



**University of Banja Luka**  
**Faculty of Mechanical Engineering**



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## PREFACE

The DEMI Conference has already been recognized as a very successful international conference that provides an opportunity to engineers, researchers and experts world over to present the latest scientific and professional accomplishments in mechanical and industrial engineering.

The goal of the DEMI Conference is to bring closer new research and development results in mechanical and industrial engineering to the conference participants as much as to discuss the possibility of applying them in the industrial systems. The aim of the DEMI 2017 Conference has been to present scientific and professional accomplishments and possibilities for their application, but also to set course for future research and development, in order to improve manufacturing aspects of industry by introducing new technologies.

Following the strategy and mission of the Faculty of Mechanical Engineering, 132 papers were presented at the Conference including eight thematic fields:

- Production and Computer-Aided Technologies
- Energetics and Thermal Engineering
- Mechanics and Design
- Mechatronics
- Automotive and Traffic Engineering
- Quality and Ecology
- Maintenance of Engineering Systems and Occupational Safety Engineering
- Materials Science

For the first time, the 13<sup>th</sup> DEMI Conference was co-organized with the Faculty of Mechanical Engineering, University of Niš, Serbia; the Faculty of Mechanical Engineering Podgorica, University of Montenegro, Montenegro and the Faculty of Engineering Hunedoara, University Politehnica Timisoara, Romania, with the motivation to offer an excellent international platform for academic community, researchers, engineers and industry representatives to share their experience and to establish new professional and business bonds.

On behalf of the Organizing Committee of the Conference, we would like to express our gratitude to all our colleagues, scientists, researchers and experts from the industry for participation in the DEMI 2017 Conference as well as to the reviewers who have greatly contributed to the quality of the Conference by providing their evaluations, views and suggestions.

Banja Luka, 20 May 2017

Chair of the Organizing Committee  
Prof. Zorana Tanasic, PhD

## KEYNOTE LECTUERS





## INTEGRATED ENERGY DESIGN – MULTIDISCIPLINARY APPROACH TO DESIGN OF BUILDINGS

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### Summary:

The reduction of energy use and greenhouse gas emissions is the most important measures to combat global warming. Reports from both the OECD and the IEA claim that in order to reach the goal of limiting the concentration of greenhouse gasses in the atmosphere to 450 ppm, energy efficiency will have to be responsible for two thirds of the emissions reduction. In the western world, buildings account for approximately third of both all energy use and of greenhouse gas emissions. Energy reduction in the building sector is therefore essential. At the same time, it is more cost effective and environment-friendly than extending the capacity in the supply system.

The concept of Integrated Energy Design is a workable solution to achieve buildings with the expected quality. This involves a process of establishing clear goals for the environmental performance, employing multi-disciplinary cooperation from day one, and using advanced tools for performance documentation throughout the process. All projects have to follow an overall design strategy of reducing the need for energy and related GHG emissions as much as possible, before optimizing the energy supply systems. This is in accordance with the so-called “Trias Energetica” strategy.

**Keywords:** *Greenhouse gas emissions Energy use in buildings, Integrated Energy Design*



**13<sup>th</sup> International Conference on Accomplishments  
in Mechanical and Industrial Engineering**

**DUAL STATOR WINDING CAGE INDUCTION GENERATOR FOR WIND  
OR HYDRO VARIABLE SPEED LOW POWER CONVERSION ENERGY  
SYSTEM**

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**Summary:**

Cage rotor induction generators have been employed to operate as wind turbine generators and small hydroelectric generators in isolated power systems, due to their practical advantages related to low maintenance cost, better transient performance, ability to operate without dc power supply for field excitation, and brushless construction. With the development of the packaged high speed gas turbine and high speed diesel engine, it becomes increasingly for the prime mover and the generator to be connected by a gear reducer. On the contrary, a direct connection between the prime mover and the generator has many advantages, such as low noise, high efficiency, and high power density. In a split-wound machine, the stator winding consists of two similar but separate three-phase windings wound for the same number of poles. Both stators are fed by the same frequency and the rotor is a standard squirrel cage. The two stator windings are mutually coupled and small unbalances in the supplied voltages generate circulating currents. Furthermore, because of the low impedance of the harmonic currents there is a high level of circulating currents when a non sinusoidal voltage source supply is used, adding losses and demanding larger semiconductor device ratings.

**Keywords:** *induction generator, dual stator winding, optimization, control, experimental work*



## POROUS AND LATTICE MATERIALS: MECHANICS & MANUFACTURE

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### Summary:

We consider a host of regular lattice architectures and present analytical and computational approaches to derive the structure-property relationship for such structured material by exploiting the translational periodicity of infinite lattices. Two specific geometries – the so called hexagonal honeycomb and the woodpile lattice – are studied analytically and computationally. The elastoplastic response in the case of the first, and the bending response of lattice beams for the second, are considered. These specific problems have been motivated by biostructures relevant to medical implants and scaffolds. We also present novel methods to additively manufacture such lattices. When possible, the response is obtained as an analytical function of the microstructural parameters described by the geometry of the repetitive elements of the lattice, such as characteristic diameter, length, or thickness. Alternative methods of manufacturing materials with random internal architectures are also presented. The relative strengths and weaknesses of the two classes of materials with respect to analysis and manufacture are discussed.

**Keywords:** *Lattice materials & structures, scaffolds & implants, additive manufacturing*



**PRODUCTION AND COMPUTER-AIDED  
TECHNOLOGIES**





## CONFIGURING OF VIRTUAL 5-AXIS HYBRID KINEMATIC MILLING MACHINE

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### Summary:

This paper presents a part of research results obtained during the configuring of 5-axis hybrid kinematic milling machine tool. This machine tool configuration consists of 3-axis developed parallel mechanism and 2-axis serial mechanism that is placed on platform of parallel mechanism. Using realized mini-laboratory and desktop 3-axis PKMM (parallel kinematic milling machine) pn101\_st research is continued aiming to develop 5-axis HKMM (hybrid kinematic milling machine). Configured 5-axis hybrid kinematic milling machine has been verified by successful making of the virtual machine with control and programming system. The paper describes the structure of the hybrid kinematic milling machine, configured virtual prototype and control and programming system based on PC real-time Linux CNC platform.

**Keywords:** *hybrid kinematic milling machine, configuring, virtual machine, EMC2*



**13<sup>th</sup> International Conference on Accomplishments  
in Mechanical and Industrial Engineering**

**INVERSE THERMAL MODELING OF THE ELECTRICAL DISCHARGE  
MACHINING**

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**Summary:**

Investigation of the electrical-thermal energy conversion is of key importance in electrical discharge machining (EDM). This paper takes a different approach towards the identification of the thermal process of the EDM by using the inverse heat conduction problem. The inverse problem was used for modeling and analysis of thermal energy conversion processes in order to improve machining efficiency. In addition to the temperature field, this method allows the determination of heat flux density distribution on the workpiece. By using surface temperature and heat flux, the thermal inverse problem allows efficient identification of discharge energy parameters to achieve the highest possible productivity and quality.

**Keywords:** *EDM process, discharge energy, temperature, heat flux, inverse problem*



## ROBOT MACHINING SIMULATION IN STEP-NC MACHINE ENVIRONMENT

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### Summary:

This paper presents an approach for applying new programming method based on STEP-NC standard in machining operations by using industrial robots. The paper discusses about programming and simulation of industrial robots for machining using software STEP-NC Machine. Programming verification has been realized by simulation in STEP-NC Machine using available and configured virtual robots in STEP-NC Machine environment through several examples.

**Keywords:** *robot for machining, STEP-NC, programming, machining simulation*



**13<sup>th</sup> International Conference on Accomplishments  
in Mechanical and Industrial Engineering**

**MICROSTRUCTURAL CHANGES DURING HEAT TREATMENT OF  
SINTERED AUSTENITIC NICKEL-FREE STAINLESS STEEL**

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**Summary:**

Production of nickel-free austenitic stainless steels is usually performed using sintering or melting in nitrogen atmosphere, where nitrogen as austenite forming element replaces nickel. These steels can also be produced by additional nitriding in solid state of final ferritic stainless steel components. In this case, properties of the steel do not depend only on casting or sintering parameters, but also on nitriding and post sintering heat treatment parameters. In this regard, effect of subsequent heat treatment parameters on properties of the sintered austenitic nickel-free stainless steel were analysed in this work. Post sintering heat treatments, in nitrogen atmosphere, were performed using dilatometer DIL 402/C/7. Microstructural changes after heat treatment and dilatometer test results are presented in the paper.

**Keywords:** *nickel-free austenitic stainless steel, sintering, nitriding.*



## OPTIMIZATION OF OPERATION SEQUENCING USING PRECEDENCE CONSTRAINTS AND SIMULATION TECHNIQUE

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### Summary:

This paper considers the problem of defining feasible sequences of machining operations in process planning by using precedence constraints as well as optimizing their machining time by applying the appropriate simulation technique.

Precedence constraints are defined based on dimensional, geometric, technological and economic relationships. According to these relationships, precedence matrices for operation sequencing are created. Variants of process plans are obtained by generating processes that contain feasible groups of machining operations. Finally, the optimal process plan is generated by simulating the defined variants of process plans in the SolidCAM software with the machining time as an objective function.

**Keywords:** *process planning, operation sequence, precedence constraints, simulation, optimization*



**13<sup>th</sup> International Conference on Accomplishments  
in Mechanical and Industrial Engineering**

**THE ANALYSIS OF TECHNOLOGICAL PROCESS IN MANUFACTURING  
FACILITY “SANI GLOBAL” AND PROPOSED MEASURES TO IMPROVE THE  
PROCESS**

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**Summary:**

Technological process is not constant, it is subjected to constant improvement and continuous innovation. Dynamics of the technological process is necessarily not only because of technological level of production and production time, but also for the competitiveness of product on the market and for the existence of given production system. In this paper, for the given production system which produces baach plywoods, massive beech panels, stair treads etc., technological process of the massive panels production has been analysed and appropriate measures of its improvement along with the measures to increase the production competitiveness has been proposed.

**Keywords:** *Analysis, technological process, production, product, CNC machine, production system*



## SIMULATION CASTING POINT IN THE PROCESS OF PLASTIC INJECTION UNDER

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### Summary:

The most common problems, which with the manufacturers of tools meet in their work are: defects in the casting part that reveals only in the production process, so it is losing a lot of money and time on corrections, while sometimes the only solution is to design and production of tools again.

In this paper it will be shown, using CAE system, which are mainly based on the finite element method analysis of injection casting technology, which refers to the simulation of tool cavity filling, cooling process and contraction allowing for removal of shortcomings, such as the accumulation of materials, parts with thin walls, the problems in the flow of material, the residual gases, etc., which significantly reduces waste

**Keywords:** *injection molding, polymer material, simulation*



13<sup>th</sup> International Conference on Accomplishments  
in Mechanical and Industrial Engineering

**INFLUENCE OF PROCESS PARAMETERS ON THE FRICTION COEFFICIENT  
IN ONE AND MULTI PHASE STEEL STRIP DRAWING IRONING TEST**

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**Summary:**

Part of the experimental results of influence on friction in the stripe ironing process with double thinning are presented in this paper. Applied was Schlosser model for evaluating influence of lateral force, contact pressure, average absolute roughness height and thinning strain on friction coefficient. Applied was classical model because of sufficient intensity of drawing and lateral force. If a lateral and drawing forces are small, classical model is not suitable and give unreal negative friction coefficient values. 20 mm wide and 2.5 mm thick strips of mild steel DC04 sheets were used in the single, three and four-phase process with a maximum thinning deformation of about 29%. Appropriate lubricant, mineral oil, was used in conditions of lower speed of 20 mm/min. Three and four phase process was realized with variable lateral force of 5, 10, 15 and 20 kN. The applied experimental test procedure enables the precise quantification of lateral force, contact pressure, thinning strain and roughness influence on friction to be established. Test also enables evaluation of lubricants quality.

**Keywords:** *strip ironing test, mild steel, friction coefficient*



## EMPIRICAL MODELLING OF LASER ASSISTED MILLING; OVERVIEW AND CASE STUDY

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### Summary:

Empirical modeling is the most widely used way to model very complex processes, such as, for example, laser assisted milling. This paper starts with a short overview of techniques used in modeling of laser assisted milling up to date. In the second part of the paper a case study and a comparison of different techniques for empirical modeling the actual laser assisted milling process is presented. The impact of four process parameters, including two machining (spindle speed and depth of cut) and two laser (laser power and distance between the laser spot and the cutting tool) on the cutting forces is investigated.

**Keywords:** *empirical modelling, laser assisted milling, DOE, artificial neural networks*



**13<sup>th</sup> International Conference on Accomplishments  
in Mechanical and Industrial Engineering**

**SIZING OPTIMIZATION OF PARAMETRICALLY DESIGNED TRUSSES**

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**Summary:**

In this paper parametric modeling of sizing optimization truss models is developed. Sizing optimization of trusses views element cross-sections as variables with the goal of minimizing overall mass while maintaining equivalent stresses within acceptable ranges, as well as limiting displacement. In order to conduct such a process, models need to be created with parameters, and outputs which can be used to create an objective function. Furthermore the models in each iteration of the optimization are subjected to finite element analyses to determine stress. Parametric models of standard 10 bar, 17 bar, and 25 bar trusses are created to facilitate optimization. The heuristic optimization method used is genetic algorithm. Optimization results obtained from these models are compared to those from literature and the initial model.

**Keywords:** *truss, sizing optimization, parametric model, genetic algorithm*



## ANALYSIS OF STATIC BEHAVIOUR OF THE BEARING ASSEMBLY FOR AGRICULTURAL MECHANIZATION

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### Summary:

This paper presents an analytical-numerical model to analyze the static behaviour of the bearing assembly support with double row ball bearings with angular contact for agricultural mechanization. Bearing analytical model was developed based on John Harris's quasi-static equilibrium equations and Hertz's contact load. Based on the analytical model contact loads, change the contact angle and stiffness for each position of the ball are determinate. Results obtained by analytical models are applied to the 3D finite element model of the bearing assembly. The apply of the models are presented an analysis of the influence of the external load on the static and dynamic load capacity, stress and bearing life for different values of contact angle and the distance between the bearing raceways. The research in this paper show that the contact angle significantly affects the capacity and bearing life, while the distance between the bearing raceways affect the change of the stress of the entire bearing assembly for agricultural mechanization.

**Keywords:** *Ball bearing with angular contact, static analysis, finite element method*



**13<sup>th</sup> International Conference on Accomplishments  
in Mechanical and Industrial Engineering**

**COMPARATION OF THEORETICAL, EXPERIMENTAL AND NUMERICAL  
METHODS FOR PROCESS ANALYSIS FOR DEEP DRAWING WITH  
REDUCTION OF WALL THICKNESS**

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**Summary:**

For analysis of deep drawing with reduction of wall thickness it is necessary to analyse loads on multi-step tools, which are used in process.

Theoretical expressions for deformation force allows us to predetermine the maximum force in drawing process based on known dimensions of workpiece, blank, number of rings in multiple tool and his geometry.

Experimental research gave drawing force values on five-step tools for two groups of workpiece in laboratory and industrial environment. FEM analysis of deep drawing process gave values of stress and deformations in referent sections studied five-step tool.

**Keywords:** *deep drawing with reduction of wall thicknes, multi-step tools, theoretical, experimental and numerical methods*



## CONCEPT OF THE SYSTEM FOR CUSTOMIZED IMPLANT MANUFACTURABILITY ANALYSIS

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### Summary:

Modern structures, parts and components for various devices require new materials that can withstand complex stresses, chemical, and physical activity. For these materials must be carried out various technological processes of processing. In addition to production and resistance of these materials to chemical action, special attention should be paid to the processing technology to the final mounting position in the structure. Particular attention should escort them to the intensity of the residual stress and the size of cracks that can lead to distortion of structural integrity in their application. The paper discusses the impact: the geometric parameters of the workpiece and the tool, the position of layers deformation degree and intensity of deformation at the double layer.

**Keywords:** *Customized Implant, Manufacturability Analysis, Knowledge-Based System*



**13<sup>th</sup> International Conference on Accomplishments  
in Mechanical and Industrial Engineering**

**DEVELOPMENT OF SMALL BATCHES OF FUNCTIONAL PARTS USING  
INTEGRATION OF 3D PRINTING AND VACUUM CASTING TECHNOLOGY**

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**Summary:**

In conditions of dynamic market environment there is an increasing requirement for rapid development and production of complex and functional parts from different materials. In this paper, we present the process of development and production of small batches of functional parts in the integrated system of additive and vacuum casting technology. All advantages of this integrated approach were used during the research. Data obtained from the manufacturer were used for the proper selection of materials and they relate to the value of mechanical characteristics.

**Keywords:** *Additive Manufacturing, Vacuum casting, Functional parts, 3D Printing*



## SOME OPTIMIZATION ASPECTS IN TURNING PROCESSES

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### Summary:

Effective application of turning technology necessities the determination of optimal turning process parameter values. Turning process optimization is an active field of research where different optimization algorithms and methods are being applied to solve different single and multi-objective optimization problems. This paper focuses on some aspects of turning optimization regarding the analysis of main parameters values that can be achieved on a given lathes as well as suggesting the application of discrete optimization methods, i.e. brute-force search algorithm and its hybridization with the epsilon-constraint method for solving and multi-objective turning optimization problems, i.e. Pareto optimization problems. The optimization solutions obtained by previous researchers using different optimization algorithms and optimization solutions obtained by the proposed optimization approach were compared and discussed. Key words: Turning process, single-objective optimization, Pareto optimization, epsilon-constraint method

**Keywords:** *turning process, single-objective optimization, Pareto optimization, epsilon-constraint method*



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**FUNCTIONS FOR PROCESSING OF WOKPIECE CAD MODEL FOR  
PREDICTION AND OPTIMIZATION OF MILLING PROCESS**

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**Summary:**

This paper deals with specific presentation of wokpiece volume and with functions for manipulating them in order to extract necessary data for various functions in virtual manufacturing environment. Basic idea was to use standard STL output of created model of blank material and convert to Z-map model. Functions for simulation of material removal process and extracting of geometry of instant tool immersion conditions are developed in Matlab environment. Exacting of engaging (tool immersion) map along discretized tool path is of great importance for application of model for instant cutting forces, based on simulation of discetized cutting geometry of the tool. Such simulation algorithm provides a solid base for prediction of cutting forces along tool path and for optimization of NC part program via feedrate scheduling. Presented methodology is tested in milling operations for machining of planar contours with flat end-mills, and some illustrative results are shown.

**Keywords:** *machining simulation, CAD/CAM, milling, NC program optimization, Z/map*



## FEATURE CENTRIC MANUFACTURING AUTOMATION – A CONCEPT

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### Summary:

This research is directed toward increasing level of automation of a manufacturing execution system (MES). In the concept presented central role belongs to the machining feature and the STEP standard that defines it. Particular feature type advises specific machining algorithm on its one. This intrinsic property of machining feature was already recognized by STEP-NC developers. But if we combine or extend feature's STEP model with Product and Manufacturing Information (PMI) than it can become driver for not only CNC machinery but other manufacturing resources too, like robots, transport subsystems, embedded systems, etc. Datum features, GD&T and special annotation can complement feature definition to advise positioning, robot gripping, fixture setup and other algorithms. With the aim to obtain common solution, independent of a particular CAD system, the only STEP format of test parts were used. The initial solutions were developed using Visual C++ 2013 and open C++ class libraries: ST-Developer from STEP Tools, Inc. and OCCT from Open Cascade.

**Keywords:** *STEP standard, EXPRESS, Machining feature, Application protocol, STEP-NC machine, C++*



**ENERGETICS  
AND THERMAL ENGINEERING**





## THE IMPACT OF PARTIAL REFURBISHMENT ON THE HEATING ENERGY CONSUMPTION OF A RESIDENTIAL BUILDING SECTOR

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### Summary:

The energy used in buildings represents a large share of national energy use in most countries, so one of the conditions for the reduction of total energy consumption has become improvement of the energy efficiency in the building sector. Understanding of the buildings energy performance at the city level is necessary in order to form a city energy planning policy and make a strategic decision on which buildings should be thermally improved. In this paper, the impact of new windows installation on the heating energy consumption of a multi-family residential building sector, built before 2012 in the city of Kragujevac, Serbia, was investigated. Heating energy consumptions and reductions were estimated by engineering bottom-up method which uses representative building types and building energy simulation program. After the simulation of the new windows with  $U=2.2 \text{ W/Km}^2$  and  $U=1.4 \text{ W/Km}^2$  installation, the reductions of the total annual heating energy consumption of a multi-family residential building sector were 15.97 % and 19.26 % respectively.

**Keywords:** *energy consumption, building sector, refurbishment, energy reduction*



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**METHODOLOGY FOR TECHNO-ECONOMIC OPTIMIZATION OF SOLAR ASSISTED HEATING SYSTEMS**

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**Summary:**

This paper has objective, to estimate the thermal performance of solar assisted heating systems in regard of solar fraction and perform life cycle cost analysis to assess the feasibility of their implementation in residential sector. In general it is known that the resource for solar thermal systems i.e. the solar irradiation is free, but the equipment to collect it and convert in to useful form (heat or electricity) has a cost. Solar thermal systems are characterized by high investment and low operational cost. It is presented methodology for obtaining the right size of a solar thermal assisted heating system that gives the lowest combination of solar and auxiliary energy costs.

Thermal performance of the solar thermal systems are estimated using numerical methods and software since the solar processes are transient in nature been driven by time dependent forcing functions and loads. The system components are defined with mathematical relationships that describe how components function. They are based on first principles (energy balances, mass balances, rate equations and equilibrium relationships) at one extreme or empirical curve fits to operating data from specific machines.

As a result of the analysis specific indicators are derived in order to facilitate the techno-economic analysis and design of solar assisted heating systems.

**Keywords:** Solar thermal, optimization, LCC, simulation, TRNSYS, heating system



## HEAT RECOVERY OF VENTILATION AIR IN EXISTING EDUCATIONAL BUILDING IN DOBOJ

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### Summary:

This research is related to the heat recovery of ventilation air. The analysis includes the heat recovery of air in case when ventilation is defined according to the air changes per hour and according to the current presence of people in ventilated zones. The research was conducted for an existing nonresidential (educational) building in Doboj. The large heat losses through the ventilation system can be reduced by installing a energy recovery ventilator. Analysis of the presence of people in the zones can have a major impact on the operation of the ventilation system and electricity consumption. It is assumed that the dependence of these two factors is very important and that the study could be a starting point for solving this problem in a given area. The analysis was conducted in the software EnergyPlus.

**Keywords:** *Heat recovery, ventilation, EnergyPlus, nonresidential building.*



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**INFLUENCE OF HOT WATER TEMPERATURE IN DHW SYSTEM ON  
BUILDING EXERGY OPTIMIZATION**

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**Summary:**

Exergy can be used for the optimization of energy losses in different energy system. Exergy is also used for design and performance evaluation of energy systems. In this paper it is investigated the Serbian residential building with photovoltaics and solar collectors on the roof. The building has electrical space heating. Exergy optimization (including embodied exergy) was performed with the aim to determine the maximum value of the generated electricity. The residential buildings with variable temperature in DHW system are investigated. It is also analyzed building energy consumption with or without embodied energy of solar systems. The buildings were simulated in EnergyPlus, Open Studio plug-in in Google SketchUp was used for buildings design and Hooke-Jeeves algorithm for optimization. GENOPT was used for software execution control during optimization.

**Keywords:** *Exergy, Photovoltaic, Solar collector, Simulation, Optimization*



## EXPERIMENTAL STUDY RAYLEIGH–BÉNARD CONVECTION IN A RECTANGULAR MOTOR OIL TANK

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### Summary:

Measurements of temperature distribution were performed in a rectangular tank with aspect ratios  $4 \times 2 \times 1$ , using motor oil as a working fluid. The experimental setup was adjusted to be as close to real fuel tanks exposed to solar radiation, as in airplane wings. The measurements were taken at fifteen different positions on the faces of the tank. Probes used are PT100 elements. In order to obtain as uniform temperature as possible, double bottom was used, with water as medium for obtaining the constant surface temperature. The results are compared with those obtained by IR camera.

This paper is part of the research done within the National Program of Integral and interdisciplinary Investigations, project number: III42008, funded by the Government of Republic of Serbia.

**Keywords:** *Rayleigh–Bénard convection, temperature profile, PT100, motor oil*



## INFLUENCE OF THE INITIAL CONDITIONS ON WATER HAMMER IN RESERVOIR-PIPELINE-VALVE SYSTEM

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### Summary:

In this paper influence of the initial conditions (pressure and velocity) on water hammer in simple reservoir-pipeline-valve hydraulic system is investigated. Water hammer is induced by fast closing of the electro-pneumatic valve at the end of the system. Experimental results are obtained on the small scale experimental setup designed and developed in the Laboratory for Energetic Processes at the University of Montenegro for investigating water hammer and its side effects. The experimental setup has been tested for a number of steady and transient flow conditions. Numerically, water hammer is described by discrete gas cavity model (DGCM) which take into consideration occurrence of the transient cavitation and column separation. For pipeline friction losses convolution-based unsteady friction model (CBM) is used. The DGCM and the CBM unsteady friction model are explicitly incorporated into the staggered grid of the method of characteristics. Numerical results are compared and verified with results of measurement.

**Keywords:** *water hammer, experimental setup, unsteady friction, column separation, DGCM (Discrete Gas Cavity Model)*



## POSSIBILITY OF USE HEAT ENERGY FROM WASTE WATER SEWAGE SYSTEM FOR HEATING OF BUILDINGS

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### Summary:

This paper presents the initial research on the possibility of using energy from the sewage. The analysis presented in the paper aims to show how the system of waste water in buildings reject energy, which can be re-used to heat hot water and buildings. Waste water from toilets, washing machines, showers and kitchen has a certain thermal energy which can be used in heating systems with heat pumps. The waste water can be used via heat exchangers to increase the coefficient of efficiency of the heat pump COP. In this way it is possible to achieve substantial savings of energy required for heating. The analysis was conducted for the City of Doboj, Bosnia and Herzegovina.

**Keywords:** *energy, sewage water, sewage sludge, heat pump*



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**COMPUTER PROGRAM FOR CALCULATING HEAT TRANSFER THROUGH  
TRANSPARENT WALLS IN GLASS HOUSE COATED WITH FOIL**

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**Summary:**

This model explains the heat flow in a confined space with transparent walls (glass or plastic). A software is used to analyze the behavior of transparent walls coated with "LLumar" film. This film has many advantages, but in this paper, we will focus on energy savings. Energy savings give quick return on investment and are considered a smart investment. Energy-saving LLumar film can increase performance of almost every window system, significantly reducing energy consumption and requirements. Professional energy audits have shown that buildings with LLumar film can achieve annual energy savings of up to 15%, blocks 99% of harmful UV rays and improves comfort by reducing heat and glare. Regardless of whether it is residential, commercial or glass house space as described in this paper, LLumar the world's leading brand of architectural film for decades improves the well-known buildings around the world with proven results. LLumar films will greatly increase energy efficiency, appearance and functionality of glass partitions. The results are lower overhead expenses, increased comfort, improved privacy and better protection from accidents. Heat balance in glass house space is shown in the following pages.

**Keywords:** *thermal resistance, glass wall, glass house, demand for heat*



## COMPUTER PROGRAM FOR CALCULATING DISTRIBUTION OF WATER-FLOW IN HEAT EXCHANGERS WHICH ARE USED IN GRAPHIC INDUSTRY

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### Summary:

This paper represents, an analysis of the influence of the input elements on the distribution of water flow in cylindrical evaporators in the graphic industry. Based on a mathematical model a computer program has been developed, that determinates the degree of uneven distribution of water flow in the pipes of the pipe bundle at cylindrical evaporators. A numerical example of such propellants is made and an overview and recommendations for changing certain structural elements that contribute to optimal operation of evaporators or meeting the criteria for uneven distribution of water flow in the pipe bundle.

**Keywords:** *water-flow, evaporator, heat exchanger*



## EXPERIMENTAL AND NUMERICAL INVESTIGATION OF A SOLAR DISH COLLECTOR WITH SPIRAL ABSORBER

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### Summary:

The objective of this work is to investigate experimentally and numerically a solar dish collector and to examine the impact of possible improvements in its performance. The examined solar dish collector has a spiral absorber and it is lightweight, fact that makes the system to have low cost and to be sustainable. The experimental results are compared with the results of a developed numerical model written in EES (Engineering Equation Solver) and validation between the results is observed. The validated numerical model is used for further investigation of the solar collector for operation with Therminol VP1. In the first part of the investigation, the impact of flow rate on the thermal and the exergetic performance is examined, and finally 200 l/h was found as the best solution. The next part is the optical investigation of the collector and greater optical efficiencies are tested. It is found that optical performance of 75% leads to maximum exergetic efficiency of 22.49%, three times greater than 7.49% which corresponds to the present situation of 35% optical efficiency. In the last part of this study, the selective absorber is compared to the non-selective of the real system and it is found that the use of the first is vital for achieving high operating temperature levels. The results of this study can be used as guidelines for the future improvement of the present facility.

**Keywords:** *Solar dish collector, thermal analysis, exergy analysis, parametric analysis*



## INSTITUTIONALIZATION OF ENERGY MANAGEMENT INFORMATION SYSTEM IN REPUBLIC OF SRPSKA

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### Summary:

According to the report Regular Review of Energy Efficiency Strategies in BiH gross total primary energy consumed per unit of GDP in Bosnia and Herzegovina is 2.5 times the average of 27 EU countries and higher than almost any other country in the south-east Europe. Republic of Srpska (RS) as a part of Bosnia and Herzegovina (BIH) is characterized with a low efficiency within the residential, non-residential/public, industry and service sector. In order to meet this energy intensive consumption demand, a significant amount of budget funds must be allocated for energy expenditures of public buildings (educational, health, municipal etc.). At the same time, Bosnia and Herzegovina has one of the most significant energy conservation potentials in the region and could base its further development on energy efficiency improvement measures in the residential and public sector.

Bosnia and Herzegovina also signed various international conventions and obligations in the field of energy with the commitment to harmonize its legislative framework with global trends. According to this obligations, BiH is obliged to report to the Energy Community on energy consumption and energy savings on state level. Currently there is no energy management system in Bosnia and Herzegovina, as well in Republic of Srpska. In the residential and public sector, information about energy and water consumption are usually provided only on a monthly basis. This paper presents the implementation of an information system as a tool for energy management for public sector regarding buildings in Republic of Srpska.

**Keywords:** *energy management, energy consumption, energy efficiency, information system*



## AN EQUATION FOR FITTING SPREADING DIAMETER OF A LIQUID DROPLET IMPACTING ON FLAT SURFACES

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### Summary:

The experimental data of normal impact of liquid droplets onto solid, dry surfaces has been fitted. The goal is to find a simple function that predicts time evolution of droplet spreading diameter for different impact velocities. The focus of this paper is the quantitative determination of the influence of the impact velocity on the droplet spreading. Generally it is difficult to find a function that describes this process well. Sets of experimental data, of droplet spreading diameter in terms of time, are fitted using a proper rational function. The rational function has two negative poles, i.e. the numerator is the first order polynomial and the denominator is the second order polynomial. Data for the impact of a water droplet, with diameter of 2.7 mm, and the Weber numbers 50, 90, 161, 391, 763 and 1076 are fitted to the rational function. The coefficients of rational functions are defined using the physical properties of the droplets and the experimental maximum. Experimental maximum corresponds to a stationary point of rational functions. The proposed function fit the data well.

**Keywords:** *carbon footprint, carbon dioxide, coal, thermal power plants, emission factor*



## IMPACT OF INDOOR AIR QUALITY ON HEALTH EFFECTS

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### Summary:

In modern industrial society man spends the greater part of his life indoors. A large proportion of the population, over 90 %, spends more than 20 hours a day in an artificial environment: at home, at the workplace, at shops, at variety of recreation places, cafes, theaters, cinemas, galleries, etc), during transportation etc. Since we spend most of our time indoors the character of the Indoor Environment Quality (IEQ) is of great significance for how we feel, for our health, wellbeing and productivity. Indoor environment quality has a special role as health determinant, and management of indoor air requires different approaches than outdoor air. To achieve indoor environment quality is determined by many factors, but the designers are focused on four different perspectives such as: Indoor Air Quality (IAQ), Thermal Comfort (TC), Visual Comfort (VC) and Acoustical Comfort (AC). The concept of Indoor Air Quality (IAQ) is used as a general denomination for the cleanliness of indoor air. The requirements of the occupants for the indoor air quality in a space are first that the health risk of breathing the air should be negligible and second that the air should be perceived to be fresh and pleasant rather than stale, stuffy and irritating. Indoor air quality may be controlled by a combination of pollutant source control and ventilation. Indoor air quality is vital to human health because most human activities take place in the indoor environment. Therefore the indoor air quality have become priority a for federal, provincial and regional health authorities.

**Keywords:** *Indoor air quality, WHO Indoor Air Quality Guidelines for Europe, outdoor air pollution, particulate matters (PM), ozone, nitrogen dioxide, sulfur dioxide, indoor air pollution, tobacco smoke, radon, volatile organic compounds (VOCs), mold, building materials*



## SELECTING LOCATION FOR INFRASTRUCTURAL INVESTMENT PROJECT IN RENEWABLE SOURCES OF ENERGY USING MATLAB AND FUZZY LOGIC

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### Summary:

Energy consumption in the world is constantly increasing. For environmental reasons, there is a growing social pressure to intensively use renewable sources of energy. Infrastructural investment in renewable sources of energy project is best solution for resolving energy problem. Selecting the location for renewable energy is a complex process that involves not only technical request, but also economic, social, environmental and political demands which can result in conflicting goals, and that's why, it is necessary to create the best model that would help in the selection of infrastructure project for investment.

Paper will use MATLAB and fuzzy logic methodology to determine the priorities for investment in renewable energy sources and decide which sites should be given the highest priority with respect to their benefits and costs.

**Keywords:** Infrastructural investments, Benefits and costs, Renewable sources of energy, MATLAB, Fuzzy logic, Site selection



## METHODOLOGY AND CHALLENGES OF CALIBRATING THE INSTRUMENT FOR SIMULTANEOUS THERMAL ANALYSIS

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### Summary:

Simultaneous Thermal Analysis (STA) represents combination of Thermogravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC) which are simultaneously applied to the same sample. Simultaneous sample analysis by two different methods of thermal analysis allows acquiring more data about the sample than applying these methods individually, providing more accurate data analysis. The main disadvantage of STA is lowered sensitivity for one or more signals which is the result of compromises that had to be made due to instrument's complex structure. Therefore, it is of great importance to carry out appropriate and correct instrument calibration in order to acquire relevant information. After successfully completed calibration for specific operating conditions (atmosphere and heating rate), various material characteristics can be determined, such as proximate analysis data required for fuel characterization. In this paper the calibration of device for STA from NETZSCH manufacturer, model "STA Jupiter 449F5" is presented. This instrument was acquired by the Fuel and Combustion Laboratory of the Faculty of Mechanical Engineering in Belgrade within realisation of project financed by Ministry of Education, Science and Technological Development of Serbia. During calibration, attention has been focused on output diagram analysis in order to define specific temperatures and latent heat of tested reference materials, required for defining calibration curves of temperature and sensitivity calibration, which are later presented.

**Keywords:** *Simultaneous Thermal Analysis, Thermogravimetric Analysis, Differential Scanning Calorimetry, calibration*



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**METHODS FOR PREDICTING THE PERFORMANCE OF CENTRIFUGAL PUMPS WHEN OPERATING IN THE TURBINE MODE**

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**Summary:**

In order to reduce the price of energy obtained from renewable sources, small and micro hydro power plants have lately been increasingly using pumps that which operate in the reverse mode, i.e. pumps as turbines (PAT). Pumps in the reverse mode have lower degrees of efficiency than conventional turbines, but their price of procurement and exploitation is also lower. The efficiency of PAT can be increased through constructive corrections of pumps. When selecting a PAT, it is essential to predict the performance the pump when it operates in the reverse mode based on its characteristics. There are various methods for predicting the performance of a pump that operates as a turbine.

The paper presents the available methods for predicting the performance a centrifugal pumps when operating in the turbine mode. The authors analyze the applicability and reliability of particular methods, depending on the width of the work area in relation to the optimal operating point

**Keywords:** *Centrifugal Pump, Pump as Turbine, Performance, Efficiency, Renewable energy*



## CFD ANALYSIS OF FLUID STREAMING IN ROTARY DRYER

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### Summary:

The dryer in which drying of material is being done by rotation moving of the drying stands around which hot air is streaming represents an innovative technical solution. Counter-streaming movement of the rotor with drying stands through the stream of hot air enables a higher drying intensity. In order to get a clearer picture of the hot air streaming among the drying stands and the effects of the individual components on the streaming of fluid through rotary dryer, it is necessary to perform a detailed CFD analysis.

**Keywords:** *Rotary dryer, streaming, drying, CFD*



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**COMPARATIVE ANALYSIS OF GEOTHERMAL HEAT PUMPS**

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**Summary:**

Geothermal Heat Pumps (GHP) belong to a class of modern sustainable technologies that use energy (heat) available underground for heating or cooling households and residential buildings, as well as commercial and industrial spaces. They are widely deployed across Europe and enable savings in primary energy sources, simultaneously cutting down the costs of heating/cooling.

This paper discusses advantages of GHPs, especially the pumps of the type earth-water and provides a comparative analysis of different types of those pumps currently available on the market according to their coefficient of performance (COP), CO<sub>2</sub> emission footprint, and power.

Based on the collected data from 309 different GHP models coming from 32 different manufacturers, we derive expressions for characterizing GHPs of the type earth-water, which can be useful in performing initial feasibility studies and system designs.

**Keywords:** *geothermal energy, heat pump, COP, heating, cooling*



## MHD FLOW AND HEAT TRANSFER IN POROUS MEDIUM WITH INDUCED MAGNETIC FIELD EFFECTS

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### Summary:

The magnetohydrodynamic (MHD) flow and heat transfer of viscous incompressible fluid through porous medium has been considered in the paper. Fluid flows through porous medium between two parallel fixed isothermal plates which have been kept at the two constant different temperatures. External applied magnetic field is homogenous and perpendicular to the plate. Due to the fluid flow magnetic field is induced along the fluid flow direction. The general equations that describe the discussed problem (momentum, magnetic induction and energy equation) under the adopted assumptions are reduced to ordinary differential equations and closed-form solutions are obtained. Solutions with appropriate boundary conditions for velocity, induced magnetic field and temperature have been obtained. The influence of Hartmann number, Reynolds magnetic number, suction parameter and porosity parameter have been presented graphically to show their effects on the flow and heat transfer characteristics.

**Keywords:** *MHD flow, heat transfer, porous medium*



## TWO-PHASE FLOW ANALYSIS IN SPIRAL EVAPORATOR TUBE OF STEAM GENERATOR

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### Summary:

Objective of this paper is analysis of one-dimensional, uniform two-phase flow of liquid and steam phase. In first part of the calculation, parameters of water, steam and two-phase mixture were obtained by numerical solving of mass, momentum and energy balance equations for one-dimensional one-phase or two-phase compressible fluid. By applying the „two-fluid“ model, solving balance equations for each phase and using corresponding constitutive correlation, parameters of water and steam were obtained as well as volume fraction of water and steam. Balance equations were solved using Runge-Kutta method after they were transformed from partial differential equations to ordinary differential equations. In calculation were took into account change in density due warming along evaporator canal with the assumption that the water heats with uniform heat flux over the entire length. The results of conducted calculation were presented graphically.

**Keywords:** *Two-phase flow, Numerical simulation, Runge-Kutta method, parameters of water and steam, evaporator tube*



## INFLUENCE OF A CONSTRUCTION SITE TO THE IMMEDIATE SURROUNDINGS AIR QUALITY

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### Summary:

Construction sites can make a significant impact on the surroundings. Impact to the grounds and the underground waters is routinely performed, but the impact to the surrounding air is slightly more complicated and rarely done. Therefore, an analysis of pollutant levels, as well as solid particles impact to the immediate surroundings, will be presented in this paper. All construction phases – from the terrain preparation to the final implementation of the greenery will be considered. Special consideration will be given to the changing atmospheric conditions. Developing buildings, roads and similar infrastructures have significant temporary influence to the local air quality. Air quality monitoring can give us insight into the influence of particle and other pollution in the immediate vicinity of such sites.

As result, some guidelines and good practices on air quality monitoring and improvement will be presented, for new objects, as well as for the demolition sites. Ideally, an efficient system for air quality monitoring and control should be established on the basis of collected data on air quality, atmospheric conditions and particle size.

**Keywords:** *air quality, construction sites, monitoring, particle analysis*



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**AIR POLLUTION REMOVAL AND CONTROL BY GREEN LIVING ROOF SYSTEMS**

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**Summary:**

Cities are open and dynamic urban ecosystems, which consume, transform and release matter and energy. By erecting buildings change in the flow of energy and matter through the urban ecosystems occurs creating multiple environmental problems. Those problems are amplified by transportation and production systems, which influence the elements of the ecosystem negatively. Air pollution in the urban environment, as one of the problem, is a major threat to human health. Conventional air pollution management programs focus on controlling the source of air pollutants but do not address the pollutants already in the air. Green roof implementation strategy is an innovative approach that can be adopted to remove existing air pollutants thereby reducing air pollution concentrations to an acceptable level, as vegetation plays important roles on remediating air pollution after the emission occurs. The green roof can be used to supplement the use of urban trees in air pollution control, especially in situations where land is not available and public funds are insufficient.

This review paper presents collected data comparing the findings from different research conditions and approach, to explore the important role that the green living roofs can play in the dense urban areas, mainly considering the impact on air quality. Pollution level, type of green roof involved in researches, and different material selection, for both plants and soil, have considering the influence on the performance of the green roof as a passive natural air filtration system.

**Keywords:** *green roof, air pollution, environment, building*



## WIND ENERGY POTENTIALS OF THE NORTHERN BALKAN MOUNTAIN

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### Summary:

Obtaining of all acceptable locations is one of the main tasks for siting of wind turbines. However, economical factors are usually very limiting. One of the possibilities to increase the rentability of the wind farm is to reduce the transport loses, as well as the initial investment, by using produced energy as close to the production site as possible. This paper focuses on the possibilities of northern part of the Balkan mountain wind potentials usage in the nearby city of Zaječar. The estimations were obtained using the WAsP simulation software. The results are compared by means of the quality and quantity of the wind data and capacity factor. Finally, the economical analysis of the acceptability of the installing of wind turbines was done.

This paper is concerned by the National Program of Energy Efficiency, project number: TR33036, funded by the Government of Republic of Serbia.

**Keywords:** *wind power assessment, complex terrain, CFD.*



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**NUMERICAL ANALYSIS OF CONVECTIVE HEAT TRANSFER FROM A  
PERFORATED PLATE**

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**Summary:**

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 perforated plate heat exchangers. Perforated plate heat exchangers consist of a series of perforated plates, separated by a series of spacers. In the present study, numerical simulations were performed to determine the overall heat transfer coefficient of a perforated plate with square arranged cylindrical perforations. Three parameters were varied in the study: plate porosity (in the range of 10 to 50%), hole-based Reynolds number (in the range of 100 to 10000 Re), and the working fluid (one-, two-, and three atomic gasses). The resulting Nusselt number was correlated as the function of per-hole Reynolds number, Prandtl number, and geometric parameters. At the end of the paper, the Nusselt number prediction was compared with different authors correlations. The data agreed on qualitatively with the results obtained using a CFD. Using these data, a Nusselt criterial equation was obtained.

**Keywords:** *Matrix Heat Exchangers, Nusselt Criteria, Peforated Plate*



## NUMERICAL INVESTIGATION OF CAVITATING FLOW IN VENTURI NOZZLE

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### Summary:

Cavitation problems occurs in water flow where the local pressure reaches saturated vapour pressure, due to the sudden increase of local velocity values, forming bubbles and different forms of flow discontinuity. Water flow in the Venturi nozzle is the typical example of potentially cavitation flow. Due to the large importance of Venturi nozzles in engineering practice, it is important to determine their cavitation characteristics, such a cavitation number and loss coefficient of the nozzle. In case we are unable to obtain cavitation characteristics of the nozzle experimentally, there is the possibility to conduct numerical simulations of the flow in the Venturi nozzle. The objective of this study is to present the possibilities of obtaining cavitation characteristics of Venturi nozzles by applying numerical simulations, and to determine the optimal numerical modelling of flow in the case of Venturi nozzle.

**Keywords:** *Venturi nozzle, numerical simulation, cavitation, cavitation number, Venturi loss coefficient.*



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DETERMINATION OF OPTIMAL ENERGY MIX SUPPLY FROM RENEWABLE ENERGY SOURCES BY USING MULTI-CRITERIA OPTIMIZATION

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**Summary:**

Energy supply chain has been defined as the trajectory of all energy transformations from the fuel source or primary energy sources to useful energy form delivered to end users. In general, every single energy supply chain can be uniquely defined by several criteria. These criteria are generally categorized into the three groups: energy, environmental and economic criteria. There are following criteria: energy efficiency of observed chain, exergy efficiency of chain, the coefficient of exergy quality for different products at energy chains, specific investment cost per totally installed power of all machines and plants in the energy chain, €/kW, production cost of energy chain per 1 kWh of the lower heating value of produced biofuels or energy, €/kWh, CO<sub>2</sub> emission in the total chain due to the fossil fuels consumption for 1 kWh of the lower heating value of produced biofuel or energy, kg/kWh and availability of usable resources on its territory and possibility for its use in defined percent. Optimal energy supply chain can be chosen by using multi-criteria optimization. Selected optimal energy supply chain fulfils important set of criteria, which are defined and adopted for this type problem, previously. But the main goal in this paper is not to choose optimal energy chain, rather than determination energy mix from several renewable energy supply chains. Determination of optimal energy mix comes down to determination of the percentage share of each component of renewable energy supply in defined boundary of the observed problem. To meet its energy needs, each country, region or defined area uses the energy available to it, in different proportions. This is what we call the energy mix. Depending on definition of the criterion matrix for optimization, this matrix will define the possibility of applying this method on different energy supply chains and regions. For total ranking of renewable energy chains for production of fuel or energy and selection of optimum variant, the multi-criteria optimization and VIKOR method can be applied. In VIKOR approach, the compromise ranking



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is performed by comparing the measure of closeness to the ideal alternative. This is main reason why this methodology is very good for application in determination of optimal sustainable energy mix. The measure of closeness to the ideal alternative is directly in correlation with percent of share in modelled renewable energy mix. This approach for determination of optimal energy mix have been applied and tested on several real supply bioenergy chains in this case: CHP plant, pellet plant and wood heating boiler.

**Keywords:** *optimal sustainableenergy mix, multi-criteria optimization, energy chains, renewable energy, VIKOR*



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**MHD FLOW AND HEAT TRANSFER OF MICROPOLAR FLUID WITH  
INDUCED MAGNETIC FIELD EFFECTS**

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**Summary:**

In this paper, the MHD flow and heat transfer of an incompressible electrically conducting micropolar fluid through a parallel plate channel is investigated. A uniform magnetic field was applied perpendicular to the flow and, due to the fluid motion, a induced magnetic field appears along the lines of motion. The upper and lower plates have been kept at the two constant different temperatures and the plates are electrically insulated. Partial differential equations governing the flow, heat transfer, micro rotation and magnetic field conservation are transformed to ordinary differential equations and solved under physically appropriate boundary conditions. Solutions obtained for the velocity, micro-rotation, temperature and induced magnetic field in function of the coupling parameter and the spin-gradient viscosity parameter are presented graphically.

**Keywords:** *Micropolar fluid, heat transfer, MHD flow, magnetic Reynolds number.*



## ANALYSIS AND EVALUATION OF SOLAR ENERGY SYSTEMS

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### Summary:

In Serbia, it is usually to use electricity for domestic hot water (DHW) heating. As about 70% of electrical energy is produced by using coal, with high greenhouse emission, it is beneficial to environment to use solar energy for DHW heating in solar DHW system (SDHWS).

This paper represents the optimization of design, implementation in practice and operation of the solar collectors in space and time, as elements of solar installations, in order to determine the feasibility of the proposed concept modern methods of energy monitoring and energy diagnostics. These investigations use computer software EnergyPlus. The used weather data are from the meteorological station. In this paper, a use of Hooke-Jeeves algorithm is reported to obtain the maximum amounts of performances for different SDHWS use as a function of number of optimum positions of the solar collector in SDHWS during year for Belgrade, Serbia.

Solar energy systems have been improved, whereby we obtain minimum consumption of fossil energy, reduction of the use of energy resources, maximizing energy security, as well as the minimum impact on the environment.

**Keywords:** *Optimization; Solar system for heating of DHW; simulation; solar collector; solar fraction*



## THE IMPACT OF INPUT TEMPERATURE AT PANEL HEATING SYSTEM TO HEAT THE SPORTS HALL

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### Summary:

Low temperature heating panel systems offer distinctive advantages in terms of thermal comfort and energy consumption, allowing work with low energy sources. The low temperature panel systems, by their nature work at a low temperature sources. However, this method of application panel system is not suitable for work in large spaces such as the sports hall. The aim of this study was to investigate the effect of inlet temperature of the panel systems in order to facilitate their application in sport halls. Simulation models are developed in the EnergyPlus software package developed by Lawrence Berkeley Laboratory in the United States.

**Keywords:** *energy, radiant panel heating, temperature, Energy Plus*



## NUMERICAL ANALYSIS OF UNSTEADY HEAT TRANSFER IN U-TUBE GEOTHERMAL HEAT EXCHANGER

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### Summary:

This paper presents a numerical model for unsteady heat transfer in geothermal borehole heat exchanger. Heat transfer in the fluid circulating in the pipe is considered as one-dimensional and the governing differential equation is discretized using control volume method. Heat transfer through the pipe wall, grout, and surrounding soil is regarded as three-dimensional and the governing equation is discretized using 3D CVFEM method. The final solution is obtained by simultaneously solving the coupled systems of equations.

The numerical solution is verified through comparison with analytical solutions for the cases of simplified geometry and boundary conditions. Overall numerical model is validated through comparison with available experimental results.

The abilities of proposed numerical model are demonstrated through analysis of unsteady heat transfer following the step change of inlet fluid temperature where temperature profile of heat transfer fluid along the pipe as well as heat fluxes on the borehole wall and short circuit heat flux are of interest. Finally, the influence of various parameters (velocity and fluid temperature at the inlet, thermal properties of pipe, grout, and soil, shank spacing and groundwater flow) are analysed and the results are systematically presented.

**Keywords:** *geothermal heat pump, borehole heat exchanger, 3D CVFEM*



## HYDRAULIC TRANSIENTS CALCULATIONS ON KOMARNICA HPP

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### Summary:

This paper deals with hydraulic transients on hydropower plant Komarnica, whose construction was adopted from energy development strategy of Montenegro. Calculation of hydraulic transients is one of the most important parts during the design process of the hydro power plant. The cases of emergency shut-down of both and one unit are investigated as well as protection against undesirable pressure rise during these processes. For all numerical calculations commercial software Simsen Hydro is used. Based of the obtained numerical results closing time of the Francis turbine wicket gates is chosen.

**Keywords:** *hydropower plant, emergency shutdown, hydraulic transients, Francis turbine.*



## OPTIMAL CONFIGURATION OF A POLYGENERATION SYSTEM FOR THE ENERGY DEMANDS OF A PUBLIC SWIMMING POOL BUILDING

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### Summary:

A polygeneration system is an energy system capable of providing multiple energy outputs for the local demands, by application of high process integration. In this paper, optimal configuration and capacity of a polygeneration system for an indoor swimming pool building is determined using TRNSYS and GenOpt software. Based on the locally available resources, the following polygeneration modules were chosen for the case study analysis: an internal combustion engine cogeneration module, a vapour compression chiller, and adsorption chiller, a ground source heat pump, flat plate solar thermal collectors, photovoltaic collectors and heat storage. The modules are integrated to form a superstructure of the analyzed polygeneration system in TRNSYS modeling environment. The net present value of the polygeneration system construction project is used as goal function of the optimization problem.

**Keywords:** *optimisation, polygeneration, renewable energy sources, swimming pool*



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**HEATING WITH BIOMASS – BENEFITS OF THE INVESTMENTS**

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**Summary:**

This paper attempts to give an overview of the positive effects when conventional fuel – light home heating oil or fuel oil is replaced with fuel from renewable sources of energy – wood biomass as energy source for heating the premises of public objects. While it's done consideration of the current situation in a several public buildings, a heat capacity is required in accordance with standard procedure for calculating, there are proposed solutions for the reconstruction and replacement of part of existing heating installation. The main emphasis is given to the analysis of the possibilities of replacing fuel oil with wood pellets and benefits of it.

By analyzing of the current situation and the situation after reconstruction, an overview of the parameters of the economic justification for applying pellets in both cases is given. The suggested mathematical model gets parameters therefore indicators of justification of this activity. This is confirmed by the financial benefits, by which clearly outlines the justification for accession to this reconstruction, but emphasis is also given by non-financial and other benefits, such as environmental impacts on living and working environment.

**Keywords:** *Heating installations, classic fuel, wood biomass pellets, reconstruction, mathematical model, saving, environmental and working protection etc.*



## ANALYSIS OF CARBON FOOTPRINT METHOD-AN REVIEW

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### Summary:

As the carbon dioxide is considered one of the major causes of the greenhouse effect, tracking emissions of this gas is of vital importance to the preservation of the environment. In this paper, an analysis of gasses that affect on global warming, with special emphasis on carbon dioxide emissions, is presented. Carbon footprint is also analyzed in this paper. The term carbon footprint is used for greenhouse gas emissions and is generally expressed as CO<sub>2</sub> equivalents (CO<sub>2</sub>e), which consists of emissions of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O. These gasses are translated into the amount of CO<sub>2</sub> (this is called the equivalent amount of CO<sub>2</sub>). For each sector, it is possible to calculate a specific amount of carbon footprint. Of all sectors, the energy sector has the highest value of the carbon footprint, primarily due to the combustion of fossil fuels in power plants.

**Keywords:** *carbon footprint, carbon dioxide, global warming, greenhouse gasses*



## A KINEMATICALLY DRIVEN SLIDER CRANK MECHANISM

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### Summary:

Two approaches are possible for kinematically driven multibody systems: a classical and a computational approach. In the classical approach it is assumed that the system degrees of freedom can easily be identified and all the kinematic variables can be expressed in terms of the degrees of freedom. When more complex systems are considered, the use of another computer-based method, such as the computational approach, becomes necessary. A V engine slider crank mechanism is an example of the complex system. In the computational approach, the kinematic constraint equations that describe mechanical joints and specified motion trajectories are formulated, leading to a relatively large system of nonlinear algebraic equations that can be solved using computer and numerical methods. In this paper, we use the computational approach for kinematic analysis of the position, velocity and acceleration of a slider crank and a V engine slider crank mechanism. The influence of nonuniformity rotation of the crankshaft on the movement of the piston will be given.

**Keywords:** *kinematically driven systems, slider crank mechanism, kinematic constraint*



## CARBON FOOTPRINT METHOD-A CASE STUDY FOR THERMAL POWER PLANTS IN REPUBLIC OF SERBIA

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### Summary:

There are many methods for the analysis of the negative impact of thermal power plants on the environment. In this paper will be presented a method Carbon footprint. Carbon footprint originated from the Ecological Footprint and independently developed. This method is one of the newer methods. By defining this method the goal is to raise the awareness of citizens about pollution. This method can be applied in other areas, not only in terms of the power plant. Carbon footprint is based on the definition of greenhouse gasses through carbon dioxide equivalent. From there the name of this method Carbon footprint. In this paper, is done research how the work of thermal power plants that use coal as fuel affect emissions. Was analyzed the operation of thermal power plants that use fossil fuels because in the Republic of Serbia the most electricity is obtained from these plants.

**Keywords:** *carbon footprint, carbon dioxide, coal, thermal power plants, emission factor*



## EXPERIMENTAL DETERMINATION OF SMALL FLOW RATE WITHIN HYDRAULIC COMPONENTS

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### Summary:

A hydraulic system and loss of hydraulic power are significantly affected by the flow rate of hydraulic fluid from the higher pressure to the lower pressure zone, through clearances in components with contactless sealing.

The optimization of hydraulic components implies enhancing energy efficiency and improving control, especially in applications which require rapid and precise positioning of actuators. This is why it is necessary to develop mathematical models for fluid flow rate that would also include the flow rate through clearances.

This paper explains an experimental installation for the measuring of small flow rate within hydraulic components that enables verification of mathematical models.

**Keywords:** *leakage, hydraulic components, flow rate*



## ADVANTAGES OF DRYING OF VEGETABLES USING THE INTEGRATED HEAT PUMP TECHNOLOGY

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### Summary:

The world is facing an increase in human population and consequently need to produce more fresh and dried products for this expanding population. New technologies should fulfill the objective of economical profitability, which is mostly dependable on energy efficiency due to the trend of increasing energy cost. Currently, as a drying process consumes up to 50% of the total amount of energy used in industrial purposes. One of the relatively new technologies for these requirements is heat pump drying (HPD).

In this work a laboratory heat pump drying is applied for vegetables drying. The drying of vegetables was conducted in fluidized bed. Fluidized bed gives important advantages such as good solid mixing, high rates of heat and mass transfer and easy movement of materials. The air drying was adjusted on temperature regimes of 45°C and 15°C with three relative humidity levels. Some of the limitations in fluidized bed drying application are high pressure drop and high electrical power consumption. The results have shown that higher temperatures increase the rate of moisture removal from the vegetables (green peas). Difference in relative humidity of the air drying plays an important role in the process.

**Keywords:** *drying, heat pump, vegetables, fluidized bed*



**13<sup>th</sup> International Conference on Accomplishments  
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**INVESTIGATION OF WOOD BIOMASS MARKET IN SOUTHEAST SERBIA**

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**Summary:**

A hydraulic system and loss of hydraulic power are significantly affected by the flow rate of hydraulic fluid from the higher pressure to the lower pressure zone, through clearances in components with contactless sealing.

The optimization of hydraulic components implies enhancing energy efficiency and improving control, especially in applications which require rapid and precise positioning of actuators. This is why it is necessary to develop mathematical models for fluid flow rate that would also include the flow rate through clearances.

This paper explains an experimental installation for the measuring of small flow rate within hydraulic components that enables verification of mathematical models.

**Keywords:** *leakage, hydraulic components, flow rate*

# MECHANICS AND DESIGN





## APPLYING THIRD ORDER SHEAR DEFORMATION THEORIES IN THE FREE VIBRATION ANALYSIS OF CROSS-PLY SYMMETRIC AND ANTI-SYMMETRIC LAMINATE PLATES

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### Summary:

The paper analyses the free vibrations problem of simply supported laminate plates. The problem is being considered applying third-order shear deformation theory. Navier's forms of solutions of partial differential equations have been used for obtaining results. Theoretical assumptions for using this theory are given, as well as the process of obtaining matrices which are created as a result of stacking layers in a laminate. The paper considers cross-ply laminates with angles of layers orientation of  $0^\circ$  or  $90^\circ$  in relation to the x axis of the adopted coordinate system. The results for symmetric and anti-symmetric laminate plates are given in tabular and diagram form. The influence of geometric characteristics of the plate as well as the influence of the material elasticity module are presented. The solutions have been obtained in the software package Matlab using symbolic and numerical programming. The results have been verified by the results presented in the papers based on high-order shear deformation theories.

**Keywords:** *free vibrations, third order deformation theory, composite laminates, analytic solutions, Navier's solutions.*



## OPTIMIZATION OF MINE HOIST ROPE ATTACHMENT ASSEMBLY USING FEM ANALYSIS

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### Summary:

Cage rope attachments are important part of mine hosting systems and their maintenance is necessary in a mining facility. In this paper the mine hoist rope attachment assembly from Coal Mine Zenica, excavation “Raspotocje”, is considered and investigated. The original design dimensions of rope attachment assembly parts are altered in order to reduce weight whilst satisfying all design and safety criteria. Different design scenarios of rope attachments parts are analysed by FEM software and as a result of the investigation the improved design of rope attachment assembly is proposed.

**Keywords:** *FEM analysis, mine hoist, rope attachment assembly*



## MODELLING AND FINITE ELEMENT ANALYSIS OF ELEVATOR BUCKETS

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### Summary:

The bucket elevator with centrifugal discharge designed for transport of grains is analysed in the paper. Operation, main characteristics and major elements of bucket elevator are described in the paper. Essential elements of calculation of the drive mechanism are presented, bucket discharge type is adopted and main elements of transport device are selected. A rubber belt is selected as traction device. Available transport capacity ranged from 15 t/h to 45 t/h, while lifting height was 18 m. Based on initial data and calculations, a spatial 3D model of the elevator is formed. Static finite element analysis (FEA) of the elevator bucket was conducted based on previously formed model. A modified version of the bucket was made in order to show the influence of design change on mass, deformation and the stress states of the elevator buckets. Modelling of the elevator bucket was conducted using 3D Autodesk Inventor software.

**Keywords:** *bucket elevator, bulk materials, buckets, FEA*



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**TWO-CARRIER TWO-SPEED PLANETARY GEAR TRAINS WITH BRAKES ON  
SINGLE SHAFTS**

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**Summary:**

This paper considers two-speed planetary gear trains with four external shafts, composed of two simple planetary gear trains. Possible schemes of these planetary gear trains are pointed including systematization of variants. By putting brakes on different shafts transmission ratio changes and also power flow through the planetary gear trains. This fact makes possible application of two-carrier two-speed planetary gear trains at the systems which need transmission ratio changes under load.

Apart from the two-carrier two-planetary gear trains structures definition, the analysis of the operation of the trains with different layout variants also included in the paper.

**Keywords:** *two-speed planetary gear trains, transmission ratios, brakes on the single shaft*



## STRUCTURAL ANALYSES OF BALISTIC MISSILE FIN CONFIGURATION DURING SUPERSONIC FLIGHT CONDITIONS

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### Summary:

Attention in this work is focused on aerodynamic heating and aero-thermo-mechanical analysis of fin type structures on the missile at supersonic flight. The modeling of aerodynamic heating of supersonic and hypersonic flights has been under intensive consideration in recent years. At high Mach number the heat due to friction between body and flow, i.e. viscous heating must be taken into account because the velocity field is coupled with the temperature field. The flow field around the fins of the missile and especially the temperature distribution on its surface, as well as aerodynamic-thermal/structural analyses are numerically modeled in ANSYS Workbench environment. The investigation was carried out for two Mach numbers ( $M = 2.3$  and  $M = 3.7$  with same angle of attack of  $5^\circ$ ). Available structural experimental results have been used for computational structural mechanics validation and verification, in order to assure credibility of numerical fluid-thermal-structure interaction. In this work a multidisciplinary framework for numerical aerodynamic-thermal/structural analyses, based on only one multi-module software, was used to analyse thermal effects on fin structure during supersonic flights conditions.

**Keywords:** *Missile fins, Supersonic flight, Aerodynamic heating, Heat transfer, Aerodynamic-thermal/structural analysis*



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**DETERMINATION OF MECHANICAL PROPERTIES OF COMPOSITE  
MATERIALS-THE RUBBER CONVEYOR BELT WITH CARTRIDGES MADE OF  
POLYESTER AND POLYAMIDE**

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**Summary:**

A large number of cracking the conveyor belt, which occur during exploitation at stress level lower than the permitted, indicates a risk of damage and breakage. Therefore in designing it is necessary to define criteria by which one can achieve safety of exploitation conveyors with rubber belt from damage and breakage. In this analysis it is very important to treat the rubber conveyor belt as a classical composite material, which consists of a rubber as a matrix and a polyester-polyamide canvas as reinforcements. Rating of mechanical and exploitation properties, i.e. the emergence and development of damage in composite materials due to the static and dynamic loads is a complex phenomenon which consist: micro cracks in the rubber, a breakage of fiber of polyester-polyamide canvas, weakening of connection rubber-canvas and delamination. In this paper is presented the results of experimental studies of composite materials the rubber conveyor belt with cartridges made of polyester and polyamide. It is also presented the results of a new and exploited rubber conveyor belts in the direction of the load action, as follows: tensile strength, modulus of elasticity, Poisson's coefficient and strain.

**Keywords:** *conveyor belt, tensile strength, stress-strain, Poisson coefficient, modulus of elasticity*



## OPTIMIZATION OF FIBER ORIENTATION ANGLE OF A HYBRID Al / COMPOSITE CARDAN SHAFT

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### Summary:

One important property of composite materials is the possibility to change their characteristics by changing the fiber orientation angle. By determining the optimal fiber orientation, the resistance to the torque effect, as well as the value of the critical rotational speed, can significantly be increased. In this paper, using the finite element method, we have examined the effects of fiber orientation angle on the basic static and dynamic characteristics of the shaft (twist angles, natural frequency). The shaft is composed of a combination of aluminum and composite layers of carbon and aramid fibers. In the conclusion section of the paper, optimal variants of the shaft have been identified.

**Keywords:** *shaft, twist angles, natural frequency, aramid fiber, carbon fiber*



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**ASSISTIVE HUMANOID ROBOT MARKO: DEVELOPMENT OF THE WAIST MECHANISM**

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**Summary:**

This paper presents the development of the waist mechanism for humanoid robots. The research was conducted within the project which is developing a humanoid robot Marko that represents assistive technology in physical therapy for children with cerebral palsy. There are two basic ways for realization of the robot trunk. The first is based on multi-joint viscoelastic structures that have variable flexibility and the second one is based on low backlash mechanisms with one joint that has high stiffness. Based on the kinematic-dynamic requirements a dynamic model of the robot upper body is formed. Dynamic simulation for several positions of the robot was performed and the driving torques of the waist mechanism are determined. Realized waist has 1 DOF and enables movements in the direction of flexion-extension 90°. It consists of a gear mechanism with bevel and helical gears. It has a high carrying capacity and reliability, high efficiency and low backlash that provide high positioning accuracy and repeatability of movements.

**Keywords:** *assistive robot, humanoid Marko, waist mechanism, mechanical design*



## COMPUTATIONS AND EXPERIMENTAL STRENGTH ANALYSIS OF HELICOPTER TAIL ROTOR BLADES MADE FROM COMPOSITE MATERIALS

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### Summary:

This work considers fatigue strength behavior of construction made from composite materials. Primary attention in this work is focused to fatigue strength behaviors of helicopter tail rotor blade made from composite materials. To analyze fatigue strength behavior of composite blade here the blade tested under static and fatigue load spectrum. For precise definition of load spectrum of helicopter tail rotor blades here computation fluid dynamic (CFD) numerical simulation are used. In this consideration for determination aerodynamic loads of helicopter tail rotor blades two computation models are used. In first model isolated tail rotor blade is considered. In the second computation model the complete helicopter is modeled including fuselage together with main and tail rotor blades. To verify strength of the tail rotor composite blade here is tested with respect to static/fatigue for one critical load case. In addition to experimental verification of tail rotor blade here is illustrated computation procedure for initial fatigue life estimation of critical metal part of composite tail rotor blade.

**Keywords:** *Helicopter tail rotor blade, Composite materials, Fatigue strength, Experimental verification, FEM, CFD*



## CALCULATION OF STRESS STATE OF GEAR MADE OF COMPOSITE MATERIALS

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### Summary:

Stress state of composite gear is very relevant and interesting topic for researchers due to their increasing use, especially in the automotive industry. In recent years, great progress has been made in this area. The gears are usually made of steel, but the progress of materials science make tendency that gears are more often made of material less weight. Reducing weight of mechanical transmission is often the aim of constructors and implementation of composites became very attractive to car designers because of their specific characteristics. In this paper, using Ansys program, is made analysis of the stress-strain state of gear. The results obtained by software were compared with the results obtained by analytic, and thus confirmed the credibility of the calculation. With examination on the same model of conical gear pair made of composite materials, it was concluded about the behavior of composite materials and their stress state.

**Keywords:** *gears, composites, stress, Ansys*



## THE ROLE OF INDUSTRIAL AND SERVICE ROBOTS IN THE 4th INDUSTRIAL REVOLUTION – “INDUSTRY 4.0”

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### Summary:

As it is well known, the fourth industrial revolution, entitled “INDUSTRY 4.0” appeared for the first time at the Hannover Fair in 2011. It comes from the high-tech strategy of the German federal government that promotes automation and computerization of industry. Ever since 2012, the working group of the German government presented recommendations for the introduction of “Industry 4.0” in the production processes. The strategy consists of adjustment of industrial production to complete smart automation, which means the introduction of self-automation method, self-configuration method, self-diagnosing and removal of problem, knowledge and intelligent decision making. The central figures of “Industry 4.0” are industrial robots, as well as service robots. Their application in all production processes, with the support of information technology, will lead to “intelligent automation” and “intelligent factories”. In the nearby future (expected by 2025), machines, devices, robots and humans need to be mutually connected, so that they can work side by side and communicate with each other via the internet platform (IOT). The paper states the role of robots in the fourth industrial revolution, as well as predictions of the development and implementation of robots in the industrial processes. Smart automation or smart factories will create a society in which the wealth, created through the strengthening of global competitiveness, would serve to meet social issues in the society.

**Keywords:** *industrial robot, service robot, intelligent automation, industry 4.0, smart factory, robotic revolution.*



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**ANALYTICAL SOLUTION FOR THERMAL VIBRATIONS OF SINGLE-LAYERED GRAPHENE SHEETS WITH VARIOUS BOUNDARY CONDITIONS**

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**Summary:**

This paper deals with analysis of thermal vibration behaviour of orthotropic single-layered nanoplate with various boundary conditions. The new first-order shear deformation theory is reformulated using nonlocal differential constitutive relation of Eringen. The governing equations of motion are derived from Hamilton's principle. Using Galerkin method, analytical solution for rectangular nanoplates under various boundary conditions are obtained. Numerical results are presented to show variations of the dimensionless frequency of single-layered nanoplates corresponding to various values of the nonlocal parameter and temperature change.

**Keywords:** *Nanoplates, Thermal vibration, Galerkin method*



## INFLUENCE OF OPERATING AND AMBIENT TEMPERATURE ON LOAD CAPACITY OF UNIVERSAL WORM GEAR REDUCER

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### Summary:

The problem of worm gear heating is analysed in this paper. In most of cases, this heating has great impact on load capacity of worm gears, but in a great measure defines efficiency of worm gear transmission. Heating of worm gear is restricted by thermal power capacity of the gearbox. Thermal power capacity of the gearbox is defined as the biggest input power of the gearbox which could be transmitted by the gear unit, with the condition that power losses can be given to the surrounding without overheating of the gearbox, in the case of normal air temperature. Determination of the operating temperature represents the main problem for defining thermal power capacity of the gearbox. The highest operating temperature represents a limit until the gearbox (the oil in the gearbox) can be heated, but also in dependence of surrounding temperature (the ambient temperature where the gearbox operates). Influence of these temperatures is analysed in this paper.

**Keywords:** *operating temperature, ambient temperature, thermal power capacity, worm gear.*



## CORRELATION DIMENSION OF NONLINEAR TIME-SERIES AND EXPERIMENTAL ANALYSIS

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### Summary:

Time series some physical value obtained by experimental measurement and registration of results in the time domain. Many values in nature and technology have characteristics non-linear time series: mechanical oscillations, oscillations of temperature, strain, force and others. Non-linearity, dissipativity and external excitation are conditions for chaotic (disordered, irregular) behavior. The intensity of chaos is determined by the indicators of chaos. As simple and adequate indicator of chaos Grassberger and Procaccia introduced correlation dimension in 1983., which is determined through the correlation sum. The correlation dimension is applied to the scalar and vector time series. The lack of correlation dimension is the impossibility of distinguishing clearly chaos and stochasticity.

**Keywords:** *nonlinear time-series, indicators of chaos, correlation dimension, correlation sum*



## SOLID PHASE VELOCITY DISTRIBUTION OF TWO-PHASE TURBULENT FLOW AT PNEUMATIC TRANSPORT IN STRAIGHT CHANNELS OF QUADRATIC CROSS

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### Summary:

In pneumatic transport of solid particles it is necessary to determine the velocity of transported particles in order to perform the assigned material transport. The paper considers a two-phase turbulent flow of air-solid particles in a channel with a square cross-section. The full Reynolds stress model was used to model the turbulence and calculate turbulent stresses and turbulent temperature fluxes. The paper provides diagrams of velocities and positions of transported solid particles of quartz, ash and flour, transported by a transporting fluid (air) through the channel.

**Keywords:** *pneumatic transport, solid particles, two-phase flow, secondary flow.*



## CRITICAL BUCKLING TEMPERATURE OF CERAMIC-METAL FUNCTIONALLY GRADED PLATE

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### Summary:

A thermal buckling analysis of functionally graded thick square plate is presented. Mechanical and thermal properties of the functionally graded material, except Poisson's ratio, are assumed to vary continuously through the thickness of the plate according to a power-law distribution of the metal and ceramic volume fractions. Formulations of stability equations are based on high order shear deformation theory including shape function as well as von Karman type of nonlinearity. An analytical method for determination of critical buckling temperature of plate is developed. Comparative results of critical buckling temperature for different type of shape functions are presented. The accuracy of the presented formulation and obtained numerical results is verified by comparing the results available in the literature. The effects of power-law index and temperature gradient on mechanical responses of the plates are discussed and appropriate conclusions are given.

**Keywords:** *functionally graded plate; thermal buckling; von Karman nonlinear theory; power-law distribution; high order shear deformation theory*



## FAILURE STRESS ANALYSIS OF FIBER REINFORCED COMPOSITE LAMINATES

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### Summary:

The target materials of this paper are failure analysis of fiber reinforced composite laminates. Laminates are constituted of successive layers of lamina, whose layers can differ in constituents and the orientation of the fiber. In order to study the mechanical behavior of materials, it is necessary to determine the stiffness matrix. Constitutive relations are determined by classical lamination theory of first order. Then, the composite material is applied to the failure criteria, to determine whether failure occurs in a lamina. Due to the lack of maximum stress criterion, there is no interaction between the stress components, and therefore Tsai - Hill failure criterion was applied for composite laminates. In this paper the results are presented for several materials, different sequence numbers and loads.

**Keywords:** *composite materials, classical laminate theory, failure criterion*



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**CRACK PROPAGATION ANALYSIS OF CYCLICALLY LOADED STRUCTURAL COMPONENTS**

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**Summary:**

The present paper proposes a computational model for the failure analysis of finite plate with quarter-elliptical corner crack located at a hole. Such a theoretical investigation takes into account the stress intensity factor calculation and fatigue life estimation. Fracture mechanics based analytical approach is employed to analyze the stress-intensity behaviour, whereas the stress-ratio dependence crack growth model is applied for assessing fatigue life to failure. The crack growth estimations show a good correlation with experimental data.

**Keywords:** *fatigue, quarter-elliptical crack, stress-intensity behaviour, residual life calculation.*



## MODELING FRACTURE MECHANICS PARAMETERS OF CRACKED STRUCTURAL ELEMENTS UNDER THERMOMECHANICAL LOADS

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### Summary:

In this work, the computation procedure is performed to determine stress intensity factors for structures with surface crack under the influence of thermal loads. Structural components of aero engine turbine are the most important components. It operate at high temperature and under conditions of extreme environmental attack such as oxidation, corrosion and wear. During the service of turbine, components suffer from initiation and increasing tip cracks. These conditions can cause cracking of rotational components. The failure damage modes of turbine are classified in terms of main components as flow path parts, rotating such as rotor, groove, disk, and blade. Aero-engine turbine components such as disks and blades are susceptible to environmentally assisted cracking. Unlike fatigue crack growth, this involves crack growth under constant load. If the crack grows long enough, sudden failure can occur with catastrophic consequences. It is therefore desirable to identify the limiting crack size within fixings so that they can be inspected at regular intervals and removed from service before failure occurs. Three dimensional axi-symmetric finite element models were created to simulate a disc and the portion of a blade. The finite element method allowed the prediction of the point of crack initiation and the crack propagation using the orientations of the maximum principal stresses. Stress intensity factor (SIF) is the base parameter in strength analysis regarding fracture mechanics. For correct determination SIF in this paper, combining J-integral approach and FEM is used. J-integral is path independent integral around the crack tip. The stress intensity factor (SIF) for an embedded elliptical crack in a turbine rotor under thermal and centrifugal loading, for a semi-



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elliptical surface crack in a finite plate are determined by means of finite elements and J-integral method.

**Keywords:** *Aero-engine, Turbine components, Fracture mechanics, Stress intensity factor, J-Integral approach*



## MEASURING SYSTEM FOR DETERMINING SN CURVE BASED ON THE ARDUINO PLATFORM

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### Summary:

For the determination of SN curves of friction stir welded joints sophisticated measuring systems are required. The parameters that are measured are cumulative numbers change loads, the moments of specimen fractures and frequency of variable load. In order to reduce the duration of the tests, a special design for the simultaneous testing of a large number of specimens was developed. Specimens are arranged in a series of the console loaded with different masses at each end. For the generation of harmonic oscillations of the console, high-frequency electrodynamic machine (shaker) Sentek Dynamics is used. Because the testing tool is a package of 12 samples rather than one sample, it is necessary to detect the moment of fracture of each sample. The use of conventional measuring equipment is extremely expensive. The probability of damage of equipment is large. For these reasons, an inexpensive, simple, reliable, and autonomous measuring system was developed with a large measuring potential based on ARDUINO platform.

**Keywords:** *SN curves, autonomous measuring system, friction stir welding*



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**DESIGNING OF FIXATOR FOR VIBRATION TESTING OF WELDED JOINTS SPECIMENS**

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**Summary:**

Light welded constructions from aluminum alloys are widely used in the automotive and aerospace industry. Particularly interesting are the lightweight construction made of aluminum alloys that are difficult to weld conventional welding procedures. Such structures are welded with Friction stir welding (FSW), which is a relatively new way of welding. When dynamically loaded welded structures it is necessary to carry out testing of fatigue behavior of materials (the legality of fatigue crack growth and testing fatigue strength and determination of S-N curves).

On Faculty of Mechanical Engineering in Nis has been developed a methodology based on the vibration tests based on the estimation that the fatigue behavior of welded joints achieved with FSW. In order to reduce the duration of the test, the test setup was developed for the simultaneous testing of a large number of specimens. For the generation of harmonic oscillations of console set specimen, used high-frequency electrodynamic vibration test system (shaker) Sentek Dynamics. The connection between the armature of shaker and test specimens is accomplished using a specially designed fixator.

**Keywords:** *Fixator for vibration testing, Welded joints specimens, Fatigue strength, Shaker*



## GENERALIZED SIMILARITY INCOMPRESSIBLE BOUNDARY LAYER EQUATION WITH VELOCITY AND SHEAR STRESS DISTRIBUTIONS FOR UNSTEADY FLOW AROUND CIRCULAR CYLINDER

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### Summary:

The equations of unsteady incompressible boundary layer, by introducing the appropriate variable transformations, momentum and energy equations and one similarity parameters set, being transformed into generalized form. These parameters are expressing the influence of the outer flow velocity and the flow history in boundary layer, on the boundary layer characteristics. The numerical integration of the generalized equation with boundary conditions has been performed in: 1) full two parametric approximation, where the first unsteady and dynamic parameters will remain, while all others will be let to be equal to zero, 2) two-once localized parametric approximation where only first unsteady parameter remained and 3) two-once localized parametric approximation, only with first dynamic parameter, where also parameters will be let to be equal to zero. So obtained generalized solutions are used to calculate the distributions of velocity and shear stress in laminar-turbulent transition of unsteady boundary layer on circular. It's found that in diffuser region of contour, the fluid acceleration increases the friction and postpones the boundary layer separation, and vice versa the fluid deceleration reduces the shear stress and favours the separation of flow.

**Keywords:** *Aproximations of boundary layer equation, velocity and shear stress distribution*



## THE BENDING TECHNOLOGY DESIGN AT HIGHER PRECISION

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### Summary:

Bending industrial processes of complex elements inevitably require analysis of stress and strain in the contact zone of tools and materials if an accurate geometry and fast implementation. One of the effects that inevitably accompanies the elastic springback of the folded parts. Residual stresses always conditioned by changing the geometry of the finished part after leaving the tools that must be included in the construction tool positions that directly affect the final geometry. Knowing the springback value and its analysis by finite element method greatly facilitates the entire design process technology in both simple and highly complex finished components.

**Keywords:** *Bending, technology of plasticity, stress, strain, springback*



## CALCULATION OF LBKz FACTOR FOR CARBON FIBER REINFORCED POLYMER UNDER COMPRESSION AND THEIR COMPARISON WITH OTHER LIGHTWEIGHT MATERIALS

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### Summary:

The aim of this paper is to show which material, based on the LBKz factor, is more applicable in lightweight constructions. The LBKz factor has been calculated for three different groups of material (CFRP, hybrid laminates and materials applicable in additive technologies), and the calculation was based on the results obtained from our own experimental testing, as well as from the research results shown in available papers of other authors. The experimental compression testing was performed on the CFRP material.

**Keywords:** *Lightweight design, LBKz factor, CFRP, compression*



## ANALYSIS OF LOAD CARRYING CAPACITY OF WORM GEARS FROM THE ASPECT OF ENGINEERING PRACTICE

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### Summary:

Worm gears have numerous advantages in regard to other transmission types, especially in compact design, large transmission ratio, reliability during operation, ability to suppress vibrations, as well as design advantages in division of power. Disadvantage of worm gears is a relatively low efficiency which lead to increased transmission heating, wear and decrease of the operating life. This paper presents analysis of load carrying capacity of representative family of worm transmitters which is of interest for the engineering practice. Based on performed analysis the recommendations for selection of relevant design parameters is given.

**Keywords:** *Worm gears, Load carrying capacity (LCC)*



## TRIBOLOGICAL BEHAVIOUR OF TIN-BASED MATERIALS –TEGOTENAX V840 IN OIL LUBRICATED CONDITIONS

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### Summary:

The present paper investigates experimentally the effect of sliding distance, rotation speed of shaft and normal load on friction, surface roughness special position on bearing inner surface and wear property of radial plain bearing made of tin-based white metal alloy -TEGOTENAX v840 under lubricated contact sliding against stainless steel shaft, to do that, a test rig apparatus was designed and fabricated. Experiments were carried out in conditions of different loads and different speed. Results show that the wear rates increase with the increase of sliding speed and normal load. It is also found that friction coefficient increases with the increase of sliding speed and decreases with increase normal load. It is also found that the roughness change with sliding distance in special position bearing inner surface.

**Keywords:** *tegotenax v840*



## DETERMINATION OF STRESS AND TORSION ANGLE OF THE CARDAN SHAFT FOR KNOWN LOAD

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### Summary:

In the course of the exploitation of freight vehicles there is a change of load and variations in working conditions. If the cardan shaft holds a certain time interval maximum load It can be considered that it will not come to its disadvantage at lower loads. In this paper are given the maximum voltage values on the shaft as well as the shaft tapping angles for the known load. Based on the obtained results, the diagrams are formed, which show the tendency of the stress development and curvature, for the results obtained. For the same load was performed numerical analysis of stress state on the cardan shaft cross.

**Keywords:** *cardan shaft, cardan shaft cross, torsion angle of the shaft, stress states.*

# MECHATRONICS





## NEURAL NETWORK BASED SYSTEM FOR HUMAN ACTION RECOGNITION

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### Summary:

Human action recognition is often used in human-robot interactive applications, such as the visual surveillance, rehabilitation and robotics. Another thing that attracts a lot of attention is a human action recognition based on the trajectory of human tracking. In other words, it is necessary to transform quantitative data of the human movements into qualitative data, so that the numerical characteristics such as speed, direction, etc., of the observed person can be presented as “moving towards something” or “moving away from something” or “standing relative to something”. The research presented in this paper refers to the problem of identifying human action based on information received from the robotic vision system that uses a camera as a sensor, in order to carry out tasks when a robot behaves like a human’s assistant. For the purpose of this paper, the classifier based on neural networks was developed in order to classify the human actions.

**Keywords:** *human action recognition, neural network, robotic vision, human tracking, mobile robot.*



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**COEFFICIENT CONTRAST ASSESMENT OF THE HOMOMORPHIC  
FILTERING BASED ON IMAGE HISTOGRAM**

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**Summary:**

The functioning of the mechatronic systems demands precise registering of processes, phenomenon or objects. The necessary data are easily obtained by using cameras. In most cases, end results usually do not have satisfactory quality, due to their realisation under unfavorable circumstances. In order to improve their quality, many techniques have been developed. Each of those techniques is developed with purpose to solve a very specific type of a problem. Especially important is the technique based on application of nonlinear filtering, because it gives results usable in real conditions. In the class of nonlinear filtering techniques, homomorphic filtering is the most interesting one.

In this work, the described technique is the homomorphic filtering, applied to improve image quality. Also, automatic evaluation of the contrast coefficient is taken into consideration. The impact of the contrast coefficient with homomorphic filtering onto quality of the processed image is very important, and its value depends on the environment conditions under which the image is formed. Based on previously done analysis, a functional dependency of the bimodal image histogram contrast coefficients is assumed, an algorithm is formed and testing on concrete examples. The whole purpose of this coefficient evaluation is to automatise the image quality process.

**Keywords:** *homomorphic filtering, automatic coefficient contrast determination based on bimodal digital image histogram, image quality improvement*



## ADVANCED OPTIMIZATION TECHNIQUES FOR MARSHALLING YARD MANAGEMENT PROBLEM

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### Summary:

This paper deals with stability problem of cart inverted pendulum controlled by a fractional order PD controller. Inverted pendulum is an underactuated mechanical system because it has one control input and two degrees of freedom. Mathematical model of cart pendulum system is derived and fractional order PD controller is introduced in order to stabilize it. Control strategy consists of two parts, a swing up controller and stabilizing controller. Problem of asymptotic stability of closed loop system is solved using the D-decomposition approach. Stability regions in control parameters space are calculated using this method, and tuning of the fractional order controller can be carried out.

**Keywords:** *inverted pendulum, fractional order PID, D-decomposition, asymptotic stability*



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**APPLICATION OF THERMAL IMAGING SYSTEMS FOR OBJECT DETECTION**

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**Summary:**

Detection of different kind of objects by machine vision system is widely used and it can have many purposes. However, different scenarios, where illumination and weather conditions can vary, have great effect on detection quality. In good lighting conditions, systems with an operating range in the visible region of the spectrum, can be used for detection of the objects. In low-light conditions, these systems provide poor results, and in that purpose thermal imaging systems can be used. These systems are based on thermography technique that enables visualization of radiation in the IR region. In this paper, the state-of-the art in detection of the objects in different scenarios and applications using thermal imaging systems, such as thermal camera, is presented.

**Keywords:** *object detection, low-light conditions, thermal camera*



## NEW APPROACH IN THE RESEARCH OF DYNAMIC BEHAVIOR OF ROLLING ELEMENT BEARING

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### Summary:

Rolling element bearings are among the most common components to be found in rotating machinery. Their dynamic performance is often the limiting factor in the performance of the machines that use them. Specific functional principle and design of rolling bearings are one of the most important causes for generation of noise and vibrations in mechanical systems. This paper presents results of research the author in the field of mathematical modeling and experimental testing of the impact construction bearings for their dynamic behavior.

**Keywords:** *Rolling element bearing, Rotor vibrations, Ball passage frequency*



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**ENERGY SAVINGS USING FREQUENCY REGULATION IN THE HYDRAULIC  
SYSTEM WITH A PUMP OF CONSTANT DISPLACEMENT**

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**Summary:**

Requirements that often arise in practice in the application of hydraulic system are such that they need at any time to respond to changing demands of the Executive. Hydraulic pumps are designed so that they can give variable and constant capacity of fluids. Some structure with increased demands that need to respond are characterized by the relative complexity and higher cost price of such pumps. Hydraulics and electronics in recent years has been mutually complementary, so that the complexity of a single hydraulic components which would answer growing demands of working devices and machines can meet some simpler components of these areas. For this purpose, a hydraulic system and pump applies a constant displacement with frequency converter instead of complex and expensive pump variable displacement. As a way out of this structural solution has the considerable energy savings. The paper presents the experimental results where proving energy savings in this hydraulic system.

**Keywords:** Hydraulic pump, frequency converter, saving energy



## DATA RECORDING SYSTEMS WITH TELOC - 1500 FOR UPGRADING SAFETY SYSTEMS ON LOCOMOTIVE SERIES 441-521

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### Summary:

In recent years, railway traffic is being developed in the EU and in the neighboring countries of Bosnia and Herzegovina and the Republic of Srpska. In these countries rolling stock are used for cheap transport of passengers and goods, with a high reliability, high level of safety and low operating costs. In the Republic of Srpska, railway traffic is used to transport goods, primarily coal and iron ore. The fleet is quite old and not very safe for traffic. Installing systems such as TELOC 1500 provides exceptional measurement and acquisition system for additional safety train 441-521. This paper describes a data acquisition system for electric locomotive 441-521, with key parameters, speed, braking systems, the use of the system for alarm and memory of all the changes that occur during operation. The system further improves safety system in railway traffic. The work explains the practical operation of such a system with the analysis of the data obtained in this way, as well as opportunities offered by the introduction of such a system. The paper was written as part of a successful project commissioning test train series 441-521 after implantation TELOC 1500 device. Everything is supported by real measurement data from real-time analysis of railway traffic in Doboj, Republic of Srpska.

**Keywords:** *Data acquisition system, safety systems, railway traffic*



**AUTOMOTIVE  
AND TRAFFIC ENGINEERING**





## TRENDS IN THE DEVELOPMENT OF BRAKE SYSTEMS OF THE AGRICULTURAL TRACTORS AND TRAILERS

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### Summary:

Vibrations are oscillatory movements of the mechanical system, in which displacements of points are small compared to the dimensions of the system. In transport, comfort is one of the important factors in the study of the quality of the vehicle. It can be said that the comfort in the vehicle depends on the values and the way of transmission of vibrations to the man. After the measured values of vibrations is obtained an accurate account of deformation of the human body. In this paper we conducted measurements of the vibrations on the human body during the process of driving at different speeds. The measurement values of vibrations are transmitted to the spine of the human using a software package Ansys. Numerical analysis were determined Von Misses stresses and displacements of the spinal vertebrae driver, due to different levels of vibration.

**Keywords:** *vibration, comfort, spinal vertebrae, numerical analysis*



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COMPARISON OF NUMERICAL INTEGRATION METHODS IN THE LINEAR  
DYNAMIC ANALYSIS

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**Summary:**

Direct integration methods for ordinary differential equations encountered in analysis of dynamic problems of vibration are studied and compared. Examples considered are a single degree of freedom oscillator and a multi degree of freedom linear model of vehicle. For one degree of freedom system, numerical solutions are compared with analytical solution. The time-integrators used include both explicit and implicit methods of Runge-Kutta, Newmark, Wilson, the central difference method. The fourth-order Runge-Kutta method has been the preferred numerical integration scheme for solving linear single degree of freedom system or two degree of freedom systems. This method is very accurate, but requires very small time-steps and four equation solutions per time-step. These drawbacks hinder the solution of problems in multi degree of freedom systems, therefore implicit methods are considered for multi degree of freedom. Methods are compared in terms of accuracy and ease of formulation.

**Keywords:** *dynamic analysis, numerical integration methods, direct integration methods, vehicle dynamics*



## EXPLOITATION SPECIFICITIES OF E-BUSES IN WINTER CONDITIONS FROM THE ASPECT OF ENERGY EFFICIENCY

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### Summary:

Currently on the market there is no vehicle in which the intelligent transportation systems (ITS) have not found application. One of the most developed ITS lately is the Adaptive Cruise Control (ACC). The ACC is a new technology which requires the use of sensors for detecting the velocity and distance of the vehicle in front of a vehicle equipped with the ACC system and enables ACC vehicle to adjust its velocity accordingly. In this paper we have developed an ACC model. Also, we have analyzed the results obtained by its simulation. The MATLAB program is used to calculate the values ACC model needs in order to operate. We present a physical and mathematical model as well as the simulation results in the form of diagrams.

**Keywords:** *Intelligent Transport Systems; Adaptive Cruise Control; new technologies*



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**ANALYSIS OF EFFECT OF FLYWHEEL ON CRANKSHAFT SPEED NON-UNIFORMITY IN ENGINE OPERATING RANGE**

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**Summary:**

Internal combustion engine, as a cyclical energy machine, produces a variable effective torque as well as crankshaft speed consequently. Various factors have a major role on instantaneous value of effective engine torque, such as speed and load regime, number of cylinders and the cylinder arrangement (in-line engine, V engine etc.). Given these facts, as well as variable external engine loads, the crankshaft speed is variable even in the case of steady state operation regime. A higher coefficient of crankshaft speed non-uniformity causes, as a side effect, instability in the engine control system and increase vibrations transmitted to the vehicle and the passengers themselves. Therefore, in order to avoid these side effects, flywheel is used, leading to reduction of speed non-uniformity to reasonable and acceptable level.

In this paper, an analysis of non-uniformity of engine speed without flywheel being attached on crankshaft is carried out. On the basis of the obtained results and recommendations for coefficient of speed non-uniformity, selection of appropriate characteristics of flywheel is carried out.

**Keywords:** *nternal combustion engine, flywheel, coefficient of speed non-uniformity, moment of inertia*



## AIRBORNE WEAR PARTICLES FROM AUTOMOTIVE BRAKE SYSTEMS IN URBAN AND RURAL AREAS

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### Summary:

Nonexhaust vehicle emissions are currently thought to be tyre wear, brake wear, clutch wear, road surface wear, corrosion of other vehicle components, corrosion of street furniture and crash barriers, and the resuspension of road dust. Among non-exhaust sources, brake wear can be a significant particulate matter (PM) contributor, particularly within areas with high traffic density and braking frequency. Regulations for brake pad performance are influenced by many bodies across the world, including the Particle Measurement Programme by the United Nations Economic Commission for Europe (UNECEPMP). In order to continuously improve their products and ensure regulatory compliance, brake pad manufacturers conduct brake performance tests and they can be carried out on vehicles and on dynamometers. The main topic of this paper regards the potential impact of the emitted PM on the human health, depending on the mechanisms of formation and toxicity of the particles. On-going European projects dealing with this important problem will also be discussed in the paper.

**Keywords:** *Brake system; wear particles; legal requirements; health*



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**DETERMINATION OF LOSSES RELATED TO FRICTION WITHIN THE  
RECIPROCATING COMPRESSORS – INFLUENCES OF TRIBOLOGICAL  
OPTIMIZATION OF PISTON AND CYLINDER**

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**Summary:**

Measures to reducing friction inside the reciprocating machine make a decisive contribution to further improvements of machines efficiency. A number of influencing parameters have already been tested on diesel and gasoline engines. The friction between piston and cylinder liner is a major contributor to overall engine friction. Reducing friction in reciprocating machines can be achieved by using appropriate materials and optimizing the structure of the piston and piston group. Tribological materials and coatings are one of the options for increasing strength of the aluminum parts of reciprocating engines and compressors. This initial manuscript describes the influences of the piston skirt and cylinder liner design. The differences in frictional losses are determinate for the entire compressor operating map for base aluminum construction, as well as coated aluminum construction.

**Keywords:** *Reciprocating Machines; Aluminum; Coating; Friction*



## IDENTIFICATION OF COMBUSTION NOISE

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### Summary:

Noise is unpleasant sound that can have harmful effect on people's health. Motor vehicles and working machines are mobile sources of noise, in which engine is one of the key elements that create noise. Engine noise can be divided into mechanical noise and combustion noise. Diesel engines are always considered to be louder, and, as such, they are used to identify engine combustion noise. Increase of pressure in engine cylinder is typical for combustion noise. Based on this, an experiment was performed, during which a cylinder pressure and noise emitted by the engine were simultaneously recorded. By coherence analysis of acquired data, it was concluded that it is possible to separate engine combustion noise from mechanical noise of the engine.

**Keywords:** *noise, combustion noise, coherence analysis*



## RESEARCH INFLUENCE OF ROAD-OFF ROAD ROUGHNESS ON TERRAIN MOTOR VEHICLES

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### Summary:

Analysis of road roughness on the vehicle as an object road roughness may occur in any capacity for two. First as an external disturbance that acts on a vehicle that, when considering how dynamic processes or characteristics of the vehicle with them are not directly related. Others appear as input parameters of the vehicle as an object with the effect that manifests itself in the basic functional requirements such as the characteristics of ride comfort, stability, movement, mobility and so on. This paper presents some results of measurements of parallel profile and on access use through spectral analysis to determine the basic characteristics of response vehicles. Data for the analysis were obtained from records at the inertial measuring device road-off road profile and appropriately equipped vehicle testing "PUCH 300 GD" that moves with constant velocity.

**Keywords:** *road-off road, roughness, vehicle, behavior, spectral analysis*

# QUALITY AND ECOLOGY





## MEASUREMENT OF ROLLER BEARING GEOMETRY DEVIATIONS USING COORDINATE MEASURING MACHINE

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### Summary:

The focus of this paper is to determine dimension deviations of two representative roller bearings that have the same nominal dimensions and that are intended to be used for the same purpose. The only difference between the chosen bearings is their market price, which implies the difference in quality. We tested two samples, the one assumed to have lower quality and whose price is 40% lower than the other one. The measuring of geometry deviations is accomplished by the coordinate measuring machine.

**Keywords:** *Bearing, Coordinate Measuring Machine, Dimensions Deviations*



## AIR QUALITY IN RURAL RESIDENTIAL AREA

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### Summary:

Air quality in rural areas remains a neglected issue so far. Significant share of the population in Western Balkan region live in the small and medium size settlements where air quality is heavily influenced by the residential heating systems, mainly using biomass as a fuels, as well as agricultural activities related to soil fertilization. Although biomass is a renewable source of energy with significant advantages from aspect of climate changes mitigation, biomass combustion is a significant air pollution source, which have regional and local impacts on the air quality and public health. The main harmful pollutants emitted during combustion of biomass in residential stoves are particulate matter (PM), with attached BC, PAHs, especially BaP, which is well-known human carcinogen. This paper shows the results of the measurements of mass concentration of particulate matter (PM<sub>10</sub>) and elemental analysis of PM<sub>10</sub> in rural area during the winter and summer season as well as meteorological measurements. Source apportionment was done using PMF model in order to identify dominant sources of the pollution. The results of provided analysis shown that wood burning processes are the largest source of trace elements and PM<sub>10</sub> with significant influence of meteorological conditions. Efficient measures for air quality improvement were analyzed.

The objective of this paper is to highlight the public health importance of the so far neglected issue of quality of air in rural areas and to attract the attention of the scientific community to the need for further research in this area.

**Keywords:** *biomass combustion, PMF, air pollution, PM<sub>10</sub>*



## AN INTEGRATED APPROACH TO THE IMPLEMENTATION OF AN ENVIRONMENTAL MANAGEMENT SYSTEM AND LIFE CYCLE ASSESSMENT METHOD IN COMPANY

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### Summary:

Environmental protection is one of the leading issues at the global level today. In line with that, customer habits are changing, especially in relation to the environment. While buying products customers analyse its ecological acceptability. Because of this, producers use different measures for protection of the environment for the whole life-cycle of a product. An important measure for the protection of the environment is a Type III environmental labelling that provides quantified and reliable data about the product in relation to environmental protection which third party verified. In the process of collecting data for eco-labelling, it is good for producer to use an integrated approach including Environmental management systems and the LCA method.

**Keywords:** *Environmental labelling, Type III, EMS, LCA, ISO 14025*



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**IMPLEMENTATION OF LEAN CONCEPT IN SMEs**

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**Summary:**

For the last twenty years the introduction and application of Lean concept has had a significant impact on many manufacturing companies. Previous studies have shown that the implementation of Lean concept enables business systems to improve their business, and reduce inventories, leading time, configuration time, and so on, under the condition that they adopted certain principles from practice. Likewise, analysis of the implementation of Lean concept so far has shown that Lean methods and tools cannot be applied to small and medium enterprises (SME) as equally as they can be applied to large enterprises.

The aim of this paper is to present a critical review of the implementation of Lean concept in SMEs with the claim that Lean concept can be successfully applied in all branches of industry, provided that the Lean concept is fully understood, namely its meaning, principles and practice. Given that SMEs have limited resources, they are often faced with difficulties during the implementation of all Lean tools and methods. This paper proposes a model for the implementation of Lean concept in SMEs.

**Keywords:** *Lean concept, SMEs, model*



## THE APPLICATION OF QUALITY AND MANAGEMENT TOOLS IN THE AUTOMOTIVE INDUSTRY

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### Summary:

Modern business conditions have transformed the whole world into a single, global market where everyone has an equal chance to succeed through competition, but only the companies that are organized and flexible in their business surroundings may occupy an enviable position among their global competitors. The answer to this market trend, not only for foreign but also for domestic companies, is in the introduction of Lean Six Sigma concepts in their business. The paper describes the case study of a Serbian company, which ensured its place in the market through an efficient quality system and application of Lean methods in processes. The aim of Lean implementation is to enable the company's way to business excellence. The paper first analyzes all the processes of the company, and then determines the real state of the company's business in terms of Lean Six Sigma concepts by applying specific management tools. The real state, with all the advantages and disadvantages, is analyzed in the end, in order to identify development opportunities for gaining competitive advantage and creating an enviable market position.

**Keywords:** *Lean Six Sigma, Improvement, Waste, Pareto analysis, Ishikawa diagram*



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**BOLOGNA PROCESS IN SERBIA – TEN YEARS AFTER**

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**Summary:**

The main idea of this paper is reflected in consideration the changes and challenges that Higher Education (HE) System in Serbia has been already faced for ten years. Like the other social processes the process of HE isn't subject of a strict rules, and therefore during the implementation of a new model some difficulties and deviations appeared to the proposed one. These difficulties and deviations mostly stem from the specificities of Serbian society, and the influence of the former HE system on legislators, creators of the system, academic staff, as well as the students themselves who were mid-studies when the new system began to be implemented.

The main objective of this paper is comparative analysis of projected and actual innovations, practical occurrences and results obtained after the new system of HE came into place. Also, it will be examined future challenges that area of HE will be faced. Taking into account the fact that the new system of HE has been around for ten years, and several generations of students have already acquired academic and professional titles, so it is possible to analyze the performance and consequences of implemented changes.

**Keywords:** *changes and challenges in higher education, improving of higher education, future challenges*



## DEVELOPMENT OF MODEL FOR THE DESIGN AND IMPLEMENTATION OF QUALITY MANAGEMENT SYSTEM ACCORDING TO ISO STANDARD 9001:2015

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### Summary:

A model that allows organizations to really satisfy requirements of ISO 9001:2015 was developed in the paper, based on research of the problems of design and implementation of quality management system. Model enables defining of the necessary phases, by applying process approach, that need to be performed in a particular order and according to certain rules defined by the respective actions (procedures, instructions, etc.). Actions should be implemented in the work processes of the organization, and then monitored, measured, analyzed and improved.

**Keywords:** *design, quality system, model, requirements*



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**ENVIRONMENTAL LABELLING WITH TYPE I ECO LABELS**

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**Summary:**

Environmental (ECO) labelling is an important issue in the actual global framework for more than 25 years. In this work is given a review of European Union (EU) and regional environmental labelling programs and standards, as well as a review of the development of the environmental labelling. Standard ISO has identified three broad types of ECO labels: Type I, Type II and Type III. In the frame of this study the special emphasis will be given to the Type I ECO labels.

**Keywords:** *Environmental labelling, ECO label, Type I, ISO 14024*



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## THE QUALITY OF THE EDUCATION SYSTEM

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### Summary:

Quality assurance in the education system is an extremely dynamic process that is based on a construction, the progress and changes that are in line with the changes taking place both in society and in the economy. Increase of public and private universities, colleges, and the number of students requires systematic monitoring, and development of a system for internal quality assurance, so that higher education institutions and their students remain competitive, recognizable and accepted throughout the European Union. This phenomenon of growing competition in the field of higher education has contributed to the increased attention paid to the needs and desires of students. Quality system gets more and more important due to the implementation of the Bologna Process on higher education institutions. However, it must be noted that the reform of the educational system based on the Bologna convention does not give positive results. There is more to detect the presence of crisis, depression and unemployment of educated population, and that is consequently opening very intriguing questions: Whether it constituted system of education is responsible for this state; Whether the knowledge and skills of different profile of professionals in a wide network of educational institutions is adjusted the current economic and social situation and the times in which we live. Therefore, it can be concluded that education in the XXI century has a great challenge and task, ensuring the continuous quality of the higher education system. Faster and inevitable development of society based on knowledge, and the impact of internationalization and globalization, and increasingly important development of market conditions in the higher education system and the establishment of market of knowledge, require finding new ways and directions in the development and improvement of higher education. Therefore, it is very important that higher education institutions recognize the importance of continuous quality assurance and its continuous improvement, as well as the aspiration to achieve high quality standards, which will become the commonplace, both in academic community and beyond.

**Keywords:** *Quality Management; quality systems; quality of knowledge; quality of education; Bologna Convention*



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**MEASURING THE QUALITY AND PROGRESS OF SOFTWARE PROJECTS  
WITH PROJECT METRICS**

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**Summary:**

Day by day software project quality gains more and more attention of practitioners and researches equally. Bug or defect free software that meets customers' expectations regarding design, functionalities and similar requirements, project delivered on time and project delivered within budget are the key aspects of software project quality, both for users and development teams. In order to improve these constraints and project and, consequently, software product quality, project progress monitoring is essential. What enables progress monitoring are metrics. Metrics become even more essential when certain project measurements need to be closely monitored due to repeated changes of requirements which is frequent with software projects. This paper presents a case of metrics use in game development process in order to measure and improve software project quality and progress. The metrics used were chosen after excessive literature review and based on specific project characteristics and demands. First, data from 9 sprints were analyzed. Following, chosen metrics were applied for the next 10 iterations, where data were gathered through interview, sprint retrospectives notes and supporting project management tools. Results show that with introduction of velocity, defects rate and sprint burn down chart into the alpha game development process, team productivity and effectiveness were elevated, resulting in software project quality improvement. Chosen metrics have facilitated transparency of work, enabling better organization and reduction of bottlenecks, detection of problem roots and more effective communication.

**Keywords:** *Software development quality, Metrics, Progress monitoring*



## KNOWLEDGE AUDIT AS A QUALITY TOOL

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### Summary:

Quality and knowledge are the most important topics in functioning of all types of organization on current global world's market. Paper elaborates some possible misunderstandings in process of management of these two aspects and proposes conducting of knowledge audit in regular terms to avoid it. As a framework for effective evaluation process on the way to reach organisation knowledge and wisdom, paper presents possible model of developing integrated management system which integrate quality and knowledge management.

**Keywords:** *Organization knowledge, Knowledge audit, Quality.*



**MAINTENANCE OF ENGINEERING SYSTEMS  
AND OCCUPATIONAL SAFETY ENGINEERING**





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**DEVELOPMENT OF INNOVATIVE METHODOLOGY FOR ECODESIGN OF PRODUCTS AND PROCESSES FOR THE REGION OF VOJVODINA**

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**Summary:**

Product design is the life cycle stage that has a dominant impact on product's functionality, cost effectiveness, aesthetics, reliability, maintenance, service, and environmental properties. With the raise of importance of environmental issues in product designing, Ecodesign becomes an indispensable concept within the product design stage. It can be realized by considering the sustainable development concept and integrating the environmental aspects into product's development and design. The subjects of this research are tools for ecodesign, life cycle assessment, multi-criteria analysis, and their optimization and integration with final goal to develop the innovative methodology for ecodesign of products and processes for the region of Vojvodina. Designing practices from production industry from Vojvodina region have been analysed in terms of industry sectors, production processes, material availability and use, energy sources, recycling practices and other. The developed methodology tends to help the designers and decision makers for the region of Vojvodina in product's development and design stage. Innovative methodology for product's ecodesign will produce guidelines based on a sustainable development concept and previously developed ecodesign strategies and guidelines. Furthermore, aim is to optimise production processes and to reduce product's and processes environmental impacts through each life cycle stage.

**Keywords:** *ecodesign, life cycle, environmental impacts*



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**THE APPLICATION OF THE ISHIKAWA METHOD FOR DETERMINING THE  
CAUSE OF ACCIDENTS AT WORK**

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**Summary:**

Modern business conditions require a high level of security in operating systems, that is, risk assessment and avoidance of unexpected events. The consequences of unexpected events are often manifested as workers' injuries, termination of the technological process and/or damage to material and natural resources. In order to act preventively so the level of safety could be raised, risks at work reduced and worker protected from injury, damage and health disorders, it is necessary to know the causes of accidents at work.

This paper presents the application of the Ishikawa method for the identification of all causes of occupational accidents that can lead to negative consequences and for the selection of the basic cause where corrective action is focused. Also, the new paradigm is shown referred to as Zero Accident Vision - ZAV whose implementation in business systems is to achieve safer conditions and a higher level of protection at work.

**Keywords:** *accidents, risk, cause, Ishikawa method, Zero Accident Vision*



## ARTIFICIAL NEURAL NETWORK FOR PREDICTION OF THE BEGINNING OF DELAMINATION AT RUBBER CONVEYOR BELTS

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### Summary:

Indispensable parts of all modern industry systems are conveyor belts. Qualitative and reliable conveyor allows continuous operation of the conveyor system and increases the efficiency of the entire production process. Rubber conveyor belts may contain a steel core or multiple layers of rubber and canvas (carcass). One of the most common causes of failure and main issues in the use and maintenance of rubber conveyor belts with carcass is delamination. In this paper, in application of artificial neural network, the prediction of the beginning of delamination at rubber conveyor belts is presented. A multi-layer feed forward artificial neural network is used and the two input variables considered in the artificial neural network: length of the conveyor belt and the number of layers. Results point that artificial neural network can be trained with exploitation data and later effectively used in predicting of the beginning of delamination at rubber conveyor belts. Thus presented methodology can be used in the control and maintenance of conveyor belts.

**Keywords:** *rubber conveyor belts, delamination, prediction, artificial neural network.*



**13<sup>th</sup> International Conference on Accomplishments  
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**SECURITY APPLICATIONS OF INSULATION MASK**

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**Summary:**

In the case of interventions in accident situations and works in which the necessary use of insulation apparatus has a major role their own reliability. This reliability depends on the correct choice of breathing apparatus and quality maintenance of its modules. In particular this applies to the module isolation masks and lung machines. If the modules or their components defective inevitably leads to the risks and hazards that endanger users. However, the question which is to limit malfunctioning individual components of the appliance module that will lead to the risks and hazards. The limit of harmfulness is very difficult to determine and its definition would take a number of years, and eventually would again raise the question of whether this research is relevant. Therefore, it is necessary to regularly inspected and examined modules breathing apparatus in shorter periods of time with the appropriate specific equipment in order to increase the level of safety and reliability of breathing apparatus.

**Keywords:** *Insolation mask, particular matter*



## LUBRICATING OILS FOR AUTOMOTIVE NATURAL GAS ENGINES

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### Summary:

Because of their advantages, natural gas engines are very popular choice today, especially for use in commercial and public vehicles (commercial vehicles, trucks, buses, trains). Lubricant is an important element of the gas engine, as well as of any other type of internal combustion engine. The lubricant has multifunctional role. From reducing friction between surfaces, through transferring heat, neutralizing acids, removing hard carbon deposits and maintaining desired viscosity. In order to fulfill effective, long run and economical functioning of the engine, appropriate lubricant must be selected and used. Also, it has to be compliant with the fuel gas quality, exploitation conditions, environmental requirements et cetera. The purpose of this paper is to present the important properties of lubricating oils for automotive internal combustion engines powered by natural gas.

**Keywords:** *Automotive engine oil, lubrication, lubricant, maintenance*



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**SIGNIFICANCE OF HYDRAULIC SYSTEM WORKING FLUID MAINTENANCE  
WITH INTEGRATED LOGIC AND BUILT-IN COMPONENTS**

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**Summary:**

Based on the need to make small and compact aggregates, modern hydraulic systems are usually designed using built-in hydraulic components. Built-in components require low space and provide the possibility to drastically reduce the number of hydraulic fluid ducts, without the use of pipelines. In contrast to classical components, logic components provide the possibility of operation of hydraulic systems with high flows, as well as low space requirements and compactness. The disadvantage of built-in and logic components however, is that they require a specific level of fluid quality, which additionally imposes preventive and regular working fluid maintenance within prescribed ranges of cleanliness. This paper presents, through an example from practice, the significance of working fluid quality for the performance of a shear machine hydraulic system with logic and built-in components.

**Keywords:** *maintenance processes; tribology; hydraulic systems; working fluid cleanliness.*



## THE HEAT DISTRIBUTION AT COMPRESSION FILLING OF BOTTLES AND EXPANSION OF MEDICAL AIR

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### Summary:

SCBA bottles apparatus (Self Contained Breathing Apparatus - for selfbreathing apparatus with own air reservoirs with no external power supply; eg. air supply through the pipe system) are made of steel, and composite and half composite materials. During their medical charging air pressure increases as well as the amount of compressed air. As a consequence of the temperature increasing, which may cause thermic expansion, which might have influence on the occurrence of accidents, in the case of the defective bottles in which medical air is compressed. Heat distribution is in a function of time and charging and materials of walls of the bottle. Charging time is a function of volume and nominal pressure of cylinders, which directly affect the amount of compressed air. Heat distribution is monitored by thermal imaging cameras during the compression and expansion of medical air.

**Keywords:** *composite materials, compressors, expansion, thermal expansion, thermal imaging cameras.*



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**CONSTRUCTION OF ACCOMMODATION FACILITIES FOR BASIC  
MAINTENANCE AND TESTING OF AIRCRAFT IN SERBIAN ARMY**

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**Summary:**

Institutions in the Serbian Army engaged in maintenance and testing of aircraft accomplish their mission without adequate energy-efficient construction facilities, facilities to accommodate equipment, tools and installations for the basic aircraft maintenance procedures required in reference standards. Particularly critical situation is in terms of providing adequate working space to perform activities of basic maintenance tasks, installation of test instruments and equipment on aircraft. Aviation maintenance specialty was to determine whether the working environment differed from other specialty's working environments and does the environments has so significant influence on work quality. In air carrier maintenance, the three considered most important for worker proficiency are lighting, noise, and temperature. Discussions may include topics such as heating problems, use of proper job clothing, and any other matters designed to minimize problems with the physical environment. Nonetheless, the nature of the work and the environment mean that certain problems remain.

**Keywords:** *safety, working condition, hazards*



## NONDESTRUCTIVE DISASSEMBLY PROCESS OF TECHNICAL DEVICE SUPPORTED WITH AUGMENTED REALITY AND RFID TECHNOLOGY

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### Summary:

This paper presents nondestructive disassembly process of technical device supported with augmented reality system and RFID technology. During the last few decades, the rapid development of automobiles, electric and electronic equipment, resulted in creation of billions tones of waste. For instance, "around 3 billion tonnes of waste are generated in the EU each year - over 6 tonnes for every European citizen. The new recycling/reuse concept uses the nondestructive disassembly process of technical device supported with augmented reality and RFID technology. System includes marking the products with components of interest by using a RFID tag. The products can be marked with a RFID tag that will contain the ID of the product design in the centralized database. The recycling/reuse facilities use this ID to download data relevant for nondestructive disassembly of the product and obtaining the components of interest. The system is modular and extensible in terms of the services and re-manufacture offered. The overall system has a forum that is helpful in communication between recycling/reuse facilities and product designers. Augmented reality system offers video presentation when possible to visualize the disassembly process. The database contains valuable data for the product regarding the materials and component of interest used for each of the components in the product. Main objective of this paper is developing of a new recycling/reuse concept by using the nondestructive disassembly process supported with augmented reality and RFID technology.

**Keywords:** *disassembly, reuse, augmented reality, RFID*



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**SPATIAL ORIENTATION USING VIRTUAL REALITY, CASE OF FACULTY OF  
MECHANICAL ENGINEERING, NIŠ**

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**Summary:**

Spatial ability is one of the main components of human intelligence and is especially important for orientation and wayfinding. In this paper, studies using Virtual Reality to investigate aspects of spatial ability will be discussed. For this purpose Virtual Reality tour of Faculty of Mechanical Engineering – University of Nis was created. The main goal of this research is investigating the possibility of enriching traditional way of indoor orientation by creating an interactive Virtual Reality presentation. Possibility of web based and Head Mounted Display use for presentation is investigated and compared.

**Keywords:** *Virtual Reality, orientation, wayfinding, web, Head Mounted Display*

# MATERIALS SCIENCE





## RESTORATION AND CONSERVATION OF SIGNIFICANT RIFLE FROM I. WORLD WAR

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### Summary:

Within the professional work of the members of the research program group "Synthesis and characterization of materials", in cooperation with the National Museum of Contemporary History of Slovenia significant rifle from the I. World War MANNLICHER M 1895 was restored and conserved.

Conservation - restoration procedure, accomplished in the museum workshop, is described in detail. Due to different levels of conservation of the rifle discussed it was treated by different methods.

Material analysis of barrels, bolts and other components and analysis of injuries were made using non-destructive investigation methods in laboratories of the Department of Materials and Metallurgy, Faculty of Natural Sciences, University of Ljubljana, laboratories of authorized institutions, and partner universities.

**Keywords:** *rifle, restoration, conservation, artefact*



## COMPOSITE FOR RADIATION PROTECTION

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### Summary:

In this paper the possibility of synthesis of radiation-protective composite on the basis of nanotube asbestos and lead tungstate embedded into a lead-borosilicate matrix is studied. The paper also presents the data on linear attenuation coefficient of  $\gamma$ -quanta in composites of different compositions got by the calculation ways. On the basis of theoretical calculation we described the graphs of the  $\gamma$ -quanta linear attenuation coefficient depending on the emitted energy for all investigated composites.

**Keywords:** *radiation protection; polymer composite; gamma radiation; nanotechnology*



## RESEARCH ON THE INFLUENCE OF THE VACUUMING PARAMETER ON THE GAS CONTENT IN STEELS

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### Summary:

The research was carried out at an electrical steelwork, equipped with an electric arc furnace type EBT (Electric Bottom Tapping) capacity 100t, LF (Ladle-Furnace) facility, VD (Vacuum Degassing) facility and a 5 wires continuous casting (ITC) facility. In the research conducted, the influence of pressure and the vacuum processing duration on the final content of hydrogen and nitrogen were analyzed, as well as their removal amount. The data obtained from industrial experiments were processed in EXCEL and MATLAB calculation programs, in order to obtain correlations between the parameters analyzed.

**Keywords:** *steel, vacuum, hydrogen, nitrogen, correlations, treatment*



## ANALYSIS OF QUALITY OF WELDED JOINT ACHIEVED WITH FLUX CORED WIRE IN PG WELDING POSITION

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### Summary:

Stable boxy reservoirs, due to a better degree of utilization of space, are increasingly replacing cylindrical tank. In processing are used the technologies of plastic deformation and welding. How for production of tanks are used small thickness sheet metals, in welding process is necessary to enter minimum quantity of heat to ensure good welded joint. Through the work we analyze the comparative quality technological test of the weld achieved of MAG welding with the use of solid wire and flux cored wire in the PG welding position.

**Keywords:** *welding, PG position, flux cored wire*



## CONDITIONS FOR THE SELECTION OF WELDERS

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### Summary:

In the metalworking industry welding occupies a vital and important role. With the purchase of modern welding equipment, choice of welder plays a crucial role in maintaining the quality and productivity of enterprises. However, despite the previously acquired education, specialization and additional training of welders, the productivity of the enterprise greatly influenced by personal characteristics welders: diligence, agility, motivation, ambitions and phobias. This paper presents a summary of the standard requirements and personal visions of conditions that should be met staff who are trained and work as welders.

**Keywords:** *conditions, choice, welder*



## APPLICATION OF POLYURETHANE WASTE IN VIRGIN RUBBER BLENDS

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### Summary:

With the wide application of polyurethane foam, large amounts of polyurethane wastes are generated. Polyurethane waste from vehicles, waste of electrical and electronic equipment and many other sources attracted great attention worldwide as a result of rapidly rising amounts and increasingly tight legislation on its treatment and disposal. Polyurethane waste is recycled in two primary ways. Mechanical recycling, called powdering or recycling of regrind, involves grinding of waste containing polyurethane, and one of the fractions obtained is polyurethane powder. Thus obtained powder is mixed with virgin polymer materials and it can be used for new products. Chemical recycling takes the material back to its various chemical constituents. In this article polyurethane waste from electrical and electronic equipment is used as fillers in virgin rubber. Different amount of polyurethane powder was added to rubber blend and their influence on mechanical properties and structure of rubber blends were examined. This study determined the optimal share of powder, in which there is no significant decrease in the properties of rubber compounds.

**Keywords:** *polyurethane waste, recycling, rubber blends*



## PACK ALUMINIZATION PROCESS OF HEAT RESISTANT FeCrAl AND NiCr ALLOYS

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### Summary:

Pack aluminization process is one of the possible production methods to improve oxidation resistance at high temperatures of various types of metallic materials. It is a chemo-thermal process where products are embedded in the powder mixture, consisting of Al powder, halide activator  $\text{NH}_4\text{Cl}$ , and inert diluent  $\text{Al}_2\text{O}_3$  powder, and annealed at high temperature. This exposure to high temperature causes the Al diffusion into the base material and formation of the aluminide surface layer. During the component service at elevated temperatures, the oxidation resistance is obtained due to the constant formation of an aluminium oxide film that forms on the aluminide surface layer and acts as an oxygen impermeable barrier. In the present study, FeCrAl and the NiCr heat resistant alloys in the form of 1 mm thick sheet were aluminized at various process parameters. The effect of time, temperature, concentration of aluminium and halide activator in the powder mixture as well as the influence of furnace atmosphere on coating formation mechanism, mass gain and the thickness of the aluminide diffusion layer was evaluated by scanning electron microscopy, X-ray photoelectron spectroscopy and micro hardness analytic techniques. Isothermal exposure tests at 1200 °C for 24h in air were conducted and compared with untreated samples for high temperature oxidation resistance estimation.

**Keywords:** *Aluminizing, heat resistant alloys, FeCrAl, NiCr, high temperature oxidation*



## MODERN METHODS OF EXAMINATION THE RAILWAY AXLES ON FATIGUE

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### Summary:

The exploitation is still occurring due to fatigue cracks in the most stressed cross sections shaft, in the areas of stress concentration and where there is damage to the material (or corrosion for hollow shaft). To determine the actual endurance needed numerous tests at the newly drawn railway shaft real dimensions, as with most of the testing process applied to the craft stands and railway vehicles.

In this paper is presented contemporary methods of investigation of the effect of rotation on the durability of the axle assembly, the real dimensions of fatigue, the city radius of the transition part of the railway axle behind the seats, wheel hub, where it occurs the greatest pressure force fact of external loads and solid swept by pulling a point on the shaft. According to this method only focused on examining the work of the transition radius axle behind the seats, wheel hub. The aim of the quantification of the impact of fatigue on the axis of rotation that can help increase the lifetime axle assembly and quantitative calculation of the impact of increasing the speed of rotation of the durability of the axles produced according to the manufacturing procedure used today in mass production.

**Keywords:** *Railway axles, fatigue materials, dynamic loads*



## METALLOGRAPHIC TESTS AND STRENGTH OF THE MATERIAL OF CHAINS SNOW

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### Summary:

Driver safety in winter conditions depends not only on the technical correctness of the transport vehicles, but also on winter equipment used. Snow chains, in addition to technically correct vehicles and tires, are one of the most important factors for driving safely on snowy roads. This paper presents a analysis of the quality of materials and anti-corrosion protection of snow chains that are frequently used in Bosnia and Herzegovina, Croatia and Serbia. For the purpose of analysis several tests were performed on tensioning the chains (at room temperature and at a temperature of -200C), hardness of the chains (Vickers method) as well as the test of the thickness of galvanized layer (metallographic method). All tests were performed in accordance with the relevant standards such as EN ISO 6507-1:2005; EN ISO 6892-1:2009; EN ISO 1461:200.

**Keywords:** *metallographic test, straining i hardness, snow chains, safety and security in traffic*



13<sup>th</sup> International Conference on Accomplishments  
in Mechanical and Industrial Engineering

SEM ANALYSIS OF FRACTURE SURFACE OF THE CuAlNi SHAPE MEMORY ALLOY AFTER HEAT TREATMENT

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**Summary:**

CuAlNi shape memory alloys (SMA) belongs to a group of alloys that exhibit shape memory effect which is related to the thermoelastic martensitic transformation. In this paper the influence of heat treatment (quenching and tempering) on fracture surface morphology of the CuAlNi SMA after tensile testing was examined by scanning electron microscope. It is observed a small difference on alloys mechanical properties and surface morphology between casted and quenched (850 °C/60'/WQ) condition. But after tempering at 300 °C/60'/WQ the mechanical properties and surface morphology is drastically changed. In both states (casted and quenched) can be noticed a transgranular type of fracture showing that the small amount of plastic deformation occurred, and along long oriented grains it is observed an intergranular type of fracture. After tempering the CuAlNi sample shows mostly intergranular type of fracture after tensile testing.

**Keywords:** *shape memory alloys, CuAlNi, heat treatment, fracture analysis, microstructure*

# МИНИСТАРСТВО НАУКЕ И ТЕХНОЛОГИЈЕ РЕПУБЛИКЕ СРПСКЕ

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## Влада Републике Српске Министарство науке и технологије

Кључни циљ у области науке и иновација до 2021. године јесте значајно унапређење ефикасности и ефективности научноистраживачког и иноваторског система у Републици Српској.

### Визија

Наука у Републици Српској заснована на институционалном оквиру који подстиче изврсност, националну и међународну видљивост у науци и иновативности са научноистраживачким резултатима који значајно доприносе економском развоју, конкурентности привреде и развоју друштва у цјелини.

### Мисија

Наука у Републици Српској заснована на институционалном оквиру који подстиче изврсност, националну и међународну видљивост у науци и иновативности са научноистраживачким резултатима који значајно доприносе економском развоју, конкурентности привреде и развоју друштва у цјелини.

**Стратегијом научног и технолошког развоја Републике Српске 2017-2021. године – „Знање за развој“** дефинисано је шест стратешких циљева:

1. Подстицање научноистраживачког квалитета и изврсности
2. Подстицање интернационализације науке и иновативности
3. Подстицање сарадње научноистраживачке и иноваторске заједнице са привредом
4. Стварање услова за повећање издвајања за науку и иновативност
5. Развијање људских ресурса у науци и иновативности
6. Подстицање паметне специјализације (области: Информационо-комуникационе технологије, Развој енергетике, Производња хране и Креативна економија)

# МИНИСТАРСТВО ПРОСВЈЕТЕ И КУЛТУРЕ

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Министарство просвјете и културе врши управне и друге стручне послове из области просвјете који се односе на:

предшколско, основно и средње образовање и васпитање; образовање дјецe грађана Републике на раду у иностранству; нострификацију и еквиваленцију иностраних школских свједочанстава; ђачки стандард; припремање програма образовне сарадње са другим државама и међународним организацијама и међународних споразума у области образовања у складу са Уставом Републике Српске и Уставом Босне и Херцеговине; високо образовање; студентски стандард; припремање програма образовне сарадње са Федерацијом Босне и Херцеговине, другим државама и међународним организацијама и међународних споразума у области високог и вишег образовања у складу са Уставом Републике Српске и Уставом Босне и Херцеговине.

Високо образовање има кључну улогу и значај за изградњу и функционисање, не само образовног система, већ и друштва уопште, јер се школовање кадрова који преузимају лидерску улогу у свим сегментима друштва врши управо на овом нивоу образовања. У том смислу, развој система високог образовања неопходно је посматрати у контексту будућег развоја Републике, што подразумијева и изузетно велику одговорност. За Републику, образовање и наука су развојни приоритети који јој могу обезбиједити дугорочну друштвену стабилност, економски напредак и културни идентитет. Суочени са динамичним промјенама у друштву, привреди и култури у глобалном свијету у којем ниједна држава не може да постоји као издвојена заједница, само подизањем квалитета високог образовања могуће је успјешно одговорити на бројне и различите изазове у овој области: од примјене савремених технологија, преко људских, материјалних и природних ресурса, који се морају користити на најбољи могући начин, до ограничене могућности предвиђања дугорочног развоја и потребе да у сваком тренутку будемо, као друштво, спремни на прилагођавање.

Примјеном Болоњске декларације у Републици извршене су крупне и значајне реформе у складу са принципима ове декларације. Много је учињено у интернационализацији система високог образовања, отварања ка свијету и усклађивања са савременим токовима Европског простора високог образовања (*European Higher Education Area – EHEA*).

Високо образовање организовано је у три циклуса; уведен је европски систем преноса бодова (*European Credit Transfer System – ECTS*), уведен је „додатак дипломи“ (*Diploma Supplement*) као пратећи документ који пружа детаљне информације студијском програму на којем је диплома стечена, тј. о знању, вјештинама и компетенцијама које је студент стекао; уведена је „заједничка дипломе“ (*Joint Degree*) које издају двије или више установа; бинарни систем академских и струковних студија; дефинисан је поступак признавања стечених квалификација и диплома у складу са Лисабонском конвенцијом; извршена је интеграција високошколских установа; интензивирана међународна сарадња; те појачана активност у међународним пројектима усмјереним ка развоју високог образовања и науке и успостављене везе са иностранством.



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## O FIRMI

Preduzeće TRI BEST d.o.o. Banja Luka je osnovano 1996. godine i posluje u oblasti Metalne industrije, počevši sa uslugama servisiranja, projektovanja i izradom hidrauličnih komponenata (cilindara, agregata, ventila, pumpi i sl.) kao i istraživanjem tržišta.

Prve značajnije rezultate preduzeće počinje ostvarivati krajem 1998. godine kada su nabavljene mašine za obradu metala i formirana radionica koja je počela da proizvodi sopstvene proizvode i usluge.

Sljedeća faza razvoja firme počinje 2000. godine kada su urađeni planovi dugoročnog razvoja firme koji su se realizovali u proteklih 16 godina. Tada je definisana osnovna djelatnost firme koja se bazirala na sljedećem:

### Djelatnost firme

Osnovna djelatnost preduzeća je podijeljena u nekoliko oblasti i to:

1. Projektovanje, proizvodnja, montaža i servis liftova i platformi,
2. Projektovanje i proizvodnja mašina, hidrauličnih i pneumatskih uređaja i instalacija po zahtjevu kupaca,
3. Proizvodnja i montaža hidromašinske opreme (zatvarači, čistilice, rešetke, itd.), metalnih konstrukcija, vodovodnih i energetskih instalacija i uređaja,
3. Trgovina opremom, repromaterijalom i dijelovima iz oblasti hidraulike, pneumatike, opreme za liftove,
3. Usluge servisiranja i održavanja mašina i opreme u industriji i građevinarstvu.

Trenutno se poslovanje obavlja na zemljištu površine 8500 m<sup>2</sup> na kome je izgrađeno poslovnog, proizvodnog i skladišnog prostora veličine 2300 m<sup>2</sup>. U toku je proces izgradnje dodatnog proizvodnog prostora površine 1800 m<sup>2</sup> za koji su nabavljene ili su u procesu nabavke CNC mašine.

TRI BEST d.o.o. trenutno zapošljava preko 60 radnika. Uvedeni su informacioni sistemi za praćenje procesa proizvodnje i projektovanje kao i ISO standardi 9001:2008, a u toku je i certifikacija ISO 14001:2015 i 18001:2007.

# altera

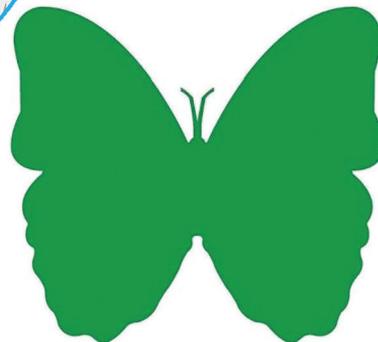
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