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CNN TECH

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

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MINISTRY OF EDUCATION, SCIENCE AND TECHNICAL DEVELOPMENT

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Programme

and

The Book of Abstracts

05 – 08 July 2022

Zlatibor, Serbia

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

CNN TECH 2022

05 – 08 July 2022

Hotel Mona, Miladina Pecinara 26, Zlatibor, Serbia

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CNN TECH 2022

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The organizing committee of the 6th International Conference of Experimental and Numerical Investigations and New Technologies – CNN TECH 2022 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.

We are also grateful to companies, **3D Republic**, **Shimadzu** and **IMW Institute** who have significantly contributed to the organization and realization of the conference.

PREFACE

Dear Friends and Colleagues, Welcome to CNN Tech 2022 Conference and the fabulous mountain of Zlatibor!

With 88 papers (19 by international authors) and contributions by authors from 14 different countries, International Conference of Experimental and Numerical Investigations and New Technologies CNN Tech 2022 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 2022 focuses on the following topics:

- Mechanical Engineering,
- Engineering Materials,
- Chemical and Process Engineering,
- Experimental Techniques,
- Numerical Methods,
- New Technologies,
- Clear sky,
- Dental Materials and Structures
- Advanced Materials and Technology,
- Artificial intelligence and
- Student session.

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 2022 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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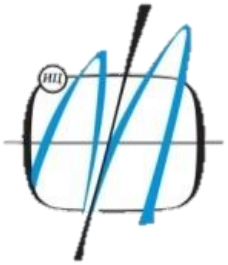

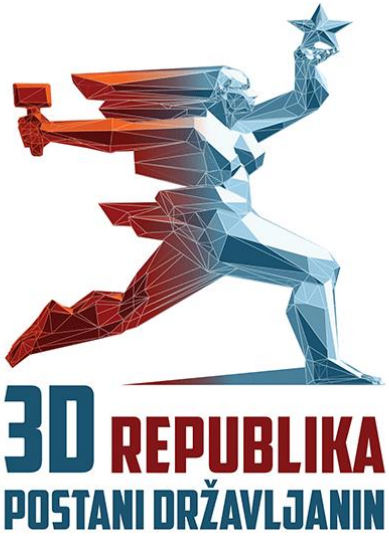

ABSTRACTS

Mechanical Engineering

Invited lecture

REVITALIZATION OF RAILWAY INFRASTRUCTURES IN SECTION BELGRADE NOVI SAD

Marko Ristic[1*]

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Abstract

This paper will present the modernization of railway traffic and infrastructure in Republic Serbia. Modern and fast railway system is one of the significant parameters for developing industries. This modern traffic system will enable fast and efficient transport of goods, raw materials and passengers. In the past, there was never a comprehensive reconstruction of the railway system, but only local partial improvements of the system. In addition to the procurement of new trains, it was necessary to do the reconstruction of the infrastructure so that modern trains could run smoothly and reliably. This was done in several phases, first phase was reconstruction form Belgrade to Stara Pazova, second section was from Stara Pazova to Novi Sad and third section which will be done in next several years from Novi Sad to Subotica. The new railway infrastructure consists of two tracks that will enable uninterrupted traffic in both directions. One focus of revitalization is the construction of tracks but the other, much more significant, is the installation and implementation of equipment that will enable autonomous operation of the system and uninterrupted traffic of modern trains on the system ETCS 2. The main focus of this paper will be on the equipment installed during the modernization of the sector from Belgrade to Novi Sad with basic data and characteristics. The section from Belgrade to Stara Pazova was very characteristic for the execution of works, because the complete reconstruction had to be done under traffic. New signal safety equipment had to be made to enable safe traffic during the reconstruction. The Institute Mihajlo Pupin has developed and produced a significant amount of the equipment that is integrated with the equipment delivered form China Railway. The institute has developed LED signal safety devices that are installed next to the track (main signals, limit track signals, shunting signals). In addition, the institute has developed and installed a significant amount of wheel detection sensors whose main task is to show the position of the train. This paper will also show the way of implementation of the new standards and advantage of new install equipment in Serbian Railway.

Keywords

Railway, sensors for wheel detection, LED signalizations.

Acknowledgement

Research described in this paper are financed from Ministry of Education, science and technological development Republic of Serbia

Invited lecture

RESIDUAL STRESSES – ANALYSES AND INFLUENCE ON MACHINE PARTS

Zoran Stamenic[1*]

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Abstract

Having in mind today's race for profit, great market competition, energy efficiency and energy savings, any unexpected failure of machinery (its machine parts) and production standstill leads to large financial costs. One of the causes of such conditions is residual stresses. These are the stresses that exist in the material, while the machine part has not yet been installed in the machine assembly. The all production processes of machine parts, thermal treatments, coating, assembly and welding processes are accompanied by the appearance of residual stresses. This is very evident in the welding processes, especially in the heat affected zone (HAZ), as a consequence of elasto-plastic deformations due to the cooling or solidification process. Considering that the residual stresses are the result of a nonlinear nonstationary thermo mechanical process, with a number of influential parameters and limitations, including structural changes of metals in the HAZ, it is clear that their exact numerical determination is extremely complicated. Knowing the maximum workload and the level of residual stresses, can show us exactly how the machine part will behave in operation. Considering that residual stresses are superimposed with stresses due to workload, it is clear that they very much affect the reliability, working capacity and service life of machinery and its machine part. Therefore, it is imperative to determine the levels of residual stresses by measuring them or through numerical simulations. The review of residual stresses formation mechanisms, types, as well as their negative and positive effects on the behaviour of structures in operation are presented in this lecture.

Keywords

Residual stresses, types, formation mechanisms, negative and positive effects

Acknowledgement

This research has been developed within the activity by the Contract 451-03-68/2022-14/200105 from 04.02.2022., Subproject TR35029, financed by the Ministry of Education and Science of the Republic of Serbia.

LOW-CYCLE FATIGUE TESTING SETUP FOR ADDITIVELY MANUFACTURED 316L STAINLESS STEEL MATERIAL

Ivana Jevtic[1*], Aleksa Milovanovic[1], Goran Mladenovic[2], Milos Milosevic[1], Isaak Trajkovic[1]

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Abstract

During exploitation metallic components are subject to dynamic loading, thus a better understanding of material behavior in such conditions is mandatory. Loading conditions in such cases include creep and fatigue, with more failure cases in the fatigue regime. Fatigue tests can be performed in Low- and High-cycle regimes, depending on chosen control parameters. The High-cycle regime controls the amount of stress, and opposite to it Low-cycle regime is performed in a strain-control state. The subject of this research is Low-cycle regime testing, i.e., testing in control of strain amplitude. Regular dynamic machines for this type of test require the definition of cycle frequency, amplitude level, and specimen geometry to assess the dynamic properties of the material. The material of interest is an austenitic stainless-steel material 316L, which is a low-carbon version of 316 steel. Due to high corrosion resistance and possible high-temperature applications, targeted material can be used in the petrochemical, marine, biomedical industry, etc. High-temperature applications may include fatigue tests at elevated temperatures, thus fatigue machine must be equipped with a heating chamber. For fatigue testing, specimen surfaces have to be smooth and clean, to prevent crack initiation from surface irregularities. Because of the nature of AM process, i.e., surface irregularities are expected, each specimen must be polished and etched, and afterward treated surfaces must be inspected on an optical and SEM microscope. Specimens that pass the inspection can be fatigue tested. After testing, results from the machine must be data processed in order to obtain cyclic stress-strain curves (hysteresis loop), cyclic hardening/softening curve, and Manson-Coffin representation.

Keywords

316L stainless steel, fatigue testing, metallic components, AM process

Acknowledgement

This research is financially supported by European Union’s Horizon 2020 research and innovation program ‘’SIRAMM’’, under grant agreement No. 857124. The presented research is financially supported by the Ministry of Education, Science and Technological Development Republic of Serbia under the Agreement No: 451-03-68 / 2022-14 / 200105 from the 4 th of February 2022.

DYNAMIC BALANCE AND ALIGNMENT OF ROTARY MACHINES WITH VIBRATION PARAMETER CONTROL

Marko Ristic[1*], Ljiljana Radovanovic[2], Borivoj Novakovic[2], Luka Djordjevic[2], Jasmina Perisic[3]

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Abstract

A concrete example of diagnostics of the rotary machine state, i.e. a turbine for extracting dust from a plant for processing of building materials, is described in this paper using the method of vibrodiagnostics. The goal of the implementation of vibrodiagnostics is timely detection of potential faults, which in this case refers to a slight unbalance of the impeller and misalignment between the drive unit of the electric motor and the working machine, i.e. the turbine. Based on the results obtained from the measuring points and spectral analysis, potential problems on the machine were identified. When it comes to some of the most common causes related to the failure of rotary machines, the unbalance of the rotor is one of the common problems, as well as the misalignment of drive units (electric motors) and the executive element, the impeller. These two mentioned phenomena affect the reliability of operation and the service life of the machine, because they largely lead to bearing damage, covered shaft, gear damage, if they exist in the system, and in order to avoid such issues, it is necessary to spot problems on time, which can be achieved by implementing vibrodiagnostics as a method for system condition monitoring. Based on the data obtained through the vibration information, appropriate corrective measures, laser alignment or dynamic rotor balancing are taken.

Keywords

Vibrodiagnostics, maintenance, unbalance, misalignment

Acknowledgement

Research described in this paper are financed from Ministry of Education, science and technological development Republic of Serbia

VENTILATION MILL NUMERICAL SIMULATION OF MULTIPHASE FLOW

Marko Ristic[1*], Ljiljana Radovanovic[2], Ivana Vasovic Maksimovic[3], Jasmina Perisic[4]

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Abstract

Main aim of this paper is to present results of the analyses obtained by numerical simulation in frame of the possibilities increasing the wear resistance of the ventilation mill working parts for coal grinding in the Kostolac B power plant. The possibilities for modification are based on 3D numerical simulation of multiphase flow of ventilation mill. Mineral materials during the process of milling in the ventilation mill causes strong wear of the suction plates. The multiphase flow simulations are performed in order to obtain the mineral materials paths and velocity vectors. The mixture model of the Euler–Euler approach is used. The results obtained in the numerical simulation serve for the selection of an optimal redesign of the suction plates. The application of this approach can reduce the number of possible repairs and extend the period between them, resulting in significant economic effects.

Keywords

Ventilation mill, wear, suction plate, CFD, working life

Acknowledgement

Research described in this paper are financed from Ministry of Education, science and technological development Republic of Serbia

COMPRESSOR VALVES BOLTS FAILURE ANALYSES

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Abstract

Damage of material, like fracture, is under influence of numerous factors, such as: mechanical stresses, temperature, composition and properties of atmosphere, shapes and dimensions of a part or construction, structure and properties of material and quality of surface. As-received compressor valves bolts were broken and deposit-coated. Chemical composition was analyzed by use of spectrophotometry and structure properties with light optical microscope. Fractured surfaces of broken bolts, as well as deposit chemistry, were analyzed by use of Scanning Electron Microscopy with Energy Dispersive System (SEM-EDS). After visual and radiographic examination, their chemical composition and structure were analyzed. Afterwards, fractography was performed on fractured surfaces to try to get an impression about bolts failure mechanism. Qualitative analysis of deposit was employed in order to confirm any possible influence of surrounding during their failure in terms of corrosion-assisted cracking. The macro fractography of originally broken surfaces shows a rough and complex topography of fracture surfaces indicating on a possibility that bolts failure has been a result of complex loading conditions. Presence of Sulphur containing particles on the fracture surfaces of broken bolts and in deposit reveals a possibility that failure was environmentally-assisted.

Keywords

Fracture analysis, Bolts, Chemical, Structure analysis, Deposit analysis

Acknowledgement

Research described in this paper are financed from Ministry of Education, science and technological development Republic of Serbia

ANALYSIS OF DIFFERENT MODELS FOR DESIGN AND OPTIMIZATION OF PLATE HEAT EXCHANGERS

Mirko M. Dobrnjac[1*], Tihomir S. Latinovic[1], Tatjana G. Ruzicic[1], Nemanja M. Dobrnjac[2]

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Abstract

This paper presents the development of two models for the design and optimization of plate heat exchangers. Methods based on the idea that a multi-pass plate heat exchanger can be reduced to an arrangement consisting of single-pass plate heat exchanger assemblies were used in the development of the model. A model that uses algebraic equations has the limitation which is not affected by end channels and channels between adjacent passages. However, industrial plate heat exchangers generally have more than 40 thermal plates. Numerical calculations were used to obtain the field velocity and temperature of the working medium for different conditions. A parametric analysis was conducted regarding the impact of changes in these operating and design characteristics on the values of average heat transfer coefficients and specific heat fluxes within the exchanger. The performed analysis can serve as a starting point in the optimization of geometric characteristics and operating conditions, which makes it possible to achieve maximum thermal efficiency and efficiency of the exchanger.

Keywords

Plate heat exchangers, heat transfer, numerical analysis

ON-TRACK VEHICLE DYNAMICS TESTING – OBSTACLE AVOIDANCE AND DOUBLE LANE CHANGE TEST

Uros A. Stanojcic[1*], Branko Z. Milicic[1], Ivan A. Blagojevic[1]

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Abstract

Evaluating the behavior of vehicles when passing through a corner is a very important task in the testing of passenger vehicles, i.e. in assessing the ability of vehicles to maintain the specified direction of movement. Some of the most important tests that evaluate these vehicle characteristics are the so-called severe lane-change maneuver: double lane change test or obstacle avoidance test. ISO 3888-1 and ISO 3888-2 standards define the test track dimensions and conditions under which tests are performed. This paper describes the method of performing the mentioned tests on the example of the BMW 650i 2014 vehicle, the equipment used for the test, and the comparison of the obtained results for various conditions. The results of measurements include pitch, roll, yaw rate, and acceleration, of the vehicle body. Lateral acceleration and longitudinal velocity of the vehicle are also shown for every test.

Keywords

Vehicle, dynamics, testing, lane, change.

Acknowledgment

The research presented in this paper is funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia under agreement No. 451-03-68/2022-14/200105 dated 4.2.2022.

PIPE RING TENSILE SPECIMENS STRAIN MEASUREMENT

Milan Travica[1*], Nenad Mitrovic[2], Aleksandar Petrovic[2], Isaak Trajkovic[1], Milos Milosevic[1], Aleksandar Sedmak[2], Filippo Berto[3]

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Abstract

For various pipe manufacturing methods, data on the pipe's strain and stress state in the circumferential direction is necessary (e.g. in the oil industry, the process of manufacturing seamless pipes with a conical shaft). The purpose of this research is to create a method for determining the strain and stress behaviour of Pipe Ring Tensile Specimens (PRTS) in the hoop direction. The absence of official methods for assessing a PRTS suggests that it could be developed. The implementation of the digital image correlation approach for evaluating plastic PRTS is discussed in this research. A specially constructed steel instrument with two D blocks is used to test PRTS. Two D-shaped mandrels are fixed on the tensile tool and tensile testing equipment, and a 3D printed PRTS is placed over them. The three-dimensional Digital Image Correlation (3D DIC) approach was used to capture the strain evolution in the gage length of the specimens. All specimens are 3D scanned to evaluate the geometry of the PRTS cross-section following fracture. Six groups of PRTS were studied, with three different filling percentages (60, 90, and 100 percent) and two different geometric kinds (Single and Double PRTS). The results reveal that the kind and percentage of filling, as well as the printing method, affect material behaviour; however, the methodology using a DIC system, 3D printer, and scanner is an excellent tool for mapping entire strain fields in PRTS and thereby defining pipe mechanical properties.

Keywords

Digital Image Correlation method, Pipe Ring Tensile Specimen, tensile testing machine, 3D scanning, stress, strain

Acknowledgement

The results presented here are the result of research supported by the Ministry of Education, Science and Technological Development Republic of Serbia under the Agreement No: 451-03-68 / 2022-14 / 200105 of 4.2.2022.

SCANNING OF THE CHARACTERISTIC DIMENSIONS OF THE CONTROL PATTERN FOR CHECKING THE RAILWAY WHEEL TREAD PROFILE USING A 3D SCANNER ATOS CORE 200

Aleksandra Kostic[1*], Ivana Jevtic[2], Branko Milicic[1], Uros Dzodan[1], Marija Sljivak[1]

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Abstract

Wheels for rail vehicles are made according to precisely defined geometry and dimensions. The wear of the wheel profile in operation is not uniform, so the initial profile changes. It is a consequence of the inevitable slippage, which is influenced by a large number of factors. Certain changes in the profile can be important for the safety of movement and riding quality, so the shape of the profile in operation must be regularly checked through characteristic dimensions measurements: the flange thickness, the flange width and its slope. Changing the characteristic measures can lead to: thinning of the flange over the allowed limit, which can lead to its cracking, increase in the height of the flange, which can cause problems with derailment at crossings and switches, reducing the slope of the flange, which can lead to derailment on the switch tongue. The paper presents the verification of the dimensions and shape of the pattern for control wheel profile for the type of tread shape S1002, which are used to control the wheel profile after reprofiling. The dimensions of the S1002 wheel profile are given in EN 13715 on the basis of which the control patterns are made. After making the pattern or the control accessories, its dimensions were checked by scanning on a 3D scanner Atos core 200. The resolution of the scanner is 0.08 mm, and its working surface is 200 x 150 mm. The 3D model was obtained by scanning, from which the coordinates of the scanned profile were obtained with the help of the GOM Inspect software package. Based on these coordinates, a comparison was made and a deviation from the nominal profile.

Keywords

Railway wheel profile, 3D scanning, Pattern for profile control.

VARIOUS MATERIALS WELDABILITY FOR STEEL CASTING

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Abstract

The aim of this paper was the welding of various materials that will be used in the exploitation of a rotary excavator for coal mining. Problems observed in practice are frequent welding errors, repairs, loss of time, loss of additional material and hiring a large number of people. Welding was performed on caterpillar crawler pad. In this paper, welding was referred to the steel castings of GX120Mn13 and G22NiMoCr5-6 with structural steel S355. Welding process was defined by MAG procedure, plasma cutting, bending on press brakes, welding parameters and errors in joints. Also, the complete manufacturing procedure that was performed was described, starting from cutting parts to surface protection. This explains how the crawler pad of rotary excavator was made, where errors occurred, what were the weaknesses of the material as where was a lack of process organization. Through the paper, it has been shown where the manufacturing process will be conducted more rationally with minimal errors and deformations.

Keywords

Plasma cutting, hydraulic press, rotary excavator, MIG/MAG welding

Acknowledgement

The authors of this paper would like to express gratitude to the Academy of Applied Technical Studies Belgrade for their support.

ANALYSIS OF ELECTRIC ARC WELDING OF STEEL STRUCTURE IN THE CONSTRUCTION OF PREFABRICATED FACILITIES

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Abstract

The topic of this paper is welding analysis of steel construction of prefabricated facilities. The basic material for making steel structures – steel S235JR, with an adequate technological process was selected and used. In a detailed paper introduction, a layout algorithm of all operations performed during production is defined. During the production of prefabricated facilities, beside machining and welding, special attention is paid to the choice of basic and additional material, preparation and cleaning of welding edges, defects and repairs of welded joints. Welding was performed by an electric arc process which represents one of the most efficient ways of welding nowadays. The choice of methods used in this paper is determined by the nature of the problem of undesirable errors in the weld. Also, welding control of welded joints with the Ultrasonic method is presented. The obtained results showed that the welded joints were of good quality. This importance of this research is reflected through its practical application.

Keywords

Electric arc process, steel S235JR, welded joint, welding control

Acknowledgement

The authors of this paper would like to express gratitude to the Academy of Applied Technical Studies Belgrade for their support.

DYNAMICS OF CONSTRAINED ROBOTIC SYSTEMS: A GEOMETRIC APPROACH

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Abstract

Robotic systems are typical examples in which external contact forces play an important role to the system dynamics. Mathematical modelling of these systems is challenging due to a variety of reasons. Mathematical models for these systems contain differential equations with the associate algebraic equation. In this work, dynamics of the constrained robotic manipulators have been investigated with the use of a geometric approach. The necessary and sufficient conditions for the existence and uniqueness of the solutions were derived for such systems. The proposed approach can be utilized for the dynamic investigations of the constrained robotic systems that are in contact with rigid frictionless surfaces in their working regime. The robotic manipulators were modelled as singular (semi-state, descriptor) systems so that dynamics originated from the environment interactions could be incorporated. The controllability condition of the system state implied that it was possible to steer the system from any initial to any final position within a predefined time window. The sufficient controllability conditions of such systems were based on the generalized Lyapunov equation that was derived while the geometric approach was used. The sufficient algebraic conditions were derived for controllability testing. The presented methodology could be used as a foundation for further investigations of the nonlinear time-variable and time-discrete singular systems.

Keywords

Robotic Manipulators, Singular Systems, Geometric Approach

Engineering Materials

Invited lecture

BIOMIMETIC BIOREACTORS IN CHARACTERIZATION OF NOVEL BIOMATERIALS

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Abstract

Development of novel biomaterials for potential biomedical applications requires comprehensive preclinical studies. Traditional methods for biomaterial evaluation are based on in vitro testing routinely performed in monolayer cell cultures followed by in vivo animal studies. However, these methods have numerous limitations. Although studies in cell monolayers allow rapid evaluation of biomaterials by standardized protocols, quantitative and comparable results, cell metabolism and morphology is changed in the 2-dimensional environment often leading to unreliable results. On other hand, animal studies are complex, time-consuming, expensive and raise ethical concerns. One of the approaches to address this problem and obtain reliable results in a more efficient way is utilization of biomimetic bioreactors. These bioreactors are primarily developed as an essential component in tissue engineering mimicking physiological in vivo conditions in particular tissue or organ by providing all necessary biochemical (e.g. pH, nutrients, gases, growth factors) and biophysical signals (e.g., shear stress, hydrostatic pressure, mechanical strains) for cell differentiation and metabolic activity. Some examples include perfusion bioreactors, bioreactors with shear stresses and/or dynamic compression, and bioreactor with stretch and shear stresses imitating conditions in vascularized tissues, articular cartilage, and vascular grafts, respectively. Such physiologically relevant, while strictly controlled environment is also beneficial for biomaterial assessment, investigation of cell-biomaterial interactions, and prediction of biomaterial behaviour upon application. The present review provides readers with up-to-date studies and results regarding utilization of biomimetic bioreactors as tools for comprehensive and efficient evaluation of novel biomaterials, such as determination of mechanical characteristics, release of bioactive substances, cell-biomaterial interactions and cytotoxicity.

Keywords

In vivo-like conditions, cytotoxicity, mechanical characterization, release studies

Acknowledgement

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SORPTION PROPERTIES OF OXIDIZED COTTON LINTERS ACCORDING TO CATION COLOR MB

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Abstract

The increase in the number of human population on Earth, joined with the introduction of new technologies, has led to accelerated environmental pollution. One of the most severe forms of this problem is certainly the water pollution. If the presence of pollutants in the environment exceeds the permitted concentrations, they can lead to severe consequences for human health. Removal of pollutants by the use of adsorption is a commonly utilized method that has been thoroughly examined in this paper, for the removal of methylene blue. Recent research has been conducted with the aim of using natural materials as colour adsorbents, such as MB (10 ppm). The aim of this paper is to remove the cationic adsorbate by the use of cellulose modified with a neutral 2,2,6,6-tetramethylpiperidinyl-1-oxyl radical (TEMPO) according to the TEMPO/NaBr/NaClO system. Characterization was performed on a sample modified in such a way, and the concentrations of CHO and COOH groups were determined. The adsorption isotherm, thermodynamic and kinetic parameters were obtained at temperatures of 25 °C, 35 °C and 45 °C. The appearance of the surface of unmodified fiber samples, before and after the sorption, was recorded by scanning electron microscopy (SEM), while the method of infrared spectroscopy with Fourier transform (FTIR) was used for qualitative analysis of functional groups and structural characterization of materials. The maximum adsorption capacity was acquired using the Langmuir model - 86.88 mg/g at a temperature of 45 °C. Adsorption of MB ions on modified cellulose linters is a spontaneous and exothermic process.

Keywords

Cellulose, TEMPO-mediated oxidation, cotton, lead, sorption, environmental protection

Acknowledgement

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BENEFITS OF USING COMPOSITE MATERIALS IN THE PRODUCTION OF SPORTS EQUIPMENT

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Abstract

The daily development of material production technology is proportional to the improvement of processing technologies. With more frequent use of composite materials, we are moving towards a complete replacement of traditional materials. Composite materials are a combination of two or more materials that have different physical and chemical properties. The reasons for their use instead of traditional materials are a) improved properties of their basic materials and b) applicable in many production conditions. The advantages of composite materials are primarily their unique mechanical properties, they allow design flexibility, are corrosion resistant, are good heat isolators, have high tensile strength, do not require a high degree of maintenance, and, are cheaper compared to traditional materials. One of the spheres in which composites are applied exponentially is the production of sports equipment. Some of the benefits of applying composites, which will be pointed out in this paper, are related to low weight, dimensional stability (meaning the shrinkage and cooling of, say, wood at low, i.e. high temperatures), and corrosion resistance. In this paper, the characteristics of limbs made of composite materials and traditional materials, used in archery are analyzed. Comparative analysis of the characteristics of this sports equipment made of composite materials and traditional materials gives a detailed overview of the advantages and disadvantages of each used material in relation to the specified requirements, and thus assesses the justification of the use of composites in this sport. This conclusion can make us believe, that because of the overall improvement in sports results, composites will eventually replace all other materials used for the equipment.

Keywords

Composite materials, sports equipment, archery limbs

Acknowledgement

This study has been supported by the Central European Initiative (CEI) as an action of technology transfer in the territories of Central Europe, within the context of the project “Composites for All”.

COMPARISON BETWEEN DIFFERENT METHODS FOR FATIGUE STRENGTH ESTIMATIONS OF WELDED BOGIE FRAMES OF RAILWAY VEHICLE

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Abstract

In this paper, multidisciplinary critical analysis and possible improvements of current methods to determine fatigue strength of welded bogie frames of railway vehicles will be stated after a brief introduction of those methods. Railway vehicles, both for freight and passenger transport are subjected to evermore dynamic nature of their workload due to an increase in speed and weight capacity, respectively. This dynamic nature is the base for the development of fatigue-related fractures that are accelerated by material changes due to welding processes. Welded bogie frames with their intended purpose of connecting the hull of the vehicle and wheels are needed with the highest possible reliability. EN 1993-1-9 Eurocode 3: Design of steel structures - Part 1-9: Fatigue gives the basis for traditional assessment of fatigue strength for welded joints of steel structures based on the Goodman diagram. This traditional method is discussed in this paper in comparison to Holm and de Mare method and notch stress assessment method. Holm and de Mare's method is based on different assumptions about the cycle of load, which are theoretically corroborated by sets of linear equations. Results of those equations are obtained by MATLAB script. Because of the complex geometry of bogie frames and welded joints, it is important to differentiate between fatigue strength under nominal stress and notch stress. The notch stress method allows closer assessment of local geometry in welded joints.

Keywords

Fatigue strength, Welded joints, Railway vehicle, Bogie

Acknowledgement

Authors express gratitude to Ministry of Education, Science and Technological Development of Republic of Serbia and to the Department of Railway Vehicles of Faculty of Mechanical Engineering for guidance and support.

RAPID PROTOTYPING WITH COMPOSITE MATERIALS USING PLASTIC 3D PRINTED MOLDS

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Abstract

Even with all the advances in realistic virtual worlds, simulation software, and decades of experience, it is still a very challenging task to design new molds for parts with complex geometry that has to be made of composite materials. Manufacturing parts for unmanned aerial vehicles (UAVs) most often requires working with carbon fiber and epoxy resin because of the need for the best strength to weight ratio. In the past, all sorts of additive manufacturing (AM) processes or 3D printers were used to create a model that is later used for mold production. There are many other known ways for mold production ranging from simple hand shaping by eye in materials such as wood and foam through to expensive 5 axis CNC machining in modelboard from specially developed materials. The fastest and most cost-effective process would be to directly 3D print single-use or low-volume molds. This process unlocks rapid prototyping of carbon fiber parts. It is shown that this can be done using the most accessible processes which are Stereolithography (SLA) 3D printing with resin or Fused Deposition Modeling (FDM) with materials such as Polyethylene Terephthalate Glycol (PETG). After 3D printing a mold it is possible to further process the surface of the mold and then apply the release agent and coating resin before the hand-lamination process. This way it is possible to have fast and cheap prototyping of both molds and carbon fiber parts ready for usage on UAVs.

Keywords

Rapid prototyping, composite materials, plastic 3d printing, mold 3d printing, carbon fiber-reinforced polymers

MODELING OF FRACTURE MECHANICS PROBLEMS USING NUMERICAL METHODS

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Abstract

Modelling the problem of fracture mechanics requires appropriate treatment of the singularity of the displacement, deformation, and stress fields around the crack tip, with the biggest problem being the drastic increase in the discretization error that occurs if classical FEs are used. In the framework of this paper, the possibilities of applying different numerical approaches to the solution of this problem are analyzed. A fairly good solution is obtained by applying a special FE around the crack tip, which contains the singularity of the deformation field at the crack tip. The region around the crack tip is modelled by arranging the elements into concentric circles so that the closer they are to the top, the smaller they are. The area that undergoes plastic deformation must be precisely modelled with a larger number of FE, while the elastic analysis of the stress state does not require an excessively fine network, which is important for calculation speed.
The latest method used to model the behaviour of cracked materials is based on the extended finite element method, ie XFEM. XFEM is used in solving a wide range of problems that include discontinuities such as cracks, dislocations, or grain boundaries, with different improvement functions defined for different cases of discontinuities. The main feature of XFEM is that it enables the modelling of a discontinuous physical field independently of the generated finite element network. It can be concluded that, unlike the classical finite element method, where the crack growth process requires successive grid generation to be able to follow the growing geometric discontinuity, XFEM does not require a comfortable mapping between the grid and the discontinuity geometry. Thanks to XFEM, it is possible to use an arbitrary crack shape in the network of elements, and the fatigue growth simulation can be performed without generating new nodes around the crack tip as it progresses.

Keywords

Numerical methods, fracture mechanics, finite element method, extended finite element method.

Acknowledgement

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IMPROVING SAFETY PROCEDURES AND PROTOCOLS DURING LABORATORY TESTS OF ENGINEERING MATERIALS

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Abstract

Laboratory testing of engineering materials is essential for the development and validation of products and processes, and for gaining a fundamental understanding of how will materials behave in different conditions. Although the application of computer modelling and analysis of materials behaviour has enabled the development of significant preliminary analyses and designs in engineering, the need for experimental testing of materials characteristics remains intact. This paper analyses the possibilities of improving safety procedures and protocols during experimental testing of engineering materials, as well as what proactive steps would need to be taken to ensure safe operation during laboratory testing. It is necessary to define safety protocols, i.e. steps for establishing procedures that are adjusted to ensure working conditions in laboratory premises without the occurrence of incidents.

The paper analyses the safety procedures and protocols applied during several different types of testing of engineering materials following the experimental procedures defined by the standards. The analysed examples included laboratory tests of fracture mechanics parameters of metallic materials (stainless steel and titanium alloys), using three-dimensional measuring equipment and a standard testing machine; laboratory tests of biomedical parts using a servo-hydraulic dynamic and static testing machine; laboratory tests of surface modifications of Nimonic sheets done by pulsed picosecond and nanosecond Nd: YAG laser.

To ensure that corrective measures are taken immediately in the event of an incident, it is necessary to define the formal protocols that are followed in these cases. It is proposed to introduce assessment guidelines, checklists, and forms for online inspection, to adequately define and plan laboratory inspections concerning established hazard assessments. By analysing the guidelines for safe laboratory and experimental work, it is necessary to define risk assessment matrices, taking into account the likelihood of safety hazards and the severity of the outcome thereafter. It is proposed to create thematic safety data which will be available online. By analysing the data presented in this paper, it can be concluded that safety is of paramount importance during experimental testing and that to ensure safe laboratory work all participants must have appropriate training.

Keywords

Engineering materials, safety procedures, safety protocols, experimental procedures, laboratory tests.

Acknowledgement

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FINAL STRETCH ZONE WIDTH DETERMINATION

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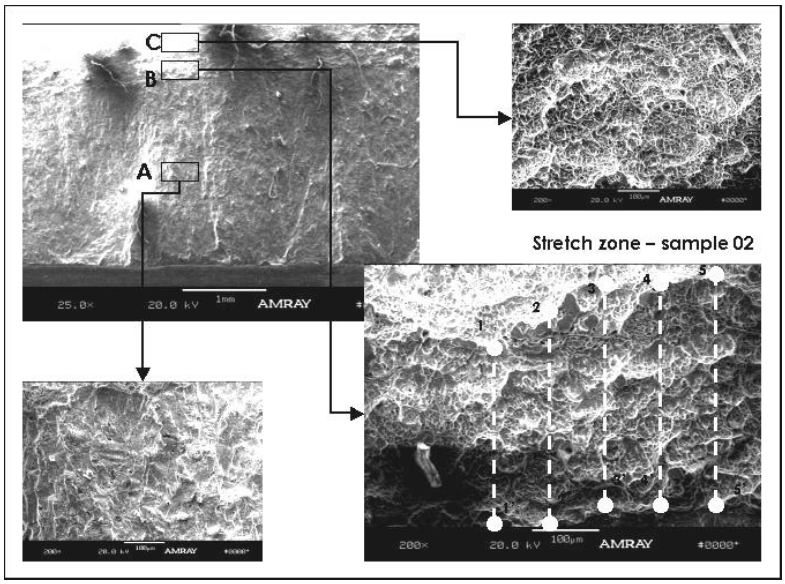
Abstract

The failure (crack initiation) occurs when J integral reaches some critical value, which is different for different materials and is considered to be material parameter. One can thus define value J_{IC}, which characterizes the toughness of a material near the outset of crack extension. Several methods based on different specimen configuration and loading conditions were developed for J_{IC} determination. ASTM Standard defines precisely how to determine J_{IC} for each of these standard test methods (ASTM 1152-87 for determination of J-R curves). The critical J integral value can be obtained from J-R curve as value that corresponds to the average stretch zone size or average stretch zone width (SZW). In this paper the SZW was measured on MP35M alloy made of Ni, Co, Mo and Cr with aim to evaluate its J_{Ic} value.



SEM image of fracture surface for 3PB bar MP35N: A – Fatigue crack, B – Stretch zone and C – Stable crack propagation.

From “B” one can measure 1-1’, 2-2’, … 5-5’ distances and calculate the average SZWL as: $SZW_L = \sum_{i=1}^{m} \frac{SZW_i}{m}$

where: m=5-10 and SWZ_i is instantaneous value of SZW, i.e. equal to $\overline{11'}$, $\overline{22'}$, $\overline{33'}$ etc. (according to Figure 5-B). Results are given in the following table:

Section	1-1’	2-2’	3-3’	4-4’	5-5’	average
SZW_i [x 100 μm]	2.69	3.15	3.31	3.31	3.46	3.184

Keywords

Final stretch zone, J integral, fracture mechanics, MP35N

Chemical and Process Engineering

ADVANCED OXIDATION PROCESSES FOR TREATMENT OF INDUSTRIAL WASTEWATER

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Abstract

Due to the increased pollution of waters, the general interest is to put this issue in the foreground, as one of the biggest problems of modern society. Following that, there is a need for the development of various technologies for their purification, as well as their constant improvement from the point of cost-efficiency of the process. Because of that, various techniques called ''advanced oxidation processes'' are applied to remove pollutants from wastewater. They differ in the mode of action and application in specific cases of water pollution (i.e., the origin and type of treated wastewater). The following techniques are most commonly used: ozonation, ultrasound (US), UV radiation, and different combinations of them: ozonation with US, UV radiation with various catalysts, ozone with hydroxide-peroxide, etc. Before the advanced processes, the application of standard wastewater treatments (such as coagulation, flocculation, sedimentation, and filtration) was performed to optimize the applied treatment, as well as to assess the increase the overall efficiency of so-called ''coupled technologies''. In this study, the wastewater samples originating from the armor industry were treated firstly by coagulation, and then with a combination of ozone and US. The purification efficiency was analyzed by reducing the concentration of heavy metals (Pb^{2+}, Cd^{2+}) using atomic absorption spectroscopy (AAS). The concentration of organic pollutants was followed by the values of chemical oxygen demand (COD) and biochemical oxygen demand (BOD_5). The removal degree of metals were over 70%, and organic compounds were 95%). Based on the obtained results, combining the conventional and advanced wastewater treatment, the optimal purification solution was determined.

Keywords

Environmental engineering, wastewater treatment, AOPs, ozonation, ultrasound

Acknowledgment

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EXPERIMENTAL DETERMINATION OF LIQUID-LIQUID EQUILIBRIUM DATA ON TERNARY WATER SYSTEMS

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Abstract

Due to the increase in energy consumption at the global level, it is necessary to examine new possibilities of substitution of classical energy-intensive separation processes based on evaporation of more volatile components, separation processes based on liquid-liquid equilibria (LLE), ie extraction of components from liquid solutions. This procedure would also include the replacement of standard industrial solvents with environmentally harmful characteristics with new, green solvents. Diethyl adipate can be used for these purposes because it is relatively non-toxic, obtained from renewable sources and is biodegradable. In order to examine the possibilities of using green solvents, the possibilities of adequate replacement and process design, it is necessary to know thermodynamic data such as liquid-liquid equilibria (LLE) data, the corresponding binodal curve and equilibrium lines. The liquid-liquid balance data of the ternary system water + ethanol + diethyl adipate will be determined experimentally at a temperature of 298.15 K and atmospheric pressure. Binodal curves will be determined using the synthetic blur method using both the titration technique and the equilibrium lines via the refractive index. The obtained experimental data will be used in determining the complete phase diagram of the mentioned system.

Keywords:

Liquid-liquid equilibrium (LLE); binodal curve; ternary diagram; aqueous solutions; green chemistry; thermodynamic properties

Acknowledgement

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PROCESSING OF PHENOL-FORMALDEHYDE SOLID WASTE RESULTING FROM THE PRODUCTION OF THERMAL INSULATION MATERIAL OF INORGANIC ORIGIN

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Abstract

Phenol-formaldehyde solid waste is generated in the process of production of thermal insulation materials of inorganic origin of fibrous structure, which consists of fibrous skeleton and air pores. Crosslinking, ie gluing of fibers is done with formaldehyde resin, so that most of the phenol and formaldehyde after evaporation is found in wastewater, while part is generated as solid waste. In order of a more detailed consideration of the potential of pollution, and having in mind the chemical nature of waste, the paper characterizes solid waste by chemical analysis: UV-VIS spectrophotometry, atomic absorption spectrophotometry and gas chromatography. Laboratory data were processed by mathematical and statistical methods in order to obtain square arithmetic means by the method of least squares and the method of mean square approximation. Based on the obtained results, the paper presents an eco-technical solution for waste stabilization by processing phenol-formaldehyde and metal waste by supercritical aqueous oxidation.

Keywords

Phenol-formaldehyde waste, Wastewater, Waste stabilization

RETROFIT DESIGN OPTIMIZATION OF DEHUMIDIFIER FILTER OF A PHOSPHORUS PROCESSING PLANT

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Abstract

After sulphuric acid, phosphoric acid is the second most developed inorganic acid in volume, it is used to produce phosphate salts for fertilizers, animal feeds, detergents, pharmaceutical ingredients, and in sugar and textile industries. The wet production process, using phosphate minerals decomposed with acid accounts for 95% of the production of total phosphoric acid in the EU. In the production process, forced circulation evaporators are applied, and the dehydration is followed by a filter unit. In this paper, the thermodynamic properties of the operation of the filter unit are measured and analysed to avoid the problems of condensation and impact on the structure of the unit due to the formation of acids. The temperature and fluid flows are measured during the operation of a real production facility. Retrofit design parameters are chosen according to the most demanding scenario, and based on an energy balance, a strategy for the reduction of condensing acids in the filter unit is proposed.

Keywords

Phosphorus production, dehydration process, condensation

Acknowledgement

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Experimental Techniques

EXPERIMENTAL APPROACH TO ASSESSMENT OF SAFETY AGAINST DERAILMENT OF FREIGHT WAGONS

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Abstract

For many years, methods for assessment the safety against derailment of railway vehicles have been developed and improved. Possible approaches to solve this task are the application of MBS simulations or conducting real tests. The goal of both approaches is to reliably determine the lateral Y and vertical Q forces and their Y/Q ratio. The limit values of this ratio, which should not be exceeded, are defined by standards and technical reports. Based on the complex geometry of the wheel-rail contact and other parameters of the vehicle and the track, this should ensure that derailment will not appear. In the experimental approach or measurement of relevant parameters, there are several methods defined by the standard EN 14363. All of them are extremely complex and demanding in terms of conditions to be provided and logistics, so in recent times tendencies are to apply simulations. This paper presents the results of the derailment safety tests of several types of freight wagons using method 2 of EN 14363. The application of this method was made possible by the development of an original wayside system for measuring the wheel-rail contact forces and the development of hydraulic test rig for twisting a complete wagon. The results of these tests show that some freight wagons, although with standard running gears and standard dimensions, have quite high ratio Y/Q forces during curve negotiation and that manufacturers of new wagons must keep all vehicle dimensions and characteristics within tolerances, to keep probability of derailment occurrence low.

Keywords

Derailment safety, wheel-rail contact forces, wayside system, hydraulic test rig

Acknowledgement

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ANALYSIS OF WHEEL CONTACT SURFACE DAMAGE AND BRAKE BLOCKS BREAKING

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Abstract

The paper presents an analysis of possible causes of damage to the tread of wheels and cracking of brake blocks of heavy-duty motor tower car VMT 980 C-GR. In order to determine the possible causes, a series of tests were done to check all the influences that led to the occurrence of these damages. The analysis included checking the regularity of the brake operation, non-destructive testing of the tread damage, and visual inspection of the brake blocks. The correctness of the brake operation was checked by stationary brake tests. The examination of the damage to the tread of the wheels was performed by non-destructive methods, using means for detecting microcracks and measuring the hardness. The results of the conducted tests indicate that the characteristics of the brake system are within the designed limits and are not the cause of damage to the wheels and the brake blocks. The measured values of hardness on the side and on the tread are higher than the minimum required for test samples according to EN 12362. The wheels are made of ER7 steel, which is used as a standard for railway wheels, with a chemical composition within the prescribed limits. Further analysis showed that significant surface damage to the brake blocks is a consequence of previous damage to the tread surface of the wheels. Visual inspection of the wheels showed flaking and cracking, indicating contact fatigue and the presence of thermal stresses as the most likely causes of brake blocks and wheel damage.

Keywords

Contact fatigue, thermal stresses, non-destructive testing, brake characteristics, heavy duty motor tower car

Acknowledgement

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STRESS AND DEFORMATION STATE OF STRUCTURAL ELEMENTS OF SAFETY MESH FOR CONSTRUCTION OBJECTS

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Abstract

The aim of this paper is to show the stress and strain state of the structural elements of the safety mesh used for buildings from the aspect of safety at work. The paper presents the analytical and numerical determination of the equivalent stress and strain of the safety mesh. There are three parts to the paper. In the first part, the equivalent stress and deformation of the net model were obtained analytically. In the second part, the finite element method was applied to the models, and the obtained results were compared with the analytical calculation. In the third part of the work, the design and calculation of the safety mesh were done, which was later performed on the construction site.

Keywords

Structural elements; Finite elements method; Stress; Deformation; Safety mesh

COMPARISON OF FRACTURE MECHANICS PARAMETERS DURING TESTING OF SENT SPECIMENS MADE BY DIFFERENT ADDITIVE PRODUCTION TECHNIQUE

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Abstract

How and in which field products made by additive technologies can be applied depends not only on the type of material and manufacturing technique but also on the economic aspect. The most affordable materials and techniques are often used for rapid product development. These products are very often a replacement or temporary part in a machine assembly. The integrity of such an assembly due to the mechanical characteristics of the materials used in additive manufacturing most often depends on the element made by additive manufacturing. In order to understand the question of the integrity of the element itself and on that basis to choose the technique and material for the production of elements, it was necessary to compare the parameters of fracture mechanics for two types of materials. In this study, the results of fracture mechanical parameters will be presented. Parameters of fracture mechanics was obtained by using the Aramis 2M system by the method of digital image correlation (DIC) and a universal machine for testing the mechanical properties of materials (Shimadzu AGS-X 100kN) on SENT (Single Edge Notched Tension) type specimens. One part of the tested specimens was made of PLA (polylactic acid) material on a FDM (Fused Deposition Modeling) type printer while the other part of the tested specimens was made of photopolymer resin (Photopolymer resin Gray, FLGPGR04 by FormLabs) made by stereo lithography technique on an SLA (Stereolithography Apparatus) printer. The examination confirmed the repeatability of the results and on the basis of them the parameters of fracture mechanics for both types of specimens were determined.

Keywords

Additive Manufacturing, Fracture Mechanics Parameters, DIC, 3D printing, SENT

Acknowledgement

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THEORETICAL ASSESMENT OF RAW MATERIALS FOR SUSTAINABLE BIOGAS PRODUCTION

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Abstract

Rapid industrialization together with issues over the depletion of traditional fuel supplies and environmental concerns have prompted researchers to look into developing an environmentally safe, renewable, cost-effective, and long-term alternative energy source. Agriculture biomass is recognized as a potentially viable solution for utilization in the energy sector for achieving the sustainable and long-term transformation into energy and/or fuels. This type of biomass is generated in large amounts across the world, which may be converted to biofuels using a variety of methods. However, concerns related to the competing agricultural biomass applications need to be thoroughly examined taking into account both the short- and long-term actuality, and its impact on the soil by conversion to biofuels. According to common practice agricultural biomass is dominantly used for biogas production due to its availability and simplicity of handling. Based on all mentioned the assessment of the most applicable raw materials for biogas production is essential for achieving the sustainability criteria and promoting using biomass for energy production. In this paper, a theoretical approach was applied for experimentally obtained results of proximate and ultimate analysis of different biomass materials as a possible feedstock for biomass production. Based on data of proximate and ultimate analysis the theoretical biomechanical methane potential (TBMP) for considered samples was calculated. According to obtained results, agricultural biomass shows validity of use for biogas production considering the fulfillment of the raw material minimum quantity.

Keywords

Agricultural biomass, raw material, biogas, theoretical approach, TBMP

Acknowledgement

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ANALYSIS OF THE INFLUENCE OF THREE DIFFERENT COSMETIC DEVICES ON SKIN SAMPLES USING A THERMOVISION CAMERA

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Abstract

Today, cosmetics have become an unavoidable feature of the modern way of life of individuals. The size of the global cosmetics market is estimated at 380.2 billion dollars in 2019 and is projected to reach 463.5 billion dollars by 2027, with a CAGR of 5.3% from 2021 to 2027. According to the client's request, a study of comparing three different cosmetic devices (ProLift^{ftr}, MagicEye, MiniMeso) was conducted at the Centre for Optical Measurements of the Faculty of Mechanical Engineering, University of Belgrade. By using the images obtained with the PeakTech 5620 thermal imaging camera, the effects and quality of the device's effect on the skin were pointed out.

All three devices have cosmetic performance and after a certain number of treatments show improvement in the form of skin tightening, wrinkle reduction, and reduction of swelling around the eyes, but one stands out in terms of application and treatment on the skin. To be specific, the device Prolift^{frf} has the best properties, which after moving the probe from the place of skin treatment allows faster cooling and a more pleasant treatment without burning and overheating. In addition, it can be seen that the Prolift^{frf} cosmetic device compared to the other two MiniMeso and MagicEyes has software that is easier to use and allows quick access, and clearly defined items, which increases the speed of work in salons, and allows more customers. This device achieves better treatment results in a shorter of therapy and thus increases the number of satisfied clients.

Keywords

Termal imaging camera, Cosmetology, Prolift^{frf} cosmetic device

EXPERIMENTAL ANALYSIS AND COMPARATION OF MECHANICAL PROPERTIES OF STANDARD GREY RESINS, WITH AND WITHOUT POST-CURING, AND BIOCOMPATIBLE SLA 3D PRINTED MATERIALS

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Abstract

Stereolithography (SLA) 3D printing is a commonly used type of additive manufacturing (AM) technology in many industries. Definitely, the development of AM technologies depends on the development of AM materials. In this regard, one of the priorities is the analysis of mechanical properties as well as understanding the influence of different printing parameters on them. In this paper, four different SLA 3D printed materials are analysed: “Anycubic basic grey resin”, “IFUN denture clear”, “Formlabs Grey” and “BioMed Amber” resin. All materials are printed with 0,05 mm layer height. In addition, for “Anycubic basic grey” and “Formlabs Grey” resins, specimens are analysed with and without UV post-curing. The main goal of this paper is to compare tensile strength values of UV cured and non-cured specimens (UV cured are treated for 10 minutes in a UV chamber) with the mechanical properties of biocompatible resins. Already, there is a theory that UV curing not only helps the material to get better mechanical properties but also turns regular resin into a biocompatible one. The secondary goal is to discuss the efficiency of 10 times cheaper SLA 3D printer vs an expensive opponent by comparing the mechanical characteristics of specimens along with economic sides. This research is an introduction to exploring and understanding the effects of UV curing of basic resins, in order to use them in medicine, veterinary or dental medicine.

Keywords

SLA material, resin, mechanical properties, UV curing

Numerical Methods

NUMERICAL SIMULATIONS OF CRACKED THIN-WALLED AIRCRAFT STRUCTURAL COMPONENTS

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Abstract

The rapid development of computer technology, which marked the last three decades has brought real solutions to problems that are increasingly demanding in terms of numerical simulations. With proper application of numerical modelling it is possible to reduce the cost and time required to develop new or to monitor the integrity of existing products in the real exploitation conditions. The basic dependences between the geometric and physical variable in the theory of thin walled shell type structural element consists mainly in setting up links between the state of stress, strain and external load, which is described by differential equations, ordinary or partial. In the case of complex and large construction systems such as aircraft structures exposed to arbitrary loads, including complex boundary conditions, solving differential equations by analytic methods is very difficult or impossible. The solutions require using numerical methods, most often, using finite element method (FEM). This paper considers the finite element simulation of cracked thin-walled aircraft structural components. To determine stress intensity factors (SIF`s) of cracked thin-walled stiffened shells on aircraft wing type structure and lugs special singular finite elements are used. Good agreement between present computation results using singular finite elements and analytic solution is obtained.

Keywords

Aircraft, thin-walled structures, fracture mechanics parameters, singular finite elements.

Acknowledgement

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DEVELOPMENT AND STATIC STRENGTH ANALYSIS OF THE MODIFIED MILITARY SEMI-TRAILER BEARING STRUCUTURE

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Abstract

The development of a new semi-trailer presents a great challenge for designers, as well as the investment of a significant amount of money and time. Army vehicles have specific characteristics and allow certain flexibility in measure dimensions which can be defined according to the specific needs of customers. This paper presents the reconstruction and modification of an old semi-trailer with the aim to reduce manufacturing costs. The base for modification was a semi-trailer, 30 tones load bearing, which spent approximately 30 years in exploitation. According to the assessment of the state of the current bearing structure and materials, the vehicle owner decided, to retain half construction, reconstruct and develop another half to the specific purchaser's requests. The first step was to remove one-half of the construction which must be reconstructed by cutting. Furthermore, a 3D and numerical model of the bearing structure was formed. Static strength analysis of the modified vehicle structure was performed using an adequate software package and finite element method. Analysis was done for the different load cases and defined by valid standards and purchaser requests. Obtained results showed that modified vehicle structures can withstand defined loads without any permanent deformation. After producing 2D documentation, production of prototype semi-trailer was launched, and a vehicle was delivered and involved in exploitation. After a year of exploitation test, the modified bearing structure satisfied all required criteria and serial production can be started.

Keywords

Semi-trailer, Modification, Prototype, Static strength analysis

Acknowledgement

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ENVIRONMENTAL EFFECTS ON THE BEHAVIOUR OF LAMINATED SHELL STRUCTURAL ELEMENTS

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Abstract

The aim of this work is to model some moderately laminated structures in the form of shells in order to simulate the behaviour of composite structures exposed to environmental effects. In this research a Higher-Order Shear deformation Theory (HOST) of elastic shells is developed for laminated shells, taking into account environmental effects on the behaviour of the shell such as the following: moisture, temperature, prestress and obviously normal charge at the shell surface. The stress analysis of laminated plates or shells were carried out by finite element method (FEM). Methods of analysis have been developed for analyzing the stresses in moderately thick laminated plates and shells subjected to combined elevated temperature, absorbed moisture and mechanical loads. The shell model is based on a displacements field in which the displacements of the middle surface are expanded as cubic function of thickness coordinate and the transverse displacement is assumed to be constant through the thickness. So, the distribution of shear deformation is parabolic and there is no need to use shear correction factors. The stresses at layered composite material due to ambient condition are very important too and FEM can be effective applied in it calculation.

Keywords

Laminated shells, thin-walled structures, HOST, finite elements, hygrothermal effects.

Acknowledgement

This research has been supported by the research grants No. 451-03-9/2021-14/200066, of the Serbian Ministry of Education, Science and Technological Development.

MODELING JOINTS OF MOMENT-RESISTING STEEL FRAMES FOR NONLINEAR STATIC PUSHOVER ANALYSIS

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Abstract

The effect of the real behaviour of steel joints on the seismic response of steel moment-resisting frames has long been recognised as a crucial aspect in ensuring a safe structural response. Predicting the behaviour of steel joints under cyclic loading can be quite complex and impractical in engineering practice. Numerical approaches based on finite element methods require lengthy calculations and are very exhausting and time-consuming in practice. Laboratory tests, on the other hand, can be time-consuming and costly. A hysteresis envelope model is presented in this paper as a simple way of modelling the joints of moment-resisting steel frames for nonlinear static pushover analysis. The hysteresis envelope model is defined as a trilinear model. The principle of determining the parameters of the hysteresis model is based on the previous definition of the monotonic curve of joints. The monotonic behaviour of joints can be achieved by applying the principles of the component method, which is accepted in Eurocode 3 for the design of joints in steel structures and is available in numerous commercial software. The nonlinear moment-rotation curve, obtained by the component method, should be idealised with a trilinear curve. The parameters of the hysteresis model are then obtained by multiplying the parameters of the monotonic model with a nonlinear exponential function. A double extended beam-to-column bolted connection is used to demonstrate the use of the hysteresis envelope model. Predicting the cyclic behaviour of the connection using the hysteresis envelope model is satisfactory for practical application. The results are based on an estimate obtained by numerical simulations.

Keywords

Beam-to-column joint, hysteresis envelope model, moment-resisting frame, nonlinear static pushover analysis

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NUMERICAL METHOD FOR WORKSPACE DETERMINATION OF FLIGHT SIMULATOR WITH STEWART PLATFORM MECHANISM

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Abstract

One of the most important characteristics of the mechanism used for flight simulation is its workspace. The workspace of any mechanism (including parallel mechanisms, which has a closed kinematic chain) is a set of positions and orientations reachable by its end-effector. In order to be able to successfully simulate flight with a motion platform, on which the pilot sits while in training, its workspace has to meet some criteria. Based on previous, it is essential to have a computationally fast and efficient but at the same time also accurate workspace determination process in order to design and optimize the geometry of the mechanism used for the flight simulator. Full flight simulators are most often with parallel mechanisms based on the Stewart platform which has six degrees of freedom inside the workspace. There is no analytical solution for the workspace of this type of mechanism that considers all constraints (such as motion limits of joints) and that can be practically used in the design process. One option is to simply test all significant positions and orientations, this includes defining the range for each axis and value change step (increment between consecutive values) and then testing all possible combinations. In order to lower the number of combinations that must be tested space is divided a few times, first with the coarser step and then with the finer one just around the boundary of the workspace. The final step is defining the boundary surface based on points that are within the workspace.

Keywords

Flight simulator mechanism, numerical workspace determination, stewart platform workspace, parallel robot workspace, space division

DESIGN AND DEVELOPMENT OF STATIC LOAD TEST STAND FOR VARIOUS SIZES OF MULTICOPTER ARMS

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Abstract

The constant advance in the usage of unmanned aerial vehicles (UAVs) of all types, including electric multicopters (rotary-wing drones), requests further advancement on all project levels in order to create a competitive final product. With the usage of composite materials, mainly carbon fiber in epoxy resin, it is possible to have a very lightweight structure that is strong enough to sustain all anticipated loads. Arms are a crucial part of multicopter structures that are often made entirely of composite materials. Each multicopter arm has at least one electric motor and propeller on one and a connection with the body on the other end. A static load test stand for various sizes of arms is designed and developed in order to test prototypes within the design process and to be able to test the mechanical characteristics of each produced final part that will be later assembled with other parts. The test stand consists of a robust steel frame, part mounting clamps, a movable low-speed hydraulic cylinder with an appropriate hydraulic power pack powered by an electric motor which is controlled by a variable frequency drive, a load cell for force measurement, and a linear displacement transducer for displacement. A custom digital electronic circuit with a microcontroller is developed in order to control the actuator and obtain data from sensors. Also, custom user-friendly software with a graphical user interface is designed to control experiments and process measurements.

Keywords

Static load test stand, test stand design, experimental testing, multicopter arm, rotary-wing drone arm

SPECTRA LOCALIZATION ANALYSIS OF GYROSCOPIC SYSTEMS

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Abstract

Vibrations and stability analysis of gyroscopic systems have been investigated by many authors and several types of solutions are given. Gyroscopic systems correspond to spinning structures where the Coriolis inertia forces are taken into account, and they are widely known to exhibit instabilities. The nonlinear eigenvalue problem for these systems is and associated with holomorphic matrix function P(z)=Az^2+Bz+C in a connected open set Ω⊆C, where A, B, C are real and sparse; A and C are Hermitian, B is skew-Hermitian and the matrix A is positive SDD matrix. These systems can be divided into damped and undamped, and the matrices that describe them are real and differ in the linear part. Here, a numerical method for computing spectra localization sets of this eigenvalue problem that uses the property of strictly diagonally dominant matrices and the Gershgorin theorem is used. This spectra localization technique is generalized to apply the Gershgorin theorem and properties of some other classes of strictly diagonally dominant matrices: Alpha 2 and H-matrices. In this way, better localization sets are obtained. This method is suitable for solving gyroscopic system eigenvalue problems in situations when the exact position of each eigenvalue is not needed, but it is sufficient to know only the position of the spectrum of the observed problem. In this way, savings in calculation costs are achieved.

Keywords

Quadratic eigenvalue problem; gyroscopic system, numerical methods, Gersgorin’ s theorem

NUMERICAL SIMULATION OF A HEMISPHERE IN A TURBULENT BOUNDARY LAYER USING VERY LARGE EDDY SIMULATION

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Abstract

Architectural constructions having the hemispherical or dome shape are interesting for various purposes such as sports, exhibitions or trade. For constructive stability of such structures it is important to study the aerodynamic forces acting on them as created by the wind flow. For that purpose, these structures are modelled as isolated wall mounted structures in the atmospheric boundary layer. As it is observed that such a complex flow cannot often be accurately modelled by turbulent models relying on eddy-viscosity concept, the alternative, higher fidelity approaches, including the Large Eddy Simulation (LES) were subsequently tested. In this study we are investigating the scale-resolving type of hybrid model known as the Very-Large Eddy Simulation (VLES) as being less computationally demanding relative to LES, in the form which was previously validated in the case of smooth laboratory-scale hills. For this computational study we use the open source CFD code freeCppuccino. Our simulations are based on flow cases investigated in wind tunnels for Reynols number values of 36000 and 64000. Similar complex features as in the case of the smooth hills are present in the case of the hemispheric dome such as separation, reattachment, complex vortical structures in the wake of the body. The study shows comparative results and proposes practical modelling and simulation advice for wind engineers.

Keywords

Turbulent flows, hemisphere, computational fluid dynamics, RANS, LES

Acknowledgement

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SENSITIVITY WITH RESPECT TO CERTAIN RANDOMLY SELECTED PARAMETERS IN FRICTION STIR WELDING NUMERICAL ANALYSIS

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Abstract

In the friction stir welding (FSW) model there is more than twenty parameters. Most certain are the parameters of the model geometry, and the velocity and the rotational speed at which the tool should move. Other parameters, as density, mechanical and thermal properties of materials, coefficients of interactions, are mostly uncertain. Apart from substantial number of parameters, the problem of the FSW numerical analysis is that it is extremely time consuming, and it is almost impossible to keep track of all the errors that may occur while comparing results for different model setups.

In this work, the most common FSW numerical model was used, rectangular plate and tool with cylindrical shoulder and pin, both slightly rounded at the bottom. The influence of the parameters which are not usually mentioned in the final work or are randomly selected was carried out. The calculations were performed in Abaqus using Coupled Eulerian – Lagrangian (CEL) approach. Only first plunging phase of the FWS process was considered. The model was selected from another author with all parameters well documented except heat transfer coefficient at the bottom of the plate and friction coefficient between tool and plate.

As expected, it was difficult to obtain the same results since the model is overly sensitive to these two parameters. It is also difficult to accurately determine sensitivities due to the time required to complete one full simulation.

Keywords

Friction stir welding, FSW, uncertainty analysis, Coupled Eulerian-Lagrangian approach, CEL

Acknowledgement

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NUMERICAL ANALYSIS OF PLA MATERIAL ORTHOPAEDIC PLATES

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Abstract

Additive Manufacturing (AM) provides many applications in different high-demand engineering fields, i.e., automotive, aeronautical and biomedical fields. For biomedical applications, biodegradable thermoplastics, such as PLA (PolyLactic Acid), are suited for the fabrication of orthopaedic plates. FDM (Fused Deposition Modeling) AM technology provides the creation of structures with different infill percentages, thus enabling drug delivery application. As PLA material degrades, drugs incorporated within the structures are being released into the system- enabling tissue healing. The subject of this paper is the structural integrity assessment of one orthopaedic plate design via numerical analysis. Degradation of material is not the concern of this paper, just the time period when the PLA material holds its primary mechanical values. Fracture mechanics fatigue experiments on Compact Tenson (CT) specimens gives valuable data concerning Paris law constants: C and m. There are three different pairs of these constants, relative to printing layer height: 0.3, 0.2 and 0.1 mm. Fatigue tests have shown that the least result scatter is present in 0.1 mm layer height, thence this set is used primarily for numerical simulation in Ansys software. Pre-crack is applied to the simulation with a 0.5 mm crack depth. Boundary conditions and loading are used as suggested in the previous research. The final result of this research is crack propagation diagrams, relative to a number of cycles- thus showing how long a chosen PLA structure can endure in such an application.

Keywords

PLA; FDM; orthopedic plates; numerical analysis;

Acknowledgement

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New Technologies

APPLICATION OF THIN WALL BEAM THEORY TO CALCULATION OF RAFT CONSTRUCTION

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Abstract

The paper presents analytical and numerical determination of the equivalent stress and deformation of thin-walled „U“ and „Z“ cross section cantilever beams loaded with torsion. The aim of this paper is to present the application of thin-walled beams on cargo raft load-bearing structure from the aspect of strength and reliability. Equivalent stress and deformation were obtained with analytical calculation for encastred model over whole cross section. The finite element method was applied to the beam models, and the obtained results were compared with the analytical calculation. The paper presents the profiles that are installed in the load-bearing structures of vessels (rafts) and gives a way to use the results of the presented analyses in order to increase their reliability. The calculation of the load-bearing structure of the raft was done.

Keywords

Thin-walled beams, finite element method (FEM), equivalent stress, deformation, cross-section

CAVITATION RESISTANCE OF THE MATERIAL PA 3200 GF PRODUCED BY SELECTIVE LASER SINTERING

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Abstract

The present study focuses on the results of cavitation resistance research of samples obtained by the Selective Laser Sintering technology. The material used was Polyamide powder PA 3200 GF reinforced with glass fibers. The laser-sintered samples were produced from 100% new and recycled powder mixed with 70% of new powder. The samples were tested under cavitation conditions using an ultrasonic vibration method with a stationary sample according to the ASTM G-32 standard. Examination of the morphology of cavitation damage was investigated by scanning electron microscopy. The change in mass loss during different cavitation times was measured on the tested samples. The main objective of the research was to determine the validity application of the tested material in cavitation conditions.

Keywords

Polyamide powder PA 3200 GF; morphology, cavitation rate, laser sintering, SEM

Acknowledgement

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COMPARISON OF DIGITAL INNOVATION HUBS WORK IN SLOVENIA WITH MORE DEVELOPED COUNTERPARTS

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Abstract

This research provides new insight into the work of digital innovation hubs (DIHs) in Slovenia, thus contributing to the knowledge of the different ways that the DIHs operate with a more detailed and balanced understanding. Data clearly show that not all variance in the DIHs' work can be explained by literature or registered services. Their work is shaped by the environment in which they operate, and only field research provides the real picture of the work and effect of DIHs.

The results of the survey show that for Slovenian respondents, among other things, are important reasons for establishing DIHs and opportunities to apply for EU projects, innovations and new technologies. Respondents from Slovenia focused their support on digital transformations, smart solutions - smart entrepreneurship, smart technologies, smart cities & regions, and those from Austria are focused on Production & Manufacturing Technologies, Security, Data Science, and Intelligent Production.

Keywords

Digital Innovation Hubs, Slovenia, Austria

SMART PATHOLOGY PLATFORM FOR SAMPLE TRACKING

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Abstract

Approximately 70% to 80% of major clinical decisions, especially in oncology, are based on information coming from the pathology laboratory. Pathology departments play a crucial role in diagnostic process, as precise and rapid diagnoses are vitally important for patients. There are two main reasons why automation is now creeping into pathology. One is the automation of digital pathology through artificial intelligence (AI) and we are in the early stages of its adoption. The second is that pathologist can use it as a tool to improve the specificity and sensitivity of the diagnosis. Optimization and automatization of pathology processes not only increase the efficiency of routine tasks but also provide flexibility, productivity, quality control, and safety of patient data and material. The other reason is the growing use of molecular testing, DNA, RNA, or protein-based. Laboratory automation aims to reduce human error, paperwork, and the number of steps in requiring human intervention. Clerical and identification errors are responsible for a large fraction of poor outcomes for hospitalized patients, and almost 40% of errors occur during the preanalytical phase. Proposed solution of our smart pathology platform is equipped to support all pathology workflows: 1) Sampling and registration of samples; 2) Preparation of slides and cases, 3) Macroscopic examination; 4) Microscopic reporting; 5) Revision, validation, sending of the results.

The combination of automation and computerized interfaces has the potential to reduce the risk of clerical and identification errors. Such a high-quality system is flexible, enables maximum functionality, and provides a user-friendly solution designed for pathologists, by pathologists for increased productivity.

Keywords

Sample tracking system, pathology laboratories, platform, and laboratory automation

Acknowledgement

The Grant “Smart Start” of the Innovation Fond, Republic of Serbia, supports the project.

STRATEGIES DEVELOPMENT FOR ROUGH MILLING IN FREE FORM SURFACES MACHINING

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Abstract

Several years ago, research has begun in the field of free form surface machining at the Production engineering department at the Faculty of Mechanical Engineering in Belgrade. In this research, cases with ball end mill cutter machining were analysed, especially when it is possible to machine with maximal cutter diameter loaded from software database. On this way, it is possible to obtain an approximate shape of the free form surface faster than machining with ball end mill cutter. Using developed strategies for rough machining it is possible to reduce machining time and according to this reducing the cost of production and the cost of final product. In previously developed CAM application, new machining strategy was implemented and NC code was generated using that application. Experimental verification of generated NC code was performed on the CNC milling machine. After machining, measurement of produced part was performed and it was concluded that machining was performed in defined tolerances.

Keywords

CAD/CAM systems, Free form surfaces, Rough machining, End mill cutter

Acknowledgement

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PART DEFORMABILITY PREDICTION DURING THE MILLING OF AlMgSi1 (6082) MATERIAL

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Abstract

The hypothesis that the part is homogeneous and isotropic simplifies the processing planning process. However, assumptions also have a negative impact on the processing result. Residual stresses within the material, which can affect the deformability of the part during and after the machining process, are directly reflected in the final dimensions and the desired geometry of the part. Experimental research was conducted on the material AlMgSi1 (6082), in order to establish a model for predicting the intensity of deformability of the work. The experiments were conducted on two different parts, obtained from the preparation of the same geometry and dimensions. In the first case, the part in the shape of a vessel was processed, from solid material, while in the second case, the bottom was removed. It turns out that when machining parts of greater height, without a bottom, from solid material, there is a significant probability that the work will twist. In the case when the bottom is retained, the intensity of deformations is also present, but in a much smaller percentage. Such knowledge is extremely important in proper production planning. In this way, significant savings in production time and cost can be achieved by adequately defining offsets for rough and fine machining, while obtaining a part that meets the defined accuracy according to the technical documentation.

Keywords

Machining, Milling, Deformability, Cost Reduction

Acknowledgement

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CHARACTERIZATION OF 3D PRINTED PARTS

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Abstract

3D printing as digital fabrication technology became widely popular and used due to its ease in production and customization of any type of design in various fields of industry, medicine, or research. Different printing processes are based on making an object by deposition of material layer by layer, from previously created CAD model. Quality of 3D printed parts is dependent on many parameters such as chemical composition of used materials, printing parameters (infill percentage, infill pattern, building orientation, raster angle,..), thermal behaviour during and after printing processes, aging effect, mechanical properties (static and dynamic analysis), accuracy of printed parts, morphology and topology. With regard to the area of characteristics, which should be examined, different standards, procedures and equipment are employed. In this context, it is challenging task to link various parameters to obtain the best part performances. Given the large number of different possibilities in testing of final 3D printed product, understanding the influential parameters of structure of the material and final part is essential. This paper presents an overview of characterization methods that can be used in order to observe morphology and topology of printed parts.

Keywords

3D printing, quality parameters, characterization.

Acknowledgement

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POSSIBILITIES IN PRODUCTION OF 3D PRINTED CONTACT LENSES

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Abstract

Contact lenses have been used and manufactured for decades now, but recently 3D printing technologies were introduced as a new way of production. As a rapidly developing technology, 3D printing offers new possibilities for development and advantages in the manufacturing process of lenses, due to easy customization and geometry modelling. Standard production is not leaving much space for individual demands, concerning different ophthalmic diagnoses and unique patients' eye characteristics. In this paper, the main emphasis is on the further development of the design and characteristics of lenses fabricated by this technology that can satisfactorily overcome the drawbacks of production approaches used until now. Areas of possible improvements are significant, meeting the individual demands of patients, customizing needed parameters for better therapy, biocompatibility, the possibility to integrate different optical sensors for diagnostics, even making the smart lenses, etc. There are a very limited number of studies dealing with 3D printing and examination of printed contact lenses, which leads to the conclusion that this is the research area of the future.

Keywords

Contact lenses, 3D printing, customization, production.

Acknowledgement

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3D TECHNOLOGIES USED AT TECHLAB TEHNOPOLIS

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Abstract

3D technologies such as 3D modelling, 3D printing, and 3D scanning are indinspancible tools of every manufacturing process, especially important for developing innovative ideas and functional prototypes. Our poster will present the capabilities of those technologies as well as the most important projects we managed to manufacture so far, for the purposes of agriculture activities, the medical department, and the IT sector.
One of the main objectives of our laboratory is to give support to the innovators, start-up companies, and Master and Ph.D. students, mainly for converting their ideas into the 3D CAD model and/or functional prototypes which they can use for functionality testing or scientific investigation. During the previous year, we gave support to several start-up companies and innovators, by employing capabilities of SolidEdge 3D modelling software and Artec Space Spider 3D scanner, Dynamical DT 60 industrial FDM 3D printer, and sophisticated Markforged Metal X 3D BMD metal printer. Together with innovators and partners, we managed to finish several projects which have great chances to go into the production in small series based on market demands. Our prototypes were made from several types of printing thermoplastics, plexiglass, all bond, resins, and 17-4 PH stainless steel. During some projects, we incorporated the 3D scanning process together with the basic implementation of reversed engineering techniques.

Keywords

3D modeling, 3D scanning, 3D printing, functional prototyping

ANALYSIS OF METHODS FOR TOOL PATH GENERATION USING COMMERCIAL CAM SYSTEMS

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Abstract

Parts with free-form surfaces can be found in a wide range of products and components in almost all industrial segments, including goods, toys, electronic devices, dies and molds, automotive, even in medical and aerospace industries. Today, there are many commercial CAM systems capable for generating G codes for free-form surfaces machining. In this paper, tool path generation is presented using different commercial CAM systems. It is presented differences in machining time in accordance with used machining strategies. Used machining strategies gives different scallop height of machined surface and according to given surface roughness it is used different machining parameters in every used strategy. It is also given differences in machining time in dependence of chosen CAM software. As the conclusion it is given that the different CAM software have implemented different machining strategies and according to this it will generate NC codes which will have different tool path. Difference in tool path has impact on surface roughness and total machining time and according to that impact on final product price.

Keywords

Tool path, CAM, CNC milling

Acknowledgement

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DEVELOPMENT AND RAPID PROTOTYPING OF THE NEW ROLLING BEARING DESIGN

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Abstract

Nowadays, the rolling bearings are used in almost all machines with rotating parts as a support for shafts (or axes). Bearings can transfer radial and/or axial loads. Radial bearings sustain loads that are dominantly perpendicular to the axis of the shaft. Thrust (axial) bearings sustain axial or thrust loads that are parallel to the axis of the shaft. Taking into account that operational load is almost never fully radial or axial, different types of rolling bearings are developed, which can sustain both radial and axial loads at the same time – such as angular rolling bearings. In the last decade, the development and progress of the additive manufacturing technologies allows the construction of the new rolling bearing designs which could better sustain both axial and radial loads, but were not possible to be manufactured earlier. One of the ways to optimise the construction of the radial-axial rolling bearings is to optimise the shape of its rolling elements (bodies). Usually, for the transfer of the axial loads, balls are used as bearing rolling elements, and for the transfer of heavy radial loads – the cylinders. The compromise between balls and cylinders are ellipsoids, which possess the desired characteristics of both shapes. The main problem generated by the ellipsoidal rolling elements is the shape of the rolling bearing cage openings which must fully correspond to the shape of the rolling elements (ellipsoids) – as they need to prevent the rotational movement of the ellipsoids around the vertical perpendicular axis, allowing its rotation around the longer axis. The first steps in solving this problem are already being made, as the first prototypes of the new radial-axial rolling bearings are manufactured using available 3D printers – such as one shown in the Figures 1a and 1b. After the presented concept is finally proofed, the next steps of research will focus on the optimisation of the other component parts of the developed rolling bearing design, as well as definition of the optimal 3D printing parameters.

Keywords

Rolling Bearings; 3D printing; Rapid Prototyping; Product Development; Machine Design;

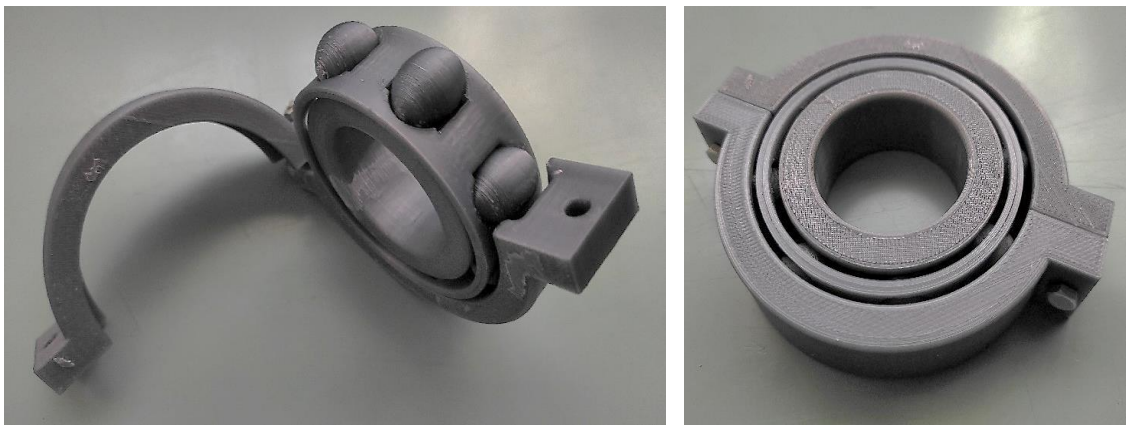

Fig. 1a. and 1b. *One of the prototypes of the new rolling bearing design*

Clear sky

MOULD TECHNOLOGY TO TEST MECHANICAL CHARACTERISTICS OF BIOCOMPOSITE STRUCTURES

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Abstract

Composite materials are a combination of two or more materials at the macroscopic level. They have better characteristics than individual components. By combining different types of mountings and matrices, new advanced materials can be obtained to improve performance. In complement to standard structures (carbon-epoxy, glass-epoxy), increasing importance is given to biodegradable materials. Most often, materials with a vegetative part of fungi (mycelium-mesh structure of hyphae) are used, which are increasingly used to realise biocomposites with unique processing technology. These composites have relatively good mechanical properties and are environmentally friendly because they are biodegradable. Today, biocomposites are used in packaging production, fashion, and construction, and the emphasis is on the food industry. This paper presents the making mould technology to set the biocomposite structure and test their mechanical characteristics. The mould for pressing biomaterial connected with mycelium is made of two parts. The primary purpose of the mould is to bring the loose natural material into a solid preparation following the standards ASTM D7250 and ASTM C393, which include testing the technologically prepared and hardened sample for bending and shearing. The testing included two phases. In the first, hardened samples without moisture were tested. The second involved the technological process of drying after sowing mycelium so that a variant of the mould with a perforated bottom was used to harden the samples thoroughly. A comparative analysis of the results in both phases was performed, which was a further guideline in examining the improvement of composite characteristics.

Keywords

Biocomposite materials, fungi, design, testing, mould

Acknowledgement

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THE INFLUENCE OF THE REYNOLDS NUMBER ON THE AIRFOILS

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Abstract

The wind speed is one of the major parameter influencing the design of the wind turbine, which varies widely over the different part of the country and globe. So, significant research is going on for the design of wind turbine for low, medium and high wind speed. Currently, many researchers have started designing small-scale horizontal axis wind turbines (HAWT) in world, to adapt their use to households. The advantage is reflected in the simple and affordable construction, uninterrupted operation and satisfactory power that wind turbines create. An airfoil is defined as the cross section of a body that is placed in an airstream in order to produce a useful aerodynamic force in the most efficient manner possible. The cross sections of wings, propeller blades, windmill blades, compressor and turbine blades in a jet engine, and hydrofoils are example of airfoils. A computational study has been conducted on various airfoils to simulate flows at different Reynolds numbers (Re) and wind speed to provide understanding and guidance for other low Reynolds-number designs. The numerical computational method used in this study is a boundary element method (BEM) which is implemented in software Qblade. It is an alternative deterministic method which incorporates a mesh that is only located on the boundaries of the domain and hence are attractive for free surface problems. The airfoils investigated in this study include NACA 4412, NACA 63-415 and S809. Performances such as power, power coefficient and tip speed ratio were compared.

Keywords

Renewable energy, wind turbine, airfoils, Reynolds number, QBlade

Acknowledgement

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PERSPECTIVES OF THE INTEGRATION OF AN ABSORPTION REFRIGERATION CYCLE IN ENERGY PRODUCTION SYSTEM

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Abstract

Global warming and ozone depletion issues have had an impact on novel approaches to integrating some of the energy production systems. At present, fossil fuels such as oil, coal, and natural gas still are the primary sources of energy used to provide the majority of the cooling requirements in vapor compression systems. In addition, this high energy-consumption systems work with substances that contribute to ozone layer depletion and are typically based on fluorinated gases (F gases), that as well, can have a global warming impact thousands of times greater than CO2. Much research has been done on reuse and waste heat utilization within different systems to achieve a reduction in high carbon fuel consumption. The method that aims at improving the value of the exergy of the available renewable energy sources is the absorption refrigeration cycle (ARC). With ARC, the concept of "cooling with the heat" can be achieved, with a variety of benefits such as integration of the energy production systems, implementation of sustainable-based technology in the industry of cooling, and the possibility of establishing a district cooling system, etc. The cooling demands can be met through the utilization of solar radiation, energy from biomass, waste heat from industrial processes, and geothermal energy.

In the terms of the importance of low-temperature heat sources and the reuse of heat energy, currently, present researches have focus on identifying engineering and cost-effective approaches to enhance the efficiency of an integrated system. That kind of system affects the output parameters of energy production and energy consumption, so the possibilities to compare the different systems from the exergy and economic standpoint, based on the different parameters are vast. The criteria of comparison and investigation of the effects of integrated systems in the majority of cases would be based on: better performance at very low temperatures, carbon dioxide emissions, and cost savings. Despite the existence of different obstacles, the integration of different energy production systems will have a considerable impact when it comes to overcoming the challenges in the energy production sector.

Keywords

Absorption refrigeration cycle, system integration, renewable energy, low-temperature sources

APPLICATION OF ADDITIVE MANUFACTURING TECHNOLOGY IN AEROSPACE INDUSTRY

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Abstract

The emergence of additive technology (AT) in the 1980s and its rapid development in the early 21st century had an impact on production processes in many industries. The possibility of making parts of complicated geometry, saving materials and time in the production process, as well as reducing production costs compared to conventional methods are the main reasons why the aerospace industry is one of the largest users of additive technology. By applying 3D printing in the aviation industry, it is possible to perform a wide range of processes such as production and repair of parts, mold production, rapid prototyping, casting patterns, etc. Also, the possibility of rapid optimization provides the improvement of one of the most important factors in the aerospace industry, that is, the weight-to-strength ratio. Additive technology techniques can be divided into the following groups: sheet lamination, binder jetting, material jetting, vat photopolymerization, material extrusion, powder bed fusion and direct laser deposition. Rigorous requirements in aviation regarding the quality of workmanship of parts and their operational characteristics are the main barrier to the use of most 3D printing techniques. On the other hand, the scientific research community around the world is making great efforts to ensure that this technology meets the design, economic and operational requirements to fully enable the realization of AT production processes in the aerospace industry. This paper presents several techniques that are most commonly used in the aerospace industry, as well as a review of some 3D printing techniques that are not used but that may be the subject of future research.

Keywords:

Additive Manufacturing, Airspace Industry, Production process

Acknowledgement

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THE SIGNIFICANCE OF 3D PRINTING IN TEXTILE-POLYMER COMPOSITE STRUCTURES REALIZATION FOR SPECIAL PURPOSE

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Abstract

This paper presents the 3D printing technology for various textile materials. The application of this technology is vital in manufacturing various clothing items, primarily for specific purposes: hikers, firefighters, soldiers, and athletes. The installation of sensors, life function parameters monitoring, and the usage of the new materials are the basis for the future development of the textile industry. Today, thermoplastic and textile materials are increasingly used in practice. Polylactic Acid (PLA) thermoplastic materials were used in the paper - in the spool, Polyvinyl Chloride (PVC), and Nylon (in strips); while from textile materials, polyester, viscose, and silk in the form of finished fabrics were considered. The technology of preparation of textile fibers for 3D printing using laser is shown. This technology makes it easier to combine textiles and molten filament. The pros and cons of joining different materials are discussed. Further research would go in the direction of making constructive solutions and testing the mechanical properties of various textile-polymer composites.

Keywords

3D printing, Textile, Thermoplastic materials, Laser cutter, Composite structures

Acknowledgement

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Dental Materials and Structures

Invited lecture

PHYSICOCHEMICAL PROPERTIES OF CALCIUM SILICATE-BASED SEALERS

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Abstract

In recent years, calcium silicate formulations of root canal sealers have emerged on the market, being a scientific and clinical extension of MTA-based materials. The basic idea was to create a group of sealers by summarizing the good biological and physicochemical properties of MTA, which would combine well with the basic root canal filling with different obturation techniques, with adequate flow and setting time. Today, there are several such sealers which, although derived from the same basic formulation, have their own specifics and differ in: composition, radiopacifier, particle size and delivery system. These specificities can affect the biological and physicochemical properties of calcium silicate-based sealers as well as their behaviour within the root canal.
The aim of this lecture is to provide an overview of physicochemical properties of recently developed calcium silicate -based sealers and to do a comparative analysis with a gold standard epoxy- based root canal sealer.

Keywords

Calcium silicate, root canal sealer, bond strength, radiopacity, flexural strength

Invited lecture

THERMOPLASTIC MATERIALS IN THE ORTHODONTIC PRACTICE

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Abstract

Thermoplastic materials have been widely used in orthodontic treatment during recent decades. Due to their mechanical properties thermoplastic materials have been used as removable retainers, night guards, splints, but also as appliances for tooth movement in cases of mild teeth irregularities. Because of the high esthetic demands of the patients, transparent aligners made from the plastic polymers have become an important part of the invisible orthodontic treatment.

Materials that are mostly used for the aligners are polyester, polypropylene, polyurethane, and polycarbonate. These viscoelastic materials are used for programmed tooth movement and should provide light continuous forces to the teeth. Beside required mechanical properties, materials should be biocompatible and environmentally stable. Mechanical properties of the thermoplastic materials in orthodontics such as tear strength, elongation at break, stress relaxation rate differ among polymers. Different blends were made to improve their mechanical characteristics, to obtain forces for orthodontic tooth movement. In the experimental conditions, there are certain signs of cytotoxicity of these materials used for the aligners. Thermoforming process used to shape the aligner influences their cytotoxicity. To overcome the thermoforming procedures that also impact the mechanical properties of the materials, 3D printing of the aligners has been suggested as an alternative method. Another important aspect of thermoplastic materials use is the influence on nature since they are the derivatives of petroleum.

Future investigations should be used to improve the mechanical properties of the materials, their biocompatibility and stability in the oral cavity, but also their recycling to decrease impact on the environment.

Keywords

Thermoplastic materials, Orthodontics, Treatment

Invited lecture

GRAPHENE NANOMATERIALS APPLICATION IN DENTAL PULP NERVOUS TISSUE REGENERATION

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Abstract

Both stem cells and nanomaterials are in the focus of regenerative therapy-related studies. Stem cells (SCs), emerged as a promising tool, due to their ability to differentiate into numerous cell lineages, their immunosuppressive activity, and high self-renewal capacity. Several types of stem cells with variable differentiation potentials have been isolated from dental tissues. At the same time, novel biocompatible carbon nanomaterials have also been developed, including different forms of graphene-based nanomaterials (GBN). Graphene, with its unique physicochemical properties and bactericidal and antiviral effects, is also becoming increasingly appealing in bioengineering.

The aim of the present study was to assess the neuro-stimulatory effects of nanomaterial (graphene dispersion-GD and graphene film) on dental SCs.

Isolated SCs were cultivated in neuroinductive medium supplemented with GD or graphene films. After seven days cells were subjected to neural marker analysis by real-time PCR (NF-M, NGN-2, β III-tubulin, MAP2) and immunocytochemistry (NeuN and β III-tubulin). In addition cell morphology was observed using inverted microscopy.

Relative gene expression of neural markers was significantly higher using GD, which was also confirmed with immunocytochemistry. In conclusion, GD seems to enhance neural differentiation of dental stem cells and should warrant further studies with the aim of finding a superior solution for autologous regenerative therapy of pulp tissue.

Keywords

Graphene, dental stem cells, nanomaterials, regenerative dentistry, nervous tissue regeneration

Acknowledgement

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Invited lecture

OSTEOGENIC POTENTIAL OF GRAPHENE IN REGENERATIVE DENTISTRY

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Abstract

Dental tissue is a suitable source of stem cells that can be used for therapeutical and regenerative purposes. Previous research has shown that graphene stimulates differentiation and this property is important in tissue engineering, especially in terms of bone regeneration. The aim of this study was to investigate the osteogenic and chondrogenic potential of graphene-based nanomaterials on dental stem cells. Dental stem cells, originating from immature wisdom teeth, were osteo- and chondro- induced with standard differentiation medium or graphene dispersion, separately and in combination. Differentiation potential was confirmed by specific staining and expression analysis of osteogenic (ALP, BSP, Runx2, OCN, BMP2) and chondrogenic (COL1 and COL2A1) cell surface markers by real-time PCR (qPCR) method. The results where analyse by Software package SPSS ver. 20 (SPSS Inc, Chicago, USA). The expression of osteogenic genes (Runx2, OCN, BMP2) was significantly higher in cells induced by the combination of differentiation medium and graphene dispersion compared to cells induced by standard differentiation medium ($p<0.05$) or graphene dispersion ($p<0.01$) only. Graphene addition did not appear to stimulate chondrogenesis. Graphene dispersion enhances osteogenic differentiation of dental stem cells, which makes it a promising material in dental implantology and bone tissue regeneration of the maxillofacial region.

Keywords:

Graphene dispersion; regenerative dentistry; osteogenesis; chondrogenesis; dental stem cells.

Acknowledgement:

This research was supported by the Science Fund of the Republic of Serbia, GRANT No 7750038, Oral Cancer – New Approaches in Prevention, Control and Post-Operative Regeneration – an In Vivo Study – ORCA-PCR“.

Invited lecture

MAGNETIC PROPERTIES OF ROTARY NI-TI INSTRUMENTS AFTER FRACTURE

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Abstract

The emergence of smart Ni-Ti alloy with good biomechanical properties is one of the greatest evolutionary developments in endodontics and has significantly contributed to improving the quality and efficiency of root canal treatment. Unlike stainless steel instruments, which visibly deform before a fracture, rotary Ni-Ti instruments often break without warning and visible signs of deformation. Fracture of machine Ni-Ti instruments occurs as a result of torsional stress, cyclic fatigue, or a combination of these two factors during their use.
This lecture aims to present the ultrastructural changes and changes in the magnetic properties of Ni-Ti rotary instruments that have suffered a fracture using optomagnetic imaging spectroscopy (OMIS). The properties of the change in the crystallographic structure of Ni-Ti alloy during phase transformation and the possible change in the magnetization of Ni-Ti alloy caused by external stress were used for the first time to apply the OMIS method in the analysis of Ni-Ti instruments. Testing and understanding the exact surface and molecular changes of Ni-Ti instruments during their use has become a trend in dental research and optomagnetic imaging spectroscopy is a simple method that does not require special sample preparation..

Keywords

Ni-Ti alloy, magnetic properties, fracture, OMIS, endodontics

Invited lecture

BEHAVIOR OF NANOSTRUCTURED BIOMATERIALS IN ANIMAL MODELS FOR BONE REGENERATION *IN VIVO*

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Abstract

In an attempt to obtain material which will enable better bone regeneration novel bone tissue substitute (scaffold) on the basis of calcium hydroxyapatite (HAP) was synthesized. In order to activate its surface, it can be coated with poly-lactide-co-glycolide (PLGA). Aim of our study was to examine biocompatibility and bone tissue regenerative potential of new HAP-based material.
In our research biocompatibility of HAP+PLGA was investigated by subcutaneous implantation in Wistar rats. Bone regenerative potential was assessed by implantation in the rat's tibial and rabbit's calvarian defect, and by segmental osteotomy reconstruction of rabbit's ulna. Histologically structure of epithelial tissue, density and localization of inflammatory infiltration, presence of tissue edema and vascular congestion, and thickness of capsule were evaluated. Histomorphometic analysis was conducted to determine the new bone formation ratio. Materials showed that defects were filled with connective tissue, unabsorbed graft particles and formed bone tissue. The amount of newly formed bone was the largest in the HAP+PLGA group compared to control groups. Newly formed bone had lamellar structure with osteocytes, which indicated bone vitality. HAP+PLGA didn't cause an significant inflammatory reaction in epithelial, connective and bone tissues. Vascular congestion and edema tissue weren't present. Moreover, we showed the reconstruction of large bone defect in ulna can be achieved.
In conclusion, we demonstrated that PLGA presented a superior coating option capable to considerably improve the bone regenerative potential of the synthetic hydroxyapatite. Further systematic investigations are necessary in a bigger animal model and in patients to confirm these initial promising results.

Keywords:

Hydroxyapatite, bone reconstruction, poly lactic co glycolide, tibial defect, calvarian defect.

Acknowledgement:

This study was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Project No. 172026, 45005 and 41013).

POROUS HYDROXYAPATITE/ALGINATE AND CELLULOSE SCAFFOLDS EFFECTS ON OSTEO- AND CHONDRO-DIFFERENTIATION OF DENTAL PULP STEM CELLS

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Abstract

Specific cell subpopulations identified as dental pulp stem cells (DPSCc) can be isolated from the pulp tissue of adult teeth. Generally, DPSCs have a marked differentiation potential that can be used in regeneration therapy.Scaffolds play an important role i. e. they provide structural support for cells to attach, grow, migrate and differentiate in vitro and in vivo. The aim of the study was to analyse the effects of hydroxyapatite based scaffolds with addedpolymers (alginate or cellulose) on characteristics of DPSCs,with emphasis on theirviability and differentiation potential. Specific staining was used for osteo- and chondro-differentiation confirmation, along with the expression analysis of osteogenic (ALP, BSP, Runx2, OCN, BMP2) and chondrogenic (COL1 and COL2A1)markers. The scaffolds did not show cytotoxicity based on MTT assay. DPSCs differentiated into osteogenic and chondrogenic lineages, as judged by staining and higherexpression of specific markers. Concomitantly with differentiation, the levels of stem cell marker CD90, CD105 and CD73 decreased in the cell cultures. In conclusion, DPSCs exhibit the capacity to differentiate in the presence of hydroxyapatite based scaffolds, a characteristic that may potentially be useful in the development of new tissue engineering strategies for the treatment of largedefects following complex maxillofacial surgical procedures.

Keywords

Dental stem cells, hydroxyapatite, scaffolds, stem cell differentiation.

Acknowledgement

This research was supported by the Science Fund of the Republic of Serbia, #GRANT No 7750038, Oral cancer – new approaches in prevention, control and post-operative regeneration – an *in vivo* study – ORCA-PCR.

SURFACE WETTING AND ADHESIVE CONTACT ANGLE ON DENTIN WITH ARTIFICIALLY INDUCED CARIES

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Abstract

Dentin surface wetting is a phenomenon that describes the ability of dental adhesives to spread over the surface and penetrate into dentin. The aim of this study was to measure contact angles of reference liquids and a universal adhesive on dentin with artificially induced caries.
Eighty human, intact, third molars extracted for orthodontic reason were sectioned mid-coronally to produce 1mm-thick dentin disks. The experimental group consisted of samples with artificially induced caries (AIC) formed by the lactic acid method using 8% methylcellulose and 0.1M lactic acid (pH 4.6). The control group consisted of intact dentin samples (ID). Each group was divided to one subgroup treated with phosphoric acid for 15s (TE), and the second consisting of untreated samples (SE). Contact angles of three reference liquids (distilled water, ethylene glycol, diiodomethane) and a universal adhesive (G-Premium Bond, GC Europe) were measured using the sessile drop method.
In TE_AIC samples, contact angles were significantly higher for all reference liquids and for the adhesive (DV_69,97±0,86°;EG_69,38±5,13°;DM_51,30±5,63°;PB_30.87±3.85º) compared to SE_AIC (DV_51,67±2,30º;EG_34,74±4,76º;DM_27,28±3,02°;PB_25.31±2.67º). Significantly lower contact angles for reference liquids were found in TE_ID (DV_51,09±5,37°;EG_30,32±4,68°;DM_25,44±4,24°), compared to SE_ID (DV_58,99±6,58º; EG_48,22±6,26º;DM_45,69±8,47°). No difference was found for adhesive contact angles between TE_ID (PB_31.77±3.97º) and SE_ID (PB_28.15±2.34º).
SE_AIC showed better surface wetting than TE_AIC with lower adhesive contact angle indicating better adhesive spread over dentin surface. The opposite was true for surface wetting of intact dentin but with no effect on adhesive contact angle.

Keywords

Dentin, caries, contact angle, surface free energy, universal adhesive

Acknowledgement

GC company Serbia for materials used in study.

CHARACTERISATION OF POLYMETHYL-METHACRYLATE WITH GOLD NANO PARTICLES

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Abstract

Polymethyl-methacrylate (PMMA) is the most commonly used material for dentures. Local infections are common in patients with dentures, due to the easy accumulation of biofilm on PMMA surface. Gold nano particles (AuNPs), have shown to have antibacterial properties, so we incorporated AuNPs into PMMA, to improve its mechanical and biological properties. The aim was to compare the antibiofilm properties of PMMA with AuNPs to conventional PMMA. The antibiofilm characteristics were analyzed in vitro using 12 discs, 14 mm in diameter, made by a process of cupping with concentration of 1 g/l AuNPs. Pure PMMA was used as the control group. Candida albicans (ATCC 10231) monomicrobial biofilms were formed in RPMI 1640 medium and incubated statically at 37º C in aerobic conditions for 24h. Antibiofilm activity was analyzed by counting the number of colony forming units (CFU) on discs and the solution around the discs, as well as by performing MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide) assay on discs. The amount of biofilm formed on the AuNPs/PMMA discs was significantly lower by both methods, CFU(p=0.013) and MTT (p=0.003). On the other hand, the number of CFU of the solutions did not show statistical difference between the two materials (p=0.909). AuNPs/PMMA is shown to have much better antibiofilm properties, and could be interesting for the prevention of denture stomatitis.

Keywords

Denture stomatitis; Nanotechnology; PMMA; AuNPs;

SOLUBILITY OF DIFFERENT CALCIUM SILICATE AND CALCIUM ALUMINATE DENTAL CEMENTS

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Abstract

Solubility of dental cements presents dissolution in fluid that surrounds cement. Root canal repair cements should have low solubility. It was shown that dissolution of calcium silicate cement caused lower adherence to dentin canal wall. Dissolution of dental cements may allow leakage, leading to treatment failure. The aim of this study was to compare dissolution of different calcium silicate and calcium aluminate dental cements in phosphate buffered saline (PBS).Specimens were prepared mixing cement powder and distilled water (ratio 1:3), and then, puting into teflon cast. After setting of the cements, cylindrical specimens (6x4mm) were dried and measured on analytic scale. Specimens were immersed into PBS for one month, and after that period, dried and measured on analytic scale.

Two calcium silicate cements (Portland and MTA) showed dissolution after standing in PBS for one month (-2.41% and 1.22%, respectively). On the other hand, calcium aluminate (pure), calcium aluminate + SrCO3, calcium aluminate + SrF2, showed significant increase in mass (+7.71%,* +2.24% and +14.05%*, respectively).*

Dissolution of dental cements allows micro leakage of fluids and bacteria, leading to failure of treatment. Unique characteristic of calcium aluminate dental cements to precipitate phosphate ions from PBS fluid, enables creation of biological apatite on its surface. In addition, hydration processes continues after setting of these cements, leading to increase in mass. These features may be clinically important, enabling fill of micro gap between cement and dentinal wall.

Keywords

Dental cements, calcium silicate cements, calcium aluminate cement

DIMENSIONAL CHANGES OF DIFFERENT ENDODONTIC CEMENTS: THREE-DIMENSIONAL OPTICAL DEFORMATION ANALYSIS

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Abstract

Calcium-silicate-based types of cement have remarkable potential for clinical use in endodontics. It is due to their dimensional stability and adhesivity, which allows them to have adequate sealing abilities. Lack of expansion and contraction of the material helps seal the area that it is being placed on. The potential existence of microleakage along the cement-dentin interface would contribute to the colonization of microorganisms, potential periapical infection and tooth loss. The aim of this study was to measure and compare the strain and displacement of three calcium-silicate-based types of cement: Bio MTA+ (Cerkamed Company, Poland), Biodentine (Septodont, Saint-Maur-des-Fossés, France) and Well-Root PT (Vericom, Gangwon-Do, Korea), which were used to fill perforations on dentine discs. For that purpose, the digital image correlation method (DIC) was used and 3D surface deformations were analysed using the 3D optical system Aramis 2M (GOM, Braunschweig, Germany). The zones of greater and lower displacements were established by tracking the surface markers on the cement surface. Dimensional changes were observed in all experimental groups. The largest total displacement was observed in the MTA group.

Keywords

Calcium-silcate cements; Digital corelation method; MTA;

Acknowledgement

The authors of this paper would like to express their gratitude to the Innovation Centre of the Faculty of Mechanical Engineering in Belgrade for their support in the realization of this study.

TISSUE REACTION AFTER SUBCUTANEOUS AND INTRATIBIAL IMPLANTATION OF HYDROHYAPATITE COATED WITH POLY (LACTIC-CO-GLYCOLIC) ACID

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Abstract

Dental biomaterials not only substitute for missing or damaged tissues but also promote tissue regeneration. The interface between the tissue and the biomaterial plays a crucial role in determining the achievement of soft and hard tissue regeneration. The aim of the study was to investigate the acute and subacute inflammatory response (IR) to hydroxyapatite (HAP) coated with poly (lactic-co-glycolic) acid (HAP+PLGA), called ALBO-OS, in comparison to Bio-Oss® in subcutaneous and osseous tissues of experimental rats. Wistar rats (n=15), randomly assigned in groups of 10, 20, and 30 days, were implanted subcutaneously with HAP+PLGA, Bio-Oss® (positive control) and with the empty tube (negative control). Consequently, implantation in defects of both hind limbs with the same materials was done. The animals were euthanized on the 10th, 20th, and 30th postoperative days. Tissue samples were prepared and analysed histologically and histomorphometrically. Normal healing of epithelial tissue without signs of infection or necrosis, minimal vascular congestion immediately around the graft, no signs of tissue oedema but with minimal thickness of capsule where present. The applied material did not cause an IR of significant intensity whereas 20 days after implantation IR was assessed mainly as minimal. The tibial specimen showed that HAP+PLGA has good osteogenic potential similar to commercially used Bio-Oss® for up to 30 days, as well as low levels of acute and subacute inflammation. It can be concluded that the HAP+PLGA material is biocompatible as much as Bio-Oss® or even better with respect to the tissues.

Keywords

Hydroxyapatite, poly(lactic-co-glycolic) acid, inflammation, bone regeneration, biocompatibility

Acknowledgement

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Advanced Materials and Technology

Invited lecture

SPARK PLASMA SINTERING OF MECHANICALLY ACTIVATED MGO-TIO$_2$ SYSTEM

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Abstract

MgTiO3 is a material often used in different types of high-frequency capacitors, temperature compensating capacitors, and chip capacitors, so the enhancement of this material is still the focus of many research groups due to its remarkable dielectric properties. Outstanding features can only be achieved when the ceramics are highly dense. Densification of magnesium titanate by Spark Plasma Sintering (SPS) was the aim of this work. Magnesium titanate ceramics were prepared by applying mechanical activation as the first step. Powders prepared in this way were SPS sintered, at 1200°C with a heating rate of 100°C/min. After reaching the desired temperature, a uniaxial pressure of 50 MPa was applied. The dwell time at this condition was 5 min, followed by cooling to room temperature at 5°C/min. X-ray diffraction was performed in order to establish the phase composition of milled powders and obtained ceramics. Differences between samples milled in various times intervals, as well as sintered ceramics were examined by means of scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS). The presence of $MgTi_2O_5$ phase was detected in XRD and was confirmed by EDS analysis for the non-milled ceramics. In the samples obtained from milled powders, no $MgTi_2O_5$ wasn't detected in XRD patterns, but this phase was detected in EDS spectra in a lower amount. Dielectric measurements were performed at a wide range of frequencies, while the hardness of the SPS samples was measured at loads up to 10 N. The highest value of the hardness was obtained from powder milled for 15 min before SPS.

Keywords

Magnesium titanate, SPS, Mechanical activation, Dielectric properties, Hardness

Acknowledgement

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INFLUENCE OF MN DOPING ON THE EVOLUTION OF MICROSTRUCTURE AND OPTICAL PROPERTIES OF MECHANICALLY ACTIVATED SRTIO$_3$ POWDERS

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Abstract

Manganese doped $SrTiO_3$ powders with various manganese dioxide weight percentages in the range of 1.5, 3 and 6 wp% were prepared by a solid-state method in the presence of mechanical activation (10, 30 and 120 minutes). A systematic investigation by X-ray diffraction (XRD), scanning electron microscopy (SEM), particle size analisys (PSA), Brunauer-Emmett-Teller (BET) methods and Raman spectroscopy has been undertaken to evaluate the role of dopants on the microstructural and morphological study of the perovskite oxide obtained. The optical properties of the different manganese doped and activated $SrTiO_3$ powders have been also evaluated. Mn insertion in $SrTiO_3$ is discussed considering the possibility for Mn ions to occupy both Ti^{4+} and Sr^{2+} sites as well as manganese segregation and Mn incorporation-related non-homogeneities. The results demonstrated that Mn has substituted into the lattice and surface layers of the particles of $SrTiO_3$ powders and the absorption onset shifted to higher values of wavelengths with increasing time of activation and dopant concentration. The lowest value of the band gap (E_g=3.10 eV) was registered with the longest activation for 120 minutes and the highest concentration of dopant (6 wp%). Combining doping with mechanical activation lower values of band gap can be achieved and that fact could be used in subsequent studies to make Mn-$SrTiO_3$ more suitable visible-light photocatalysts.

Keywords

Mn-doped $SrTiO_3$ powders, mechanical activation, structural and optical properties.

Acknowledgment

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THE INFLUENCE OF THE CHANGE IN THE NUMBER OF TEETH ON THE DEGREE OF SAFETY IN CYLINDRICAL GEARS

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Abstract

Due to the compactness of the construction, high reliability and load-bearing capacity, gear pairs have the greatest application in mechanical engineering in the field of power transmission and transformation from drive to working machine. During coupling, the contact of the teeth is achieved by the teeth of one gear entering bottom land teeth of the other, with the contact being entirely on the hips. The contact line and the attack line move along the profile of the tooth flank, that is along the side surface, during the coupling of the gears. One of the ways to improve the performance of gear pairs, and thus gears, is to increase the number of simultaneously coupled pairs of teeth, or increase the degree of coupling of the tooth profile. The aim of this paper is to analyze in detail the dependences of changes in the number of teeth and changes in the degree of safety on the destruction of hips and tooth fractures in the database of given pairs. It moves by coupling smaller numbers of teeth, towards larger numbers of coupled teeth, on the same diameter of the same material of cylindrical gears. Based on the obtained results and the introduced power of the 6kW motor, the optimal parameters of cylindrical gear pairs can be defined from the aspect of the magnitude of the degree of safety by coupling a given number of teeth.

Keywords

Gear,degree of coupling,degree of security, tensile strengt

FLUID-STRUCTURAL ANALYSIS AND OPTIMIZATION OF COMPOSITE WIND TURBINE BLADE

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Abstract

Wind energy is one of the most promising sources of renewable energy. The wind energy is converted into mechanical power through blades which are a major part of wind turbines. Nowadays, composite materials have been used for the fabrication of wind turbine blades to reduce blade weight. Fluid flows over the blade's structure surface and creates pressure loads resulting in the deformation of the blade. Numerical modeling methods are applied to estimate flow-induced deformation and they are required for the optimization of composite wind turbine blades. The wind turbine blade is analysed by computational fluid dynamics (CFD), finite element analysis (FEA), and the one-way and two-way system coupling of fluid-structure interaction (FSI) simulations of the composite wind turbine blade. The CFD was used to find the initial pressure load of the structure. Five types of the composite material were analysed to compare the results and define the optimum composite material based on the values of stress and deformation. The finite element analysis was used to test the tensile stiffness of the chosen composite laminate and to study the effect of micro-scale structural porosity on strength of structural materials. FSI simulations were performed for several wind speeds and then the results were analysed through the comparison of normal and shear stresses, blade deformations, force and moment reactions. The results are presented in the terms of the normal and shear stress distribution, and blade deformation with defined positions of the maximum values on the blade structure.

Keywords

Numerical modeling, composite materials, finite element analysis, deformation of structure, optimization of structure

ROOM-TEMPERATURE FATIGUE BEHAVIOUR OF ADDITIVELY-MANUFACTURED IN939 SUPERALLOY

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Abstract

This study aims to provide a comparison in fatigue behaviour between cast and additively manufactured (AM) IN939 superalloy. The AM technique in question was direct metal laser deposition. The material was tested in three thermodynamical states: (i) cast aged, (ii) as-printed and (iii) printed aged. In order to assess the influence of building direction, the specimens were printed in vertical and horizontal building directions (BD). The cylindrical specimens were tested uniaxially (parallel to vertical BD) with symmetrical push-pull cycles. The tests were conducted in strain control with a constant strain rate of $2 \cdot 10^{-3}$ s^{-1} at room temperature and were conducted in a low-cycle fatigue regime to evaluate the differences in cyclic plastic behaviour of the tested material states. The specimen observations prior to and after the testing were performed using scanning and transmission electron microscopy. Generally, the printed specimens exhibited significantly longer lifetimes due to the presence of casting defects in the cast material. Microscopical observations revealed that AM introduces dislocation cells which remain stable throughout the fatigue testing whereas the primary damaging mechanism in the conventional cast superalloy was the localisation of dislocations into persistent slip bands. Compared to horizontal BD at a given strain amplitude, vertical BD led to longer lifetimes, although at considerably lower stresses. The γ' precipitates, introduced to the microstructure by ageing treatment, increased the strength of the material at the cost of lower plasticity. However, in order to clarify all the aspects of fatigue damage in AM superalloys, more work needs to be conducted.

Keywords

Additive manufacturing, 3D printing, Direct metal laser sintering, Fatigue, Ni-based superalloy

Acknowledgement

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INFLUENCE OF MECHANICALLY ACTIVATED ZNO POWDER CONTENT AS A FILLER OF POLYMER NANOCOMPOSITES

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Abstract

The research is based on the synthesis and characterization of polymer nanocomposites based on Poly(vinylidene fluoride) (PVDF) polymer and mechanically activated zinc oxide powder. In order to produce the polymer nanocomposite with enchanced electrical and mechanical properties different amount of the mechanicaly activated zinc oxide powder was used as a filler in PVDF polymer. PVDF (Mw~530 000) was used without further purification. Mechanical activation of the powder was performed in a planetary mechanochemical activator (mill) with tungsten carbide balls. Activation times were 10 and 30 minutes. Ball to sample mass ratio was 40:1, while the rotation speed was 390 rpm. After the mentioned procedure, PVDF and nanocomposite films (50 μm) were obtained by casting the solutions into Petri dishes. The percentage of ZnO powder inside the polymer matrix was 5% for powder mechanically activated for 30 minutes, while for powders activated for 10 minutes the percentages were 2.5%, 5% and 10%. From the obtained results it can be concluded that the bigger amount of powder as a filler inside polymer matrix can be substituted with the prolonged time of mechanical activation time and have enhanced electrical properties also saving material and making the production of nanocomposites more economical.

Keywords

PVDF, ZnO, Mechanical activation, Dielectric properties, Mechanical properties

Acknowledgement

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EXPERIMENTAL DETERMINATION OF MECHANICAL PROPERTIES OF CYLINDRICAL SAMPLES MADE BY ADDITIVE TECHNOLOGY

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Abstract

This paper presents experimental results in determining the mechanical properties of cylindrical samples made by additive technology. In the past, additive technologies were used only for prototypes. Today, they are actively involved in the production, especially in the case of small series or parts with special geometric and mechanical requirements—the tested samples were cylindrical and printed on a printer German Rep Rap X400 (It is important to note that, during the test, the samples were not treated with acetone). The German Rep Rap X400 is an Industrial Quality 3D Printer with high precision, speed and printing volume. The test was performed in the control of displacement at a speed of 1 [mm/min], while the layer's height was 0.2 [mm]. The substrate temperature was 100ºC, while the nozzle temperature was 245ºC. The results presented in this paper can be used and are repeatable in practice and in further research.

Keywords

Additive technology, 3D printing, cylindrical samples

Acknowledgement

This paper has been performed within project SIRAMM – Structural Integrity and Reliability of Advanced Materials obtained through additive Manufacturing, supported by European Union's Horizon 2020 H2020-WIDESPREAD-2018-03 (action: CSA) under the grant agreement No.857124.

EXPERIMENTAL STUDY OF INNOVATIVE BUILDING PANEL SYSTEM

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Abstract

An experimental study of an innovative building panel system is presented in this research. The building panel system consists of three major components: exterior cladding made of gypsum fibreboard, a core made of cold formed steel thin-walled C-profiles, and polymer foam. The innovativeness of the building panel system is reflected in the connection of three different materials into one composite construction element that has a number of beneficial technical properties. The polymer foam in the composite structural element has the following benefits: (a) allows a steel profile in the core of the cross-section to be connected to the cladding panels, (b) laterally restrains the thin-walled steel profiles, and increases their flexural buckling resistance. Innovative solutions are manifested through the implementation of panel systems in the development of technology for the construction of almost zero energy buildings in an industrial way. To enable practical application of the prototype panel system as a load-bearing structural element of the building, a design model for the structural element's resistance must be defined. Therefore, extensive experimental research is required, including testing the materials of all panel components, testing the joints, and testing the panels. This paper describes the first phase of testing, which involves the experimental examination of material properties.

Keywords

Building panel system, polymer foam, open thin-walled steel C-profile, gypsum fibreboard, laboratory tests

Acknowledgement

The research presented in this paper was done within the industrial project “Prefabricated buildings of almost zero energy produced in an industrial way” (KK.01.2.1.02.0046), and scientific project “Investigation of behaviour of composite panel components with integrated steel core” (ZIP-UNIRI-1500-2-20).
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Artificial intelligence

THE MAIN FACTORS THAT DETERMINE THE COMPANY'S INNOVATION - EMPIRICAL RESEARCH OF COMPANIES IN SERBIA

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Abstract

Innovations are vital for companies, because they enable companies to penetrate new markets and stay on the markets longer. Measuring a company's ability to create innovation is an important activity for both theoretical and practical applications. This paper presents the study of 21 innovation capacity dimensions of small and medium enterprises in Serbia. The observed sample consists of 106 companies, of different sizes and activities. The following main factors that affect the innovation capacity of companies had been identified: adaptability and growth projection, business network, management style, knowledge management, company resources and the speed of product development for the market. The identified factors were used to predict the future of the company's cooperation with the academy, and whether the company will undertake activities to protect intellectual property rights, which are both considered important parts of the innovation process in companies. The results of the research indicate the important factors that determine a company's survival in the modern market conditions. They are as well significant for predicting a company's future behaviour in relation to its cooperation with the academic environment, and its approach to the intellectual property protection.

Keywords

Innovation, innovation capacities, cooperation with the academy, intellectual property protection

Acknowledgement

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AUTONOMOUS SHELF SCANNING SYSTEM FOR LIBRARY

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Abstract

The aim of this paper is to propose an automated system for shelf scanning in order to detect the book's position in the library collection, while also leaving room for additional features such as a robotic arm for placing or grasping books from the shelf. Given that library shelf reading is a tedious manual task, in many libraries with vast holdings, an automated system is often used as an alternative. Besides combining robot platforms with barcode scanning to scan books, other options such as radio frequency identification (RFID) or Colour Feature Matching of Book-Spine Images are explored for positive identification of a single book. However, barcode scanning is given preference in the proposal, since books in most libraries already have inventory stickers with barcodes on them. The frame construction with railings is suggested, to provide a way to move the robot-powered barcode scanner along the shelves, and its design and mounting are one of the challenges to be addressed. Another challenge is registering misplaced books. Connection with the circulation database is also needed so that it is clear which books are marked as "checked out". The robotic arm is one feature that can if paired with a barcode scanner, give additional possibilities like selecting one particular book from the shelf, and if a kind of small container on wheels is added, it can bring that book to the user and/ or librarian.

Keywords

Automation in Library, Barcode Scanning, Machine Learning for Optical Character Recognition, Mechatronics, Robotics.

Acknowledgement

Acknowledgements are extended to The Academy of Applied Technical Studies Belgrade for their support.

COMPARISON OF DIFFERENT MACHINE LEARNING ALGORITHMS IN PREDICTION OF CERVICAL LYMPH NODE METASTASIS IN PAPILLARY THYROID CARCINOMA

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Abstract

With its incidence increasing rapidly, papillary thyroid carcinoma (PTC) has emerged as the most common thyroid malignancy over the last decade. PTC is generally indolent but those that have cervical lymph-node metastasis (CLNM) show an elevated rate of local recurrence. However, there are no clear indications for optimal surgical resection of CLNM in clinically node negative (cN0) patients with PTC. Therefore, this study aimed to analyze Machine Learning (ML) classifiers in order to predict the risk of CLNM. We retrospectively reviewed the medical records of 273 cN0 patients with PTC. All the patients included in this study had been treated with a total thyroidectomy and prophylactic central neck dissection. In order to identify lateral CLNM sentinel lymph node biopsy was performed. A total of 7 variables including clinicopathologic characteristics of patients were used to develop and validate three ML classifiers based on K-Nearest Neighbor (KNN), Decision Tree (DT) and Support Vector Machine (SVM) algorithm. The area under the receiver operating characteristic curve (AUC), sensitivity, specificity and accuracy were calculated to test the models' performance. The results showed that 48.7% of the patients had CLNM. The AUC of three ML classifiers ranged from 0.69-0.72. The SVM classifier demonstrated the best classification performance whose AUC was 0.72, sensitivity 0.63, specifity 0.61 and accuracy 0.62 in validation set. Based on feature selection, age, tumor size and multifocality were the most important predictors for CLNM. Our research indicated that ML classifiers can achieve acceptable prediction of CLNM with SVM model yielding the best results.

Keywords

Papillary thyroid carcinoma, Cervical lymph node metastasis, Machine learning classifiers

Student session

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APLICATION OF ADDITIVE PRODUCTION TECHNOLOGY IN REVERSIBLE ENGINEERING

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Abstract

The world modern market is becoming more and more competitive every day. Therefore, requirements of cheap but quality product will soon become a solution that fulfills customer expectations. All this has led to reversible engineering becoming a very popular technology that is evolving rapidly with a tendency to be an indispensable tool. Reversible engineering is a method that creates a virtual product from a real product, after finishing and correction created on new product. The process of creating a virtual model based on the real one is enabled by the process of 3D digitization. In this paper process of reverse engineering on example of aesthetic mask for car whose digitalization comes from measuring of place where mask should be mounted is described. By taking direct measures from the place where the mask fit, we came to inappropriate 3D model. For the first prototype we make real model on 3D printer by FDM method from ABS plastic. After direct inspection on car, we measured interferences and gaps on real model and make initial correction on 3D model. One more time we made real prototype to be sure if the all gaps and interferences were removed, we made final 3D model and make masks which will be mounted on car.

Keywords

Additive production technology, FDM, reverse engineering, CAD systems

Acknowledgement

We would like to thanks Mechanical Engineering Faculty in Belgrade, especially to Laboratory for CAD/CAM and Center for Optical Measurements for support in research and writing of this paper.

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ANALYSIS OF THE ROBOTIC ARM WITH FINITE ELEMENT METHOD

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Abstract

Robotic arms have become an integral part of almost every industrial field, with applications ranging from welding and assembly of various components to high-precision work. To achieve improvements in terms of positioning precision, less flexible materials are utilized in arms production, therefore increasing its overall rigidity. To enable small businesses to benefit from robots and automation, design optimization through analysis is very important. It also lowers the cost of production and lengthens its life cycle. The design and analysis of a human arm-like robotic arm under various load circumstances using Finite Element Analysis (FEA) simulation is the focus of this research. Throughout the creation of the robotic arm, a simple approach was used. SolidWorks is used to create a Computer-Aided Design (CAD) model of the robotic arm in this paper. The Finite Element Method (FEM) is a numerical approach for performing FEA on any physical phenomenon. The visualization software is an important part of finite element computer programs. A comprehensive FEM model transforms data into a visual representation that engineers may use to easily discover design flaws and, if necessary, construct a new production plan. FEM helps save material, time, and money by providing a clear view of the design, optimization, and failure analysis. In this work, the payload distribution of the arm is investigated and alternative materials are analysed and compared in terms of static force resistance. In this method, redundant weight is minimized while maintaining the same positioning precision.

Keywords

Robotic arm, FEM, Simulation, Material, CAD/CAM

ANALYSIS OF METHODS FOR MATHEMATICAL DESCRIPTION OF FORM SURFACES AS WELL AS GENERATION OF 3D MODELS

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Abstract

The usage of parts with free form surfaces is growing day by day, not only in the field of mechanical engineering, but also in the production of parts for everyday household needs. This implies the need for developing of new methods for the production of such parts. When it comes to machining, the most common cases of production are milling with ball end mill on numerically controlled machine tools. In this paper are presented different methods for mathematical description of free-form surfaces such as Bézier curves, B-spline curves and non-uniform rational B-spline.

Keywords

Free form surface, CAD, 3D modelling

Acknowledgement

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DESIGN AND IMPLEMENTATION OF A VERY SMALL-SCALE ENVIRONMENTAL CHAMBER

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Abstract

Current electronic components shortage caused by lingering Covid-related manufacturing disruption and limited availability of critical semiconductor materials is greatly hindering the design and deployment of the electronic products, causing most device manufacturers to redesign their products by finding an alternative component solution. Quite often these alternatives change the overall durability of the final product, requiring repeated Highly Accelerated Life Testing (HALT) which is costly and time-consuming. Temperature stress tests are an essential part of HALT, while the necessary tool for performing such tests is the environmental chamber. For most research institutions and SMEs, available environmental chambers are not easily affordable. In this work, a Very Small-Scale Affordable Environmental Chamber is designed using 3D printing technology and a widely-used embedded systems platform. The chamber is printed using ABS filament as it covers the commercial temperature range of the electronic components (from 0°C to 70°C). The chamber is powered using either regular 230 V power outlets, or a standard laboratory power supply. Temperature control is performed by combining Peltier devices with passive and active cooling elements, while electronic control is performed with the NUCEO-L476RG development board. Chamber is made small so that the printing process can be performed by lower-end 3D printers, resulting in decreased material usage and power consumption. Still, the chamber is large enough so that most electronic components and small devices can be efficiently stress-tested.

Keywords

Environmental Chamber, 3D, ABS, Material, Embedded Systems

DETERMINATION OF FLEXURAL STRENGTH OF PIPES AND TILES MADE BY 3D PRINTING

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Abstract

In this paper, experimental bend tests were performed in order to obtain the mechanical characteristics of pipes and plates made of ABS-X material. The tested pipes and plates are made of ABS-X material, which is characterized by less cracking, almost perfect intermediate layers, reliable adhesion to the layer with improved mechanical properties. The method applied in this paper is a three-point bending test. Vertical orientation was applied during 3D printing of pipes and tiles. The main advantage of a three-point bend test is its simplicity (the specimen can be easily prepared and tested). Even though the highest energy absorption capacity is observed for fully solid pipes, if the specific values are taken into consideration, honeycomb, hybrid, and rib shaped pipe models also become competitive, depending on application conditions. In this test, a honeycomb was selected for the infill structure, assuming that this type of infill has the highest values of modulus of elasticity and mechanical properties. In order to compare and test the influence of infill density on mechanical properties, pipes and tiles with an infill density of 50% and 100% were tested. The results are presented in the paper and can be used in practice and in further research.

Keywords

ABS X material, 3D printing, honeycomb, bending properties

Acknowledgement

This paper has been performed within project SIRAMM - Structural Integrity and Reliability of Advanced Materials obtained through additive Manufacturing, supported by European Union's Horizon 2020 H2020-WIDESPREAD-2018-03 (action: CSA) under the grant agreement No. 857124

MAGNETIC ORIENTATION AND MAGNETORECEPTION IN BIRDS

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Abstract

Migratory birds travel vast distances each year, finding their way by various means, including a remarkable ability to perceive the Earth's magnetic field. Although it has been known for a long time that birds possess a magnetic compass, avian magnetoreception is poorly understood at all levels from the primary biophysical detection events, signal transduction pathways and neurophysiology, to the processing of information in the brain.

Migratory orientation in birds involves an inclination compass based on radical-pair processes. According to the radical pair model, the magnetic compass sense of migratory birds relies on photochemical transformations in the eye to detect the direction of the geomagnetic field. Magnetically sensitive radical pairs are thought to be generated in cryptochrome proteins contained in magnetoreceptor cells in the retina.

Birds can use two kinds of information from the geomagnetic field for navigation: the direction of the field lines as a compass and probably magnetic intensity as a component of the navigational 'map'. The direction of the magnetic field appears to be sensed via radical pair processes in the eyes, with the crucial radical pairs formed by cryptochrome. It is transmitted by the optic nerve to the brain, where parts of the visual system seem to process the respective information. Yet in spite of considerable progress in recent years, many details are still unclear, among them details of the radical pair processes and their transformation into a nervous signal, the precise location of the magnetite-based receptors and the centres in the brain where magnetic information is combined with other navigational information for the navigational processes.

In the near future, the radical pair-based magnetoreception sense in birds can be examined and used as inspiration in new technological advancements and understandings of animal life on Earth.

Keywords

Magnetoreception, Radical pair, Magnetic orientation, Cryptochrome, Biophysics

DESIGN OF THE VTOL UAV “KOS”

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Abstract

Project “Kos” is a project organized by team “Beoavia” centred in the University of Belgrade for competing in the New Flying Competition 2022 in Hamburg. The main goal of the competition is to locate the correct objects with as little energy consumption as possible.
Maximum take-off mass is 15 kg including the 2 kg payload. Mass and load both lead us to pick composites as the main production material. They provide required structural strength with less mass that makes space for usage of propulsion system with higher efficiency. Aircraft is meant to use advantages of both vertical take-off (high autonomy in choosing the take-off and landing geographical positions) and fixed-wing high efficiency cruise flight with the possibility of manoeuvring, carrying useful payload and sensors. The idea is to utilize airborne ground scanning via optical gathering of data and its subsequent analysing. Serious emphasis must be given to energy management i.e. aerodynamic and propulsion performance for dominant flight regime.
For the configuration selection, the idea was to evaluate several different configurations for given aerodynamic surface, with priority being given to aerodynamics, mass and simplicity of production and assembly. Evaluation process was conducted in a manner where each sub-team developed and analysed solutions in its respective field and then formatted design matrices by proposing weighting factors.

Keywords

UAV design, VTOL

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