Innovation Center of Faculty of Mechanical Engineering

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CNN TECH

# „International Conference of Experimental and Numerical Investigations and New Technologies“

**Sponsored by:**

**MINISTRY OF EDUCATION, SCIENCE AND TECHNICAL DEVELOPMENT**

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# Programme

# and

# The Book of Abstracts

**02-05 July 2019**

**Zlatibor, Serbia**

**„International Conference of Experimental and Numerical Investigations and New Technologies“**

# CNN TECH 2019

**02-05 July 2019**

**Hotel Mona, Miladina Pecinara 26, Zlatibor, Serbia**

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# Programme

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# The Book of Abstracts

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# CNN TECH 2019

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The organizing committee of the 3th International Conference of Experimental and Numerical Investigations and New Technologies – CNN TECH 2019 wishes to sincerely thank all the institutions and individuals who by means of personal engagement and constructive action helped organizing this conference.

We particularly wish to thank our sponsor, **The Ministry of Education, Science and Technological development**, Government of the Republic of Serbia.

# PREFACE

Dear Friends and Colleagues, Welcome to CNN Tech 2019 Conference and the fabulous mountain of Zlatibor!

With 65 papers (22 by international authors) and contributions by authors from 15 different countries, International Conference of Experimental and Numerical Investigations and New Technologies CNN Tech 2019 successfully sets the high level for the future conferences. Participation of a large number of domestic and international authors, as well as the diversity of topics, justifies our efforts to organize this conference and contribute to exchange of knowledge, research results and experience of industry experts, research institutions and faculties which all share a common interest in the field in experimental and numerical investigations.

This year CNN Tech 2019 focuses on the following topics:

- Mechanical Engineering,
- Materials Science,
- Chemical and Process Engineering,
- Experimental Techniques,
- Numerical Methods,
- New Technologies and
- Industry and sustainable development: contemporary management perspectives.

Apart from a plenty of interesting lectures, the participants will have a chance to lighten up and communicate in friendly and relaxed settings.

Organizing committee of CNN Tech 2019 would like to express gratitude to Ministry of Education, Science and Technological development for financial support of the Conference.

On behalf of the Innovation center of Faculty of Mechanical Engineering, Faculty of Mechanical Engineering and Center for Business Trainings, we wish this to be splendid CNN Tech conference filled with many memorable moments.

PROGRAMME AND ORGANIZING COMMITTEE

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|---|---|
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# ABSTRACTS

# Mechanical Engineering

# OPTIMIZATION OF COMPOSITE STRUCTURE BASED ON FRACTURE ANALYSIS

Abdelnaser Abdusalam Elayeb[1*], Aleksandar Grbovic[2], Martina Balac[3]

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**Abstract**

*Over the last three decades, the use of composites in aviation structures has been increasing. The previous aircraft structure was mostly made of aluminum alloy, and the composites were limited to a level two structure. With increasing experience and confidence, the use of these materials has been extended to major structures. Moreover, composites used in vehicles industry can reduce weight and operating costs, so it is believed that their use will increase further in the near future. The research scope of this study was to develop the optimal design of a composite structure in the terms of maximum vehicle's life. To achieve this, several composite designs of a vehicle body were analyzed in Ansys Fluent to get the loads and stresses that can be expected during the service. Then, Helius PFA software for progressive failure analysis has been used. It provides powerful tools for enhanced finite element analysis of composite structures. The validity of the developed model has been investigated and compared with an experimental data collected in the wind tunnel for some composite specimens and for a developed 3D model. Moreover, a comparison study, between experimental and simulation work, was also performed with selected design cases to demonstrate the potential advantages of using the optimal composite structure to maintain fatigue long-life structures.*

**Keywords**

Composite structures; fatigue life; finite element analysis; fracture analysis

# SMART ROBOT PROGRAMMING BY DEMONSTRATION

Milos Milivojevic[1*], Djordje Sipetic[1], Nikola Lukic[1], Bozica Bojovic[1], Petar Petrovic[1]

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**Abstract**

*The aim of this paper is to present an approach of smart programming robot trajectories by demonstration. The learning algorithm, based on information from the sensor system, is integrated on end-effector (EE), providing precise and intuitive programming trajectories. The focus of this paper is the sensor system development, consisting of three coupled force feedback sensors. Two operation modes allow either translation or rotations control of EE, obtain by pressing or releasing push-button. The additional capacitive sensor security function is used for user protection in the process of robot programming.*

*The demonstration of such a system was implemented on the robot Yaskawa SIA10F with seven degrees of freedom (DoF). To accomplish the programming task, six DoF is enough to ensure the manipulation of three translations and three rotations, regardless of the seventh Dof. This robot benefits from its open architecture controller (Motoplus SDK) that enables the whole system to be formed directly through communication between robot and sensor. It should be noted that the complete developed control structure of the sensor is integrated inside of its body, and the communication between the robot and the sensor is carried out through the WiFi protocol.*

*As an example of the most intuitive learning, a robot using of pen and paper is presented. Experimental setup considers a case of identified paper position during which the robot performs the task of repeating the trajectory, previously programmed by demonstration.*

*Further system development expectation is providing the required pressure and ensuring the unobstructed writing by the sensor during the repeated task.*

**Keywords**

Please Cognitive Human-Robot Interaction, Deep Learning in Robotics, Force and Tactile Sensing, Force Control, Learning by Demonstration, Motion Control.

**Acknowledgement**

This research has been funded by Ministry of Education, Science and Technological Development of Republic of Serbia, through Project TR 35007.

# INFLUENCE OF THE SIZE AND POSITION OF WINDOWS BLINDS ON HEAT LOSSES

Milan Travica[1*], Nenad Mitrovic[2], Radivoje Batinic, Aleksandar Petrovic[2]

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**Abstract**

*Heat losses in buildings have high influence on construction materials choice, size and quality of windows, doors or glass roofs and the construction processes. For a 10 floor-building, heat losses through windows are almost half of the losses of the whole building. With that in mind, improving the thermal protection of windows and other glass surfaces can increase energy savings. One example for thermal protection increase is using blinds on windows. Influence of the size and position of the windows blinds on heat losses is analysed in this paper. A mathematical model was developed and experimental study was conducted to obtain the values of thermal losses in the function of the position and size of the blind openings. The obtained results showed the ratio of the amount of heat for the window with and without a blind. According to the measured values, the thermal insulation is increased for about 18 % on the window with blinds. The use of the blinds is profitable and the mentioned savings can contribute to the lower energy consumption in house heating and cooling.*

**Keywords**

Thermal protection, heat losses, blinds, thermographic camera

**Acknowledgement**

This research was supported by Ministry of Education, Science and Technological Development of Republic of Serbia under Project TR35031.

# REVITALIZATION AND OPTIMIZATION OF THERMOENERGETIC FACILITIES

Marko Ristic[1*], Ivana Vasovic[2], Jasmina Perisic[3]

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**Abstract**

Global demand for electricity is in constant growth, given the constant increase in the number of inhabitants and the growth of the economy. This paper present how the increasing demand for energy and the constant increase in the capacity of power plant production systems is exacerbating the working conditions of parts of this system and leading to a reducing the remaining working life.
Efficient operation of thermal power plants is the basis of economical production of electricity based on combustion of lignite. Ventilation mill as such is one of the basic equipment in thermal power plants, whose work has a significant impact on the level of energy efficiency. This paper present the complexity of the optimization problem of the different thermal power plant and system demands use of multidisciplinary research. However, any optimization of an energy plant, such as a ventilation mill, in this case, represents a unique approach to the problem of operating efficiency of the plant, and as such carries many new requirements and solutions.
In this paper are presented one way for solving this complex problem by using detail analyses of work of system of ventilation mill and dust channel by analysing the period of failures. This paper is presenting the usages of CFD numerical simulation in FLUENT software for determine the working condition in ventilation mill and dust channel. Possibilities for use the process of coating damages parts with wear resistance material and procedure for selection and coating on real working parts. Analyses of damages coated working parts of ventilation mill after examination in exploitation condition. Data analysis of working parts before and after applications coating, time and time and resource saving.

**Keywords**

Energy saving, thermopower plant, failure, coating ,CFD

**Acknowledgement**

This paper is the result of research within the project TR 34028, which is financially supported by Ministry of Education, Science and Technological Development of Serbia, Messer Tehnogas and PD TE – KO Kostolac.

# OPTIMUM PERIODICITY MAINTENANCE

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**Abstract**

*Preventive maintenance model is providing the required level of reliability and capacity of the technical systems used in the companies. The main request in the application of this maintenance model is defining the optimum period that meets mutual opposite criteria. In this research, the methodology for defining the period for electric motor preventive maintenance on the basis of malfunctions statistical data is presented. The applied methodology is based on the reliability of the analyzed electric motor (performance monitoring, malfunction occurrence in working conditions, as well as the maintenance costs). Optimum periodic preventive maintenance defined by the criteria of maximum final capacity and the one defined by the criteria of minimal maintenance costs differ. This is the reason why application of multi-criteria analysis provides the value of needed optimum period of the electric motor maintenance, taking into consideration both criteria of optimization.*

**Keywords**

Electric motor, optimum periodicity, maintenance, reliability, final capacity, minimum costs.

# DYNAMIC SIMULATION OF DUAL MASS FLYWHEEL

Jozef Bucha[1*], Jan Danko, Tomas Milesich[1], Radivoje Mitrovic[2] and Zarko Miskovic[2]

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**Abstract**

*Global trend in automotive technology such as electrification of car powertrain leads to higher diversification of powertrain designs i.e. its topology. New powertrain design poses new challenges in terms of driveline vibration or ultimately in terms of NVH (Noise Vibration Harshness). Current state of the technology for vibration damping in car powertrains is the so-called Dual Mass Flywheel (DMF). The paper deals with creation of MBD model of double mass flywheel based on CAD model of dual mass flywheel produced by ZF. Parameters of virtual model are tuned and compared with experimental measures of dual mass flywheel. Main result of tuning virtual model is to achieve same stiffness of virtual DMF as measured stiffness of real DMF. The real DMF contains oil, the resistance of must be taken into account as a force in virtual model.*

**Keywords**

Dual mass flywheel, Multi body dynamic, MSC/Adams, NVH

# 3D NUMERICAL MODELLING OF CRACK GROWTH IN SIMPLE STEEL WIRE ROPES

Gordana Kastratovic[1*], Aleksandar Grbovic[2], Nenad Vidanovic[1], Nikola Mirkov[3]

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**Abstract**

*The aim of this study is to explore and to demonstrate the capacity, performances and difficulties of numerically modelled crack growth in complex 3D structures such as wire ropes. First step within this numerical study was to analyse single cracked wire for which experimental results could be found in the available literature. This analysis was used as a “benchmark” model, for validation and verification purposes. Next, parametric 3D model of seven-wire strand was analysed, using the advanced modeling techniques. All analyses were carried out by finite element method, implemented in Ansys Workbench software. Having in mind that the experiments are still the only successful method for prediction of mechanical behaviour of the steel wire ropes, the outcome of the study suggests that the finite element method could also be a useful tool for this kind of analysis.*

**Keywords**

Crack growth, Wire rope strand, Finite element method, Stress intensity factors

**Acknowledgement**

This work is partially supported by the the Ministry of Education, Science and Technological Development of the Republic of Serbia under the projects ON 174004 and TR-33036.

# CONSTRUCTION SOLUTION OF HORIZONTAL MACHINE FOR BALANCING ROTOR MASS OF 100-1000 KG

Aleksandra D. Joksimovic[1*], Aleksandar Dj. Jankovic[1], Emil A. Veg[1], Vojislav D. Simonovic[1]

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**Abstract**

*This paper describes the process of constructing a machine for the horizontal balancing of the rotor. Quality grades of balancing, for standard rotors, are strictly defined by ISO and other National Standard Organizations. Balancing the rotor is important in the industry because it extends the life of the machine, reduces noise and vibrations, reduces the risk of damage, and increases the safety of the machine. An unbalanced rotor creates vibrations during operation. The vibration of machinery is generally problematic, and cause excessive wear of bearings, mechanical loose, noise, and what is of significant importance it is unpleasant for humans. The existence of vibration itself is usually a symptom of an internal defect. Vibrations beyond the permissible range adversely affect the lifespan of the bearings, and in case of higher intensity vibrations, some of the machine elements may be affected. When designing the rotor balancing machine, the main characteristics are taken into account: rotor mass, rotor diameter, rotor length, machine sensitivity, easy assembly and dismantlement of the rotor.*

**Keywords**

Vibrations, Balance machine, rotor.

***Invited lecture***

# CRITICAL SPEED OF FLEXIBLE COUPLING - DETERMINING WITH CAE SOFTWARE

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**Abstract**

*The present article deals with FEM analysis of flexible coupling with rubber elastic element. Working parts of coupling are half of all cylinders made with carrying ring. Elastic elements are subjected to compression loading when transmitting torque. At certain load level, forces, acting on cylinders, cause their radial displacement. By default - metal fingers, with their shape, must limit radial deformation. However, in the process of operation, under torque and speed of rotation, it deforms and changes its overall size. Fingers press the loaded cylinders and deform them plastically. Because of this deformation, coupling stops working and needs to be replaced. Elastic elements of couplings are made of a variety of polymeric materials whose properties have a significant impact on dynamic properties of coupling.*

*Radial displacement of these cylinders is determined by FEA method using CAE software. Critical speeds are defined, resulting in pinching of rubber elastic element that depends on properties of the material used. Critical rotational speed increases with increase elastic modulus of the elastic element of 4 to 8MPa and decreases with increased density of the material from 1080 to 1900 kg/m$^3$. Results show, that achieving maximum rotational speed for investigated flexible coupling without plastic deformation requires elastomer with a modulus of elasticity of E ≥ 6MPa and density ρ≤1100 kg/m$^3$. Results of these tests will be used to correct some of the geometric parameters of an elastic element or more suitable geometry of metal fingers to ensure the required coupling load.*

**Keywords**

flexible coupling, rubber element, critical speed, radial displacement, Solid works

# PREPARATION OF ENGINEERING STUDENTS FOR RESEARCH AND SCIENTIFIC WORK

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**Abstract**

*Research and scientific work today attract attention of students more than before. Students follow knowledge gaining path in order to learn fundamental and specific lessons in chosen field. On this way, they become capable of doing both theoretical and practical work. Gained knowledge has to be applied in order to develop practical skills. There are many application areas where learned lessons can be applied. It ranges from mechanics and construction, mechanical engineering, electrical engineering, thermodynamics, fluid mechanics, robotics, automation, power engineering, etc. Graduate students develop independent thinking what helps them to later lead their own and independent work. Following novel research results and new technologies they are able to solve new problems and to apply new technologies. Consequently, they are also capable to achieve scientific results. In this paper are proposed directions for engineering students on how to choose engineering research field, how to do research and publish their work, what methodologies and systems to learn to choose and how to plan practical application in order to be able to achieve practical results, innovations and prototypes. Further, practical and theoretical research paths , are distinguished and exist independently, and it is emphasised importance of being capable of doing both theoretical and practical work. Finally, importance of practical prototyping is emphasised for students in order to be able to do patent innovations.*

**Keywords**

Graduate students, research and scientific work, system and methodologies to learn, publication of scientific work, preparation for practical innovations

# THE PYROLYSIS OF WASTE BIOMASS INVESTIGATED BY SIMULTANEOUS TGA-DTA-MS MEASUREMENTS AND KINETIC MODELING WITH DECONVOLUTION FUNCTIONS

Nebojsa Manic[1*], Bojan Jankovic[2], Dragoslava Stojiljkovic[1], Vladimir Jovanovic[1], Vladimir Dodevski[3]

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**Abstract**

*As waste biomass from fruit processing industry, apricot kernel shells have a potential for conversion to renewable energy through a thermo-chemical process such as pyrolysis. However, due to major differences of biomass characteristics as the well-known issue, it is extremely important to perform detailed analysis of biomass samples from the same type (or same species) but from different geographical regions. Regarding full characterization of considered biomass material and to facilitate further process development, in this paper, the advanced mathematical model for kinetic analysis was used. All performed kinetic modeling represents the process kinetics developed and validated on thermal decomposition studies using simultaneous thermogravimetric analysis (TGA) – differential thermal analysis (DTA) – mass spectrometry (MS) scanning, over a experimental temperature range of 30 – 900 °C, at four heating rates of 5, 10, 15 and 20 °C $min^{-1}$, under an argon (Ar) atmosphere. Model-free analysis for base prediction of decomposition process and deconvolution approach by Fraser-Suzuki functions were utilized for determination of effective activation energies (E), pre-exponential factors (A) and fractional contributions (φ), as well as for separation of overlapping reactions. Comparative study of kinetic results with emission analysis of evolved gas species was also implemented in order to determine the more comprehensive pyrolysis kinetics model. Obtained results strongly indicated that the Fraser-Suzuki deconvolution provides excellent quality of fits with experimental ones, and could be employed to predict devolatilization rates with a high probability. From energy compensation effect properties, it was revealed the existence of unconventional thermal lag due to heat demand by chemical reaction.*

**Keywords**

Waste lignocellulosic biomass; Pseudo-components; Kinetics; Pyrolysis; Fraser-Suzuki deconvolution; Unconventional thermal lag

**Acknowledgement**

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# Engineering Materials

# DAMAGES ON LASER PEENING-STRENGTHENED AND NON-STRENGTHENED NIMONIC SPECIMENS AS POTENTIAL CAUSES OF CRACK INITIATION AND FRACTURE

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**Abstract**

*In this paper, two types of specimens made of NIMONIC alloy were chosen for experimental investigation, one of which was laser peening-strengthened and one which was not. Nimonic is widely used for various workpieces in industry, for example in gas turbine engines, die casting inserts and cores, exhaust valves, etc. The laser shock peening offers a lot of advantages over the conventional methods using the laser beam as a tool, and a transparent and absorptive layer to increase the pressure and protect the material. The changes in surface topography are observed and analysed by microscopy, a profilometer and a microhardness tester. Some unwanted damages on their surfaces that can lead to crack initiation were observed and described along with dimensions, shapes and locations, as well as further influence on the potential crack initiation that could lead to their fracture. Aforementioned specimens were in shapes of thin plates with holes, and the reinforced specimens were strengthened by laser shot peening method around the holes. Detailed displays of damages of both specimens are given, along with the results of roughness and hardness tests which are shown for both specimens. These two tests were performed near the damage presence in both cases. Results discussed in this paper can aid the understanding of in-service behaviour of the mechanical parts with surface damages, even of laser peening-strengthened materials.*

**Keywords**

Nimonic alloy, Thin plate specimen, LPS, Experimental investigation, Crack formation

**Acknowledgement**

The authors of this paper acknowledge the support for this investigation by Serbian Ministry of Education, Science and Technological Development for projects TR35011 and TR 35040.

# PROCESS MAPPING OF GLASS ENVELOPE DESIGN OF GEOMETRICALLY COMPLEX FORM

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**Abstract**

*The design and construction of glass facades is a very complex sector in the construction industry, whose multidisciplinary character is reflected in the application of new technologies of glass and glass facade production, in solutions for multitude requirements of the envelope performances sometimes very complex geometry, as well as in large range of various glass materials. The aim of the presented research is to create links and interactive relationship between the design process on the conceptual level, materialization and realization of geometrically complex form of glass envelope, which integrate different issues such as design, manufacture, performance and economy. Based on the survey about how architects, engineers and contractors deal with different design aspects of curved glass structures with a special focus on design and construction process, the investigation includes an overview of the findings of the interviews as a basis for the development of support tools, which could help efficient storage, access and transfer of project information. The current paper presents creation and verification of a model of process mapping which will be supportive in further research of the application of both curved glass and all other types of glass envelopes. The process map is useful for defining deadlines, understanding the role of different actors and activities, as well as their responsibility and identifying different requirements during the design and construction process. It could also be used as a basis for further development of support tools such as BIM (Building Information Modelling), and tools for optimizing glass surfaces.*

**Keywords**

Curved glass, process map, survey, geometrically complex form of building envelope

**Acknowledgement**

This research was supported by Ministry of Education, Science and Technological Development of Serbia under Projects TR36038.

# ANALYSIS OF CORROSION-RESISTANT STEELS IN LOCAL ZONES OF WELDED JOINTS WITH 3D-DIC METHOD

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**Abstract**

*The quality of welded joints is defined by properties the metals must possess in order to satisfy defined requirements, and can be achieved by choosing appropriate procedures, welding parameters and through mechanical and technology strain tests of base metal and welded joints. This paper presents investigation of important properties of welded joints of corrosion resistant steel. This particularly applies to their corrosion resistance, measures to prevent corrosion, as well as special conditions and requirements for welding of corrosion-resistant steels. Methods for evaluating corrosion resistance of this type of metal are considered and classified. However, one of the main issues lies in determining the mechanical properties of metals in a welded joint. Also, the behaviour of welded joints in local zones and their mutual influence represents significant challenges in welded structure. 3D Digital Image Correlation (3D-DIC) method was employed to obtain local von Mises strain and displacement. A specimen with parallel sides, obtained by welding of a V joint was utilized. Aramis software was used for measuring local von Mises strain and displacement in a welded joint. The paper emphasizes cases of numerous uniform welded joints. The results showed that 3D-DIC method is suitable for welded joint testing and determining of mechanical properties.*

**Keywords**

Corrosion-resistant steels, welded joints, mechanical properties, 3D-DIC method

**Acknowledgement**

The author is grateful to the Ministry of Education, Science and Technological Development of the Republic of Serbia and to the University of Belgrade for financial support of this research (projects TR35031 and TR35040).

***Invited lecture***

# APPLICATION OF NANOMATERIALS IN DRUGS, FOOD AND COSMETIC PRODUCTS

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**Abstract**

*Nanotechnology uses nanostructures and nanoparticles in various fields of science, likewise in a common goods production. Nanomaterials are defined as a material ranged between 1 and 100 nm in at least one dimension. Nanoparticles designed at the atomic or molecular level, exhibit unique structural, chemical, electrical, magnetic, mechanical, and biological properties. Their main benefits are associated with the surface properties, and functionalization of the surface opens new possibilities in diagnosis, prevention, treating and cure diseases. In the last decades, many new drugs and diagnostic tools appear on the market, and nanomaterials were successfully used also in tissue engineering. Nanotechnology is applied in various groups of commercial products – food and feed, food supplements, novel foods, biocides, pesticides, cosmetics, food contact materials etc. Due to the different characteristics, nanomaterials offer many advantages, but at the same time, raises many questions about their safety, toxicity and ecotoxicity profile. As the number of products utilizing the nanomaterials on the market grows, this field becoming an area of serious public health concern, and promoting the appropriate regulatory frame and risk assessment development.*

*The paper presents the advantages of nanomaterials over bulk materials, various types and forms used and changes of nanomaterials made in medical and pharmaceutical science and technology, food technology and cosmetic field. Current regulatory status and obstacles for faster and more fruitful growth and development in the area of drugs, food and cosmetic products, will also be communicated.*

**Keywords**

nanomaterials, drugs, food, cosmetics, regulatory issues

# QUALITATIVE CHARACTERISTICS OF FABRIC IMPACT ON THE CHLOTHING THERMO-PHYSIOLOGICAL PROPERTIES IN MAINTENANCE

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**Abstract**

*Human thermal comfort is highly influenced by clothes materials, as well as climate conditions and physical activity. Clothes care by washing is very usual, and this paper presents fabric behavior i.e., its change of diffusion and thermal properties. The water vapor permeability and thermal resistance of the clothes during exploitation (wear) were tested as the main parameters. The correlation of the physical, mechanical and thermo-physiological properties was tested on one non-coated fabric and three different coated fabrics, as well as the changes of water vapor resistance (Ret) during the washing. Standard methods have been applied for testing physical and mechanical properties of fabrics, where the heat plate measurements have been used to test the water vapor resistance (Ret) as well as thermal resistance (Rct). The obtained results indicate that certain properties of yarns for the basic fabric, as well as the characteristics of different polymeric materials (coatings and membranes) used in the production of fabrics and the constructional characteristics of fabrics significantly influence the water vapor resistance and its change during washing. The applied laminating and coating processes have led to the improvement of the physical and mechanical properties of the basic textile material. By comparing the obtained results for water vapor resistance for all tested samples at different temperature, relative humidity and air speed, the influence of these parameters on Ret value of clothes was noticed. These results also define the application field of tested textile material and the level of protection, i.e. the acceptability class for specified climatic conditions.*

**Keywords**

textile materials, water-vapor resistance, thermal resistance, heat plate

***Invited lecture***

# DUAL PHASE AUSTEMPERED DUCTILE IRON-MICROSTRUCTURE, CHARACTERISTICS, APPLICATIONS

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**Abstract**

*During the last few years, there has been an increased interest in improving the strength of ductile iron by means of heat-treating to obtain dual matrix structures that enhance the properties found in Austempered Ductile Irons (ADI). A new kind of ductile iron referred to as “dual-phase Austempered Ductile Iron (ADI)“, a material composed of ausferrite (regular ADI microstructure) and free (or allotriomorphic) proeutectoid ferrite. Additiinally, dual phase ADI could provide a wide range of mechanical properties as a function of the relative proportion of proeutectoid ferrite and ausferrite constituents, thereby replacing ductile iron with other matrices. Therefore, dual phase ADI will be appropriate for new applications in the critical parts, where a combination of high strength and ductility is a pressing requirement. Furthermore, with introduction of free ferrite into the matrix increased machinability of ADI could be achieved.*
*The objective of this paper was to review works that have been organized over the past years on the effects of process variables, mechanical properties, microstructure and applications of Dual phase Austempered Ductile Iron and to present some own findings.*

**Keywords**

ductile iron, dual phase austempered ductile iron, microstructure, mechanical properties

**Acknowledgement**

The authors gratefully acknowledge research funding from the Ministry of Education, Science and Technological Development of the Republic of Serbia under grant number TR34015.

***Invited lecture***

# PRODUCTION AND CHARACTERISATION OF NANOPHOTONIC SOFT CONTACT LENSES

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**Abstract**

*Hydrogels have unique physical and chemical properties and therefore are used in a variety of biomedical applications, including drug delivery agents, prosthetic devices, the repair and replacement of soft tissues and contact lenses. Investigation of mechanical, physical and chemical properties of hydrogels is the first step in biomedical application. Poly (2-hydroxyethyl methacrylate) (pHEMA), as a biocompatible hydrogel, was first used hydrogel for making soft contact lens. Since then, many researches have been modified pHEMA with the aim of improving its properties. Application of nanotechnology could be one of the possible solutions for improving the characteristics of this biocompatible hydrogel. In this paper, poly (2-hydroxyethyl methacrylate) was used as standard material for soft contact lenses (SL 38). This material was incorporated with fullerene $C_{60}$ (SL38-A), fullerol $C_{60}(OH)_{24}$ (SL 38-B) and fullerene metformin hydroxylate $C_{60}(OH)_{12}(OC_4N_5H_{10})_{12}$ (SL 38-C), respectively. Three new nanophotonic materials for soft contact lenses were obtained. The aim of this study was to develop appropriate process parameters for soft contact lens micro-turning. Also, studying the thermal decomposition of standard soft contact lens, pHEMA, as well as three new nanophotonic soft contact lenses was one of the main objectives. From the obtained results, it can be concluded that manufacturing process of nanofotonic soft contact lens is considered to be a micro-turning process regarding the cutting depth and tool nose ratio. Further, thermal properties of nanofotonic soft contact lenses were improved comparing to the standard soft contact lens.*

**Keywords**

Nanophotonic soft contact lenses, fullerenes, hydrogel, production, thermal analysis

**Acknowledgement**

The authors are grateful to Optix (Belgrade, Serbia) and Soleko (Milano, Italy) for providing the material used in this study.

# ANALYSIS OF PARAMETER IMPACT ON 3D PRINTED EXPERIMENTAL SAMPLES FOR TENSILE TESTING

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**Abstract**

*One of the current problems in practice of preparing functional parts, prototypes and constructions is insufficient knowledge of 3D printing parameters for various advanced materials, which often results in failure to obtain required 3D prints. Users of 3D printers and distributors alike are at high risk that the results of their 3D printing may fail due to the use of advanced materials that are not sufficiently tested. Chosen 3D printing technology is FDM (Fused Deposition Modeling), a commercially available and widespread additive manufacturing technology. Crucial impact on mechanical properties and durability of 3D printed FDM parts are chosen parameters for printing. The input of parameters is done using adequate slicer software, which prepares the G-code for stepper motors and heaters-who runs the whole 3D printing process on the machine. Previous studies show that printing parameters such as layer height, print speed, infill pattern and percentage, print orientation and temperature have a crucial impact on mechanical properties of printed parts. This technology still shows improvements, mostly in the field of new materials. Every breakthrough in the material field requires thorough testing, in order to acquire mechanical properties and determine material behaviour in exploitation.*

*In order to extend the application of production of functional parts and prototypes obtained using additive manufacturing technologies, overviewing exploitation behaviour of conventional and advanced materials due to different conditions of 3D printing, the 3D printing parameters have been varied in order to attain its influence on mechanical properties of experimental samples, that are to be used in tensile testing. This research shows that prime mechanical properties, such as tensile strength, deformation at break, Young's modulus and toughness, may vary up to 30% in their value according to chosen printing parameters.*

**Keywords**

3D Printing, FDM, Parameter impact, Sample, Tensile testing

**Acknowledgement**

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# SURFACE MODIFICATION OF DENTAL MATERIALS AND HARD TISSUES USING NONTHERMAL ATMOSPHERIC PLASMA

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**Abstract**

*Research of nonthermal atmospheric plasma (NTAP) for dental applications has been increasing in recent years. This paper presents a literature review of potential use of NTAP for treatment of surfaces of dental materials and hard dental tissues. The aim of NTAP interaction with dental materials and tissues is surface modification for stable and durable material-to-material or material-to-tissue bonds.*
*Reactive particles in NTAP and various mixtures of gasses increase roughness and hydrophilicity of material surface, which is known to be hydrophobic in implants, ceramics or dental composites. Adhesion of cells to implant surface was shown to improve by NTAP, thereby promoting successful osseointegration. Bonding ceramic materials to the prepared surfaces of teeth or fiber/metal posts was shown to improve after NTAP treatment.*
*Hard dental tissues achieve primarily micromechanical bonds with composite materials using dental adhesives. Increased organic content in the form of collagen fibrils and residual water pose a problem for achieving adequate and long-term adhesive-dentin bonds. This problem has not been solved with current adhesive application protocols. It was recently shown that application of NTAP improves the hydrophilicity of dentin surface and changes its polarity, which can contribute to better distribution of adhesive resin and deeper penetration into the hybrid layer. Previous studies pointed to similar or better initial adhesive bonds with dentin. However, adhesive-dentin bonds are subject to degradation in the long-term also after NTAP treatment suggesting the need for further optimization of NTAP for application on dentin.*

**Keywords**

nonthermal atmospheric plasma, implants, ceramics, adhesive, dentin

**Acknowledgement**

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# DIMENSIONAL CHANGES OF BULK-FILL AND UNIVERSAL DENTAL COMPOSITES

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**Abstract**

*Dental composites undergo dimensional changes as a result of organic matrix polymerization. This phenomenon is generally referred to as polymerization shrinkage and is considered one of the main disadvantages of dental composites. Shrinkage is coupled with shrinkage stress in certain clinical conditions depending on cavity design, placement technique and curing conditions. Shrinkage and shrinkage stress may lead to microcrack formation and propagation within the adhesive layer that bonds a composite restoration to the tooth tissues, creating microgaps at the restoration-tooth interface. Subsequent ingress of oral fluids and microorganisms may result in marginal discoloration, further adhesive bond degradation and secondary caries. Inorganic filler phase of dental composites not only improves their mechanical properties, but also reduces polymerization shrinkage. Nevertheless, no dental composite is shrinkage-free. In this presentation, differences in material composition between various dental composites will be explained. A brief review of current methods for shrinkage and shrinkage stress will be discussed. Recent data on shrinkage and shrinkage stress will be presented for contemporary bulk-fill and universal dental composites. It is important to point out that a clear link between shrinkage and shrinkage stress in actual clinical conditions has yet to be confirmed in clinical trials. Based on the experimental data, clinicians may adjust their practice to create optimal conditions for least damaging effect of polymerization shrinkage and shrinkage stress related to dental composites.*

**Keywords**

Dental Composites, Polymerization Shrinkage, Shrinkage Stress

# MICRO-COMPUTERIZED TOMOGRAPHY AND DIGITAL RADIOGRAPHY IN THE STUDIES OF DENTAL CEMENT MATERIALS (REVIEW STUDY)

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**Abstract**

***Background***. *Micro-computed tomography (μCT) have been applied in dental studies for several years considering physical features of dental materials. Digital radiography (DR) system, exposing easy way to record the image of object and its analysis through the many available tools by automated PC-device, displayed many studies on radio contrast of various dental materials along past two decades. The* ***aim*** *of this review is to present the benefit of μCT and DR in the studies of dental materials regarding their physical characteristics.* ***Material/methods***. *The various branded capping, lining, luting, dentine replacement and post materials (glass ionomer, calcium silicate cements and their variants) were included. The experimental calcium silicate mixtures were based on Portland cement (Pc) and addition of radiopacifiers ($ZrO_2$, $Bi_2O_3$, $SrF_2$, $SrCO_3$ $YbF_3$) and antioxidant (quercetin). Porosity was assessed by μCT device Sky-Scan-1772, Kontich by 5μm resolution. Images were analysed with CT.An 1.14.4.1 (Sky-Scan) using 34/255 threshold. Recorded parameters were measured as total, open and closed porosity. Radiopacity was investigated by the help of Trophy Radiologie Cedex digital device, CCD sensor and accompanying software programmer (Trophy for Windows Software; Trophy Radiology). Statistical methods were chosen according to study design and obtained values.* ***Results***. *The added 30%$SrF_2$ or 30% $SrCO_3$ to Pc significantly decreased its open, closed and total porosity by μCT device. μCT scan revealed lower total micro porosity in calcium silicates than glass ionomer cement as root-end plug. The addition of 10% $Bi_2O_3$ and 20% $ZrO_2$, $YbF_3$, $SrF_2$, $SrCO_3$ to Pc resulted in greater radiopacity than Pc alone by DR thus satisfying 3 mm Al of ISO requirement. DR of PC+5% quercetin mixture was insignificantly different of PC alone.* ***Conclusion*** *DR and μCT device displayed better possibilities for visualization and measurement of cement than conventional radiography.*

**Keywords**

Micro computed tomographydigital radiography, radiovisiography, calcium silicate cement, radiopacifier, radiopacity

# Chemical and Process Engineering

# CORRELATION ANALYSIS BETWEEN PHYSICO-CHEMICAL AND AERATION CHARACTERISTICS OF FLY ASH

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**Abstract**

High volumes *of coal fly ash are generated in thermal power plants all over the world. Fly ash characteristics primarily depend on coal type, combustion conditions and efficiency of particulate removal in thermal power plants. Therefore, all relevant fly ash characteristics must be investigated in order to design reliable pneumatic and hydraulic conveying systems for its removal from thermal power plants, transport to silos and disposal to landfills. A research study was conducted on more than 60 fly ash samples from a lignite fired thermal power plant. This research aim was to determine physical, chemical and aeration characteristics of fly ash samples in order to analyse their mutual correlation. Parameters that were correlated are mean diameter, bulk density, physical density, oxide compounds ($SiO_2$, $Al_2O_3$, $Fe_2O_3$, Cao and MgO), and minimal fluidizing velocity. Simple linear regresion of experimental results showed that there was no strong correlation (R) between average diameter and bulk or physical density. Fly ash oxide composition showed significant correlation to mean diameter, but multiple linear regression should be done. Significant correlation ratio between minimal fluidization velocity and mean diameter, bulk and physical density could not be obtained.*

**Keywords**

Fly ash, thermal power plant, lignite, characteristics, correlation analysis

**Acknowledgement**

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# THE EFFECT OF CARBON DIOXIDE AND NITROGEN IN MIXTURE WITH NATURAL GAS ON THE PARAMETERS OF THE COMBUSTION ENGINE

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**Abstract**

*The article discusses the influence of inert gases (carbon dioxide and nitrogen) in a mixture with natural gas on power and economic parameters of the internal combustion engine LGW 702 designed for micro-cogeneration units. The experimental measurements were made under various engine operating modes and under various compositions of fuel mixtures. The aim of the experiments was to analyse and assess the full impact of the inert components in the gaseous fuel especially on the particular integral parameters as well as on the internal combustion engine parameters relating to the course of burning the mixture. Experimental results indicate a decrease in performance parameters and an increase in specific fuel consumption with an increase in the proportion of internal gases in the mixture. The increasing proportion of inert gases leads to decreasing maximum pressure in the cylinder (a decrease approximately by 50% with the mixture CO2NG50 or by 30 % with the mixture N2NG50, compared to natural gas) and the position of maximum pressure value is shifted further into the area of the expansion stroke.*

**Keywords**

Internal combustion engine, synthesis gas, natural gas, combustion, pressure

**Acknowledgement**

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***Invited lecture***

# APPLICATION OF DECONVOLUTION FUNCTIONS AND ITERATIVE ISOCONVERSIONAL APPROACH FOR KINETIC MODELING OF BIOMASS PYROLYSIS

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**Abstract**

*Thermal decomposition and thermochemical conversion of biomass during pyrolysis process could be fundamentally described with a comprehensive analysis of thermal degradation mechanisms and identification of concurrent reactions which occurs. Hemicellulose, cellulose, and lignin as main chemical components of raw biomass material decompose in a wide temperature range, usually with overlapping effects. In order to the mathematical process description and regarding kinetic modelling for the considered conversion process, one of the deconvolution functions Fraser-Suzuki was used for peak separation and prediction of the experimentally acquired conversion rate curve by simultaneously thermal analysis (STA). Obtained separated peaks were deployed for application of iterative isoconversional approach in order to identification of activation energy and pre-exponential factor and together with theoretical conversion functions for a formulation of decomposition process mechanisms in particular case. This could be used for further pyrolysis process development and for valid selection of conversion technology for tested biomass material, taking into account the highest conversion process efficiency. Also, the presented methodology could be a possible use for the identification of thermal degradation stages and for facilitating the most reliable process for conversion of considered raw material into value-added products.*

**Keywords**

Biomass, Pyrolysis, Isoconversional, Kinetic modelling, Deconvolution functions,

**Acknowledgement**

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***Invited lecture***

# PROBABILISTIC APPROACH IN HEALTH RISK ASSESSMENT OF CHILDREN AND ADULT POPULATION EXPOSED TO POLYCYCLIC AROMATIC HYDROCARBONS – PAHS IN PRIMARY SCHOOL ENVIRONMENT IN SERBIA

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**Abstract**

*Polycyclic aromatic hydrocarbons (PAHs) are major air pollutants which strongly influence human health since many of them are toxic and carcinogenic. Children and school staff spend much of their time at schools, mostly indoors. Thus, hypothesis can be made that air quality may significantly impact on these two groups' health. A health risk assessment, represented by Incremental lifetime cancer risk (ILCR), was conducted in this study. Indoor and outdoor PAHs concentrations were measured in typical Serbian primary school. Total suspended particles (TSP) and gas-phase PAHs from air were collected both inside school building and in outside school environment. Average indoor and outdoor PAHs concentrations were used to calculate benzo[a]pyrene equivalent (BaPeq) concentration. A significantly higher BaPeq was observed in the gas-phase than in the TSP. This is associated with a high amount of low molecular PAHs present in the gas-phase. BaPeq concentration was fitted to appropriate distribution and used as an input parameter for probabilistic ILCR modelling. Different body weight and inhalation rate distributions were used for sampling during ILCR calculations. Sensitivity analysis showed that the two different recommended values of cancer slope factor had major impact on the ILCR values. Based on this, simulations were repeated using cancer slope factors for individual PAHs. The obtained ILCR values for both children and adults were greater than the significant level, indicating high potential lung cancer risk. It may be concluded that it is necessary to improve indoor air quality in schools applying measures for lowering TSP PAHs with high carcinogenic potential.*

**Keywords**

Polycyclic aromatic hydrocarbon, school population, incremental lifetime cancer risk, modelling, risk assessment

**Acknowledgement**

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# THERMO-ANALYTICAL CHARACTERIZATION OF VARIOUS BIOMASS FEEDSTOCKS FOR ASSESSMENTS OF LIGHT GASEOUS COMPOUNDS AND SOLID RESIDUES

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**Abstract**

*Thermo-analytical characterization of selected biomasses (agricultural and wood wastes) through the pyrolysis process was performed under dynamic conditions. Slow pyrolysis (carbonization) regime (with a heating rate below 50 $^{o}C\ min^{-1}$) was selected because it favours the residual solid (bio-carbon/bio-char) in higher yields (change in surface area of bio-char with pyrolysis conditions was dependent on the type of biomass feedstock). Comparison of results and discussions related to obtained percentage pyro char yields from the thermo-chemical conversion of biomass feedstocks were generated from simultaneous thermal analysis (STA) (TGA-DTG-DTA apparatus). Considering the obtained solid residues after pyrolysis, the assessment of selected biomasses for their use in preparation of bio-char based catalysts was implemented. The analysis of gaseous products of pyrolysis was carried out using mass spectrometry (MS) technique. Releasing of light gaseous compounds (mainly CO, CO2, CH4, and H2) was monitored simultaneously with TGA measurements. Release intensity and the temperature range of the occurrence of considered gases were taken into account during the analysis of the usefulness of given biomass, for its possible application in gasification (ΔT = 500 - 1300 °C). Discussion related to this issue was performed from the aspect of flexibility of fuels used, as well as the recovery of energy.*

**Keywords**

Thermo-analytical characterization; Biomass; Slow pyrolysis; Simultaneous thermal analysis; Mass spectrometry

**Acknowledgement**

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# Experimental Techniques

***Invited lecture***

# EXPERIMENTAL ESTIMATION OF AIRCRAFT SPAR FATIGUE LIFE

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**Abstract**

*Fatigue of materials and structures is a process during which cyclic loads, which are much lower than the static strength determined for this material or construction, cause damage leading to the formation of the cracks, their growth, expansion, and finally fracture. Theoretical bases of the appearance of fatigue due to cyclic loads are considered. The paper presents the experimental estimation of the fatigue life of the aircraft spar as the main structural element of the lightweight metal wing. Loads occurring under normal operating conditions of some structural elements can be shown with sufficient precision, for the needs of various engineering applications, using cyclic loads with constant amplitude and the mean value. The spar was made of aluminum alloy 2024-T3 and the load was performed in a symmetric cyclic form during the experiment. During the experiment, fatigue characteristics were measured. After processing the obtained results of the experiment, they are compared with the results obtained by the advanced numerical method.*

**Keywords**

Structure fatigue life, cyclic load, spar, constant amplitude load, metal wing structure.

# EXPERIMENTAL AND NUMERICAL INVESTIGATION OF THE T-STUB ELEMENTS WITH FOUR BOLTS IN A ROW UNTIL BOLT FRACTURE

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**Abstract**

*For the past several decades, codified design of steel connections in civil-engineering is based on the component approach. For a very common end-plate connection, tension component, named T-stub, usually dictates the connections' behaviour. This T-stub element is greatly investigated in the configuration with two bolts in a row, but configuration with four bolts in a row is usually neglected, both in the studies and codes. This paper presents an experimental investigation of T-stub elements and important aspects of their numerical modelling. Special attention is dedicated to the material testing and modelling since all of the tests were performed until bolt fracture. Uniaxial tests of steel specimens were performed using extensometers, strain gauges, and Aramis system, while bolt material is additionally tested by microscopic examination and hardness testing. In order to obtain satisfactory calibration of numerical models developed in Abaqus, knowing material parameters including damage initiation and propagation is crucial. Several iterative numerical-experimental procedures for obtaining the true stress-strain curves are outlined and compared, along with well-known Bridgman method. The advantages of using Aramis system in calibrating numerical model, for both material and assembly are demonstrated. In the end, comparisons of numerical and experimental behaviour curves are presented and satisfactory results are obtained.*

**Keywords**

T-stub element, experimental investigation, true stress-strain curve, Abaqus, Aramis system, Digital Image Correlation method

# DESIGN AND ANALYSIS OF THE EFFICIENCY OF THE VERTICALLY AXIAL WIND TURBINE

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**Abstract**

*There are significant efforts around the globe to develop effective systems for energy production from renewable sources such as wind energy. The replacement of so-called dirty technologies used for the production of energy from fossil fuels with modern clean technologies led to the development and testing of aerodynamic constituents of wind farms that can provide environmentally friendly and safe energy.*
*The objective of this paper is to present the analysis of the efficiency of vertical axis wind turbines that can be installed on the building roofs in big cities. Primary design of the turbine construction was based on idea to minimize the number of moving parts which could cause potential defects during the lifecycle. The rotor was design as a composite structure that should be resistant to stresses caused by complex weather conditions during the seasons.*
*Based on the results of two-dimensional numerical simulation of the vertical axis wind turbine motion, it can be concluded that there will be enough buoyancy forces on the rotor blades to create a torque around the axis of rotation and transform kinetic energy of the rotational movement into electrical energy.*
*Furthermore, comprehensive 3D simulation gives an even better picture of the streamlines and a clear path to the design and testing of the prototype. Due to the constant induction of the buoyant force (i.e. the moment), the continuous load on the construction will produce quieter motion of the blades, which is of great importance for people who would live in buildings under this type of wind turbine.*

**Keywords**

Wind energy, vertically axial wind turbines, composite structure, 3D simulation

# DEVELOPMENT OF THE EXPERIMENTAL METHODOLOGY OF STRAIN MEASUREMENT SIMULATED IN PARTLY-EDENTULOUS ARTIFICIAL MANDIBLE

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**Abstract**

*Examination of strain field underneath the teeth and bone structure of mandible for ''in vitro'' conditions requires thorough preparation of the examinee and equipment. For the purpose of examination of different regions of partly-edentulous mandible, the design solutions for examination of strain fields located on the determined points have been shown for different types of compensations.*
*Strain measurement was performed using contactless optical 3D system ARAMIS 2.0. Mandible model with several remaining teeth was additively manufactured using SLA technology. The measurement of acting force was performed using a dynamometer, with the maximum applied force intensity of 800N. The results of this study showed that developed experimental setup enables comparison of influence of different teeth geometries and metal compensation designs to the selected areas of artificial partly-edentulous mandible resulting in specific strain distribution.*

**Keywords**

Dental, strain field, additive manufacturing, optical 3D measurement, ARAMIS

# EXPERIMENTAL RESEARCH OF CHARACTERISTICS OF SHEARING RING

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**Abstract**

*Development of passive safety elements represents one of the most complex fields of mechanical engineering and requires practical and theoretical knowledge equally. A new standard EN15227 directed at railway vehicle structures defines the dimensions and phases of deformation of the end-of-vehicle structure during collision. Serbian railways have many passenger wagons over 20 years old that have no crash elements. These wagons are equipped with a standard buffer in accordance with UIC regulations. The challenge, therefore, is to install crash elements in line with the standard buffer as well as to define a moment when the crash element starts energy absorption. A shrinking tube absorber has the most acceptable absorption characteristics as well as being compact and compatible with the dimensions of standard buffer. In this research, the joint between the standard buffer and the collision energy absorber is a shearing ring designed to break in a specific way at a specific force. The standard buffer is designed to withstand a force of 800 kN without permanent deformation. When the force exceeds this value, the spring in the standard buffer is blocked and the shearing ring breaks, activating the energy absorber. The shearing ring is made from quenched and tempered carbon steel that has passed adequate thermal treatment. Dimensioning of the shearing ring required a series of experiments to determine mechanical characteristics using reduced- and full-scale samples. Final verification of dimensions and working principles of shearing ring was done via collision of two passenger coaches.*

**Keywords**

Passive Safety, Railway Vehicles, Shearing Ring, Experimental Research

**Acknowledgement**

The research work is funded by the Ministry of Education, Science and Technological Development of Republic of Serbia through national projects TR35045 and TR35006.

# WHEEL-RAIL CONTACT FORCES MEASUREMENTS USING STRAIN GAUGES APPLIED ON THE RAILS

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**Abstract**

*The paper presents practical application of originally developed method for wayside measurements of wheel-rail contact forces using strain gauges and an overview of recently developed similar methods presented by different authors. Presented methods were compared and some of their advantages and disadvantages were identified, including convenience for practical use. Some problems related to preciseness of location of the strain gauges application were emphasized. The main task for achieving reliable and accurate measurement results using any method is to identify locations on the rail where it is possible to avoid crosstalk and to separate influence of the vertical forces and contact point position on the lateral forces measurements. Although different authors identified such locations, it appeared that in real on-site measurements due to existence of geometry imperfections of the rails, non-uniform foundation stiffness and other influencing conditions, calibration and some post-processing of the recorded data is often needed. Also, in order to obtain reliable results involvement of alternative ways for validation of the obtained results is very welcome including use of alternative methods like identification of the contact point(s) and comparison with calibration curve families.*

**Keywords**

wayside , wheel-rail contact forces measurements, strain gauges, crosstalk

**Acknowledgement**

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# LABORATORY MEASUREMENT AND CALIBRATION EQUIPMENT - EXAMPLES OF GOOD PRACTICE AND CHALLENGES

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**Abstract**

*Over the past 60 years, WIKA has built a reputation as a renowned partner and competent specialist for various tasks in the field of measurement technology. Over 10.000 employees are dedicated to maintain and improve technology in pressure, temperature, force, and level measurement, and also in the fields of flow measurement, calibration and SF6 gas solutions. In close co-operation with recognised universities, institutions and industrial companies, solutions for specific applications are designed and developed.*
*The most important thing in every company from the field of measurement technology is that measurement equipment is specified in the right way. After this first step users must seriously take care of calibration and service of measurement devices. Everything that is important for production should be calibrated according to the calibration plan.*
*In this paper the analysis of practical problems in engineering practice occurring when in the production process is measurement equipment that was not calibrated is presented. Also, through the results obtained in the field, the guidelines are given to reduce the risk of production failure and the cancellation of individual production processes, when there are good planning and maintenance of measuring equipment.*

**Keywords**

Laboratory measurement; calibration equipment; measuring equipment; good engineering practice

# EXPERIMENTAL INVESTIGATION OF TI-6AL-4V ALLOY FATIGUE CRACK GROWTH PARAMETERS

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**Abstract**

*Analysis of stress and strain at the tip of fatigue crack by means of linear elastic fracture mechanics has led to the formulation of well known Paris' equation which brings fatigue crack growth speed (da/dN) and stress intensity factor range at the crack tip (ΔK) in a relation.For the purpose of determining the fatigue crack growth parameters of titanium alloy Ti-6Al-4V a standard Charpy specimen was used and a three - point bending method on a resonating high - frequency pulsator. Standard fracture mechanics tests on notched specimens can provide insight into the fracture behaviour of materials under constrained deformation, i.e. under a three-dimensional stress state. Specimens were taken from a plate with dimensions of 80x300x30 mm, made of Ti-6Al-4V alloy. In order to monitor the increment of crack length, strain gauges were applied to the specimens. The obtained frequency was in the range from 215 to 235 Hz, while the stress ratio was R=0.1. Average load and it's amplitude were registered with the ±3 Ncm accuracy. All tests were conducted at room temperature. Test results are intended for the finite element method (FEM) and extended finite element method (XFEM) analysis of bone fixation implants made of Ti-6Al-4V alloy.*

**Keywords**

Ti-6Al-4V alloy, fatigue crack growth, stress intensity factor, experimental testing, fracture behaviour

**Acknowledgement**

The authors of this paper acknowledge the support for this investigation by Serbian Ministry of Education, Science and Technological Development for projects TR35011 and TR 35040.

# THE SELECTION OF AN OPTIMAL SANDING SYSTEM FOR THE COATED MEDIUM DENSITY FIBERBOARD

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**Abstract**

*Medium density fiberboards (MDF) are often used in the manufacture of furniture and elements of the interior. MDF are most often coated with pigmented coatings which cover their inconspicuous surface and increase the value of the product by improving its visual characteristics. When coating the surface of MDF, it is necessary to sand the first layer of the coating to eliminate the surface irregularities that occur as a result of the substrate preparation process and/or the coating application process. In addition, sanding provides a flat surface and a good base for the following layers of coating. Sanding is most commonly performed on sanding machines consisting of cross-cut and longitudinal units equipped with chevron belts. This paper examines the impact of the selection of sanding units and the feed speed on the quality of the MDF coated with two types of coating: water-based (WB) and polyurethane (PU). The sanding speed was set to 5m/s and the sanding was done in two stages using following grits of sanding paper: 240 and 320. It was found that the lowest roughness expressed by the roughness parameters (Ra, Rz and Rt) is obtained by using the cross-cut unit in both stages. The lower roughness values were obtained at a higher feed speed (12 m/min) for PU-coated MDF,and lower feed speed (8 m/min) for WB-coated MDF. The differences at the recommended feed rates can be explained by the differences in the coating properties.*

**Keywords**

Medium Density Fiberboard, Coating, Sanding, Surface Roughness

# EXPERIMENTAL DETERMINATION OF TYPE OF FRACTURE PLA SPECIMENS IN THE FUNCTION OF PRINTING CONDITIONS

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**Abstract**

*Fused Filament Fabrication (FFF) represent one of the technologies to process polymer materials in the way of rapid prototyping. Parts produced by this method not so rarely have good mechanical properties in the tangential direction in relation to the direction of the layers, but at the same time poor in the normal direction. In order to produce a part that has desired mechanical properties in all directions, it is necessary to precisely established printing conditions, which is one of the goals of this paper. Tensile strength experiments were conducted on bio-based plastic PLA (polylactic acid) specimens. Specimens were produced on a 3D printer, with printing speed from 40 up to 120 mm/min, and nozzle temperature from 170 up to 210 °C. It was established that tensile strength has a great dependence on the printing conditions. Also, the type of fracture varies depending on printing temperature. Although there is a trend of maximal deformation growth with increasing printing temperature, at lower printing temperature, more ductile fracture of the specimens occurs. Increasing the printing temperature, fracture of the specimens becomes more brittle. At the transition from one to another, tearing of the specimens occur. Such results play a key role in the successful implementation of such a processing type of polymer materials in the automotive, aerospace, medical, etc. industries.*

**Keywords**

Fused Filament Fabrication, PLA, Rapid prototyping, Tensile strength

**Acknowledgement**

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# Numerical Methods

***Invited lecture***

# ISO 9001:2015 AS A FRAMEWORK FOR CREATION OF A SIMULATION MODEL FOR BUSINESS PROCESSES

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**Abstract**

*Establishing quality management systems within an organization has a goal to facilitate establishment of its total performances and achievement of a sustainable development. New release of ISO 9001:2015 standard has brought rudimentary changes making opportunities for the effective accomplishment of these goals. Numerous researches on this topic highlight the fact that the use of a technique for knowledge discovery has a big impact on the fulfilment of requests set in ISO 9001standards.*
*Based on the results of these researches, the authors decided to research a possibility for the creation of tools for knowledge discovery through the respect of principles, requests, and recommendations of this standard. The development of such a tool (simulator) would have a goal to predict future states of business processes of an organization what is the base for performing an efficient risk estimation and optimization of business processes.*
*This paper describes an approach to the development of such a tool (simulator) based on key business processes in an organization, data on the realization of these processes during the time, as well as placing them into a context of selected statistical methods.*

**Keywords**

ISO 9001:2015, process approach, simulation, big data

# NUMERICAL AND EXPERIMENTAL MODAL ANALYSIS OF ALUMINIUM AND COMPOSITE PLATES

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**Abstract**

*The paper presents the comparative analysis of the dynamic behaviour of two rectangular plates of different material, aluminium and composite. While their global geometric dimensions (length, width and thickness) are identical, their inner structures are quite different. Whereas aluminium plate can be considered isotropic, composite plate is a unidirectional carbon-epoxy laminate.*
*Modal characteristics of the two plates were determined both numerically and experimentally and a comparative analysis of the obtained results was performed. Responses of the plates were documented by an optical, contactless 3D digital image correlation (DIC) system that contains a set of high-speed cameras capable of recording the movement of the white-and-black stochastic pattern applied to the upper surfaces of the plates. Numerical simulations were performed by the finite element method (FEM) in the commercial software package ANSYS. The plates were excited by a modal hammer and allowed to freely oscillate. In order to determine the natural frequencies of the plates the recorded time-domain responses were post-processed, i.e. converted to frequency domain by fast Fourier transform (FFT). The first three natural modes were successfully experimentally established and compared to the corresponding numerical values. Since the differences between the two sets of results are less than 5%, the applied experimental technique can be considered valid and suitable to a wide range of engineering problems involving vibrations.*

**Keywords**

Aluminum plate, Composite plate, DIC, FEM, FFT.

**Acknowledgement**

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# CHARACTERIZATION OF HYSTERESIS PROPERTIES OF RUBBER-METAL BEARING OF ELECTRIC DRIVE

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**Abstract**

*The current trend towards increasing the volume of production of vehicles with electric or hybrid powertrain also leads to the expansion of R&D activities in this segment as new areas of construction nodes appear. One of the current areas that the present paper deals with is the idea of reducing the vibration transfer from the traction electric motor to the support structures of the vehicle, which is a source of high frequency vibration in the range of up to 2000 Hz (combustion engine is a source of vibration up to 150 Hz). To reduce the vibration transfer to the support structures of the vehicle, rubber-metal elements are used. Rubber-metal elements have specified dynamic properties such as the dynamic stiffness, the loss angle and hysteresis properties. Hysteresis properties are important to define the damping properties of rubber-metal mount. The parametric model was created for modeling of hysteresis properties. The results from simulations are compared with experimental data.*

**Keywords**

Rubber-metal mount, electric vehicle, powertrain, hysteresis properties

**Acknowledgement**

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# AN APPLICATION OF VLES TURBULENT FLOW SIMULATION METHODOLOGY TO FLOW OVER SMOOTH HILLS

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**Abstract**

*This study aims at examining predictive capabilities of a specific global (non-zonal) hybrid RANS/LES turbulent flow simulation strategy in the case of flow over smooth hills. The rationale behind recent popularity of such an approach are constraints on computational resources when one is faced with practical LES for realistic engineering flows. In present approach, which originates from the seminal work of Speziale, simulation is performed on coarser computational meshes then required by LES constraints, where the large part of turbulent kinetic energy is unresolved. A challenge of accurate prediction of wall-bounded flows is approached in hybrid models by blending two approaches (RANS and LES) into a single global model, whereby switching is applied seamlessly based on considerations of turbulent flow and grid scales. The RANS part of the hybrid model is supposed to be active in the vicinity of the wall, and the swift transition to LES model should be performed away from the wall, on a desired distance defined by calibration of switching parameters. In our study we perform transient VLES simulation on a model of smooth hill at laboratory scale, resembling well documented water tunnel experiment, and study in detail statistical flow properties by comparisons with the experimental results. Special attention is given to hybrid model switching behavior in the said case. The study gives very useful insight into simulation of flows of the industrial and environmental types.*

**Keywords**

Turbulent flows, numerical simulation, turbulence model validation, hybrid RANS/LES, Very Large Eddy Simulation

**Acknowledgement**

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# CONTINUOUS SINGULAR TIME DELAY SYSTEMS:

# FINITE TIME BOUNDNESS ON TIME VARYING SETS

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**Abstract**

*In this paper, the concept of finite time boundedness (FTB) for linear continuous singular system with time delay is induced. A sufficient condition for the finite time boundness of linear forced systems of the form* $E\dot{\mathbf{x}}(t) = A_0\,\mathbf{x}(t) + A_1\,\mathbf{x}(t-\tau) + F\,\mathbf{z}(t)$ *is presented. Moreover, the systems trajectories should maintain within the time varying sets, which are open and connected and limited on finite time interval under the consideration. The general condition is reduced to a feasibility problem involving linear matrix inequalities (LMIs). The proposed method was compared with the previously developed and reported methodologies. It was concluded that the stability investigation using the novel condition for stability was less complicated for numerical calculations. Furthermore, it gives better results in comparison with the ones obtained with other analyzed conditions and it provides superior contributions in the sense that they are less restrictive for class of system under consideration. Finally, an example is given to show the validity of the results.*

**Keywords:**

Singular linear time delay systems, Finite time boundness, LMI methods.

**Acknowledgement**

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# STABILITY OVER FINITE TIME INTERVAL OF SINGULAR TIME DELAY SYSTEMS: BASED ON CLASSICAL AND LMI APPROACH

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**Abstract**

*In this paper, the finite time stability of linear continuous singular time-delay systems is studied. By using suitable Lyapunov-like function and LMI approach, a sufficient condition is derived as a set of algebraic inequalities. In that sense the concept of simultaneous stability and attractiveness is extended to continuous singular time-delay systems and some conditions have been derived using two approach based on the classical aggregation functions defined on the space of consistent initial conditions: classical and LMI approach. The first approach is based on the algebraic matrix transformations, while the second approach uses the linear matrix inequalities. In the both cases the proposed functions do not have a need to be positive-definite in the whole state space, and there are no needs to have negative first derivatives along the system trajectories LMI approach provides a simple numerical solution and does not impose additional restriction on the state vector. The comparison of this method with some previous one is done and it has been showed that the numerical computation is reduced. Numerical example is given to show the effectiveness of the proposed approaches.*

**Keywords:**

Singular linear time delay systems, Finite time stability, LMI methods.

**Acknowledgement**

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# NUMERICAL SIMULATION OF CRACK PROPAGATION IN SEVEN-WIRE STRAND

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**Abstract**

*This paper discusses certain aspects of numerical simulation of crack propagation in wire ropes subjected to axial loading, with the aim to explore and to demonstrate the capacity, performances and difficulties of crack propagation modelling by usage of numerical computational methods in such complex structures. For this purpose, the finite element method (FEM) was used, and 3D numerical analyses were performed in Ansys Workbench software. In order to validate and verify performed numerical modelling, fatigue life based on calculated stress intensity factors (SIFS) along the crack fronts was obtained for the model for which experimental results could be found in the available literature. Finally, using the advanced modelling techniques, the parametric 3D model of seven-wire strand was analysed. Conducted analysis showed that FEM could be a powerful tool for fatigue life predictions in order to reduce the need for experiments which are still the only successful method for fatigue life estimation of wire ropes.*

**Keywords**

Crack propagation, Finite element method, Stress intensity factors, Wire rope strand

**Acknowledgement**

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***Invited lecture***

# FATIGUE CRACK GROWTH AND RESIDUAL LIFE ESTIMATION USING STRAIN ENERGY DENSITY METHOD

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**Abstract**

*In this paper is formulated complete computational procedure based on strain energy density (SED) method for residual fatigue life prediction of crack propagation phase. In this investigation, the prediction of crack growth life under uni-axial stress condition is studied by using energy concept. The model is based on a strain energy density generated ahead of a fatigue crack. Mathematical relations are expressed in terms of low cyclic material properties. The wing skin was analyzed as damaged aircraft structural component. In order to calculate corrective function (which includes geometry of structural element) important for fatigue crack estimation, analytical and finite element methods (FEM) are used to determine stress intensity factors. The accuracy of the modeling for cracked wing skin is validated with experimental results. The most important fact is that the formulated computational procedure based on strain energy density concept does not require any additional material costs for experimental research except for those needed for fatigue crack initial prediction. Due to this fact, it is possible to determine total fatigue life prediction of considered structural component. A good agreement was found between the predicted and the experimental data for cracked structural component. Verification of computational model with experimental data shows that proposed model can be used in engineering application.*

**Keywords:**

Crack growth analysis, Low cycle properties, FEM, Numerical simulation, Aircraft wing skin

**Acknowledgement**

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# JAK/STAT SIGNALLING PATHWAY IN DIABETES: MATHEMATICAL MODEL AND DYNAMICAL ANALYSE

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**Abstract**

*Diabetes mellitus is metabolic desease which is characterized by hyperglycaemia. Millions of people around the world live with diabetes. Regardless of the type of diabetes, diabetes is not yet a curable, but is very treatable disease. Recent research on signalling pathways found that JAK/STAT signalling pathway has important role and is required for normal homeostasis. When dysregulated it contributes to development of obesity and diabetes. JAK/STAT is present in brain, liver, muscle, fat and pancreas, and all these affects the course of disease. The aim of this paper is to understand biological mechanism and signalling pathways in diabetes, and particularly to JAK-STAT signalling pathway, for which we propose biochemical and mathematical model, and run simulation. We look for the control elements and recognize SOCS1, SHP 2, and phosphatases PNP and PNX as main control elements. For the chosen parameter data from the literature we run simulations, and we give qualitative conclusions. Further study will focus on dynamical analyse and bifurcation study in order to look for main regulatory molecules, system states and possible drug targets.*

**Keywords**

Diabetes, JAK/STAT signalling pathway, mathematical model, regulatory molecules, dynamical analyse

# PERSPECTIVE IN PARKINSON'S DISEASE: CROSSTALK AND DYNAMICAL MODELING OF SIGNALING PATHWAYS

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**Abstract**

*In this paper, we focus on finding signalling pathways that influence Parkinson's disease, and their crosstalk. Parkinson's disease affected more than 6 million people and typically occurs in people over the age of 60. Parkinson's disease is a slowly progressive neurodegenerative disorder that has a long lifespan, but with symptoms that are worsening over years. Here, we briefly review causes, symptoms, and hallmarks of neurodegenerative disease. Causes of Parkinson's disease can be genetical and environmental. Hallmarks of Parkinson's disease are a build-up of proteins into Lewy bodies in the neurons of midbrain part of substantia nigra that controls movements of the body. The disease is a result of the brain impairments in regions of brain that are correlated to movement, speech, sleeping, thinking and else. Damaged nerve cells in these regions lead to difficulty in functioning or in dysfunction. Symptoms like shakiness, slow movements, tremors, walking and balance problems start to appear. Also, depression to bladder problems is possible. Hallmarks are further connected with cellular systems dysfunction and signalling pathways. Pathways that are more explicitly involved in cell death are JNK signalling, p53 activation, cell cycle reactivation, and signalling through bcl-2 family. Further research will be focused on exploring these and finding other signalling pathways and performing mathematical modelling, dynamical and bifurcation study, in order to investigate states, dynamics and possible drug targets for regulating abnormal proteins or gene mutations, and to possibly revert normal functioning of cellular systems.*

**Keywords**

Parkinson's disease, signaling pathways, dysfunction, mathematical modeling, dynamical analyze

# RESIDUAL FATIGUE LIFE ESTIMATION OF STRUCTURAL COMPONENTS UNDER MODE-I AND MIXED MODE CRACK PROBLEMS

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**Abstract**

*The paper presents a residual fatigue life prediction methodology of cracked structural components under interspersed mode – I and mixed-modes (I and II). The numerical computation methods and procedures for predicting the fatigue crack growth trajectories and residual fatigue lives of notched structural components were analysed. The special attention, in this paper, was focused on notched structural components, such as aircraft wing skin type structural components under mixed modes and cracked aircraft lugs under mode-I. Stress intensity factor (SIF) solutions are required for assessment fracture strength and residual fatigue life for defects in structures or for damage tolerance analysis recommend to be performed at the stage of aerospace structure design. A variety of methods have been used to estimate the SIF values, such as approximate analytical methods, finite element (FE), finite element alternating, weight function, photo elasticity and fatigue tests. Also, the analytic/numerical methods and procedures were used to determine SIF and predicting the fatigue crack growth life of damaged structural components with notched cracks. For this purpose finite element method (FEM) has been used to derive analytic expressions for SIF of cracked structural components. To obtain the stress intensity factors of cracked structural components special singular finite elements were used. The strain energy density method (SED) and MTS criterions have been used for determination of the crack growth trajectories in thin-walled structures. Computation results were compared with experiments.*

**Keywords:**

fracture mechanics, residual fatigue life, FEM, mixed modes, crack growth trajectory

**Acknowledgement**

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# STABILITY AND FAILURE ANALYSIS OF LAYERED COMPRESSED COMPOSITE PANELS USING FEM

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**Abstract**

*Attention in this investigation is focused on stability and initial failure analysis of layered shell type structural components. In order to improve confidence in composite structures design, a better description of the failure of laminates is necessary. In this paper the buckling and postbuckling behaviour of axially compressed layered composite panels is studied by means of Finite Element Method (FEM). A series of experiments were conducted to verify the FEA-results, but also to address the stability and strength of the composite structure. Combining a geometric nonlinear finite element analysis (FEA) based on the von Karman theory and High Order Shear Deformation Theory (HOST) are used to study the first-ply failure behavior as well as the postbuckling behavior of layered type composite structures. For this purpose and for the investigation of the initial failure responses improved 4-node layered shell finite elements are used. The finite element formulation is based on the third order shear deformation theory with four-node shell finite elements having eight degree of freedom per node. A simple method is proposed to predict buckling loads and the post-buckling behavior. Comparisons between numerical and experimental results show quite a good agreement.*

**Keywords:**

Composite structures, Initial Failure Analysis, Postbuckling behavior, FEA

**Acknowledgement**

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# New Technologies

# SEMI-QUANTITATIVE ASSESSMENT OF SALIVARY GLAND FUNCTION IN PATIENTS WITH DIFFERENTIATED THYROID CARCINOMA AFTER RADIOIODINE THERAPY

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**Abstract**

*Objective: Radioiodine-$^{131}$I therapy (RAIT) has been established as an effective treatment for differentiated thyroid carcinoma (DTC). One of the most common complications is salivary gland damage, associated with early and late-onset complications.This prospective study was conducted to determine the effect of RAIT on the function of salivary glands using $^{99m}$Tc- pertechnetate scintigraphy.*

*Methods: Twenty five patients with post-surgical DTC were referred for RAIT. Before and 4-6 months after RAIT, salivary gland scintigraphy with $^{99m}$Tc-pertechnetate was performed. Regions of interest were drawn over the parotid and submandibular glands and respective backgrounds. Time-activity curves were generated and semiquantitative functional parameters, were calculated: maximum uptake fraction (MUF) and excretion fraction (EF).*

*Results: When compared between pre-ablation and post-ablation, MUF of bilateral parotid and submandibular glands were significantly increased ($p<0.001$ and $p=0.040$ respectively). Mean EF, for parotid glands was reduced as compared to baseline measurements ($p=0,003$). When compared between pre-ablation and post-ablation, EF for submandibular glands were significantly decreased ($p=0.042$). The semiquantitative scintigraphic analyses showed functional deficits with greater involvement of the parotid glands. There was not a significant positive correlation between the given $^{131}$I dose and salivary glands impairment.*

*Conclusion: The semiquantitative scintigraphy analysis showed damage to the parotid and submandibular glands. Therefore, more emphasis should be placed on salivary gland dysfunction during follow-up for DTC patients.*

**Keywords**

radioiodine therapy, differentiated thyroid carcinoma, salivary glands

# USE OF $I^{-}131$ AFTER SURGERY IN PATIENTS WITH DIFFERENTIATED THYROID CANCER: AN INFLUENCE OF GENDER

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## Abstract

***Background***: *Differentiated thyroid cancer (DTC) is a common malignancy and is increasing in incidence. Although, patients with DTC have a good prognosis, recidive development can negatively affect their prognosis. The aim of this experimental study was to gain more information about DTC recidive occurring.*
***Study design***: *This study was performed using Surveillance Epidemiology among 300 patients, diagnosed with DTC, that undergo thyroid surgery.*
***Methods***: *The demographic, clinical and pathological characteristics of selected patients were compared. Also, correlation between age at the operation (AO) and age at the moment of recidive (AR) with years after operation when recidive occurred was performed.*
***Results***: *Years of patients ranged from 9 to 79. Mean and median ages in our study were the same, 44 years. Majority of patients 85.6% (257 patients) were female. A 110 patients have received $I^{-}131$ treatment after surgery. Recidive have occurred in 32 patients, 11 male (OR= 3,86) and 17 female (OR=1.93). At the moment of recidive diagnose, years of patients ranged from 16 to 80. Mean age was 51,74 while median was 53 years. Pearson r was -0,03, for correlation between AO and years after operation when recidive occurred, and 0,1 for correlation between AR and years after operation when recidive occurred.*
***Conclusion***: *This experimental study indicate that recidives more frequently occurs in male which indicates the need for more aggressive treatment of this diseases in male. Additionally, there was no correlation between AO and AR with time that will past after operation before recidive occurred.*

## Keywords

Differentiated thyroid cancer, recidive, $I^{-}131$

# TO GIVE OR NOT TO GIVE DIURETICS AFTER TREATMENT OF DIFFERENTIATED THYROID CANCER WITH $^{131}$I, IN ORDER TO DECREASE RADIATION BURDEN TO THE PATIENTS?

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**Abstract**

*After surgery, radioiodine therapy is a usual treatment in patients with differentiated thyroid carcinoma (DTC). Radioiodine ($^{131}$I) is mostly excreted by the kidneys; one of procedures for enhancement of $^{131}$I excretion can be use of diuretics. The aim of this experimental study was to investigate the effect of hydrochlorothiazide (HCTZ) and furosemide administration on the excretion of $^{131}$I compared to controls who haven't received diuretics.*

***Subjects and methods:*** *Study included 90 patients with DTC, normal renal function and low $^{131}$I uptake in the thyroid region. Patients were divided into three groups: HCTZ, furosemide and the control group. Patients underwent measurements of the exposition dose of $^{131}$I by a survey meter with pancake probe, right after $^{131}$I administration and after 72h. On the basis of the initial and the exposition dose after 72h, expressed as percentage of the initial exposition dose, and considering the administered radioactivity, the residual activity in body was calculated and expressed in megabecquerel/gigabecquerel (MBq/GBq).*

***Results:*** *The residual activity in the body and the exposed dose after 72h were higher in HCTZ group (71.61 vs. 60.70MBq/GBq and 7.05% vs. 6.14%) compared to controls, but this difference was not significant. These parameters were significantly higher in furosemid group compared to HCTZ (11.24% vs. 7.05%, p=0.031 and 112.31 vs. 71.61MBq/GBq, p=0.017) and control group (112.31 vs 60.70MBq/GBq and 11.24% p=0.025 vs. 6.14%, p=0.009).*

***Conclusion:*** *In this experimental study we showed that use of diuretics as additional treatment after radioiodine therapy in patients with DTC increases radioiodine retention in patient's body.*

**Keywords**

Thyroid carcinoma, hydrochlorothiazide, furosemide, radiodine

# APPLICATION OF 3D PRINTING IN THE METAMATERIALS DESIGNING

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**Abstract**

*In the last couple of years, 3D printing has become one of the most popular manufacturing techniques in designing of the new prototype parts, mechanisms and machines. Available and relativly cheap 3D printing techniques allows fast manufacturing of different complicate prototypes (rapid prototyping) by using plastics as base material, like FDM. In the most cases, these prototypes are used only for functionality testing and design analyzing, yet that is a small part of the possibilities that 3D printing can give in parts design. For example, 3D printing can be utilized for creation of the cheap personalized limb prosthesis, toward specific needs of each patient. One of the biggest advantages of the method is production of the complex geometric shapes, done layer by layer, which provides a new level of freedom in part design and significantly impact their final characteristics, since conventional techniques of parts manufacturing have many limitations. By modifying the inner geometric structure of the parts produced from regular material, new properties of the engineered part are obtained, with different behavior, which the starting material didn't have. This, engineered materials are named metamaterials. Using the metamaterials it is possible to produce parts with properties that doesn't appear in nature. This paper will present how new parts, mechanisms, and machines can be designed and manufactured using metamaterials and 3D printing.*

**Keywords**

3D printing, Metamaterials, Internal structure, Smart design.

**Acknowledgment**

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# BIOMECHANICS OF CAD/CAM AND CONVENTIONAL ALL CERAMICS

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**Abstract**

*The following study represents an application of CAD/CAM technique for obtaining all ceramics crown for biomechanical investigation. Unlike conventional/standard procedure of manufacturing all ceramics crown restorations, CAD CAM implies 3D technologies of scanning and then milling ceramic blocks. The aim of this study was to compare toughness between conventionally produced all ceramic crowns and CAD/CAM (Sirona, CEREC) crowns by employing different methods for biomechanical investigations (3D and tensile testing machine). IPS e.max Lithium Disilicate was tested as a material of choice for both, conventional and CAD CAM crowns. Both crowns were placed in sity upon models made of PMMA blocks and the identical implants with straight abutments (Straumann, Germany). Experimental crowns were dynamically tested and the moment of crown fracture was marked as critical when interpreting results. Certain difference was found in the time for crack between two types of experimental crowns, highlighting CAD/CAM crown which showed better mechanical performance under dynamic loads.*

**Keywords**

CAD/CAM, all ceramic crown, conventional crowns.

# A WEAR LEVEL OF DENTAL MILLING TOOLS ASSOCIATED WITH MICROSTRUCTURAL CHARACTERISTICS OF ALL CERAMIC BLOCKS

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**Abstract**

*So far, it was shown a connection between microstructural characteristics of materials used for manufacturing CAD/CAM blocks and milling tools (instruments/burrs) in CAD/CAM machine that serve for milling, grinding and producing the final form of the dental restorations in CAD/CAM process. The goal was to compare the milling CAD/CAM tools by visual inspection (locally) and SEM (scanning electron microscopy). CAD/CAM technology (Sirona, CEREC) was employed for milling three types of ceramic blocks: Vita Enamic, Ips e.max Lithium Disilicate and Zirconia blocks. Findings provided that microstructural characteristics of applied all ceramic blocks influenced on the quality of the cutting-blade of milling tools. The highest worn level was found in tools for Zirconia block millings. Vita Enamic block was found to be a favourable material regarding the level of worn compared to Lithium Disilicate block. This type of study plays an important role in dental industry and technology, but also for current dental practitioners.*

**Keywords**

CAD/CAM milling, CAD/CAM tools, All ceramic blocks, SEM

***Invited lecture***

# SPECIFICS IN PRODUCTION OF FIXED PARTIAL DENTURES USING 3D PRINTED CAST PATTERNS

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**Abstract**

*Present paper deals with the specifics in production of fixed partial dentures (FPD) using 3D printed cast patterns. The cast patterns of four-part dental bridges were manufactured of polymer NextDent Cast using RapidShape D30 printer. Two cases of application of cast patterns were analysed – for production of press-ceramic and metallic constructions. The metallic samples were cast by centrifugal casting of Co-Cr and Ni-Cr dental alloys using different investment materials and heating regimes of the casting mold. The dimensions of polymeric cast patterns and cast bridges were measured.*

*It was established that for production of FPD with high accuracy and high adhesion of porcelain coating, precise cast patterns should be manufactured by 3D printing. The dimensions of virtual model should be corrected with coefficients, specific for each axes and application. The increased roughness of 3D printed cast patterns is disadvantage in dental constructions with high smoothness requirements and advantage for metal-ceramic FPD. Therefore, the position of patterns with respect to the building direction should be different for FPD of press-ceramics and cast infrastructures for metal-ceramics. In the first, vertical axes of teeth must be parallel to the print direction Z-axis, and in the second, they have to be at an angle between 45° - 70° to the base. For ensuring high adhesion strength of porcelain coating in metal-ceramic restorations, surface smoothing operations should not be applied to 3D printed cast patterns. The revealed specifics will be very useful in dental practice for manufacturing of accurate FPD using 3D printed cast patterns.*

**Keywords**

Fixed partial dentures, 3D printing, cast patterns, casting, press-ceramic

# DIMENSIONAL ACCURACY OF DENTAL MODELS PRODUCED BY SLA 3D PRINTING TECHNOLOGY

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**Abstract**

*Dental models are used as working models for planning and making dental crowns and bridges. Conventional methods are based on taking impressions of patient's upper and lower dental arches and require a labour-intensive manual process to create dental models. Manufacturing dental models digitally from 3D scans and subsequent 3D printing simplifies the workflow, speeds the process and lowers the costs. Except significantly reduced manufacturing time compared to conventional methods, increase in dimensional accuracy is also noticeable. Any deviation from real dimensions, especially of the remaining dental tissues, results in non-fitting of crowns and bridges, or failure in insertion. Nowadays, Stereolithography (SLA) 3D printing technology is commercially available and represents an alternative technology for dental model manufacturing in terms of production cost and speed.*

*Most SLA printers have small platform surface, and if there is a demand to print many models at once there is a request for printing them on a steeper angle. That requires more layers of print, which may influence the dimensional accuracy of a model. The objective of this paper was to assess the influence of selected orientations of dental models during printing, i.e. number of layers necessary to print a part. Dimensional accuracy was compared of dental models with 0 deg., 45 deg., and 90 deg. printing angle, according to the platform. Printed dental models, of different printing orientations, were scanned using Geomagic Capture® industrial-grade 3D scanner and attained models compared to .stl files, on the basis of which the printing was performed.*

**Keywords**

Dental model, Dimensional accuracy, 3D printing, Stereolithography (SLA), 3D scanner

**Acknowledgement**

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# DEVELOPMENT OF APPLICATION SOFTWARE FOR AUTOMATIC MANUFACTURING TECHOLOGY DESIGN OF FREE FORM SURFACES

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**Abstract**

*Development and usage of a software application representing a CAD/CAM system for automatic manufacturing technology design for parts with free form surfaces is presented. The system provides tool path generation for manufacturing input CAD models of a workpiece and a part, which will represent optimal tool path for multi criteria optimization methods. Based on already developed and implemented procedures for tool path generation and optimization, it allows usage without any user's expertise in the field of CAD/CAM systems. Obtained tool path is generated based on the loaded part and workpiece CAD models according to multi criteria optimization method which is implemented in system. The optimal tool path for manufacturing will be generated, which will be performed in the shortest time possible, having appropriate surface precision and quality. Developed procedures which are implemented in this system are the result of years of research in this field at the Department of Production Engineering, Faculty of Mechanical Engineering, University of Belgrade, Serbia. For the purpose of developed cutting force model, cutting coefficients were experimentally determined for tool/workpiece geometry and material blend. Research was conducted for combination of aluminium workpiece and ball end mill of HSSE steel. The application software is developed in MATLAB as a GUI interface and it allows generation of control (G) codes for rough and finish machining for the tool stored in the application database. According to the generated control codes by this developed software, several parts were manufactured using the ILR HMC 500/40 machine tool in order to verify developed procedures for tool path generation and optimization. Based on the conducted experiment, it was concluded that the machining was performed in allowed tolerances and cutting conditions which confirm the usability of the developed software application.*

**Keywords**

CAD/CAM systems, Free form surfaces, Tool path optimization

**Acknowledgement**

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# Industry and Sustainable Development: Contemporary Management Perspectives

***Invited lecture***

# WHEN INNOVATION IS NOT ENOUGH: IDENTIFYING VALUE FOR CUSTOMERS

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**Abstract**

*Technological development and innovations are key words noticed in many scientific and business discourses. Still, focusing exclusively on providing better and more innovative products/services is just not enough. As many noted (eg. Dillon, 2011, Schlossberg, 1990) from 80 to 95 % of newly introduced products/services to the market will fail on the market. Others (Castellion and Markham, 2013) argue that those rates are significantly lower, approaching 40 %. Nonetheless, newly introduced products to the market have a great chance of failure. On the other side, market orientation researchers argue that with proactive market orientation product success is more likely to occur (Narver, Slater and MacLachlan, 2004) or that market orientation is influencing company creativity that in turn influences new product success (Im and Workman, 2004). Hence, it is of a great importance for each company to focus on market orientation, and explore how it is contributing to new product success. In the age where sustainability is emphasized and companies are searching for ideas how to provide more value to its customers, market orientation should not be neglected. Market orientation, in its basis, has customers and providing value to them. Through researching customers' needs and wants and delivering superior value to customers (value that customers perceive as important), companies can be successful on the market. Consequently, innovation becomes not the driver but the mean of providing value to customers.*

**Keywords**

Market orientation, customer value, innovation

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# IDENTIFYING INFLUENCE OF SUPPLIER BENEFITS ON COLLABORATION BETWEEN PARTNERS

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**Abstract**

*Collaboration between company and its suppliers is important in providing value to customers. Especially in the age when companies are dominantly trying to focus on lowering costs to be more effective. But not just cost-effectiveness is a driving principle for all companies. Some companies are oriented towards establishing relationships with suppliers in order to provide value to customers. So, it is important to explore based on what these relationships are built upon. Hence, purpose of this paper is to explore relationships between companies and their key suppliers and to identify what influences their collaboration activities. Previous literature (Walter, Mueller, Helfert, Ritter, 2003) suggests that selection of companies' suppliers is based on benefits they provide to the company. Also, this influences collaboration and co-creation activities among partners. But this is still under-researched topic due to difficulty in identifying specific benefits that key suppliers provide to the company. Applying scales identified in previous research, primary research was conducted on 182 Croatian companies. Factor analysis and multivariate linear regression analysis were applied in analysing research results. Results indicate that there are several benefits that companies perceive key suppliers are providing to them. Like, market and scout function, quality function, social support function, rescue function and innovation development function. These functions, that is supplier benefits, influence company future collaboration with key suppliers and consequently influences co-creation. Research results identified that quality, social support and innovation development function influence company's future collaboration activities. Based on these results implications for marketing managers are offered and ideas for co-creation provided. Also, further research ideas are offered and limitations identified.*

**Keywords**

B2B marketing, supplier benefits, future collaboration, co-creation, Croatia

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# BLOKCHAIN PROTECTING INTELLECTUAL PROPERTY: UKRAINE'S EXPERIENCE

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**Abstract**

*Essential condition of globalization is the digitalization of the national economy. Paraphrasing the famous aphorisms W. Churchill it can be argued that «Information is money, but information is better». True (unlike money), the issue of quantity of information and its quality are two different issues, because significant level of information noise complicates the process of obtaining reliable data.*

*The paper presents the variant of solving the world problem – protection of intellectual property rights and fighting plagiarism. Annual statistical surveys indicate that among the European states, Ukraine has the lowest significance GIPC International Intellectual Property Index, which prompted the activation of internal protection programs of Intellectual property. The main aim is to present new opportunities for use of the Ukrainian IT-experience of such companies as Exonum and Bitfury, who together with the State Intellectual Property Service of Ukraine, which identified the list of works and services for which it expedient to record copyrights is using technology block chain. Namely, a group of goods and services were selected for the protection of which it is advisable to use a Ukrainian bot-registrar (PatentBo, Privat) and updating of the information system of the state land Cadaster of Ukraine, where all information about land plots and their owners for the first time among the Post-Soviet states was protected using Blockchain. The use of Blockchain protecting has another important advantage – any copyright information is quickly verified, that prevents raider attacks.*

**Keywords:**

Blockchain, International Intellectual Property Index, Blockchain space, Ukraine's experience, Intellectual Property.

# ORGANIZATIONAL CHANGES IN DEVELOPMENT PROCESS OF TECHNOLOGICAL STARTUPS

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**Abstract**

*Organizational growth and development are spurred by changes that arise as a result of business development. These organizational changes are most often explained in theory as a reaction to the resulting crisis, which ends in a transition from one to the other stage of organizational development. While in theory this topic is significantly explored within the traditional organizational forms, the changes that arise in the process of development of new technological startups are insufficiently researched. In the process of reaching business success in a highly turbulent environment, these temporary organizations are looking for a repeatable and scalable business model that will continuously deliver value to a large number of customers. In the process of development of new technological startups, there is a need for continuous changes and alignment within the organizational elements in order to achieve their goals. This paper is focused on the key changes that happen in the early stages of developing technological startups, with the aim of elaborating the most important elements of these changes that should lead to the successful development of technological startups.*

**Keywords**

Organizational development, Organizational elements, Technological startups

# QUANTITATIVE MANAGEMENT IN THE FUNCTION OF MANAGEMENT SUPPORT

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**Abstract**

*Multidimensional support for decision making is mandatory in modern day management. For that purpose, quantitative management aims to define and optimize performance of statistical learning models. Different approaches, frequently used in practice to solve problems of management, were analyzed with the intention of building an integral model of management support. Initial concept of this approach is to define most important parameters (dimensions), by analyzing measurable variables which are highly correlated to a certain business outcome. Therefore, these business outcomes can be predicted, with appropriate quantitative management techniques, since this phenomenon of predictability has already been observed in various research. It is also necessary to have in mind that significance of a certain business parameter to improving model accuracy is not always the most important criteria, since certain correlations cannot be verified with ease and speed. Another important contribution of using statistical learning as a process of quantitative management in business organizations, can be achieved through classification of all similar management systems, according to their performances on the market, or based on their industry specific ranking methods. This can enable decision makers to fully understand external trends on one side, and internal factors of success on the other side.*

*The main idea of using techniques of quantitative management is to define proper dimensionality of management support models, by exploiting variables which have a large enough level of correlation with main business outcomes, and where business dynamics is not threatened by model performance.*

**Keywords**

Quantitative management, management, statistical learning models

***Invited lecture***

# SUSTAINABILITY IN INDUSTRY 4.0: NEW TECHNOLOGIES, NEW IMPACTS

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**Abstract**

*Sustainability implies a responsible approach to economic growth that contributes to sustainable development of economy, environment and society. This three-pillar model is most often used framework for the implementation, monitoring and reporting of sustainable development. As technology-driven environment brings new dynamics and implications that generally requires digitalization and adaptation, it also brings a need to better understand the issue of sustainability in the new business context. Since the appearance of the term Industry 4.0 at the Hannover Fair in 2011, the fourth industrial revolution has been drawing the attention and interest of both academics and practitioners. Authors report that it is a next level of digitization of the manufacturing sector and implies the implementation of digital technologies, new smart factories, and the new way value is designed, developed, and delivered. Thus, digital technologies, big data, cloud platforms and others make significant impacts on business practices. Even though Industry 4.0 implies digital transformation of the manufacturing, it is still a part of a socio-economic environment and authors argue that in addition to technical feasibility, the success of the transformation depends also on its social perspective and ensuring business sustainability. The lecture will address new technologies along with their impact on achieving responsible and sustainable business practices in new industry context.*

**Keywords**

Digital Technologies, Industry 4.0, Sustainability, Sustainable Business Practices

# DIGITAL DISCLOSURE OF SUSTAINABILITY: AN EMPIRICAL STUDY OF GERMAN FREIGHT SHIPPING COMPANIES

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**Abstract**

*In addition to generating economic growth and competitiveness, companies are expected to contribute to sustainable development of economy, environment and society. Sustainability reporting, as promoted by the Global Reporting Initiative (GRI) Standards, is a company's practice of reporting publicly on its economic, environmental and social impacts and hence its contributions towards the goal of sustainable development. In recent years many companies have been using the internet as a channel of communication and representation of their environmental and social agendas. The aim of this paper is to investigate the extent to which German freight shipping companies use internet, particularly company's website, as a tool for presenting their social and environmental information to the public. The re-search was conducted in 2019 and included 82 freight shipping companies, members of the German ship-owners' association (VDR - Der Verband Deutscher Reeder). For each company, the authors measured the level of compatibility with the GRI environmental and social reporting standards. The data were analysed using nonparametric descriptive and inferential statistics. The results of this study indicate that companies seated in Hamburg, companies with group affiliation and companies with large fleets outperform those located in other German provinces, non-affiliated shipping companies and modest-sized fleets. Awareness of environmental issues plays a significant role in German public opinion. Still, there is room for improvement and reduction of heterogeneity regarding levels of social and environ-mental disclosure in the shipping industry.*

**Keywords**

Environmental and Social Responsibility, Global Reporting Initiative Standards, Freight Shipping Companies, Digital Disclosure, Germany

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