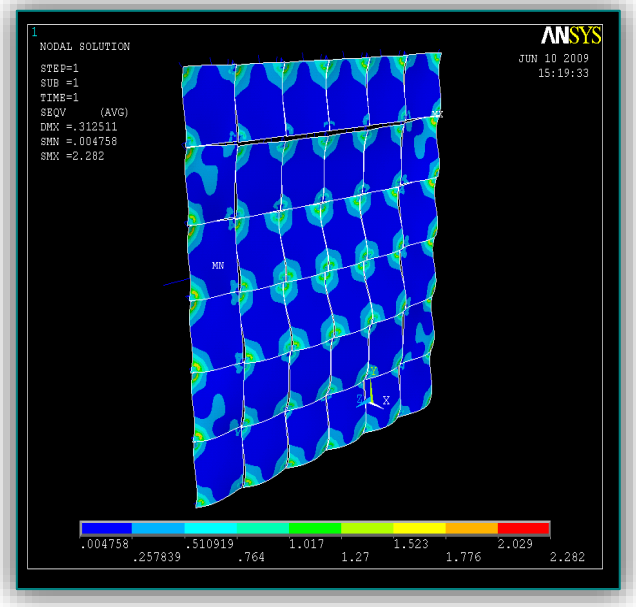

Figure 11. Stresses from dead load

Each VR takes the dead load of five panels (1panel=50kg). Total force that each VR receives from dead load is 5 x 50 kg x 10 m/s² = 2500N. According to Tab. 1 for VR cross section is equal to 78.5 mm². The force of 2500N reduced to cross section of VR is normal stress of the element equal to 40MPa. For safety reasons (earthquake and anti-lock) this value is increased for 10MPa. Second adopted modification is 50 MPa pre-tension of VR elements.

Horizontal stabilizers-HR is assumed to be pre-tensioned with the force that can eventually show up in the plane of the façade. According to Tab. 1 the cross section of HR is 28 mm². It is supposed that the force in A-A plane cannot be larger than 50 kg. In order to prevent front HR to stay stressed, it is adopted 20 MPa pre-tension of HR.

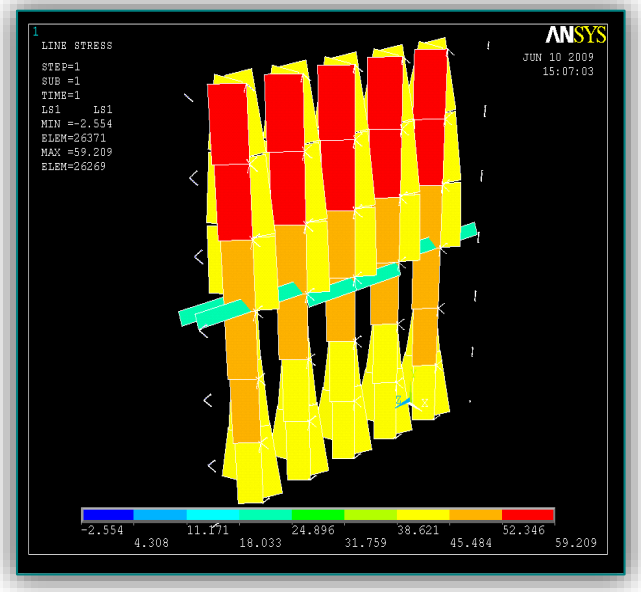

Figure 12. Stresses from dead load

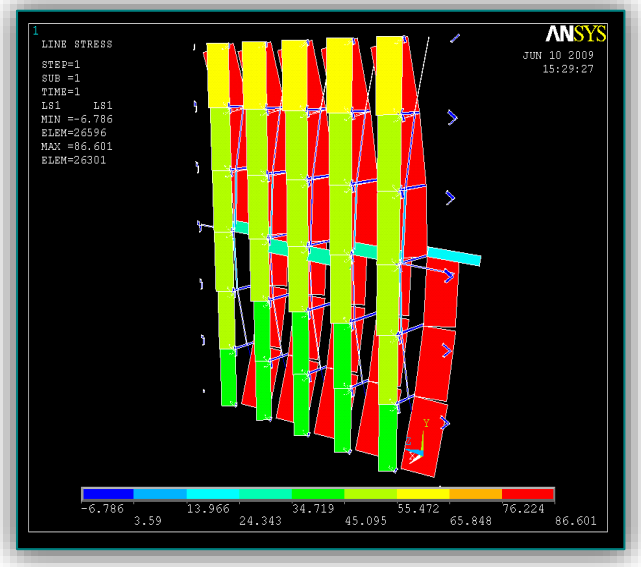

Figure 13. Stress in support structure

The changes of the initial system are shown on Figure 10 and 11. Figure 10 shows only the support system without the panels attached. Figure 11 and 12 shows the general system under dead load with and without panels shown.

It can be noticed from Figure 12 that the most loaded VR elements are the one on the top of the structure – 59 MPa. The lowest are less stressed. They should always carry minimum tension in order to maintain the stability of the system.

When the glass supported structure is subject to wind load of 100 kg/m² and dead load of all elements we get the results shown on Figure 13. Support system is on edge to become instable. The tension stress in the front arches TR-F maintains value from 3 to 13,5MPa.

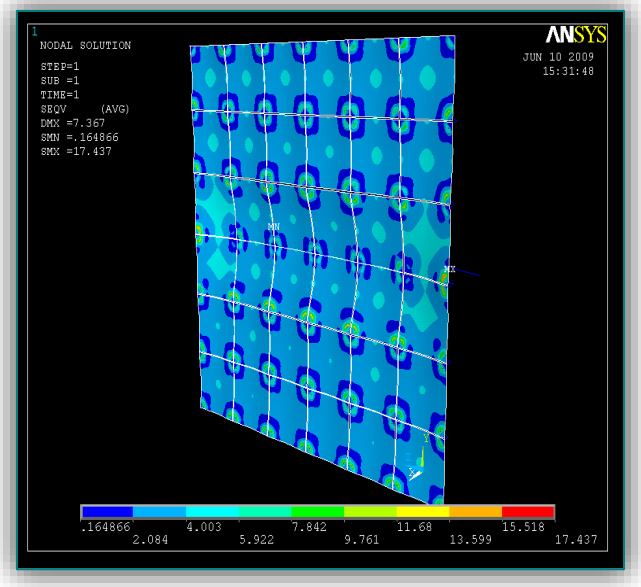

Figure 14. Stress distribution in panels

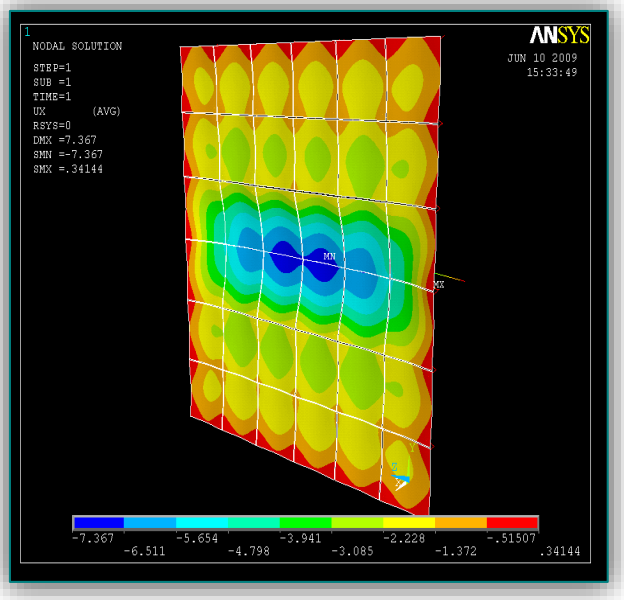

Figure 15. Total displace. in wind direction

The stress distribution of the wind panels is shown on Figure 14. Maximal value of the stress appears around the connection point with the spider arm with value of 17.4 MPa, while the average value is between 6 to 10 MPa. The thickness of the window panel is acceptable, it can be subject for further optimization, but it is used as it is in following analysis.

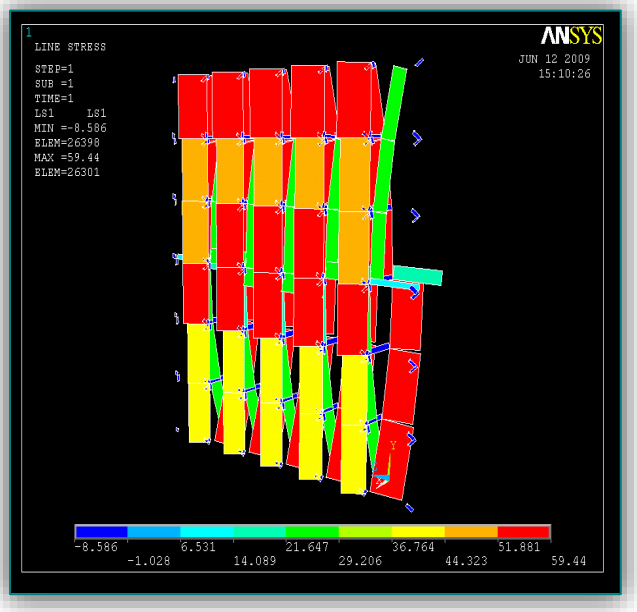

Figure 16. Modified support structure

On Figure 15 is shown total displacement of the glass curtain system. Maximal displacement is on the middle of the system and is equal to 7mm. The deflection of each panel is different and is in the range of 3-4 mm (we can calculate deflection as difference between absolute displacements). It should be noticed that above analyzed structure is usable only for pre-defined referent temperature. The referent temperature at which properties (Tab.1) are defined is approximately 23 до 25°C and the system can be considered stable for this temperature.

The structure is enhanced by changing the sections of the arches from Ø= 13 mm to Ø=20mm (A=314mm²). The results for wind load of 100 kg/m² are shown on Figure 16. The normal stress in TR-B is decreased from 86.6 to 59.4MPa and the stress in TR-F is increased to value of 21.6 to 60 MPa. The support structure now is stiffer and displacements are smaller. The last modification shows that small change in dimensions significantly contributes the stability of the system.

ANALYSIS OF THE SYSTEM INCLUDING TEMPERATURE EFFECT

Physical and mechanical properties of elements are given at nominal temperature. Above and below this temperature properties have different values.

In summer, temperature is higher than the nominal and steel elements extent causing pre-tension stress to decrease. Opposite to this case, in winter the elements are shrinking and add additional tension to the original pre-tension stress.
Support structure of the glass curtain wall is inside the building. It is exposed to sun radiation because windows are transparent and this radiation transforms in to heat [6, 7]. The infrared spectrum from the sun radiation completely transforms in to heat and it is up to the panels to filter this part of the light.

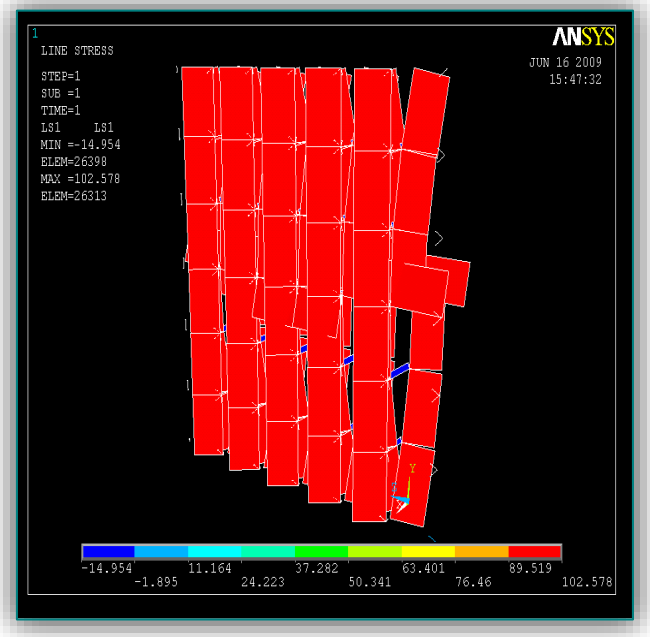

Figure 17. Pre-tension 100MPa*(nom.temp)

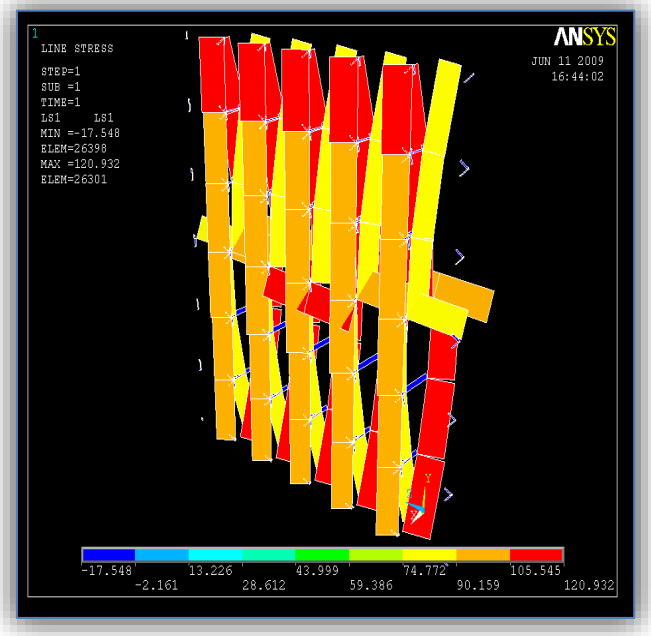

Figure 18. DL and wind load*(nom. temp)

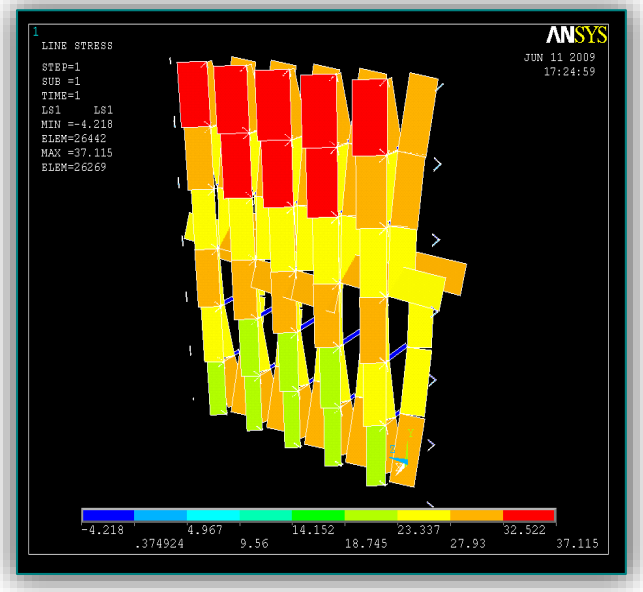

Figure 19. Dead load *(hig. temp)

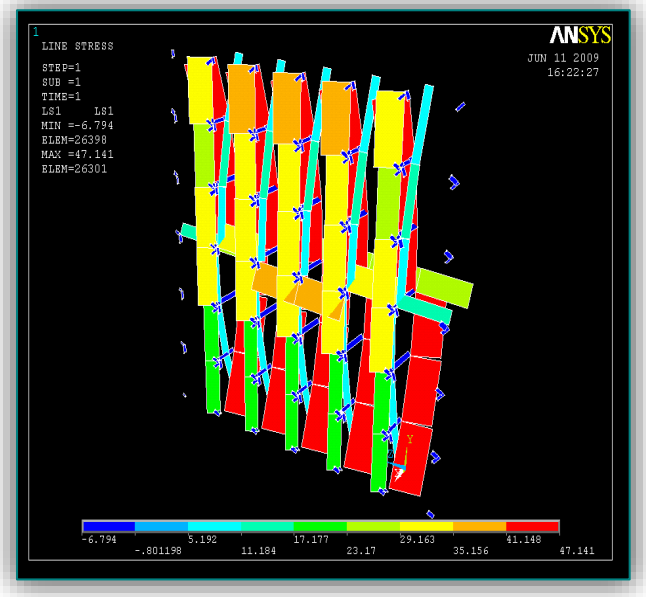

Figure 20. DL and wind load *(hig. temp)

In winter, panels should work as good isolators keeping the heat inside the building and keeping the structure at nominal temperature. Generally it is very important to know exact working conditions of the structure in order to design support structure [8,9].
The model given on Figure 16 will be exposed to equal heating in summer for +20°C, and cooling in winter for -20°C from the nominal temperature of 23 to 25°C. The model will expand and shrink with stress change $\sigma = E \times \alpha_T \times \Delta T$ [10].
Finally, the design condition for the support structure is that allowed stress should be smaller than 1/1.5 from $R_{P0,2}$ [10]. It is above economy savings of material.

SUMMER MODEL ANALYSIS

The model for simulation at high and low temperature is shown on Figure 17 and 18. Compared to the referent model (Figure 16), the difference consists in pre-tension value of the TR, VR and HR elements at nominal temperature. It is increased to 100 MPa.

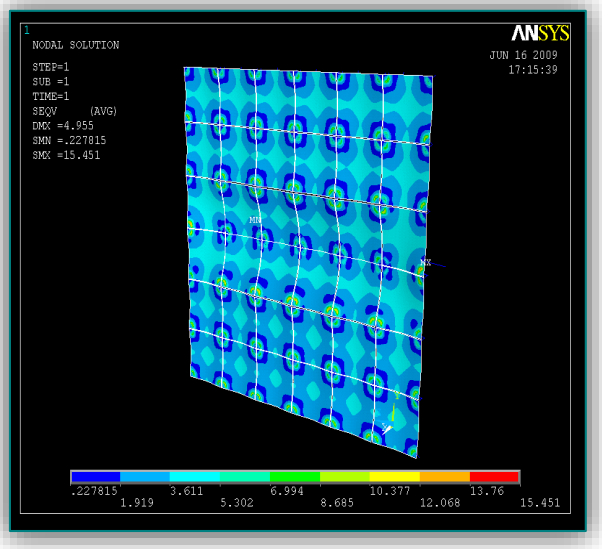

Figure 21. Stress distri. in panels*(hig. temp)

Figure 22. Total disp. in wind dir.*(hig. temp)

At higher temperatures (Figure 20), the support elements are relaxed compared to nominal temperature (Figure 18). The value of the stress in TR-F is equal to 11 MPa, while in the back 47 MPa. The analysis of the summer model shows that at higher temperatures TR-F elements have relaxed from 90 to 11MPa tension, while TR-B stress decreased from 120 to 47 Mpa (Figure 18, 20).

This is acceptable from stress point of view, but affects the stability of the structure. The higher temperatures lower the capacity of the glass support structure to stay stable.

If Figure 14 is compared with Figure 21 we can see that stresses in the window panels are lower in the last case. This is because the last model is generally stiffer than the one on Figure 14 and has smaller displacements (Figure 22). The additional stiffness comes from the increased pre-tension.

WINTER MODEL ANALYSIS

Lower temperature increases pre-tension stress which is shown on Figure 23 from value of 100MPa to value of 160-180 MPa. Decreased temperature makes support structure stiffer.

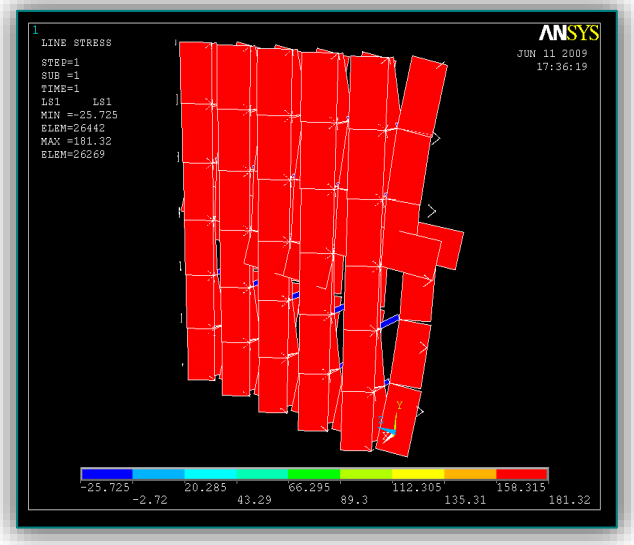

Figure 23. Dead load *(low. temp)

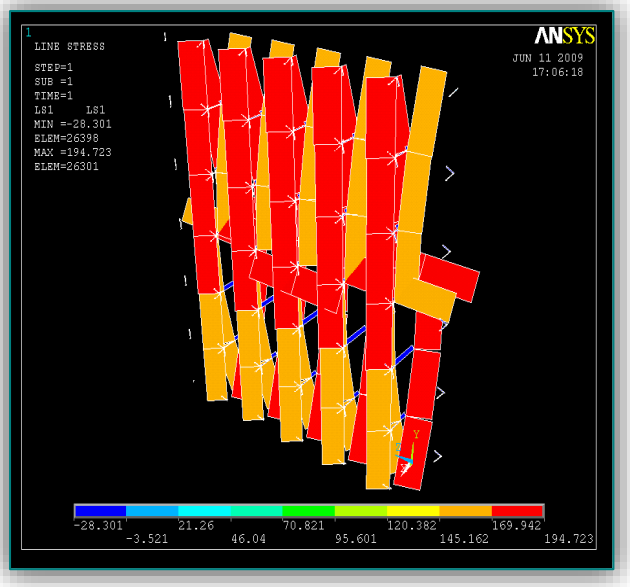

Figure 24. DL and wind load *(low. temp)

Analysis at nominal temperature (Figure 18) show that normal stress in TR-F is equal to 90 MPa and at TR-B is 120 MPa when the system is under dead and wind load. Analysis at lower temperature (Figure 24) shows that this values increases. The stress in TR-F is increases to 150 MPa and at TR-B is 195MPa. The stress distribution (Von Misses) of

the window panels (Figure 25) is similar to the one at higher temperature. The maximal value is equal to 15.5 MPa.

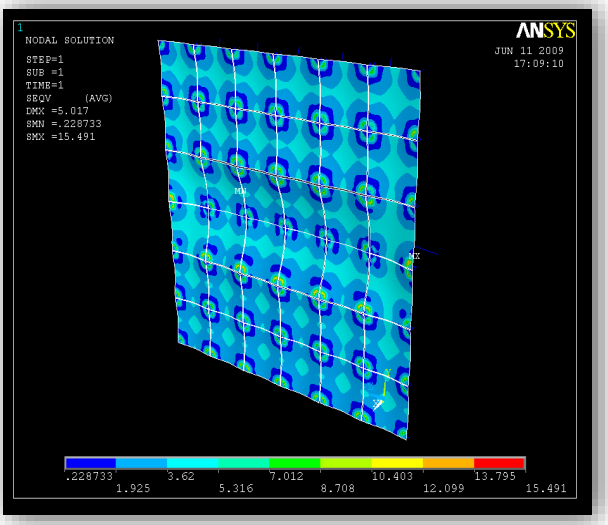

Figure 25. Stress distri. in panels*(low. temp)

Figure 26 shows maximal displacement (5mm) of the structure. Maximal displacement of panels is 3mm. The displacement at higher temperature is 4.8 mm and at lower temperature is 5mm. It looks contradictory, but there is logical explanation.

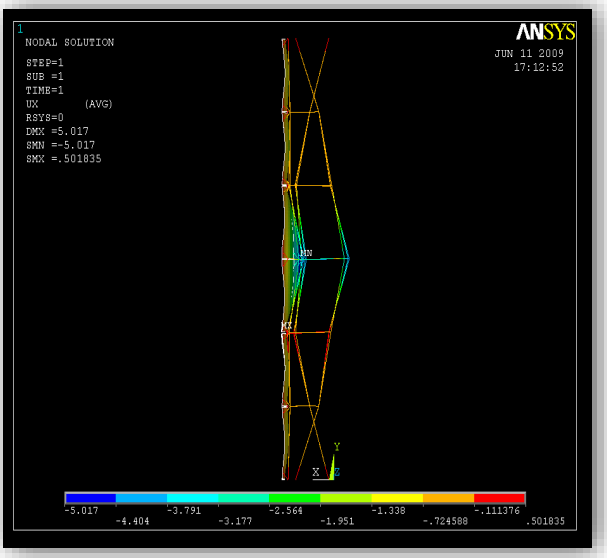

Figure 26. Total disp. in wind dir.*(low. temp)

Lower temperature causes shrinking of elements. Therefore, is affecting the arrows with higher compression force. This force is initiating deformation of the arrows and shifting the façade wall towards inside. This initial displacement is added on the total displacement with the wind load. At higher temperatures, initial displacement is in opposite direction, from the support structure towards the panels. In summer, total displacement is equal to absolute displacement from the wind minus initial displacement from the temperature.

CONCLUSION

Conclusion can be summarized as:

- TR-F and TR-B form arches that receive the wind force or force that comes from pressure difference between outside and inside of the building;
- HR elements work as horizontal stabilizers of the support structure and they take the lateral load which is in plane with the glass curtain wall;
- VR or DLR take dead load from the window panels and they should be set near the window in order to avoid the effect of bending.

All stresses in the support structure should be lower than the value 1/1.5 from the yield stress $R_{P0,2}$ in order to be on the save side; There should be minimum pre-tension at higher temperatures in the relaxed elements (i.e. arches) in order to prevent losing stability; The level of minimum pre-tension at full load should be subject for optimization.

Note: This paper is based on the paper presented at The 12th International Conference on Accomplishments in Electrical and Mechanical Engineering and Information Technology – DEMI 2015, organized by the University of Banja Luka, Faculty of Mechanical Engineering and Faculty of Electrical Engineering, in Banja Luka, BOSNIA & HERZEGOVINA (29th – 30th of May, 2015), referred here as [11].

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MASS FLOW RATE CHARACTERISTIC OF THE FLAPPER-NOZZLE PNEUMATIC VALVE

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Abstract: Flapper-nozzle type valve is commonly used for precision, flow control in pneumatic systems. For the purpose of analysis and design the paper is concerned with nonlinear mass flow rate of the valve taking into account different flow regimes. Flow rate is static, nonlinear function and could not be solved in analytical form. In this paper Particle Swarm Optimization method is used for numerical solution. Depending on supply pressure and flow area ratio along the static characteristic different segment can be observed.
Keywords: flapper-nozzle valve, mass flow rate characteristic, PSO optimization method

INTRODUCTION

Pneumatic servosystems are widely used in industrial applications because of the favourable performances/price ratio. However, high accuracy control of such systems is difficult due to their complex physical nature [1]. In order to solve the problem of design and control of such systems, it is necessary to have better understanding of their nonlinear characteristics. A mathematical model which should clarify the most relevant static and dynamic behaviour of the pneumatic system is used for that purpose.

Flapper-nozzle type valves are frequently used in pneumatic systems because of their simple structure, high precision, sensitivity and a broad bandwidth. They are usually used in control devices or measurement instruments. Different models of these valves can be encountered in the literature: starting from linearized algebraic equations to nonlinear dynamic models [2,3]. The paper analyzes the mass flow rate nonlinearity of the pneumatic flapper-nozzle type valve with high supply pressure. Various flow regimes are analyzed because when the supply pressure is higher than 0.15 [MPa], the air compressibility must be taken into consideration.

MASS FLOW RATE CHARACTERISTIC

Figure 1 presents the functional scheme of the pneumatic system which will be analyzed in the paper. The system consists of a valve and a chamber (Ch). The valve consists of a fixed orifice-type restriction (Or) and a flapper-nozzle combination ($Fl-N_z$). By rotating the flapper about the pivot P_v, the nozzle flow area (A_{en}), i.e. the mass flow rate $\dot{M}_n$ changes. As a result, there occurs a change of the pressure P at the control port. Hence, the valve is treated as a displacement-to-pressure transducer. As previously mentioned in this paper, the input signal is the nozzle flow area (A_{en}). This paper deals with the static, nonlinear mass flow rate characteristic of the valve. A detailed mathematical description of the flapper-nozzle type pneumatic servo valve with four ports can be found in [2, 3].

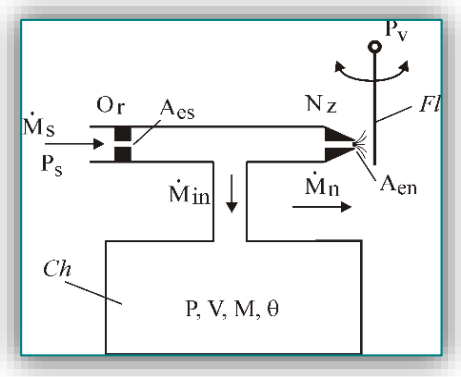


Figure 1. Pneumatic flapper-nozzle with the load chamber

The mass flow rate through the restriction can be in sonic or subsonic conditions depending upon the ratio of upstream-downstream pressure. According to the standard theory [4], it can be presented in the form:

$$\dot{M} = A_e \varphi(P_u, P_d, \theta_u) \qquad (1)$$

The effective area of restriction A_e depends on the geometry of the flow area of the restriction and the

discharge coefficient. Function φ depend on flow regime. If the downstream to upstream pressure ratio is smaller than a critical value P_{cr} (0.528 for air), the flow is sonic and the φ is linear function of upstream pressure. If the pressure ratio is higher than P_{cr}, the flow is subsonic and the φ depends nonlinearly on both pressures [4].

For a given flow area (A_{es}), and if holds $\theta = \theta_s = \theta_a = \text{const.}$ the mass flow rate through the fixed orifice depends only on the supply pressure (P_s) and the operating pressure $P\ (P_a \le P \le P_s)$. Figure 2 graphically presents that dependence.

All until $P/P_s \le P_{cr}$ (sonic regime), the flow has a constant value for the given P_s. Notice that the higher the P_s, the wider the area in which the flow rate has a constant value. For $P_{cr} < P/P_s \le 1$ (subsonic regime), the flow rate is a nonlinear function of the pressure P.

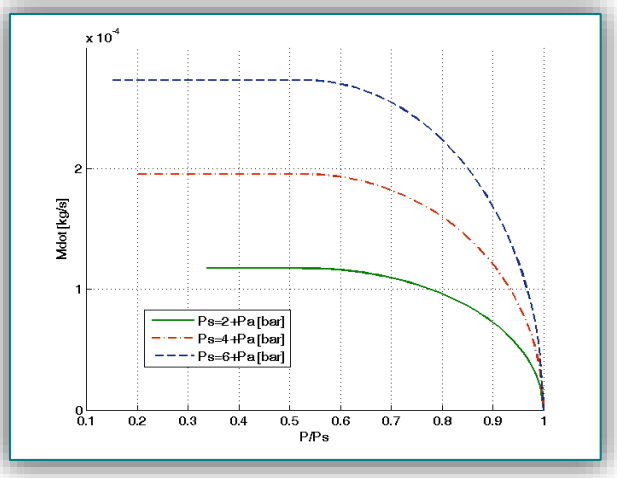


Figure 2. Mass flow rate through the fixed orifice

The mass flow rate through the nozzle, for a given P_s, depends both on the flow area A_e and the operating pressure P. Figure 3a and Figure 3b show those dependences respectively. For a given P, the flow through the nozzle is a linear function of the flow area regardless of the flow regime. The slope $\Delta\dot{M}_n / \Delta A_{en}$ increases with the increase of the operating pressure. It can be seen from Figure 3b that, in a general case, $\dot{M}_n$ is a nonlinear function of P. However, in the sonic regime ($P \ge P_a / P_{cr}$) the flow is, as in the fixed orifice, a linear function of the operating pressure.

In the steady state regime it can be written that:

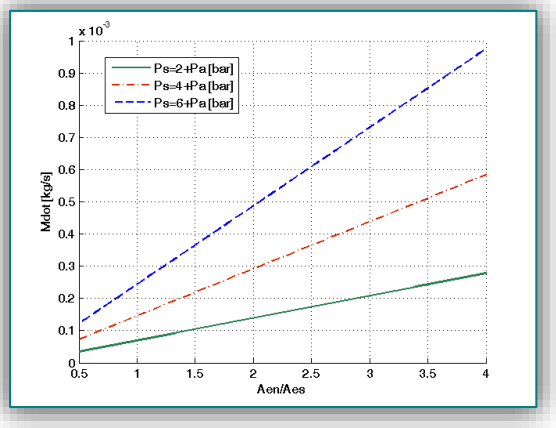
$$\dot{M}_{sN} = \dot{M}_{nN} = \dot{M}_N \qquad (2)$$

The mass of the fluid entering the chamber ($\dot{M}_{sN}$) is equal to the mass outflow through the nozzle ($\dot{M}_{nN}$). Based on (1), and (2), it follows that:

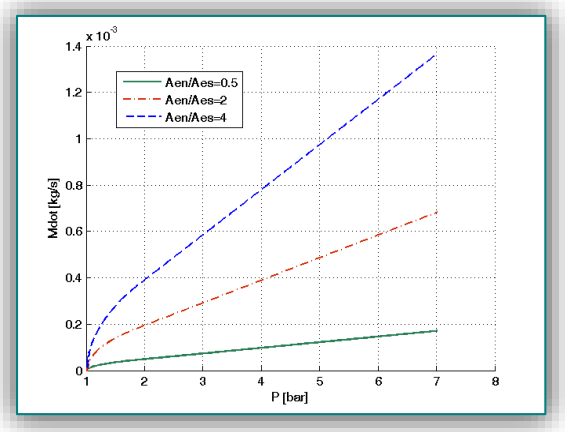
$$A_{es}\varphi(P_s, P_N, \theta_a) = A_{en}\varphi(P_N, P_a, \theta_a) \qquad (3)$$

The equation (3) could not be slolved analyticaly, in closed form. Unknown value for P_N we are looking for, depend on flow regime. On the other side, flow regime is determined by nominal pressure P_N.

Consequently we have to use numerical, iteration method. In this paper solution search is based on the Particle Swarm Optimization (PSO) method [5,6].



(a) depending on A_{en} / A_{es}



(b) depending on pressure P

Figure 3. Mass flow rate through nozzle

Figure 4 represents the algorithm of this method. Just as it is the case with all algorithms based on population, initial particle population is generated first. Position of the particle represents vector of parameters that are optimized: $x = (x_1, x_2, \ldots, x_n)$, or a potential solution. Random position in space which is explored, as well as initial velocities, is given to each particle. After that, the value of the objective function of each particle is determined, and that value is added to it as the best value for the particle in question, while the initial position becomes the best position of the particle P_{best}. When all the best values of particles are

determined, the particle with the minimum value is searched, and its position becomes the best position for the entire swarm P_{gbest}. Afterwards, it is checked whether the criteria of optimization are satisfied, and if they are, the obtained results are displayed. If the criteria are not satisfied, new velocities and positions are to be calculated.

Figure 5 presents numerical solutions of equation (3). It shows the dependence of the operating pressure P_N on the ratio of flow areas for different values of supply pressure. It should be noted that the operating pressure in the nominal regime (2) is unambiguously determined by the ratio A_{en}/A_{es} and that it does not depend on the type of load with which the flapper-nozzle is connected. The transition process depends on the type of load, but the nominal values of pressure depend only on the flapper position. On each of the curves from Figure 5, except the curve designated by number 3, there are three segments. On the curve 3 there are two segments. The segments are defined by means of the points A and B. The point A is the point on the curve at which:

$$P_N / P_s = P_{cr} \quad (4a)$$

It is the operating point at which the flow regime at the fixed orifice changes. The point B is the point on the curve at which:

$$P_a / P_N = P_{cr} \quad (4b)$$

It is the operating point at which the flow regime at the nozzle changes. Three characteristic cases of mutual ratios of the points A and B should be noted.

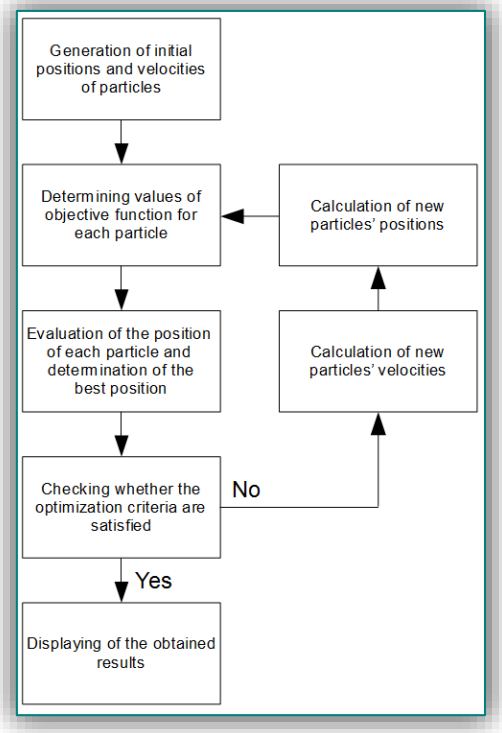


Figure 4. Algorithm of the method of particle swarm optimization

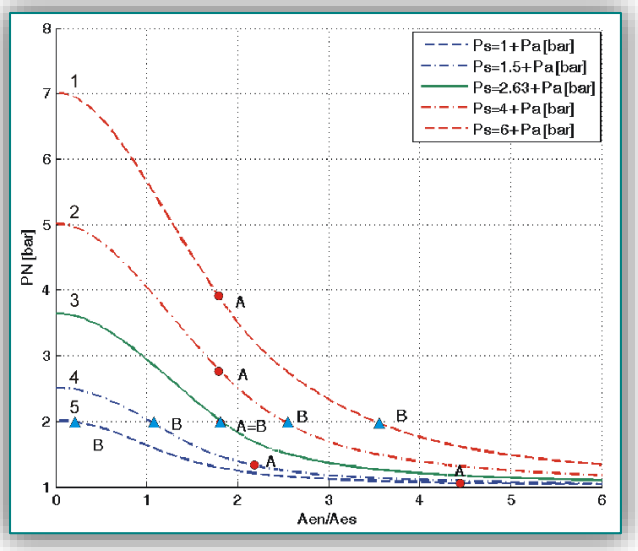


Figure 5. P_N - A_{en}/A_{es} relation in the nominal regime

CONCLUSION

Mass flow rate characteristic of the flapper-nozzle valve in steady state is a algebraic, nonlinear function of supply pressure and flow area ratio. In general case, it could not be solved in analytical form. Numerical method based on PSO algorithm represent a suitable tool for static analysis. For a given supply pressure there are three segments on flow rate characteristics: subsonic-sonic, sonic-sonic, sonic-subsonic. Width and order of these segments depends on ratio of nozzle flow area and fixed orifice flow area. Thus we can influence dynamic behavior of flapper-nozzle by choosing proper working point.

Nomenclature

$\dot{M}$ - mass flow rate through orifice [kg/s]
A_e - effective area of restriction [m²]
P - absolute pressure [Pa]
θ - temperature [K]

Subscripts

a - atmosphere
u - upstream
n - nozzle
d - downstream
s - supply
N - nominal operating regime

Acknowledgment

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Note

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referred here as [7].

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IMPROVING ENERGY EFFICIENCY OF DATA CENTRES

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Abstract: Great energy consumption and costs incurred by data centres are a huge incentive to find ways to reduce them. In a typical data centre, nearly one half of the energy consumed goes to supporting data-com equipment, and the other half is used by support systems. Hence, increasing the energy efficiency of data centres is a challenge. This paper discusses the possibilities for improving the energy efficiency of air conditioning systems and ventilation by integrating best tested devices, with special emphasis on the management and control system for air conditioning and ventilation.
Keywords: data centre, control system, energy efficiency, conditioning and ventilation

INTRODUCTION

The air-conditioning system should provide ventilation, filtration, cooling and dehumidification, humidification and heating of the air; to operate continuously throughout the year and to be flexible if an expansion is required without interrupting the operation of the data centre. Its work, servicing and maintenance, must not disrupt the operation of the centre.

The system of ventilation and air conditioning (HVAC) which maintains the foreseen operating conditions of the equipment in the data centre which consumes on average 38% of the total energy consumption in the data centre (Fig. 1). From that perspective, the design of control system for air conditioning and ventilation which achieves fast response and reliable operation is the best way to achieve energy-efficient control and reduce the cost of HVAC system.

MANAGEMENT AND CONTROL OF THE AIR-CONDITIONING AND VENTILATIONSYSTEMS

A well-designed and maintained control system for air-conditioning and ventilation in data-com centres has a significant impact on energy costs of HVAC system. When designing the control system, the goal is to design energy-efficient control solutions which optimize energy consumption, without causing any risk for the Data Centre. The control system must continuously provide working conditions in Data centre according to the Thermal guidelines ASHRAE 2004, and its task is to secure the operation of the equipment for air conditioning and ventilation work in sequences or phases which are necessary to maintain the operating conditions of the data com equipment 24 hours a day, seven days a week.

The most efficient HVAC system is the one that always complies with the needs for data equipment cooling. Using intelligent cooling control systems with the air conditioning and ventilation the cooling capacity and the cold airflow is adjusted to the current conditions in the data centre, simultaneously carrying out a coordinated management of refrigeration unit works, which is of essential importance in optimizing the efficiency of the system.

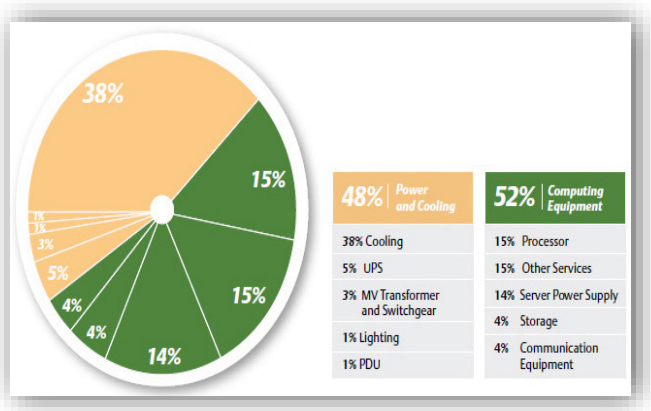

Figure 1. Data-com equipment accounts for over 50% of the energy used while power and cooling account for an additional 48% in a traditional data centre

Efficient operation and saving measures for air conditioning system and ventilation are achieved

through its components: air distribution control in the data centre, managing the air conditioning loop, control of the outside air, controlling the work of the economizers, the humidity control, the part-load operation, etc.

» **Increasing the efficiency of the fans**

The fans are components of the cooling system which consume significant amounts of energy. By increasing the efficiency of the fans the efficiency of the air conditioning system of the data centre is increased. Using variable frequency drives significantly reduces energy consumption compared with fixed-speed fans. The addition of variable frequency drives to the fan motors enables fan speed and power to be reduced inconformity with the reduction of the load. 20 percent reduction of fan speed allows almost 50 percent savings in the fan power consumption.

The use of electronically commutated fans makes possible the increase of the cooling unit energy efficiency. Electronically commutated fans are more efficient than centrifugal fans, because they eliminate the zone of losses, which runs up to about five percent.

» **Reduction of cooling unit working hours**

The cooling unit is the largest energy consumer of all HVAC equipment in the centre. Significant energy savings can be achieved by reducing the working hours of the cooling unit. It requires the installation of structural elements in the design of the cooling system, especially in centres that consume large amounts of energy. Besides the use of equipment with greater energy efficiency in the cooling system, a method of reducing the working hours of the equipment should be incorporated. Therefore whenever the conditions allowed free cooling- option should be used. Both types of economizer which can reduce the working hours of the cooling device are the following: the air-side economizers and the fluid-side economizers (often called water-side).

Economizers achieve major savings in areas where temperatures are lower, but if properly designed, they can achieve significant savings also in warmer climates. The system of economizers using outside air provide “free-cooling” cycles. This reduces or eliminates the work of the chiller and the operation of the compressor in the precision cooling units, allowing the economizers` system cooling unit to generate savings from 30 to 50 percent, depending on the average temperature and humidity of the environment.

A fluid-side economizer works in conjunction with a heat rejection loop comprising an evaporative cooling tower or dry-cooler to satisfy cooling requirements. It uses outside air to aid heat rejection, but does not introduce outside air into the data center.

» **Air distribution control system**

The right solution and control system for air distribution in data centres is one of the major factors for achieving the prescribed conditions for the data centre or the data-com equipment. To provide effective cooling the air distribution has to be appropriate to the thermal load. The distribution systems should be sufficiently flexible to be able to adapt to changes and to sizes of thermal loads. The flexibility and reserves can be achieved using the system of distribution with variable air flow (VAV), by introducing oversized systems, by cross-linking of complex systems, and by providing equipment which does not operate and is in working condition. Using a system with variable airflow and its proper control can be provided if additional capacity is ensured if necessary, and the system will work with values of the temperature and air flow which are suitable for the regulation of the optimum temperature and humidity in the data centre simultaneously reducing the energy consumption for fan operation, and the need for additional heating.

» **Managing the air conditioning loop**

Especially significant is the appropriate choice of the heated air flow paths, and its discharge from the data centre. The recirculation and mixing of the heated discharged air and cold supply air, negatively impact the achievement of the necessary work conditions of data-com equipment. The short circuit of the cold air (its untimely return to the air conditioning system) without passing through releasing heat data-com equipment, can significantly affect the performance and energy efficiency of the air conditioning equipment. It is recommended to apply date equipment in hot / cold aisle arrangement in order to reduce the mixing of cold supply air and warm air return. This date equipment arrangement contributes to the temperature increase of the supplied cold air in the room, that is, makes it easier to achieve the recommended (ASHRAE guidelines 2004). The aim is to ensure an adequate supply of cold air to the front of the data-com equipment, i.e. in the cold aisles and the removal of hot air, which is discharged at the rear of the equipment, to wit, off the warm aisles. Typical data centres have high thermal loads, and despite the hot / cold aisles arrangement of the equipment, a part of the warm air flows towards the cool aisles, making it difficult to maintain the designed data equipment working conditions. Therefore it is essential to separate the cold from the warm air, and its discharge into the air-conditioning equipment.

The physical barrier separating the warm from cold air is necessary in order to maximize the scope of separation. Anyone of the following three approaches - partition of the cold aisle, of the hot aisle and of the rack- could provide a physical separation, whereby each of them has its advantages and limitations.

Partitioning of the cold aisle allows cold air containment in the individual aisles, by means of physical barriers on the upper part and on the sides of the aisles. The barrier prevents mixing of warm air at the outlet from the data equipment with the cold air, thus providing a uniform temperature at the inlet to data equipment. The supplied air temperature can be reset to a higher value because the inlet air temperature to data equipment will be equal to that of the supplied air. The increased temperature of the supplied air will yield greater working efficiency of the cooling devices and will increase the free cooling time. Of course, the required amount of airflow will also be reduced leading to lower direct energy consumption for air recirculation. For high-density data centre a full enclosure of the cold aisles is recommended, making it easier to achieve the cooling capacity matching the thermal load of the data equipment.

In the warm aisle partition design, the whole data centre save the cold aisles, is exposed to the hot air from data equipment, and is approximately with the same temperature as the temperature of the discharge air at the outlet from the data equipment which is usually higher 11 to 22°C than the inlet air temperature to data-com equipment. Therefore, the need for containing the warm air within the warm aisles, and to open the rest of the data centre to the supply of cold air.

The partition of the racks is similar to the partition of cold and hot aisles, but it is implemented in the individual racks. The partition of the racks provides special paths for the entry of cold air and the discharge of hot air, thereby hindering the mixing of warm and cold air. The partition of the racks has its advantages, since the rack is the smallest unit in the data centre which can be placed anywhere, without strictly observing the need for hot/cold aisles arrangement.

Another possibility is the overheat space to be used as a plenum for hot air, wherefrom the warm air flows back towards the air conditioning units.

» **Control of outdoor air**

In order to control the pressure and humidity in the premises of the data centre, it is necessary to install a system for control of the outside air. The main moisture load usually comes from infiltration, therefore the employed system for supply of external air brings premises in a pressurized condition, thus preventing the infiltration of outside air, as well as meeting all the requirements for humidification and dehumidification exerted by it.

» **Part – load operation control**

To develop an effective control of part- load operation sequence for the central cooling plant it is particularly important due to the oscillation of the thermal loads in the Data Centre.

The part load operation of the data centre offers considerable energy savings due to reduced and more efficient compressor operation, either in the plant with cooling water or in the special cooling units. When choosing the cooling devices for Data centres it the operating range in which they will work should be borne in mind, taking into account working with duplicated cooling devices, and the fact that the cooling devices will often work with low capacity although they are dimensioned to match peak loads in the data centre.

CONCLUSION

Although security in the operation of data centres is a priority, significant energy reductions can be achieved without thereby reducing the reliability. Significant energy savings can be achieved by carefully implementing the free cooling plants and variable frequency drives by controlling the air-distribution system in the data centre, by managing the air conditioning loop, by controlling of the outside air, by regulating the work of air and fluideconomizers, and by monitoring the humidity and part-load operation.

Note

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MODELING OF THE BUILDING THERMAL BEHAVIOUR USING NONLINEAR SYSTEM IDENTIFICATION

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Abstract: Model-based predictive control is a very modern powerful control strategy that uses a model of the plant to predict its future behaviourand has been in focus of researchers in the area of buildings energy management. The aim of this paper is to develop and analyze NARX (Nonlinear AutoRegressive with eXogenous inputs) structure for the modeling of the building thermal behavior. A database was generated using simulation in EnergyPlus software. The NARX identification model was designed using the MATLAB System Identification Toolbox. The input variables analyzed in this paper are: outdoor temperature, heating or cooling power, and direct solar radiation. Simulation results demonstrate that the proposed nonlinear structure can be effective identificationtool for development of nonlinear buildings predictive control.
Keywords: building, NARX, identification, thermal behaviour

INTRODUCTION

Model predictive control (MPC) has been in focus of researchers in the area of buildings [1]. Model predictive control denotes a wide range of control techniques which apply a model to the prediction of future system behavior and calculate the control signals through the optimization of the objective function. The basic conditions that each model should satisfy are practical simplicity, well estimated system dynamics and satisfactory prediction properties.

Various deterministic approaches which uses knowledge of the structure and physical and material properties of a building and statistical procedures have been applied in order to derive a total model for the heat dynamics of a building.Deterministic models are based on energy and mass balance integral–differential equations and development of such type of model is a very time consuming task.

Prívara et al. [2] proposed a new methodology to obtain a model combining the building energy performance simulation tools and statistical identification. Bacher and Madsen [3] applied the procedure for identification of the most suitable grey-box models for the heat dynamics of a building on the basis of data from an experiment and prior physical knowledge of the system. Also, the grey box modelling method has been applied to derive a total model for the heat dynamics of a building by Andersen et al. [4]. Jiménez et al. [5] have been presented the application of the MATLAB System Identification toolbox to estimate the thermal properties of building components from outdoor dynamic testing, imposing appropriate physical constraints and assuming ARMAX parametric models.The nonlinear black-box models perform better than linear models (ARX, ARMAX) in predicting buildings thermal behaviour [6-9].

The present paper suggests a procedure for identification and development NARX structure for the modeling of the building thermal behaviour. A database has been generated using simulation in EnergyPlus software.

METHODS FOR NONLINEAR SYSTEMS IDENTIFICATION

Different methods have been developed in the literature for linear system identification. These methods use a parameterized model. The parameters are updated to minimize an output identification error.

The linear dynamic systems with an input u and an output y can be described by the ARX (**A**uto **R**egresivee **X**ogenous) model:

$$y(k)=\varphi^T(k)\theta=\theta^T\varphi(k) \quad (1)$$

where: $y(k)$ is the output of the model, $\varphi(k)$ is the regression vector and θ is the parameter vector.
The regression vector ARX structure is:

$$\varphi^T(k)=\{-y(k-1),-y(k-2),-y(k-3),...,-y(k-n_a)$$
$$u(k),u(k-1),u(k-2),u(k-3),...u(k-n_b)\}$$

andthe parameter vectoris

$$\theta^T=\{a_1,a_2,...,a_{n_a},b_1,b_2,b_3,...,b_{n_b}\}.$$

A wide class of nonlinear dynamic systems can be described by the Nonlinear ARX model:

$$y(k)=f(\varphi(k),\theta) \quad (2)$$

where: f is a nonlinear function whose Inputs are the model regressors.
This block diagram of a nonlinear ARX model is shown in Figure1.
The nonlinearity estimator block is combine with linear and nonlinear function in parallel and maps the regressors to the model output:

$$f(\varphi)=L^T(\varphi-m)+r+g(Q(\varphi-m)) \quad (3)$$

dis a scalar offset, m is the mean of the regressors, Qis a projection matrix.

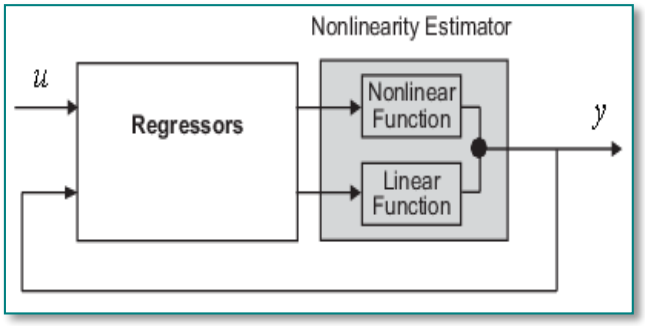

Figure 1. Structure of Nonlinear ARX Models.

The wavelet network can be trained to approximate function g as:

$$g(\varphi)=\sum_{i=1}^{n}\alpha_k\kappa(\beta_k(\varphi-\gamma_k)) \quad (4)$$

where: $\kappa(*)$ is the wavelet function, n is the number of nonlinear units and α_k, β_k and γ_k are constant.

BUILDING SIMULATION

The analyzed building consists of three zones, Figure 2.
Basic file description: 1 story building divided into 3 interior conditioned zones. Roof with no plenum. No ground contact with floor. Floor Area: 130.1 m^2. There is a single window in the west zone south wall. An electric low temperature radiant system is used for heating the floor of each zone, with power ratings of 12 kW, 8 kW and 8 kW for the north, west and east zones respectively.
The ambient air temperature profile was of Chicago, IL, USA. The disturbances due to internal heat gain and solar heat gain were different for every zone and time-varying.
In this case study, we used the EnergyPlus model as the ground truth for the building, i.e., it was considered as the "real" building. The program EnergyPlus 6.0 is used, which allows the simulation of thermal behavior of buildings during the analyzed period.

SIMULATION RESULTS

In this work, NARX (Nonlinear AutoRegressive with eXogenous inputs) structure are chosen to predict zone temperature (North, West and East). The procedure for determining proper NARX models from EnergyPlus data involves three steps: (1) obtaining input-output data by simulating (2) model structure selection (train NARX with different delays), and (3) model validation. The input vector of the considered models is:

$$u=[T_e\ P_{hc}\ R]^T$$

where: T_e is outdoor temperature, P_{hc} denote heating or cooling power and R is direct solar radiation.

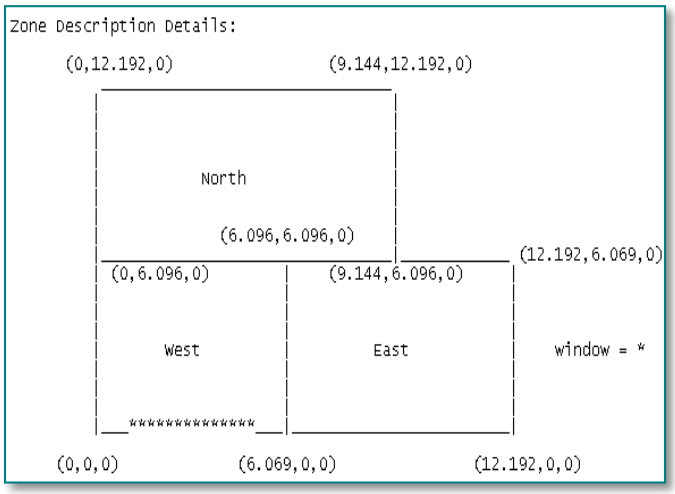

Figure 2. The analyzed building.

The number of the NARX inputs is determined by the input and output lags. In this paper, the satisfactory accuracy is obtained for regression vector:

$$\varphi^T(k)=\{T_i(k-1),\ T_e(k-1),\ P_{hc}(k-1),R(k-1)\} \quad (5)$$

The numbers of units wavelets estimator have been automatically chosen by the estimation algorithm. This section presents the results of simulations for the west zone.
The wavelets estimator for prediction WEST zone temperaturehas94 units.
The time series of the inputs and output variables are shown in Figure 3, Figure 4, Figure 5 and Figure 6.

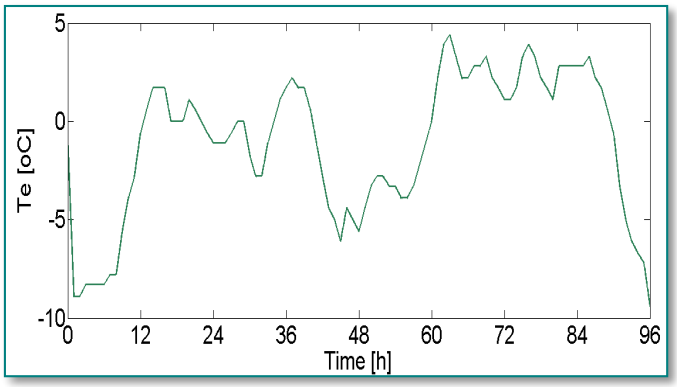

Figure 3. The outdoor temperature.

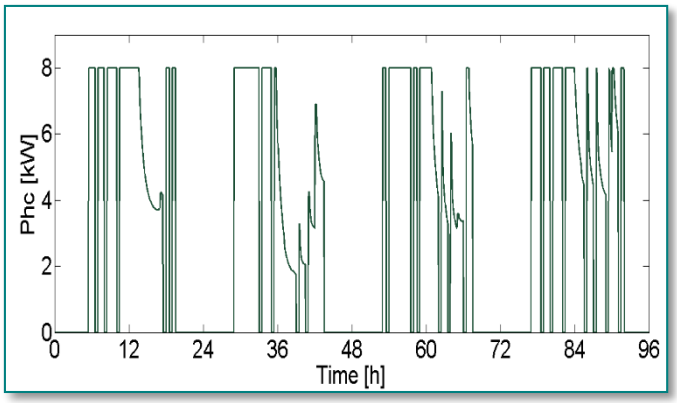

Figure 4. The power heating or cooling.

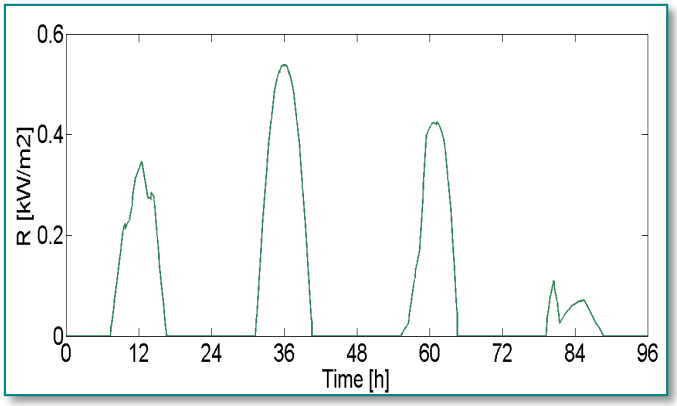

Figure 5. The direct solar radiation.

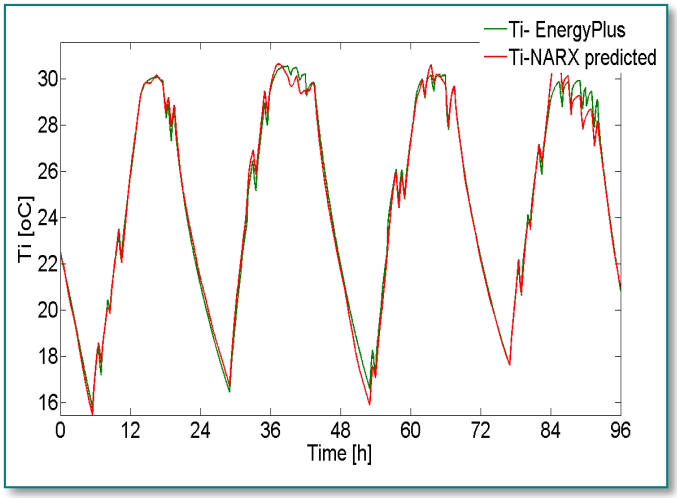

Figure 6. The indoor temperature.

CONCLUSION

In this paper, a procedure for using MATLAB System Identification Toolbox for modeling building thermal behavior is proposed. NonlinearARX model is more suitable than the linear estimator because room temperatures is governed by nonlinear equation. The result of the simulation show that NARX model predicted values are in accordance with the values obtained by the simulation.

The future research should include the application of the proposed technique on a real input–output data collection from measurements.

ACKNOWLEDGMENT

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GEOPORTALS AND GEOSPATIAL SERVICES – ANALYSIS OF OPEN-SOURCE SOFTWARE SOLUTIONS FOR GEOPORTALS

1. Opština Gradiška, Gradiška, BOSNIA & HERZEGOVINA

Abstract: Portal is a web site that is the starting point or access point for multiple web sites and online services. Portals combine a variety of information from multiple sources, providing consistent data and access to numerous applications that would otherwise pose a separate unit. The personal portal provides opportunities, especially tailored to each user, with the possibility of visiting and moving on to the page with different content. Designed for use with distributed applications, different numbers of software that act between applications and networks to integrate various services from numerous other sources. Portals provide users logging on a variety of activities, a directory service and information pertaining to a certain level of subject or organization. There are three types of portals: vertical portal for special activities, occupations and interests, private intranet portals - for employees, customers, partners, and a manufacturer, extranet portals include public and private information.
Keywords: portals, applications, service, information

INTRODUCTION

Geoportal is a target place for representation of geospatial data, displaying, editing and searching analisys. Geoportal are widely used in geographic information systems (GIS) and Spatial Data Infrastructure (SDI). The users of geographic information use geoportals for searching and retrieval of geographic information that they need. Geoportal play a major role in sharing geographic information and avoiding duplication of work, inconsistencies of data, delays, confusion and waste of resources.

The earliest concept of geoportals was created in 1994 in the United States, in the framework of the NSDI (National Spatial Data Infrastructure). In the European Union first was developed INSPIRE (Infrastructure of Spatial Information) directive, ie geoportal. There are three types of geoportals, which are:

- National and international geoportal (NSDI, INSPIRE)
- State and local Geoportal (GeoStor, CaSIL)
- Theme Geoportal (Conservation, NetCarb);

Geoportals can be marked as:

- Catalogue of Geoportal (organization and management of accessing geographic information)
- Application geoportal (on-line dynamic geographic web services).

Metadata, by definition, are "data about data" in any medium. These are data that describe the characteristics of a source in digital form. They are useful for displaying, transfering and documentation of any content. They can describe one data set of data or only some part of the whole. Metadata are widely used. It is commonly used to accelerate and improve search of large amounts of data, and reveal as much relevant information. A central role in a geoportals have metadata and web map server. It is a server that contains services for metadata management, mapping, geocoding, data downloading, etc.

SOFTWARE SOLUTIONS FOR DISPLAYING, MANAGEMENT & WORK WITH GEOSPATIAL DATA

There are a large number of commercial and free software solution for display, view, manage and work with geospatial data such as:

- OpenGeoportal,
- NJTPA Enterprise GIS
- ESRI ArcGIS Server Geoportal,
- OpenGeoportal,
- INSPIRE,
- GEOSS Portal,
- ERDAS Apollo,
- GeoServer,
- OpenLayers

There is a large number of state and local geoportals. In this paper we will discuss the main caracteristics of mantioned geoportals and possebilities of those aplication in our local

comunity as well as the goverment matter.

Inspire

In Europe a major recent development has been the entering in force of the INSPIRE Directive in May 2007, establishing an infrastructure for spatial information in Europe to support Community environmental policies, and policies or activities which may have an impact on the environment.

INSPIRE is based on the infrastructures for spatial information established and operated by the 28 Member States of the European Union. The Directive addresses 34 spatial data themes needed for environmental applications, with key components specified through technical implementing rules. This makes INSPIRE a unique example of a legislative "regional" approach.

Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) was published in the official Journal on the 25th April 2007. The INSPIRE Directive entered into force on the 15th May 2007

To ensure that the spatial data infrastructures of the Member States are compatible and usable in a Community and transboundary context, the Directive requires that common Implementing Rules (IR) are adopted in a number of specific areas (Metadata, Data Specifications, Network Services, Data and Service Sharing and Monitoring and Reporting). These IRs are adopted as Commission Decisions or Regulations, and are binding in their entirety. The Commission is assisted in the process of adopting such rules by a regulatory committee composed of representatives of the Member States and chaired by a representative of the Commission (this is known as the Comitology procedure).

The INSPIRE directive came into force on 15 May 2007 and will be implemented in various stages, with full implementation required by 2019.

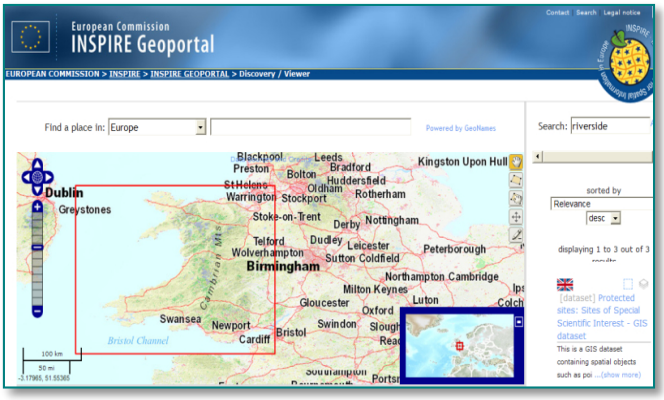

Figure 1. INSPIRE geoportal interface

The INSPIRE directive aims to create a European Union (EU) spatial data infrastructure. This will enable the sharing of environmental spatial information among public sector organisations and better facilitate public access to spatial information across Europe.

A European Spatial Data Infrastructure will assist in policy-making across boundaries. Therefore the spatial information considered under the directive is extensive and includes a great variety of topical and technical themes.

INSPIRE is based on a number of common principles:

- Data should be collected only once and kept where it can be maintained most effectively.
- It should be possible to combine seamless spatial information from different sources across Europe and share it with many users and applications.
- It should be possible for information collected at one level/scale to be shared with all levels/scales; detailed for thorough investigations, general for strategic purposes.
- Geographic information needed for good governance at all levels should be readily and transparently available.
- Easy to find what geographic information is available, how it can be used to meet a particular need, and under which conditions it can be acquired and used.

Geoportal application of the Republic Administration for Geodetic and Property Affairs of the Republic Srpska was created in a way that allows the presentation, distribution and collection of distributed data from the jurisdiction of the Board through services and applications on one side, and to ensure interoperability with data from other institutions of the Republic Srpska on the other side, which in accordance with the INSPIRE Directive and other international standards in this area.

Esri Geoportal Server Geoportal

Esri Geoportal Server is a free, open source product that enables discovery and use of geospatial resources including datasets, rasters, and Web services. It helps organizations manage and publish metadata for their geospatial resources to let users discover and connect to those resources. The Geoportal Server supports standards-based clearinghouse and metadata discovery applications.

With Esri Geoportal Server, user can:

- Reduce time and redundancy of data production by connecting geospatial data and service producers with consumers.
- Maintain data integrity by allowing organizations to easily share the authoritative version of data among its users.
- Enable easy search and discovery of existing geospatial data and services by allowing users to create and manage descriptions of their geospatial resources and supporting easy-to-use,

sophisticated, data discovery technologies.

Esri Geoportal Server was released under the Apache 2.0 license, which allows developers to freely customize and redistribute the software.

GEO Portal

GEO Portal is a central Portal and Clearinghouse providing access to Geospatial and Earth Observation (EO) data in support of GEOSS. GEO Portal allows you to discover, browse, edit, create and save geospatial information from GEO members around the globe.

GEO Portal has been implemented using Compusult's Web Enterprise Suite (www.compusult.net), a suite of applications, based on open standards, that work together to provide a comprehensive, data discovery, access, retrieval and delivery system. The GEO Portal facilitates the discovery of Earth Observation data from thousands of services, instruments, collections, libraries and catalogues worldwide, transforming the data collected into vital information for society.

The Global Earth Observation System of Systems (GEOSS) is simultaneously addressing nine areas of critical importance to people and society. It aims to empower the international community to: promote sustainable agriculture, conserve biodiversity, respond to climate change and its impacts, protect itself against natural and human-induced disasters, manage ecosystems and energy resources, understand the environmental sources of health hazards, safeguard water resources and improve weather forecasts. GEOSS coordinates a multitude of complex and interrelated issues simultaneously. This cross-cutting approach avoids unnecessary duplication, encourages synergies among systems and ensures substantial economic, societal and environmental benefits.

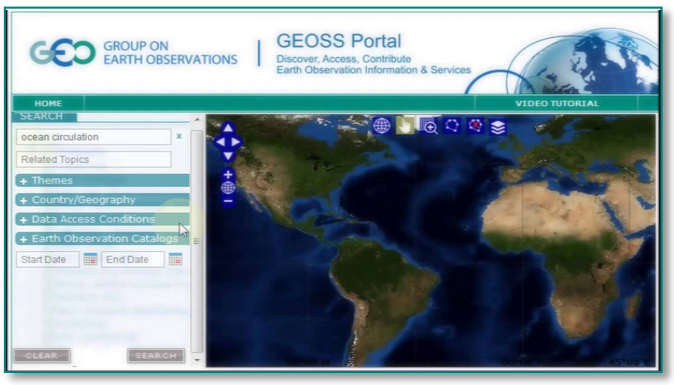

Figure 2. GEOSS Portal

GEOSS is providing solutions for:

» Forecasting meningitis outbreaks
» Protecting biodiversity
» Improving climate observations in Africa
» Supporting disaster management in Central and South America
» Managing water resources in Asia
» Promoting solar energy
» Improving agriculture and fisheries management.
» Mapping and classifying ecosystems
» Forecasting weather for the 2008 Beijing Olympics.

North Jersey Transportation Planning Authority (NJTPA)

The NJTPA has recently completed a project that centrally locates numerous geographic and related non-geographic data collected by, and stored at the NJTPA. These data sources are used by the NJTPA to inform sound decision-making. Some of the data items originate at the NJTPA but many are generated by other agencies ranging from national to local. The main product of this project is a new enterprise-class geospatial database that regularizes how data items are stored, updated, and exchanged. This product is an example of interagency coordination in action - as mentioned above numerous local, regional, and state partner agencies were and are integral contributors.

The database helps to ensure that data is current, accurate and suitable for particular uses - by NJTPA staff, NJTPA subregions, partner agencies and the general public. The Enterprise GIS (EGIS) database allows staff to respond to data requests more efficiently. As appropriate, EGIS information is available for download online at the NJTPA Geoportal, the public-facing website containing the NJTPA's data catalog. Authorized users are be able to draw directly from the EGIS database to produce tables, maps, and conduct their own analyses. During the formal Fall 2010 rollout of the EGIS, authorized users will be provided user identifications and passwords as well as training.

This effort is meant to markedly strengthen the information foundation for the NJTPA and its partners, ultimately supporting wise planning decisions for northern New Jersey. Stay tuned for updates, contributor maintenance schedules, training, information sessions and improvements.

OpenGeoportal

OpenGeoportal.org is a new site that brings together geospatial professionals, developers, metadata specialists, and librarians to coordinate the Open Geoportal (OGP) project. The Open Geoportal is a collaboratively developed, open source, federated web application to rapidly discover, preview, and retrieve geospatial data from multiple repositories. OpenGeoportal.org is also a collaborative effort to share resources and best practices in the areas of application development, metadata, data sharing, data licensing, and data sources in support of geospatial data repositories.

OpenLayers

OpenLayers is an open source JavaScript library for displaying map data in web browsers. It provides an

API for building rich web-based geographic applications similar to Google Maps and Bing Maps. The library was originally based on the Prototype JavaScript Framework.
OpenLayers supports GeoRSS, KML (Keyhole Markup Language), Geography Markup Language (GML), GeoJSON and map data from any source using OGC-standards as Web Map Service (WMS) or Web Feature Service (WFS).

Geoserver

GeoServer – an open-source server written in Java - allows users to share, process and edit geospatial data. Designed for interoperability, it publishes data from any major spatial data source using open standards. GeoServer has evolved to become an easy method of connecting existing information to Virtual Globes such as Google Earth and NASA World Wind as well as to web-based maps such as OpenLayers, Google Maps and Bing Maps. GeoServer functions as the reference implementation of the Open Geospatial Consortium Web Feature Service standard, and also implements the Web Map Service, Web Coverage Service and Web Processing Service specifications.

Figure 3. Geoserver portal

GeoServer aims to operate as a node within a free and open Spatial Data Infrastructure. Just as the Apache HTTP Server has offered a free and open web server to publish HTML, GeoServer aims to do the same for geospatial data.
GeoServer reads a variety of data formats, including:

- PostGIS
- Oracle Spatial
- ArcSDE
- DB2
- MySQL
- Shapefiles
- GeoTIFF
- GTOPO30
- ECW, MrSID
- JPEG2000

CONCLUSIONS

The focus of this paper is based on the identification of available free software solutions for geoportals. Taking in consider the characteristics of these solutions, as well as a comparison with commercial software applications, each of them gives a good representation, management and operation of the geodata. The main disadvantages of this kind is the speed and often breaking a connection with server.
Working with the free geoportal definitely reduces costs of downloading various geospatial data and work with them. They have absolutely the ability to read all types of data formats, as well as commercial applications.
Access with the open source code makes easier integration with other systems, such as content management systems, various virtual folders, desktop applications and the like. One of the most important things of open source solutions for geoportal is improved cooperation ie. It is easier to connect and share data with other geoportal, as the geoportal beyond political boundaries.
There is a strong and growing trend that aims to develop and use open source technology. Some government institutions and organizations have adopted regulations where it is desirable or compulsory use of open source geoportals. By placing the server geo come for the Apache license, which makes it easier to meet these demands. In the near future it is expected that everyone will be free geoportal type.

Note: This paper is based on the paper presented at The 12th International Conference on Accomplishments in Electrical and Mechanical Engineering and Information Technology – DEMI 2015, organized by the University of Banja Luka, Faculty of Mechanical Engineering and Faculty of Electrical Engineering, in Banja Luka, BOSNIA & HERZEGOVINA (29th – 30th of May, 2015), referred here as [9].

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OPPORTUNITIES FOR APPLICATION OF THE GENERATIVE ENGINEERING METHOD IN HEAVY MACHINE DESIGN

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Abstract: This paper presents a generative engineering method and the opportunities of applying it in the design of the structural components of heavy machines. The generative engineering method is a further development of the engineering methods currently used, which enables automatic generation of some parts or entire assemblies to the given requirements, thus saving time and avoiding errors during the design stages of a product life cycle. Generative engineering uses Knowledge-Based Engineering (KBE) to capture and reuse knowledge about the product and its design processes, various algorithms to create suitable geometrical models, and it enables Multi-Disciplinary Optimization (MDO) to be used effectively. The main model is based on parametric and associative geometric models created in CAD software, which are further enhanced with parametric design requirements. Discipline-specific analysis models are automatically derived from the main model, and they are used to verify if the requirements are met, or for further design optimization. The paper gives a theoretical description of a generative model and its constituent parts and it explains the differences between the engineering methods currently used and the generative engineering method, with a focus on the application of this method in the design of heavy machines' structural components. The proof-of-concept generative model is implemented in CATIA. It relies on standard modelling tools to create the initial definition model, and it uses VBA scripts to implement extended functionality required for generative model and to perform additional advanced operations on generative model.
Keywords: generative engineering, generative model, CATIA, heavy machine

INTRODUCTION

The pressure to deliver ever increasingly complex and higher performing products in shorter design time is a powerful motivation for search for new design methods and their implementations. One of such methods, developed from the engineering tools and methods currently used, is generative engineering.

Generative engineering uses Knowledge-Based Engineering (KBE) to capture and reuse knowledge about the product and its design processes, various algorithms to create suitable geometrical models, and it enables Multi-Disciplinary Optimization (MDO) to be used effectively. The main model is based on parametric and associative geometric models created in CAD software, which are further enhanced with parametric design requirements. Discipline-specific analysis models are automatically derived from the main model, and they are used to verify if the requirements are met, or for further design optimization.

The generative engineering method is a further development of the engineering methods currently used, which enables automatic generation of some parts or entire assemblies to the given requirements, thus saving time and avoiding errors during the design stages of a product life cycle.

GENERATIVE ENGINEERING METHOD

Systematic studies of machine design in late 19th century in Germany, and later the pressure to deliver higher quality products in shorter time have resulted in formalization of engineering methods [2]. Later, deployment of sufficiently powerful computers enabled development of expert systems and Knowledge-Based Engineering (KBE) in the most progressive fields. Currently, commercial KBE tools are also available as directly integrated components of higher-end CAx systems. Modern CAx systems (e.g. CATIA) have all key components required for implementation of generative engineering method: parametric and associative models, integration of analysis tools and easily accessible automation tools.

MOTIVATION

The reasons for development of generative engineering can be summarized as a need to create higher-level tools. This is provided by specialized tools and workflows for particular discipline and design methods that keep also the access to the underlying general principles to allow modification of generated models using standard GUI (Graphical User Interface) and commands in CAx software. This requires formalization, storage and reuse of important knowledge in those high-level tools that is connected with the underlying model, implying use of KBE approach. It also leads to better exploitation of analytical models as a fundamental design tool, because of their increased use in early design stage.

The goals of generative engineering are to get better consistency between different models (geometric, analytic) and wider use of associativity in these models where possible or desirable. This allows creating multidisciplinary models with fewer errors in shorter time that are based on proven knowledge.

METHOD AND MODEL DESCRIPTION

The most important part of generative engineering method is the generative model describing whole product. Generative model contains not only the parametric representation of product geometry and relations between its constituent parts, but also rules and procedures used to create the product, together with design intent.

There are various possible approaches to how to store this information. One, derived from manual approach, is based on complex network of interfaces between all specialized models to ensure that the entire model is always up-to-date and changes are propagated to all affected models. Other approach is to build a more abstract high-level central model and then from this central model create or update all discipline specific models. Third possibility is a hybrid approach in which one specific model (e.g. geometric) is enhanced with information from other models and therefore serves as the main model.

The hybrid approach is presented in this work. The generative model is based on geometric CAD model. Advantages of building the generative model from geometric model are the ease of creation and no need to create fully abstract model, but only enhancing the CAD model using easily accessible tools (e.g. scripting). This approach results in some disadvantages, because it usefulness is limited to mainly structural components (because they are mostly geometry based) and not complex systems (with control algorithms). It consists of 4 parts: requirements, objects, generators and evaluators. These parts are added high-level concepts, but their data are stored in the geometric model.

Requirements are groups of parameters that represent relations between objects or assign attributes and values to them. They form part of desired product specifications, contain design intent and interfaces with other components in whole product (or machine), and define what evaluators will be used.

Objects are geometric elements or components of structure. They can be fixed and unchanging geometry used as product specification (e.g. fixed shapes of functional surfaces), auxiliary objects, or generated geometry.

Generators are sequences of commands to create or modify objects. These sequences group available CAD commands and form specialised high-level operations. Although simpler generators are in their capabilities similar to predefined parametric models, programmatic approach allows more complex models to be created and most importantly, it enables creation of all analysis models at the same time when the geometry is generated. Additionally, complex generators can incorporate rules or empirical design methods.

Evaluators are basically analysis methods to check if requirements are met by the generated model under specified conditions.

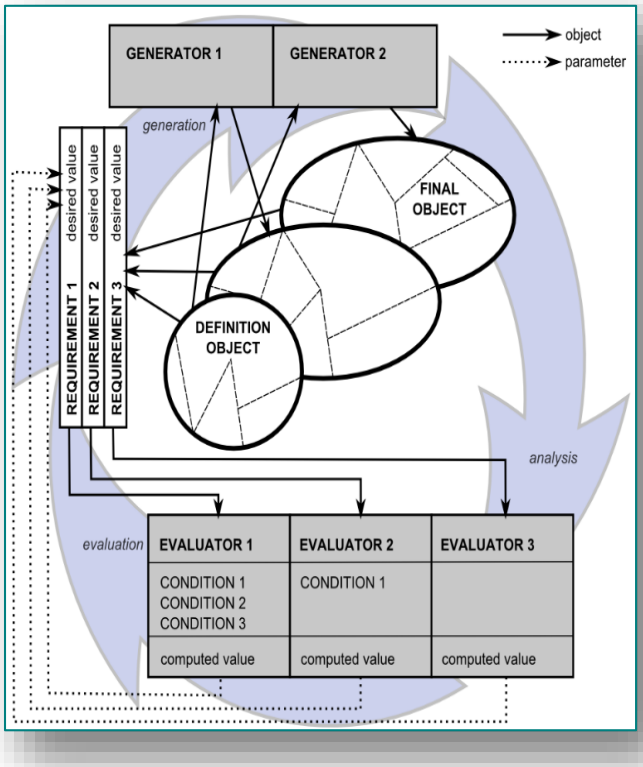

Figure 1: Diagram of generative engineering method

Basic generative loop is shown in Figure 1. It shows the 4 main parts (requirements, objects, generators and evaluators) and connections between them (objects and parameters). Generators and

evaluators contain engineering knowledge. There are 3 main steps in the loop: generation or modification of model parts, computation of analysis results, and comparison of computed values with desired values in requirements.

APPLICATION IN HEAVY MACHINE DESIGN

There are several works on application of KBE methods with generative properties in general engineering [4] or specific industry (automotive [1] and aerospace [3]). In heavy machine construction are various opportunities for application of generative engineering and design of structural modules (e.g. booms and arms) can be a good starting point of development of the method. These components are welded structures that are not very complex, there are many possible configurations and do not require many different analysis models.

The proof-of-concept generative model is implemented in CATIA using parametric models and VBA scripts. It has a maximum allowed displacement requirement and parts are automatically added to the assembly to meet the requirement under specified conditions. The generative model consists of an assembly (CATIA Product) that contains parts (CATIA Part). A definition part is included in assembly that aggregates all starting design specifications (requirements, fixed objects, e.g. design domain) of whole product. These are stored in tree structure of CATIA documents. Additionally, parts themselves may contain further specifications in similar structure.

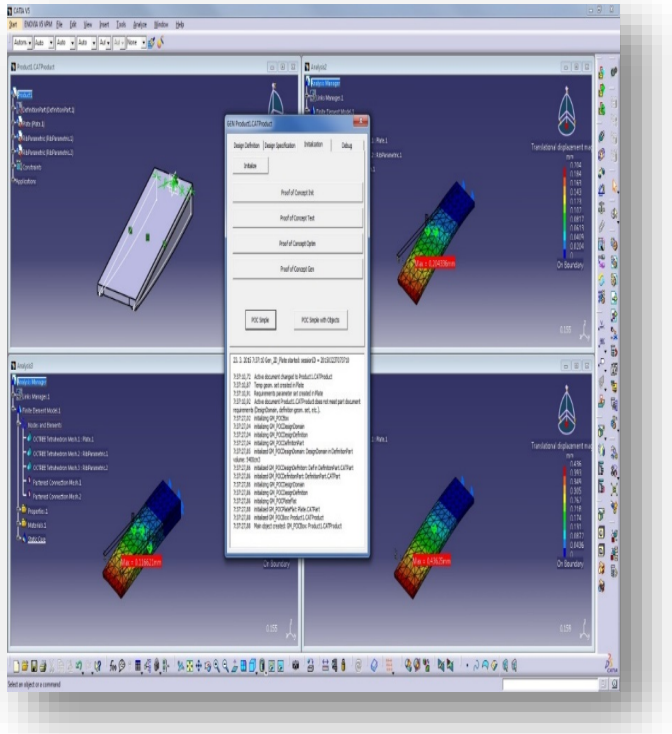

Figure 2: Generative model and custom GUI

The 4 parts of generative model are implemented in VBA, an object-based language that is available in CATIA. It provides automation support, and although it has limited capabilities compared to full object-oriented languages, generative model can be implemented in VBA as objects (in programming sense). All data are stored in CATIA files and can be accessed by user. A simple GUI for generative method is also created using VBA.

CONCLUSION

This contribution describes a generative engineering method, motivation and opportunities of its application in design of heavy equipment. The presented generative model is composed of 4 parts (requirements, objects, generators and evaluators) and has a proof-of-concept implementation in CATIA using VBA scripting.

Future work will focus on further development of this method for particular heavy machine structural module with assessment of its applicability for different components.

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POSSIBILITY OF APPLICATION OF SOLAR PUMPS IN IRRIGATION

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Abstract: Today, is very often, especially where there is no indented city water supply network, on smaller agricultural areas, farms and the like. for irrigation use solar pumps. The paper deals with the problem of dimensioning of solar pumps in irrigation. For irrigation needs, the paper analyzed the solar pump of smaller capacity which are intended for watering of small agricultural areas, such as those in greenhouses, etc.
Keywords: The solar panel, the sun, irrigation, agriculture

INTRODUCTION

In the Republic of Serbia today is about 40% of arable land, while the region of Vojvodina has 1.78 million ha of fertile arable land, of which only 28% is irrigated. [1] In stated problem lies an enormous research task, which consists of increasing the surface area that could be irrigate, and that energy that would have initiated such systems is renewable. Demand for water is greater the very sandy, particularly windy and southern positions than on the structural soils of the northern exposition [2]. Schedule of moisture on the surface of the earth is far more complex than the layout of heat and light.

Moisture, particularly in the form of water, plays an important role in the life of plant species, because it is a requirement for many the life processes who can not imagined without the participation of water. It is considered that moisture is one of the most important herbal ecological factors, far more influential than light and heat, because the diversity of flora and its a geographical layout usually depends on the just from the schedule moisture.

While the sun's rays directly receive to biomass, moisture (rain, snow) receiving himself through the land. It occurs in the form of air humidity and of atmospheric deposition [3].

Plants in themselves contain up to 95% water, but by far is higher amount of water which pass through herbal organism. The evaporation of water from plants is called transpiration, and it is of unusual importance, because it is conveyed by way of water. The relationship between taking water from the soil and allocations via the leaves called water balance of plants. It is normal that the water balance is in equilibrium, but often occur under the influence of heat, to violate this occurs and the water deficit which may be from 5 to 10 and up to 30% without any damage to the herbal organism. When this lack of exceeds a certain limit, then the plants are showing the first signs of wilting, ie. loses turgor and leaves were due to wilt wither, which can be permanently or temporary.

POSSIBILITY OF PRODUCTION ENERGY ON AGRICULTURAL OF LAND

For centuries, the sunlight is applied to produce food for humans. However, in 1970 - in those years they began to applied by solar photovoltaic panels, very often i on arable the agricultural land. This was one of the disadvantages of this form of renewable energy source, because he disturbed yields in agriculture.

Architecture and technologies of solar panels over time in sophistication, so that they used today and lands that are used agricultural production. The goal of contemporary of agricultural production is that the produce food and electricity at the same time. Such plants could provide additional sources of income for agricultural producers. By selecting of adequate of agricultural crops submitted by the of, seed, the same would be protected obscuring of: sun and high temperatures (which last year recorded an increase) heavy rainfalls, of the winds, hail and the like.

SOLAR PLANT IN IRRIGATION

In recent years, about 30% of users of solar energy in agriculture uses the sun to drive irrigation pumps, but this trend is changing rapidly in favor of those farmers who of their installation linked to the power

grid in order to sell the excess electricity produced. Some of the construction of solar panels I can change their slope as the sun changes its position. This makes it possible to provide a an increase in daily gain energy by as much as 55% [4]. When designing the solar plant for irrigation of agricultural cultures, the most important task is to choose the solution which is the largest efficiency, and the investment minimum. Selection of appropriate methods of irrigation, is conditioned by a number of factors: the land, biological, climatic, relief, economic, hydrogeological technical and technological. When designing such plants, and making a decision for selection of equipment important role is played lot size to be irrigated and its need for with water. [4]

a)

b)

c)

Figure 1. a) Fixed solar systems for solar drive pumps and irrigation, b) Semi mobile solar system for irrigation "pivot, center pivot", c) Mobile solar irrigation system

How solar photovoltaic panels produce the most energy during the summer when there is the most the sun then, in agricultural production and the greatest need for with water. The applicability of these solutions for irrigation can meet the needs of all types of agriculture production: farming, pomology and viticulture. This solar water pumps any submersible or floating, provides the water needed for the [5]:

= irrigation of agricultural cultures,
= dewatering (removal of excess water) and
= servicing households.

Depending on the types of agricultural cultures and their water needs, the size of the plot and the weather conditions, solar systems for irrigation may be:

= the fixed (Figure 1a),
= semi-mobile (Figure 1b) and
= mobile (Figure 1c).

When in dimensioning and the choice of abstraction, with regard to water availability and choices of solar pumps, to be distinguished:

= underground waters,
= surface water (rivers, lakes, reservoirs etc.).

Choice of water intake is the most important problem in defining a solar plant for irrigation. Here is certainly worth a take account of physical and chemical properties of water, its temperature etc. Water intakes of surface water courses are not limited to capacity, unlike underground of water courses.

For the purposes of extraction of groundwater the necessary the investments in drilling of wells [6].

In dimensioning of and selection of the device for irrigation, should consider the following:

= species of plant and its need for water,
= watering the duration (h).
= Tornus irrigations (number of days).
= firth norm (m^3/ha),
= the required amount of water during growing season (m^3),
= pedological content of the soil,
= parcel size (ha),
= configuration of plot,
= capacity solar pump (l/s),
= available pressure in the system (bar), etc.

The choice of solar pump is based primarily on the availability of the most affordable multimedia water intakes. It further pump selection is performed in accordance with the required quantity of water and the necessary efforts pumps.

MATERIALS AND METHODS

Irrigation systems in Republic of Serbia are usually driven by diesel or electric motors. The goal of of this paper is the presentation of the possibilities of small for irrigation of agricultural areas with solar pumps of small capacities, although solar pumps can be used for irrigation of agricultural areas with larger capacities than 1,500 l / h. Justification of this study lies in the fact is very fragmented holdings in the Republic of Serbia.

The paper presents justification of of solar pumps in irrigation, depending on their capacity. Were analyzed water demands to be used for watering of small of agricultural areas, that the application can be found in greenhouses, etc. The advantage of these of watering, the method especially dropwise, the small amount of water that are given plants. For this reasonthis paper analyzes three types of pumps: A to 2 l/h, B 4 l/h and C to 8 l/h, table 1. Average work time for which the observed justification of use of these pumps amounted to 10 h / day. Capacities the said solar pump on a monthly and annual basis are shown in table 1.

Table 1. Capacity of solar pumps on a monthly and annual basis

Size of the solar pump	Capacity (l/h)	The capacity on a monthly basis (m^3/mes)	The capacity on an annual basis (m^3/god)
A	2	0,6	10,80
B	4	1,2	14,40
C	8	2,4	28,80

RESULTS AND DISCUSSION

Using solar energy in agricultural production most appropriate is, since the highest energy is produced at those moments when it is most required for the growth of of agricultural cultures. For example. irrigating is carried out in the period when he has the most solar energy and when needs were for with water for agricultural culture is greatest. How would liberate the need the use of conventional energy sources in the irrigation of smaller of agricultural areas (eg. under the the greenhouses and glasshouses) can be used all year round solar pump with a capacity of 0.6 to 2.4 m^3/mes. Problems for wider application of these solar pumps in agriculture are:

- financial and economic aspects,
- a continuous supply of energy during the whole year [7],
- no informing of agricultural producers and others.

CONCLUSIONS

From year to year reduces the required investment for solar systems (solar pump) in irrigation and the time required for the repayment of the total investment in such systems. Due to its small investment and is very of simple of equipment today is is very economical payable application of solar pumps of small capacity of from 2 to 8 l / h. In the world investments in this equipment cost effective for a few years (2-3 years).

Because of the low price of electricity in Serbia, which is still below the average in the each region, the use of these solar plant is on the verge of profitability. But harmonization electricity prices with the prices in the region, and how there would be justification of the use of solar plants for irrigation. But by adjusting electricity prices with the prices in the region, will exist justification of use of solar plants for irrigating.

Note

This paper is based on the paper presented at The Vth International Conference Industrial Engineering and Environmental Protection 2015 – IIZS 2015, University of Novi Sad, Technical Faculty „Mihajlo Pupin”, Zrenjanin, SERBIA, October 15-16th, 2015, referred here as[8].

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ACKNOWLEDGEMENTS

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