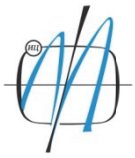

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CNN 2017 TECH

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

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

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CNN TECH 2017

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The organizing committee of the 1st International Conference of Experimental and Numerical Investigations and New Technologies – CNN TECH 2017 wishes to sincerely thank all the institutions and individuals who by means of personal engagement and constructive action helped organizing this conference.

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

PREFACE

Dear Friends and Colleagues, Welcome to CNN Tech 2017 Conference and the fabulous mountain of Zlatibor!

With 47 papers (16 by international authors) and contributions by authors from 10 different countries, International Conference of Experimental and Numerical Investigations and New Technologies CNN Tech 2017 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 2017 focuses on the following topics:

- Mechanical Engineering,
- Materials Science,
- Chemical and Process Engineering,
- Experimental Techniques,
- Numerical Methods,
- New Technologies.

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 2017 would like to express gratitude to Ministry of Education, Science and Technological development for financial support of the Conference.

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

PROGRAMME AND ORGANIZING COMMITTEE

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10:30 to 11:30	**KEYNOTE LECTURES** Aleksandra Mitrovic- Soft contact lenses based on poly (hydroxyethyl methacrylate) and fullerenes Katarina Colic - The modern approach to the design and analysis of titanium alloy hip implant
11:30 to 12:00	Coffee break
12:00 to 14:00	WORKSHOP (INTELLECTUAL PROPERTY)
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From 10:30	Zlatibor excursion

ABSTRACTS

Mechanical Engineering

ANALYSIS OF OPERATING REGIME INFLUENCE ON THERMAL POWER CAPACITY OF WORM DRIVES

Milan Rackov[1], Maja Cavic[1], Marko Pencic[1], Ivan Knezevic[1], Sinisa Kuzmanovic[1] and Zarko Miskovic[2]

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Abstract

Since there is a large power loss during the operating of worm gear drives, their load carrying capacity is often limited by thermal power capacity despite that load capacity could be much higher from the standpoint of strength of worm gear pair (strength of tooth flanks, strength of tooth heels, permissible wear of tooth flanks, permissible bending of worm shaft). Therefore, manufacturers of worm gear drives always produce gearbox housings with ribs in order to increase surface of the housing. In this way, transferring of heat from to surrounding air is maximized. Additionally, to speed up this process, a fan is installed on the high-speed shaft of worm drive, so that the air flowing around the gear unit is faster and the heat dissipation is increased which lead to increasing of thermal power capacity. However, despite all these procedures, thermal capacity of worm gear drives still limits its load capacity. In that case, manufacturers of such worm gearboxes provide the installation of special unit for cooling the oil in gear drive, so thus thermal power capacity will be increased. This paper analyses the problem of increasing thermal power capacity of worm gear drive, but especially in the case of short time duty with different approach to defining of thermal capacity, but only if it limits load capacity of worm drive. During the short time duty (usually shorter than 4 hours per day), the lowest value of service factor calculation used for operating duration is 0.8, which means the overloading of gear drive is possible from the viewpoint of strength and components durability up to 25%.

Keywords

Worm gear drive, load carrying capacity, thermal power capacity, operating temperature, short time duty

Acknowledgement

This paper is part of a research on project "Research and Development of a New Generation of Wind Generators of High Energy Efficiency" TR 35005, supported by the Ministry of Education and Science, Republic of Serbia.

EFFECTS OF INTRODUCING DYNAMIC CONSTRAINTS FOR BUCKLING TO TRUSS SIZING OPTIMIZATION PROBLEMS

Nenad Petrovic[1*], Nenad Marjanovic[1], Nenad Kostic[1], Mirko Blagojevic[1], and Milos Matejic[1]

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Abstract

Sizing optimization of trusses with the goal of minimizing overall mass is a very interesting research topic for researchers today. In this paper truss sizing optimization test examples for minimizing mass are subjected to dynamic buckling constraints, as well as the static stress and displacement constraints. Introduction of bucking testing increases the complexity of the optimization. Furthermore, buckling is a constraint which should not be ignored in order to assure practicability of a structure. Few studies implement buckling constraints in their truss optimization mathematical models, due to their complexity and increases in computational times. For the purposes of this research, static and dynamic constraints have been put into parametric optimization standard test models of 10 bar, 17 bar, and 25 bar trusses which use continual cross-sectional area design variables. The optimization algorithm used is genetic algorithm. Euler buckling dynamic constraints are added to the mathematical model constraints. Initial design models and optimal results from literature are tested for buckling to determine their practical applicability. The masses of optimal results from the mathematical model presented by this paper are compared to initial design model, and optimal models from literature. This paper aims to show the influence, and importance of implementing buckling dynamic constraints to optimization of planar and space trusses in order to achieve results which are practically applicable. At the end of the paper, conclusions are drawn and further research directions in this area are given.

Keywords

Truss, sizing optimization, buckling, dynamic constraints, genetic algorithm

ANALYSIS OF THE CHARACTERISTICS OF THE BRAKE SYSTEM ON VARIOUS TYPES OF VEHICLES

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Abstract

This paper present analysis of the brake system for the various types of vehicles. Here is represented the design of the brake system - Choice of distribution of braking force, and an analysis of the braking system and the Mercedes Benz E220, Audi A6 and VW Passat B. There are four main phases in the design of the braking system, as follows: Selection / braking force distribution of the design between the front and rear axles (or more axles), Selection of the transmission mechanism of the brake system, Selection / design executive authority braking system, ie. brake which must satisfy the requirements in regard to the exercise of certain brake torque, stability coefficient of friction, service life and noise, The selection / design of the controls of the brake system.

Taking into account the geometry and mass of the analyzed vehicles and their comparison, we can conclude that they are the same, the approximate dimensions. We could conclude by taking into account the fact that the vehicles belonging to the same segment, class and intentions.

Braking force of Fk≈12 ooo N, all three vehicles can achieve a braking coefficient q≈0,6.

Maximum deceleration by amax = 6m / s2, all three vehicles can achieve the total braking force of Fku≈12 ooon and braking coefficient q≈0,6.

Based on this, we can conclude that the aforementioned vehicles may incorporate the same braking system designed as hydraulic.

In addition to the data of the vehicle can be installed additional systems such as the ABS Anti-lock Braking System (Anti-lock Braking), ESP Electronic Stability Program (stability control system), and ASR anti-slip regulation (system control traction).

Brake force to be achieved on a given vehicle, can be achieved by a braking system of the same characteristics.

Keywords

Vehicles, brake system, analysis of characteristics of brake system.

DETERMINATION OF INTERNAL PRESSURE VALUE CAUSING PIPE BRANCH MODEL TO PLASTICALLY DEFORM

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Abstract

Complexity of pressure vessels geometry usually causes stress and strain concentrations. Modern approach of stress and strain analysis involves numerical and experimental testing. Every experimental testing on the construction could endanger construction itself. Therefore, making a model of the construction has great benefits. Sub-sized model of the pipe branch of A6 third pipeline at Hydropower Plant Perućica, Nikšić was made in order to be subjected to a detailed experimental testing. The aim was to determine internal pressure value causing pipe branch model to plastically deform, and, to use this results for determining pressure causing real structure to plastically deform, without any measurements on the structure itself. Experimental measurements were carried out using strain gauge method. Strain gauges are positioned in critical zones. Numerical pipe branch model and results obtained by using finite element method (FEM) was verified with experimental results (in elasticity area). After verification in elastic area, experimentally by increasing pressure value, critical internal pressure causing plastic deformation of pipe branch model was determined. Based on the pipe branch model behaviour, and after determination of relation between the model and the real structure, maximum calculated internal pressure value to which the structure may be subjected in exploitation is assessed. Besides, weak spots on the structure were verified by obtaining same results through experiment and calculation, which gives good guidelines for monitoring of this structure during usage, since it is possible, by using this analysis, to decrease number of measurement locations for monitoring (in order to control exactly those measurement locations which proved to be the most endangered).

Keywords

pipe branch model; plastic deformation; finite element method; strain gauges; stress

DISCRETE TIME DELAYED SYSTEM STABILITY THEORY IN THE SENSE OF NON – LYAPUNOV : DELAY INDEPENDENT AND DELAY DEPENDENT APPROACH

Tamara Nestorovic[1], Dragutin Lj. Debeljkovic[2]*, Darko M. Radojevic[3], Goran V. Simeunovic[4]

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Abstract

The concept of Lyapunov stability is largely known to the control community. However, often, this stability concept is insufficient for practical purposes, because there are some real systems which require that the system states do not exceed the specified values. Therefore, it is of particular significance to consider the trajectory of the system only on a finite time interval. The stability concept, which is based on a finite time interval, is called the finite-time stability (FTS). The system is stable if its states do not exceed predefined boundaries on a fixed time interval. This concept stability dates back to the 1950s, where the term FTS is defined for the first time. These criteria had more theoretical than practical significance. Much later, by using the theory of linear inequalities, more precise and practical criteria were derived. The time-delay, which often appears in engineering systems (electrical, mechanical, chemical, etc) is one of the main sources of instability and poor performances of control systems. Therefore, a large number of researchers were involved in the study of time-delay systems. Similarly to regular systems, the FTS concept can be applied to the class of time-delay systems.

However, in the existing literature, there are few results on the subject of FTS of discrete time-delay systems. Some FTS results for time-delay systems can be found in existing literature, but these results are either conservative or inconvenient for the application because they are based on estimates of the state vector. Recently, by using linear matrix inequalities (LMIs) and Lyapunov-like functional, some less restrictive FTS results for time-delay systems are derived, both for continuous and discrete time systems. In this paper, we introduced a new discrete Lyapunov-like functional with a discrete convolution of delayed states, for a class of discrete time-delay systems and new FTS criteria are obtained. To solve the FTS problem, the combination of the Lyapunov-like approach and Jensen's discrete inequality is applied. The sufficient condition is expressed in the form of an algebraic inequality. A numerical example has been worked out to show advantage of the proposed method.

Keywords

Linear discrete time delay systems, Finite time stability, Practical stability, LMI methods, Dependent delay and independent delay criteria

Acknowledgement

This research was partially supported by the Ministry of Sciences and Technology of Republic of Serbia - Mathematical Institute SANU Belgrade Grant OI 174001: 'Dynamics of hybrid systems with complex structures - Mechanics of materials' University of Belgrade, School of Mechanical Engineering.

ON STABILITY OF TIME VARYING DELAYSINGULAR SYSTEMS OVER THE FINITE TIME INTERVAL

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Abstract

A singular system describes a natural representation for physical systems. In general, the singular representation consists of differential and algebraic equations, and hence it is a generalized representation of the state-space system. The class of singular systems is more appropriate to describe the behavior of some practical systems like electrical systems, mechanical systems and chemical systems. It is well known that study of singular systems is much more complicated than that of regular ones. It has been observed that variety of singular systems is characterized by the phenomena of time delay. Such systems are called singular systems with time delay. Time delay can appear in the input variables, output variables and/or the state space vector. In general, the dynamic behavior of continuous-time singular systems with delays is more complicated than that of system without any time-delay because the continuous time-delay system is infinite dimensional. In this paper, finite-time stability problems for a class of singular time-delay systems are studied. The concept of finite-time stability is extended to singular time-delay systems and some conditions have been derived using two approach based on the Lyapunov-like functions: classical and LMI approach. The first approach is based on the algebraic matrix transformations, while the second approach uses the linear matrix inequalities. LMI approach provides a simple numerical solution and does not impose additional restriction on the state vector. Using classical and LMI approaches novel sufficient conditions for finite-time stability are presented. The obtained LMI conditions can be checked by using the standard numerical optimization methods. Numerical example is given to show the effectiveness of the proposed approaches.

Keywords

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

Acknowledgement

This research was partially supported by the Ministry of Sciences and Technology of Republic of Serbia - Mathematical Institute SANU Belgrade Grant OI 174001: ‘Dynamics of hybrid systems with complex structures - Mechanics of materials’ University of Belgrade, School of Mechanical Engineering.

CHANGES OF PARAMETERS DURING WELDING OF CERTAIN WELD AND THEIR IMPACT ON COOLING TIME IN TEMPERATURE RANGE OF 800 - 500° C

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Abstract

The cooling time in the temperature range of 800 - 500° C ($t_{8/5}$) has a major impact on the structures that are formed in the heat affected zone of steel welded joints. Data on the optimum cooling time $t_{8/5}$ for a particular steels can be found in the literature. Besides the shape of welded joint, the thickness and physical characteristics of the welded steel, welding process and parameters, such as amperage, voltage, welding speed and the preheating temperature also have the impact on the size of the cooling time $t_{8/5}$. During the calculation of the actual value of the cooling time $t_{8/5}$, which is obtained during the welding of the particular joint, as a rule, the assumption is that the amperage, voltage and welding speed on each section of the joint are equal to the average for the whole joint and that the temperature of the edges of the groove along the entire length are equal to the preheating temperature or inter pass temperature.

Measuring of amperage and voltage during welding of a multi-pass butt - welded joint at the high strength steel, using the MIG process are presented in this paper. Results of the measurement showed that the values of the amperage may differ significantly in certain sections of the weld, the average amperage in one part of the weld may be significantly different from the average value of the amperage in the second part of the same weld, and that both may be different from the average value of amperage for the entire weld. The influence of the changes in welding amperage on the amount of heat input and the size of cooling time $t_{8/5}$ was analysed using numerical methods. It was concluded that, at certain sections of some of the weld, cooling time $t_{8/5}$ goes beyond the given values, although the average values of the cooling time $t_{8/5}$ for these welds are within the given values.

Keywords

Cooling time $t_{8/5}$, amperage, voltage, numerical analysis

AXIAL CRUSHING ANALYSIS OF CHARACTERISTICS OF EMPTY AND FOAM FILLED CIRCULAR TUBES

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Abstract

This paper describes experimental research of improved type of collision kinetic energy absorber. Absorber works on the principle of shrinking a foam filled tube of circular cross section. During collision, a seamless tube is passing through a special cone bush, extrusion the tube and compressing the foam. Energy is absorbed by the plastic deformation of the tube, friction between the tube and the cone bush and through deformation of the PU foam. The tubes were filled with PU foam higher density. This new type of absorber enables gradual increase of deformation resistance and greater absorption power with compact dimensions. Scaled samples have been tested in the laboratory conditions. The influence of the PU foam and different geometries on absorption characteristics, as well as the benefits of using such an absorber, are presented and discussed in this paper. The results show that the foam filled absorber has approximately 12% higher absorption power than the only extrusion absorber by itself.

Keywords

Circular tube, PU foam, Energy absorption, Experimental researches, Extrusion

Acknowledgement

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

NAVAL MAINTENANCE STRATEGIES SELECTION

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Abstract

Paper presents a qualitative Maintenance Strategies Selection Model for Naval Systems based on basic RCM (Reliability Centered Maintenance) and Risk Based Inspection (RBI) principles taking into consideration particularities of a warship and maintenance in Montenegro Navy. Due to the lack of statistic data on maintenance and failures, we used expert knowledge of naval systems operators and maintainers. Creation of a specific model was also necessary due to the lack of engineering resources and time for all the required analysis of complex technical items. Advantages of both RBI and RCM approaches are used for the problem solving. Additional issue was a need to extend the ship's life cycle. With a purpose to make rational use of the resources for the analysis of all complex systems of the ship, three different approaches have been modeled depending on whether some experience in the previous maintenance exists and on the amount of the maintenance costs. Pilot-analyses conducted against this model showed its applicability and potential to reduce maintenance costs of ship's systems.

Keywords

RBI, RCM, Navy, Maintenance Strategy, Algorithm

REPAIRING OF BOTTOM PANEL OF BOILER IN HEATING PLANT

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Abstract

The method for repairing (replacement) of a bottom panel of hot water boiler in Valjevo heating plant, with a power of 30 MW, manufactured by Remming is presented in this paper. Damage that occurred on the bottom panel were a consequence of conditions under which the boiler was working, which resulted in the thinning of pipe walls of the boiler bottom panel. Metal corrosion caused this thinning of pipe walls under the presence of sulfuric acid. The procedure used for repairing, i.e. the replacing of the bottom panel of the boiler is shown. Repair welding was performed using the MAG procedure, combined with gas welding. In addition, the requirements of the welding technology related to successful repairing of the equipment are also discussed.

Keywords

Repair welding, low temperature corrosion, heating plant, boiler

Acknowledgement

The authors of this paper acknowledge the support from Serbian Ministry of Education, Science and Technological Development for projects TR35040 and TR35011.

ANALYSIS OF CRACKS THAT CAN OCCUR IN WELDED JOINTS

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Abstract

Cracks can occur (or can start propagating in the case they are already present) only in the cases where certain load conditions lead to a decrease in total energy or to it being of constant value. Due to this, critical failure conditions can be defined as the situations in which crack growth takes place in equilibrium conditions, without a change in total energy. Cracks in welded joints can be classified according to their positions. Type I and Type II cracks occur in the weld metal, whereas Type I cracks are limited to it, and Type II cracks may propagate into the parent material as well. Type III cracks occur in the coarse-grain heat affected zone and Type IV cracks occur and propagate in the area of HAZ adjacent to the PM/HAZ boundary (subcritical heat affected zone).
Type IV cracks are the most dangerous type, since these cracks have the highest void forming rate, which results in quicker fracture, compared to creep tests in the case of non-welded homogeneous specimens.

Keywords

Cracks, Welded joints, HAZ, Crack propagation

SOME ASPECTS OF MINIMUM WEIGHT DESIGN OF AIRCRAFT STRUCTURAL COMPONENTS

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Abstract

Subject of this investigation is focused on developing computation procedure for optimal design of aircraft structural components with respects to stress, displacement and technology constraints. One of the major tasks in the design of aircraft structural components is the sizing of the structural members to obtain the desired strength, weight, and stiffness characteristics. Optimization algorithms have been coupled with structural analysis programs for use in this sizing process. Most of the difficulties associated with large structural design are solution convergence and computer resources requirements. Structural optimization problems traditionally have been solved by using either the mathematical programming (MP) or the optimality criteria (OC) approach. Attention in this work is focused on minimum weight design of plates with reinforced hole. Optimal design procedure is based on combining finite element method (FEM) for the structural analysis with using optimality criteria (OC) method in optimization process. Special attention is focused on optimal design of structural components with reinforced holes. The effect of shape of reinforcements around hole to optimal design is analyzed. Some practical design examples are used to illustrate the capability of this procedure. This paper considers optimal design of representative aircraft structural component. Here plate with circular hole as representative structural component is considered. Special attention is focused to optimal design of reinforcement around hole of plate. The four shape type of reinforcement is considered. The effect of shape of reinforcement around hole to minimum weight is evident. Several different examples of plate-type structural components with reinforced holes are presented in this work. These analysis and optimization procedures can be used in practical optimal design of aircraft structural components.

Keywords

Aircraft constructions, optimal design, minimum weight design, stress constraints, FEM

Acknowledgement

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MAGNETIC PROPERTIES OF THE HUMAN COLON TISSUE USING SPINNER MAGNETOMETER: A CASE STUDY

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Abstract

The later stages of malignant growths are characterized by a severe and progressive depression in the blood haemoglobin level. Iron is essential for virtually all living organisms and participates in a wide variety of metabolic processes, including oxygen transport and electron transport. As such, ions of Fe^{2+} and O_2 are strong paramagnetic, but linked together their complex shows week paramagnetic (0.15 nT) or diamagnetic properties. As all matter consists of atoms that contain particles with an electric charge, our body and everything around us is magnetic.

In this study, a methodology usually used in rock magnetism was applied to evaluate the magnetic properties of the human tissue. We demonstrate, for the first time to our knowledge, usage of the dual speed spinner magnetometer, with accuracy ±2.4 μA/m (3pT), for measuring difference of remanent magnetism (gap) between healthy and cancer colon tissue. The ex vivo experiment was conducted on 76 samples (from 39 patients) immediately after bowel resection. Tissue samples were taken from patients of both sexes, different ages, and with confirmed histopathological colorectal carcinoma. The results indicate differences between normal mucosa (healthy tissue) and cancer with average values of 0.91775±0.046 mA/m (1.153 nT) for healthy tissue and 0.17441 ± 0.009 mA/m (0.219 nT) for cancer, and confirm the existence of differences in the measurement of paramagnetic and diamagnetic properties of healthy and cancerous tissue. Bearing in mind that the number of 32 samples is good for preliminary research but not good enough for clinical application, further studies are necessary.

Keywords

Remanent magnetism, paramagnetic/diamagnetic, human tissue, colon cancer, dual spinner magnetometer

Acknowledgement

The research is supported by Ministry of Education, Science and Technological Development, project III41006.

DESIGN OF A PROPULSION DRIVE SYSTEM FOR LATERAL MOVEMENT OF VESSEL (THRUSTER)

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Abstract

This papers covers propulsion parameter optimization and motion study of bow thrusters. Thrusters parameters for production are decided in relation with vessel length. Lateral thruster parameters are decided in correlation with vessel length. Reason for it is that thrust force is given by value of ship hull resistance and desired speed of lateral movement. Analyzed vessel in this research was “Šibenik 800- working variant”. Model of ship is made in 3D software Solid Works 2017 by use of conceptual drawings provided by company Dunkić Ltd. Hull resistance represents complex physical phenomenon of fluid-structure interaction and very often for its analysis engineers are forced to use software for computational fluid dynamics. Ansys 17.2 with its CFX module was applied for structural analysis. Investigation was divided into two sections to decrease computation time: immersed and dry part. Required propulsion force was given by assumption that acceleration is equal to zero when vessel is moving with designed ultimate speed, whereas amount of propulsion force is equal to resistance force. Considering complex variation of hydrodynamic pressure as function of vessel speed, it is to be expected that acceleration will take infinite amount of time to achieve desired ultimate speed (asymptotic value).

Keywords

CFD, FEM, HYDRODYNAMIC PRESSURE, PROPULSION

Materials Science

Invited paper

SOFT CONTACT LENSES BASED ON POLY (HYDROXYETHYL METHACRYLATE) AND FULLERENES

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Abstract

Contact lenses are in common use for visual defect corrections and, as they are in contact with the eye, the biocompatible properties of the used materials and their topographic and mechanical characteristics are of major importance in order to fulfill the ocular tissue requirements. The aim of this study was to investigate, develop and characterize new materials for manufacture of soft contact lenses based on modified poly (hydroxyethyl methacrylate), pHEMA, and incorporated fullerene, fullerene hydroxylate and fullerene metforminhydroxylate. Frontal area of nanophotonic soft contact lenses was processed using lathe cut method on a new generation toric 3-axis CNC lathe. Basic area of nanophotonic soft contact lenses was obtained by casting. Swelling properties of the materials as well as swelling kinetics were investigated. The equilibrium degree of swelling and diffusion in the basic material and nanophotonics materials were determined. Parameters of the network in hydrogels were calculated. The mechanical properties of the materials were investigated. For characterization of the materials as well as for soft contact lenses thermal analysis, UV-VIS, FTIR spectroscopy, scanning electron microscopy (SEM) and atomic force microscopy (AFM) were used. To measure the optical power, determination of a map of defects and quality of the tested soft contact lenses, modern Rotlex device was used. Tests have shown that the characteristics of nanophotonic materials such as: degree of swelling, porosity, refractive index and visible light transmittance comply the criteria for soft contact lenses as the basic material and that the properties such as mechanical properties, thermal stability, and lathe cut surface quality are significantly improved comparing to the basic material. According to the results, it is possible to develop a new generation of materials for soft contact lenses.

Keywords

Soft contact lenses, fullerenes, nanophotonic materials, thermal analysis, spectroscopy, microscopy

SOFT CONTACT LENSES NANOMATERIAL CHARACTERIZATION BY ATOMIC FORCE MICROSCOPY AND LACUNARITY METHOD

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Abstract

Over the past century, hydrogels have emerged as effective materials for variety of applications. The unique network structure of hydrogels enables very high levels of hydrophilicity and biocompatibility which makes them ideal biomaterials. Hydrogels based on 2-hydroxyethyl methacrylate are of a great interest in biomedical applications because of their tunable chemical composition and three-dimensional network structure. HEMA-based hydrogel lenses are still the most popular type of contact lens. They can be designed to have optimal water or biological fluid content in an aqueous medium without dissolution, good mechanical properties, biocompatibility, shape stability and softness similar to that of the soft surrounding tissue.
This work presents comparative research of surface characteristics of basic and new nanophotonic materials which were obtained by incorporation of fullerene and its derivatives into basic material for soft contact lenses. Basic, commercial soft contact lens material was hydroxyethyl methacrylate (HEMA). Fullerenes were used due to theirs unique structure and properties. For the purposes of surface characterization of soft contact lenses Atomic Force Microscopy was used. Topographic image of each material was imported into custom made Matlab procedures for contact lens lacunarity analysis. The surface lacunarity behavior, which is determined by gliding box method, is related to surface topology. Results of surface lacunarity analysis confirm sample surface state as belonging to either group adequate (slanted p-diagram) or inadequate (contorted p-diagram) roughness concerning tear film stability. In this investigation, nanophotonic soft contact lenses exhibited better surface roughness comparing to basic soft contact lens. AFM analysis showed that the roughness parameter values for nanophotonic soft contact lenses are lower than the ones for basic lens. This research contributes to applied optical science and biomedical application industry.

Keywords

Soft contact lenses, fullerenes, nanomaterials, AFM, lacunarity properties

Acknowledgement

This research has been partially funded by Ministry of Science and Technological Development of Republic of Serbia, through Project III 45009.

MEASUREMENT OF LOCAL STRAIN FIELD IN DENTAL COMPOSITE CEMENTS

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Abstract

Restorative resin composites have been used in dentistry for nearly 50 years. In spite of the undeniable technological advances introduced during this period, the polymerization contraction that accompanies the chain-growth polymerization of dimethacrylate monomers remains one of the major concerns for the clinical performance of composite restorations. Resin cements, a class of dental materials, are generally classified as a function of their activation reaction as self-cured (chemically activated), light-cured (photoactivated), or dual-cured (a combination of both activation reaction) cements.
The aim of this study was to determine, evaluate and measure strain field of four dental composite cements during polymerization in light-cure mode using experimental technique, 3D Digital Image Correlation (DIC) method. Cements were irradiated with a LED-curing unit (LEDition, Ivoclar-Vivadent, Schaan, Liechtenstein) for 20 s. All measurements were performed at room temperature. Three 5 × 2 mm sized samples of each cement were prepared by filling metal ring-type molds. Data were statistically analyzed by one-way ANOVA with Tukey's post hoc test. Cements tested were: RelyX U200 (3M ESPE, St. Paul, MN, USA), MaxCem Elite (Kerr, Orange, CA, USA), Multilink Automix (Ivoclar Vivadent, Schaan, Liechtenstein) and Set PP (SDI, Australia). The results of these investigation for all tested materials are compared and discussed. Visible differences between the tested materials were observed.

Keywords

Dental composite cements, self-cured cements, dual-cured cements, 3D Digital Image Correlation

Acknowledgement

The authors grateful to Tam-Auto DENTAL DEPO (Novi Sad, Serbia), 3M Science Applied to Life (Belgrade, SERBIA) and Neodent (Belgrade, Serbia) for providing the materials used in this study.

THERMOPHYSIOLOGICAL PROPERTIES OF KNITTED FABRICS FOR SPORTS UNDERWEAR

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Abstract

This paper examined and compared the properties of four knitted fabrics for making sports underwear: knitwear made of 100 % polyester and blends of polyester/cotton and cotton/elastane. The aim of the paper was choosing the appropriate knitwear for making the sports underwear, taking into account different climate conditions and levels of wearers' activities. The results showed that the thermal, and water vapor and air permeability properties, which affect the comfort of the garment, depend on the type used fiber and the structural parameters of knitwear. Knitwear in interlock pique interlacement of a blend of polyester and cotton has properties that are suitable for warmer climates and moderate activities, whereas the knitwear of polyester in jacquard interlacement with the trap on each loop is suitable for intense activities. Knitted polyester in jacquard interlacement with the trap on the second loop, according to its properties, is suitable for application in cold conditions, whereas the interlock knitwear tufted on one side of a blend of cotton and elastane is not recommended for production of sports underwear. The results of these researches are important for the selection of appropriate knitted fabrics or their combinations in sports underwear production that will satisfy certain requirements in terms of thermophysiological comfort.

Keywords

Knitted fabrics, sports underwear, activewear, thermophysiological properties, heat and moisture management

CHARACTERIZATION OF COATING 316L APPLYED BY PLASMA TRANSFERRED ARC

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Abstract

Remaining useful life extension of critical parts of mechanical construction can be carried out by various methods for applying a protective coating. The aim of this study is characterization of coatings made of stainless steel 316L, applied by plasma transferred arc on a structural steel S235JR. This paper presents the results of hardness measurement in characteristic zones of the coating and base material, as well as micro structural characterization of coatings using optical and scanning electron microscope. Also, erosion resistance tests of coatings were performed by changing the basic influence parameters of the test, especially the impact angle and speed of erodent particles. The main reason for this type of research is the fact that the material 316L is widely used in chemical and petrochemical industry.

Keywords

Stainless Steel, 316L, Plasma Transferred Arc

MICROSTRUCTURAL CHANGES AFTER LASER SURFACE TREATMENT OF Ti-6Al-4V TITANIUM ALLOY

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Abstract

There are several titanium alloys that have been developed for use in the past several decades, and one of the mostly used alloys of titanium is Ti-6Al-4V. These alloy relays on the high strength combined with a low density, good creep resistance up to about 550°C, combined low thermal conductivity and thermal expansion, properties which make it attractive for wide filed of engineering application, for example in aerospace industry in both engine and airframe components. Biocompatibility, low modulus of elasticity and excellent corrosion resistance are the most interesting properties for using this material in biomedical applications as well, mainly for orthopaedic implants such as joint replacements and bone pins, plates and screws. Titanium alloys are superior to pure titanium in terms of their significantly better fatigue properties, however fatigue failure of the Ti-6Al-4V alloy is still a problem. According to the literature, there is potential for increasing fatigue performance of this alloy after laser shock peening. Laser surface treatment emerged as a promising tool for improving surface properties of various metallic alloys. However, their application in the medical field is rather rare. In this experimental research the mechanical characterization of the titanium alloy Ti-6Al-4V is performed by means of standard tests on modified compact tension C (T) specimens. In this paper, experimental investigation of laser treated Ti-6Al-4V alloy is performed by Nd3+ : YAG pico second laser using the following parameters: pulse duration 170 ps, repetition rate 10Hz, wavelength of 1064 nm with pulse energy of 1 mJ and 2mJ, velocity 0.1 to 0.5 mm/s and numbers of scans 1 to 5. The following response characteristics were analysed: modified surface areas obtained by the laser / material interaction were observed by scanning electron microscopy; elemental composition of the modified surface was evaluated by energy-dispersive spectroscopy; Vickers micro-hardness tests were performed.

Keywords

Ti−6Al−4V titanium alloy, Surface treatment, Microstructure, Laser peening, Micro-hardness

Acknowledgement

This study was supported by Research grant TR35040 from the Ministry of Education, Science and Technological Development, Republic of Serbia.

IR SPECTROSCOPY OF THE HIGHER FULLERENE C_{76}-D_2 FOR ITS QUALITATIVE AND QUANTITATIVE DETERMINATION

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Abstract

The higher fullerene C_{76} of D_2 symmetry was isolated from carbon soot by the new and advanced extraction and chromatographic methods and processes. Characterization of the isolated C_{76}-D_2 was performed by the FT-IR(KBr) method, over the relevant region from 400 to 2000 cm^{-1}. A series of characteristic dominant and new absorption maxima of this fullerene was registered and confirmed. All the observed infrared bands are in excellent agreement with the theoretical calculations for this molecule. The molar absorptivity ε, as well as the integrated molar absorptivity ψ of its IR absorption bands was determined in adequate and different spectral regions. These results are significant for the qualitative and quantitative determination of the C_{76}-D_2 fullerene either in natural resources or in artificially synthesized and bio materials, electronic and optical devices, solar cells, organic field effect transistors, nanophotonic lenses, diagnostic and therapeutic agents, such as for diabetes, pharmaceutical substances, in biomedical engineering and so forth.

Keywords

Higher fullerene C_{76}-D_2, IR spectroscopy, molar absorptivity, integrated molar absorptivity

Acknowledgement

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Chemical and Process Engineering

MODELING, SIMULATION AND CONTROL OF A SMALL SIZE WATER DEMINERALIZATION INSTALLATION WITH AN EJECTOR

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Abstract

In this paper modeling, simulation and control of installation for water demineralization from hot springs is presented. Demineralization is done by a water ejector, where a hot water pressure is decreased in order to achieve evaporation. There can be found in the literature steady state models and some dynamic models developed by parameter identification, but there is still lack of dynamic models suitable for control purposes. In this paper, a linear model of a small size demineralization apparatus is developed. Linear model is used for designing a gain schedule PID controller. A map of the controller gains is determined by extensive simulation minimizing appropriate cost function. It is shown that the designed controller guides the demineralization process through optimum thermodynamic states of process and working fluid.

Keywords

Demineralization, Ejector, Modeling, Simulation, PID Control

ANALYSIS OF THE EFFECTS OF BUTT WELDED JOINTS ON A CARRYING CAPACITY OF A STRUCTURE TANK

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Abstract

In the present paper, after calculation using the Finite Element Method (FEM), stress distribution on the model of a part of the pressure-tank mantle without welded joints (WJ), with transversal WJ, longitudinal WJ and cross point location of WJ is analyzed. Also, FEM calculation and comparative analysis of the effects of WJ on the stress distribution have been conducted using the tank for liquid carbon dioxide as an example, on which, in addition to the mantle sheet-metal and bottom with necessary openings and elements such as saddles with supports and hangers, transversal and longitudinal butt WJ, have been modeled.

Keywords

Finite Element Method, stress distribution, pressure-tank, welded joints

Acknowledgement

This work is a contribution to the Ministry of Education and Science of the Republic of Serbia funded Project TR 35011.

THERMOGRAVIMETRIC KINETIC STUDY OF SOLID RECOVERED FUELS PYROLYSIS

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Abstract

Solid recovered fuels (SRF) are new comers on the fuel market. They are result of a "Zero to Landfill" waste management philosophy which uses a set of strategies based on the waste hierarchy designed to capture as much of the resource in the waste as possible.SRF is a fuel produced by shredding and dehydrating solid waste, typically consisting of combustible components of municipal solid waste (MSW) including biodegradable waste, recyclable material, inert waste and composite wastes. There are three options for utilisation of SRF: as a base fuel, as additional fuel for co–combustion and for thermochemical conversion. In Republic of Serbia there are significant quantities of coffee and tire wastes that can be used as SRF.

Significant differences between SRF and base fuel (coal, biomass, etc.) are cause of numerous problems in design of burners for those fuels. The objective of this study was to determine the kinetic parameters for the thermochemical conversion of selected SRF using Simultaneous Thermal Analysis (STA).Samples of coffee and tire waste were used for the experimental tests. Thermal analysis was carried out in nitrogen atmosphere at three different heating rates for each sample. Two sample sizes of each SRF were used in experiments, in order to obtain reliable TGA data for estimation of kinetic parameters for SRF pyrolysis.

Experimental results were used for determination of pre-exponential factor and activation energy according to isothermal and non-isothermal methods presented in the literature. Original Matlab codes were developed for calculation of kinetic parameters according to these methods.

Obtained results of kinetic parameters calculations are presented and compared with literature data. Presented investigations provided valuable data for coffee and tire waste that can be used in design of furnaces for combustion of SRF/coal or biomass mixture.

Keywords

STA; thermogravimetry; kinetic parameters; solid recovered fuels; pyrolysis

Acknowledgement

Study presented in this paper is part of the project III42010 Decreasing air pollution from thermal power plants in JP EPS financed by Ministry of Education, Science and Technological Development of Republic of Serbia.

USAGE OF RBI METHODOLOGY BASED ON DRAFT EU STANDARD PREN16991 FOR ADEVELOPMENT OF INSPECTION AND MAINTENANCE PLAN&STRATEGY

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Abstract

Current practice of inspection and maintenance can be significantly improved through the usage of the European draft standard prEN16991 (Standard). Inspection and maintenance programs in the industrial plants can become more cost-efficient while, at the same time, safety, health, and environmental performance is maintained or improved. Applicability has been validated in numerous examples. Savings can be achieved through the awareness what is not to be inspected and for components which has to be inspected what type, how detailed and often the inspection should be, while compatibility with international and national legislation is preserved. Standard gives procedure to follow but does not give “recipes” or tools for each and every step of the program/procedure. Some has to be developed or selected for purpose. Careful application of the Standard procedure and usage of the right tools gives possibility to develop, in many aspects, optimal or suboptimal inspection plan & strategy. Some procedural explanations and proposed tools are given in this paper as well as some achievements obtained in practical application.

Keywords

Risk Based Inspection, Maintenance, Strategy, Tools, Achievements

Experimental Techniques

EXPERIMENTAL ANALYSES OF THE IMPLANT SUPPORTED ALL-CERAMICS

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Abstract

The aim of this study was to present the possibility for digital image correlation (DIC) and finite element analysis (FEA) investigation of ceramic crowns placed on angulated and non angulated implants. Additionally, to determine strain in models composed of all-ceramics supported by angulated and non angulated implants with or without platform switching. Three-dimensional finite element (FE) and the digital (DIC) models of the Strauman cylindrical dental implant systems (4 x 12 mm; Straumann, Basel, Switzerland) placed in the polyurethane resin (F16, Axson Technologies, France) block with an inclination of the vertical axis in interval of +1, -1 and -3 degrees were created. Additionally, control FEA and DIC models with straight implants (one for each analyzing system) were created to support results obtained for models with inclined implants. Height of the block was 14.5 mm and length 11.5 mm. The width of the sample was 13 mm. The implants were placed so that their outer diameter surface was 2 mm away from the surface of interest, measured in the straight orientation (0˚). The strain was observed at two locations i.e. modes – “block implant” interface (cross section), and in the area of interest. Solid modeling for the implant and block model was performed in Ansys 13.0 APDL Multyphysics in Windows 7 OS. Finite Element analysis was performed in Ansys 13.0 by Sparsesolver. Solidworks 2015 Academia (Dassault Systemes) was used for creating block mold models. Overall von Mises strain for every sample was calculated by averaging strain values in cervical, middle and apical region. Increase of the angle of inclination increased overall strain in the apical region of the DIC and FEA models. DIC mode confirmed findings supported by FEA modes, so FEA models validate DIC models.

Keywords

Implant supported all-ceramic; digital image correlation method; finite element analysis; angled implants.

MEASURING OF STRAIN AND DISPLACEMENT USING DIGITAL IMAGE CORRELATION

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Abstract

Presented in this paper is the application of stereometric measuring method, digital image correlation, in various experiments related to measuring of displacement and strain, for the purpose of providing full insight into the behaviour of welded joints under tensile load, as well as the behaviour of composite dental filling materials, among other examples. Optical stereometric method involved the application of digital image correlation. Presented in this paper are the strain and displacement for various load levels, along with the behaviour of the welded joint as a whole. As a result of this approach, concrete and accurate values of the observed strain field of the welded joint as a whole can be compared directly, rather than as chosen representative parts that would be tested using a strain gauge in a single position, and provide a more detailed insight into the behaviour of tested specimens. With the aid of images obtained using cameras, the development of strain over time can be monitored, while pointing out the critical parts of a welded joint, allowing the determining of potential locations with increased stress intensity factor.

Keywords

Stereometric optical systems, ARAMIS software, welded joints, deformation, displacement

Acknowledgement

The authors of this paper acknowledge the support from Serbian Ministry of Education, Science and Technological Development for projects TR35040.

PLASTIC LIMIT LOADS FOR CRACKED PIPES UNDER INTERNAL PRESSURE CONTAINING TWIN COLLINEAR AXIAL THROUGH-WALLCRACKS

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Abstract

The paper provides plastic limit loads for tubes with twin collinear axial through-wall cracks under internal pressure. Based on systematic small strain finite element (FE) limit analysis using elastic-perfectly plastic materials, an effect of crack configurations on plastic limit loads are investigated. The obtained values of limit load present coalescence loads of twin collinear cracks. The results are compared to the corresponding plastic limit loads for tubes with a single axial through-wall crack.

Keywords

Limit loads; Axial through wall cracks; Finite element; Internal pressure

BIOMECHANICAL ANALYSIS OF DIFFERENT MODES OF THE SAME COMPOSITE CEMENT USING THE DIGITAL IMAGE CORRELATION METHOD

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Abstract

Recently, resin based cements have become very popular in dental practice for cementation of dental restorations, especially considering all-ceramics, due to improved adhesion features. The aim of this study was to visualize and compare strain in the self-cured and dual-cured MaxCem Elite and to investigate hardness of these two curing modes of the same cement. Strain field was measured using 3D optical system Aramis 2M (GOM, Braunschweig, Germany) based on digital image correlation method. Ten, 5 × 2 mm sized samples of the self-cured and dual-cured Maxcem Elite (Kerr, Orange, CA, USA) were prepared by filling plastic ring-type molds. Analysis of the strain fields was done using sections and stage points created by software. The distribution of the overall strain was found to be more expressive and uniform in the self-cured samples. Overall shrinkage strain ranged from 0 to 12%. Samples with dual-curing mode showed higher strain peripherally, compared to self-cured samples where the overall strain was distributed all over the sample surface. The Vickers measurements could not be carried out on self-cured samples due to incomplete chemical polymerization. The values of hardness were relatively equal in dual-cured Maxcem Elite due to hardness is interpreted as a statistical magnitude practically depends on the composition of the tested structure. Additionally, closeness between cements layers and led lamp was a factor for increasing hardness values in dual–cured Maxcem Elite. The study provided valuable data about strain behavior of Maxcem Elite during polymerization and highlighted dual-cured over self-cured mode.

Keywords

Resin based cement; hardness; digital image correlation method; strain

Acknowledgement

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APPLICATION OF THE DIGITAL IMAGE CORRELATION TECHNIQUE FOR INVESTIGATION OF DIFFERENT ALL-CERAMIC SYSTEMS

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Abstract

Mostly, mechanical properties such as elastic modulus, flexural strength and fracture toughness were assessed under static loading conditions for the initial characterization of materials. During this course authors presented the digital image correlation technique as possible method for biomechanical investigations of all-ceramics under vertical loading conditions using standard tensile testing machine and several samples of all-ceramics' blocks: E-max lithium disilicate glass-ceramics, Vita enamic, Feldsphatic ceramic and Yttria-stabilized zirconia polycrystal ceramic. Lithium disilicate glass-ceramics has a needle like crystal structure that offers excellent strength and durability as well as outstanding optical properties. For the lithium disilicate ceramics, the amount of glass phase is determinant in their fatigue behavior. Vita enamic is the first hybrid dental ceramic with a dual-network structure. Feldsphatic is a glass material with an amorphous (non-crystalline) structure. *Yttria-stabilized zirconia polycrystal is a high-strength ceramic with high values of flexular strength and fracture toughness. Zirconia, the strongest and toughest of all dental ceramics meets the mechanical requirements for high stress-bearing posterior restorations. All of these blocks were subjected to load in the tensile testing machine and the obtained strain was visualized using cameras and Aramis software. Findings provide that the highest strain was detected in Feldspathic, E-max and Zirconia all-ceramic blocks, respectively. Vita enamic was found to be the lowest strained due to polymer infiltrated its structure. This fact has significance for clinicians due to application of all'ceramic system in patients with decreased vertical occlusion and abrasion. Additionally, the hardness and elastic modulus of Vita enamic was found to be similar to those of the dental tissue values which makes this material a good choice for restoring posterior areas with inlays.*

Keywords

All-ceramic system; zirconia; polymer-infiltrated ceramic-network material; glass-ceramics; digital image correlation method

Acknowledgement

This research was supported by Ministry of Education, Science and Technological Development of Republic of Serbia under Projects TR35031 and TR35040.

3D DIGITAL IMAGE CORRELATION STUDY OF GLOBE VALVE HOUSING SUBJECTED TO INTERNAL PRESSURE

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Abstract

Globe valves are one of the most widely used industrial fittings. Due to variety in globe valve application, different loadings occur in its working life (static, dynamic, thermal etc.), but the most dominant one is internal pressure. This paper presents the analysis of standard globe valve housing under the internal pressure using 3D Digital Image Correlation method, Finite element analysis and calculation according to EN standard. Experimental analysis was focused on determining mechanical properties of critical areas, i.e. on local areas of globe valve housing with high geometrical discontinuities. Experimental system consists of cameras for 3D displacement and strain analysis and software Aramis. Models designed using FEA are verified through the experiment, while at the same time the possibility of using Aramis system for these constructions has been proven. It is found that the predictions from the model agree well with experimental results as the result differences between two methods in the area of the highest strain values vary below 30 %, which is satisfactory for engineering application. Experimental and numerical results demonstrate that the experimental method is adequate for solving geometrically complex problems and provides an opportunity for further development and improvement for practical industrial application.

Keywords

Globe valve housing; 3D Digital Image Correlation Method; Finite Element Analysis; von Mises strain, EN standard.

Acknowledgement

This research was supported by Ministry of Education, Science and Technological Development of Republic of Serbia under Projects TR35031 and TR35040.

APPLICATION OF POLYMETHYL-METHACRYLATE BLOCKS IN EXPERIMENTAL ANALYSIS OF EFFECT OF DENTAL IMPLANT GEOMETRY ON THE SURROUNDING STRUCTURE DURING AXIAL LOADING

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Abstract

Strain fields in the vicinity of the dental implant varies depending of several factors, among which is the implant geometry. This study investigates new experimental methodology for analysis of effect of implant geometry on the load transfer during axial loading of dental implant. Two dental implants, Strauman 4.8 x 14 mm and Strauman 4.0 x 12 mm, were placed in individual blocks of polymethyl methacrylate with dimensions of 68 x 25 x 9 mm. Samples were placed in the three point bending support. Axial load was applied on the implant, with maximum intensity of 600 N. 3D Digital Image Correlation method was used for strain measuring. Two FE models were developed according experimental models. Von Mises strains were presented and compared. Results show the greatest values of Von Mises strain values in the neck region of the implant, in the upper part of the block. Experimental results show Von Mises strain in the range of 0.4 – 0.8 %. Numerical models show Von Mises strains in the range of 0.4–0.6 %. Experimental and numerical models show tendency of deformation decrease in the apical region of the implant. Lower strain values in experimental and numerical analysis were observed for Strauman 4.8 x 14 mm. This coincides with reports in the literature where it is reported that implants with greater contact surface transfer lower strain values. This study shows that this methodology could be used in preliminary analysis in effect of dental implant geometry on the strains in their vicinity during axial loading.

Keywords

Polymethyl-methacrylate, dental implant, 3D Digital Image Correlation, Von Mises strain, axial loading

Acknowledgement

This research was supported by Ministry of Education, Science and Technological Development of Republic of Serbia under Projects TR35031, TR35040, III41006 and III45009

DIFFERENT METHODOLOGICAL APPROACHES FOR BIOMECHANICAL INVESTIGATION IN DENTISTRY RESEARCH

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Abstract

Various methods have been proposed for biomechanical investigation in dental medicine, so far: numerical, photoelastic models and in vivo analyses. Recently, in vitro analyses have become important in studying of the bone biomechanics, whether maxillar or mandibular, the bone substituents and dental biomaterials especially if we consider ethical parameter of these experiments. All of them have usually served for determination and analyzing stress, strain and displacement of different dental structures and biomaterials used in oral rehabilitation. Nevertheless, the main classification of these methods is based on features of materials and environmental factors used for the experimental researches. Methodological approaches in dental biomechanics depend on the type of experiment but always include relevant designs of biomaterials and human's organs to achieve physiological conditions, as much as possible. The aim of this study was to represent current techniques to be applicable in dentistry researching. The digital image correlation method (DIC) and the finite element analysis (FEA) were used to explain the possibilities of software analysis for in vitro set ups. In vitro experimental analyses were performed using the standard protocols in dental biomechanics. This study indicates that both techniques have important role for investigations in dental biomechanics. Additionally, the intention of this study was to present FEA and DIC as the possible methods for strain/displacement analysis in the field of dental biomechanics. The results obtained using both, FEA and DIC analysing can improve therapeutic success and pinpoint the best therapeutic choice in various clinical cases.

Keywords

Finite element analysis; digital image correlation technique; mandible; biomaterials

RESIDUAL FATIGUE LIFE ESTIMATION OF CRACKED AIRCRAFT LUGS UNDER LOAD SPECTRUM

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Abstract

This work deals with residual fatigue life estimation of damaged aircraft structural components under cyclic loads of constant amplitudes and load spectrum. This investigation is focused on developing efficient and reliable computation methods for fatigue life estimation of cracked aircraft lugs under cyclic loads of constant amplitude and load spectrum. The primary attention of this investigation is to establish a computation procedure for the evaluation of the residual life of aircraft attachment lug type structural elements in the presence of initial cracks. The Strain Energy Density (SED) method is used in this investigation for a residual life estimation and a crack growth analysis. A special attention has been focused on the determination of the fracture mechanics parameters of structural components such as stress intensity factors of aircraft cracked lugs. For crack growth analyses and residual lives of damaged lugs, the Strain Energy Density (SED) method and the conventional Forman`s method are used. This method uses the low-cycle fatigue (LCF) properties of the material, which are also used for the lifetime evaluation until the occurrence of final failure. Therefore, the experimentally obtained dynamic properties of the material such as Forman`s constants are not required when this approach is concerned. The complete computation procedure for the crack growth analysis using low-cycle fatigue material properties is illustrated with the cracked structural elements. To determine analytic expressions for stress intensity factors (SIF), singular finite elements are used. The results of a numerical simulations for crack growth based on the strain density method have been compared with the author`s own experimental results.

Keywords

Fatigue, aircraft lugs, fatigue crack growth, low-cycle fatigue, SED

Acknowledgement

This work was financially supported by the Ministry of Education, Science and Technological Development of Serbia under Projects OI 174001 and TR 34028.

NUMERICAL MODELLING AND EXPERIMENTAL VALIDATION OF ELASTIC - PLASTIC BEHAVIOUR OF PRESSURE VESSEL WITH NOZZLES

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Abstract

To evaluate the safety of welded structures, such as pressure vessels, it is necessary to know the material properties of which vessels are made and their behavior under different working conditions. Due to various requirements, nozzles are often welded on vessel's shell. Stress and strain analysis of the influence of two nozzles closely welded on the pressure vessel cylindrical shell, subjected to internal pressure, is presented in this paper. For analysing full field of surface strain, 3D Digital Image Correlation (DIC) method was applied. DICM with camera system in combination with Aramis software is a non-contact and material independent measuring system providing high resolution, and highly accurate information about a component's 3D shape, strain and deformation. After determination of critical areas (strain concentration areas) by experimental method, the numerical analysis of the equivalent 3D model was performed. 3D model vessel which includes material nonlinear properties of vessel was obtained by finite element analysis. Maximal stress and strain values were determined and results were comparable with experimental results. The aim of this study is to show behaviour of cylindrical pressure vessel with two nozzles subjected to internal pressure, using both 3D DIC method and numerical method. Maximum values of stress and strains, as well as their positions are shown in the paper. Differences between these two methods in the area of the highest strain values were from 2.99% to 17.8%.

Keywords

Digital image correlation, finite element method, strain, stress, pressure vessel

Acknowledgement

The research work is funded by the Ministry of Education, Science and Technological Development of Republic of Serbia, Project TR35031

Numerical Methods

Invited paper

THE MODERN APPROACH TO THE DESIGN AND ANALYSIS OF TITANIUM ALLOY HIP IMPLANT

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Abstract

This paper presents a review study of influencing factors on the design process and structural integrity of the hip implant. The modern experimental and numerical methods for preclinical testing of a hip implant are presented. Mimicking the natural human hip shape is one of the main goals of the hip implant design, and due to the fact that it is subjected to variable loads during the walking cycle, hip joint is one of the most important load-bearing structures inside the human body. Very complex project demands are requested for hip implants, since there are specific functional demands from the surgeon's standpoint, and critical limitations from the engineering perspective, due to specific design and currently available biomaterials. Although all elements of design and manufacturing of implants are improved, and fatigue fracture incidence in hip prostheses has been significantly reduced over the past decades, long-term stability of the hip implant still presents a problem. Therefore, careful evaluations of the biomaterial properties and hip implants geometry must be carried out during preclinical tests to ascertain whether existing or new designs can guarantee the mechanical resistance to the physiological load. Arthroplasty problems are closely related to the properties of the material used, and nowadays titanium alloys, particularly Ti-6Al-4V and Ti-6Al7Nb, are the most commonly used materials for the hip prosthesis. In addition to having a limited number of suitable materials, hip prostheses must also function in corrosive environment and withstand extreme loads. For effective preclinical testing, knowledge of biomechanical properties of the hip implant is important in determining possible fracture scenarios. Also, forces that can occur in vivo can be much higher than the recommended standard test values, which may have effect on implant stress field changes. An alternative approach would be the use of finite element method (FEM) to obtain a preliminary overview of the expected mechanical properties of implant designs. This method became a widely used tool in orthopaedic biomechanics, as a numerical method suitable for determining of stresses and strain in any given point within a structure with complex geometry and material properties.

Keywords

Hip implant design,Ti−6Al−4V titanium alloy,FEM, numerical analysis, preclinical tests

NUMERICAL ANALYSIS OF GLOBAL AND LOCAL BUCKLING OF BEAM

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Abstract

Due to the increasing of demands of structural plate elements, thin-walled plates and beam-columns are widely used in many industrial applications. When the compressive force is applied over entire or a part of cross section, the local or global distortion or mixed modes of buckling may appear. Linear buckling is very important for the stability of compressed beams. In order to investigate the critical buckling load, local and global buckling pattern of beam under the uniaxial compression load, the stiffened beam-columns in three configurations with two different stiffeners were designed and tested.
Stiffeners are placed on the beam and they induce redistribution of the way of buckling in terms of local and global buckling. Transverse and longitudinal stiffeners of the beam presented in this paper have the aim to increase the critical load buckling. Determination of the optimal geometry of stiffener is imperative. Examples shown in this research were carried out using the finite element method (program Abacus) for determining the critical buckling force. The results showed that the transverse stiffeners and their orientation have a significant impact on the local buckling, while longitudinal stiffeners have minor impact on the local and global buckling.

Keywords

Buckling; beam; stiffeners; finite element method

THE APPLICATION OF EXPERIMENTAL AND NUMERICAL METHODS FOR PROSTHETIC TREATMENT PLANNING IN PATIENTS WITH PARTIAL EDENTULISM FOLLOWED BY MALOCLUSSION

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Abstract

A selection of an adequate prosthetic design for rehabilitation of complete and partial edentulism has been usually investigated using numerous experimental models subjected to strain gauges, photoelastic, digital imaging, finite element or other techniques served for data processing. Nevertheless, finite element analysis (FEA) and digital image correlation (DIC) was found to be reliable methods for strain analyses. The aim of this study was to determine and analyse strain in jaw models with malocluded remaining teeth and needing for restoration with different prosthetic designs. Chosen designs were whether fixed or removable prostheses. Models with these prostheses were vertically loaded whith axial direction of the applied loads of 500N. Experimental (FEA, DIC) models were made using human-jaws prepared using standard protocols from previous studies. The methods for visual interpretation of data, FEA with ''Ansys'' and DIC with ''Aramis'' software, were used for data processing. Findings provide that lower strain was registred in the residual alveolar ridge below fixed prostheses however bone arround abutment teeth was higher strained when fixed prostheses were loaded. FEA validated DIC results thus these methods can serve for strain analysis purpose, equally. FEA and DIC methods can be usefull for prosthetic treatment planing, selection/finding of appropriate prosthetic designs for various cases of edentulism and improving the existing therapeutic concepts to avoid prosthetic failure.

Keywords

Digital image correlation technique; finite element method; fixed prostheses; removable prostheses

NUMERICAL ANALYSIS OF STRESS DISTRIBUTION IN NECK AREA ON CO CR ALLOY TOTAL HIP REPLACEMENT IMPLANT

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Abstract

Total hip replacement implants represent permanent implants, and require large bone and cartilage removal during implantation. Revision would affect joint capability to sustain load, which makes this procedure irreversible. During exploitation, i.e. everyday activities, implants are exposed to high influence of dynamic load, which will lead to failure of material by fatigue. Highest stress states on total hip replacement implants are present in neck area of implant, which is a position of crack initiation. Under loading neck area of implant contains tension and compression zones. Crack initiation on neck side under tension would lead to crack opening and certain fracture of the material. Implants are designed to reduce stress concentration on tension side of the neck and to create maximal stress concentration on compression side of the neck, where eventual crack would be pressed by material preventing its further propagation.

Implants are examined with experimental and numerical methods. Most common numerical method is finite element method (FEM), used to simulate different loading conditions. Numerical analysis of stress distribution in neck area on specific implant was computed for static load equal to maximal load applied on implant. Subject of this paper is influence of implant geometry on stress distribution in neck area, thereby analysis was performed only for implant. Contact bone-implant was compensated with adequate boundary conditions. Material properties of selected implant were obtained from literature. Four numerical models were created in order to show how certain reductions of material influence on stress distribution in neck area of implant. The objective of this paper was to analyse these solutions.

Keywords:

Total hip replacement implant, Co-Cr alloy, Stress distribution, Finite element method, Fatigue crack

APPLICATION OF FINITE ELEMENT METHOD ON THE ANALYSIS OF MECHANICAL BEHAVIOR OF VASCULAR NITINOL STENTS

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Abstract

The stent is a tubular wire device that is used in medicine for maintaining physiological values of size of blood vessel's cross section. The need for a stent device occurs due to an abnormality of the blood vessel as a result of the narrowing (stenosis) which can be lead to a complete interruption of blood flow and potential death. Stents can be made from non-degradable metals (stainless steel 316L, nitinol alloy or cobalt-chromium alloy) or degradable metals (magnesium, iron and zinc). Also, the use of degradable polymers is found. The most important is a polylactide (PLA) as a material from which is made a vascular stent. Stent exist in different geometric configurations, a variety of mechanical and chemical properties which are adapted to the application. The paper shows the use of the finite element method in order of calculation stent's behaviour, using Solid Works and ABAQUS program packages. A realistic model, according to which is numerical modeling carried out and analysis of the stent, is vascular stent that is obtained in Military Medical Academy in Belgrade as a vascular device whose expiration date has expired. Due to the geometrical complexity of the original model of the stent, there are some approximations on new model of stent. One of them is rigid connection between coils that come into contact. Overall dimensions are 90x10 mm, where a spiral thickness is 0.14 mm. Based on the relevant experimental results, obtained from the reference material, there are selected boundary conditions and the load. The load is compressive force of 0.195 N. After boundary conditions and the load, there are discretisation of the model and forming a network. For further testing is used a quarter of the model and the mesh (discretisation) was applied on it. Based on the literature references, on the numerical model of the stent was introduced mechanical characteristics that match the characteristics of NiTi alloy; Young's module of elasticity (E) of 75 GPa and Poisson's ratio (v) of 0.33.

Keywords:

Nitinol stents, NiTi alloys, numerical analysis, finite element method

NUMERICAL SIMULATION OF CRACK PROPAGATION IN HIGH-STRENGTH LOW-ALLOYED WELDED STEEL

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Abstract

The industrial application of high-strength low-alloyed steel (HSLA) in welded structures has increased the demand for understanding fracture behavior and structural integrity assessments of this type of steel and produced welded joints. The aim of this paper is to determine appropriate numerical model to simulate the experimental evaluation of the fracture mechanics specimens. The investigation is performed on two standard single edge notch bend (SENB) specimens with imposed crack in the central region. Numerical analysis was carried out by ABAQUS on 2D micromechanical models used to simulate the local fracture. The comparison between numerical and experimental results is presented through measured values of J-integral, load-line displacement $v_{LL}$and J-Δa curves. This paper, shows that numerical simulations are promising in respect to their accuracy. The application of this model enables to avoid expensive experiments for determination of the load level that causes crack propagation.

Keywords

High strength steels, welded joints, strength mismatching, finite element method, crack propagation, fracture mechanics

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New Technologies

THE PATH FROM IDEA TO PATENT FOR A DEVICE FOR THE POURING AND PRESERVATION OF WINE

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Abstract

The path from idea to patent for young researchers and often for large companies, can be complicated if all steps are not planned in a timely manner. The initial idea doesn't mean it's globally new, even though at first glance it seems to be. The expenses of the protection of intellectual property can be unbearable if they are not fully analyzed. The device forthe pouring and preserving of wine allows restaurants to serve a wide variety of wines era glass, without risking the rest of the wine oxidizing and becoming an expense. In this paper, is shown the path from the idea to patent awards, in front of the Institute for Intellectual Property of the Republic of Serbia and entry into the national phases of protection in the territory of Europe, Euro-Asia, the United States, Canada and Australia. This product has received acknowledgement for the best invention by the Chamber of Commerce of the City of Belgrade for 2015 and the City of Belgrade for 2016.
A new, award-winning, detachable wine preservation and dispensing system: preserves wine, preserves space, preserves profits!

Keywords

Patent, detachable wine preservation

Acknowledgement

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CAD/CAM SYSTEM FOR AUTOMATIC MANUFACTURING TECHNOLOGY DESIGN OF FREE FORM SURFACE PARTS

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Abstract

Apart from having strong application in mechanical engineering, parts with free form surfaces are also present in electrical industry, medicine, appliance and consumer goods industry etc. Following this increasing interest, the research team of the Production Engineering Department of the Faculty of Mechanical Engineering Belgrade in Serbia, initiated series of studies in order to develop CAD/CAM system that will provide automatic manufacturing technology design for milling operations. The designed system is intended for automatic tool path generation based on loaded inputs (part/workpiece CAD model, workpiece material and surface roughness) and a database containing sets of values for available cutting tools and cutting coefficients for tool/workpiece material while considering geometry as well. Manufacturing of the workpiece according to the generated tool path fulfills the requirements for minimizing machining time and production costs accordingly. The system generates machining parameters based on available data stored in the database, which is an integral part of the designed system. MATLAB® software package was used for developing this system, therefore no expert knowledge about CAD/CAM systems is necessary for its use. The machining of parts based on the developed optimization methods was carried out at the Faculty of Mechanical Engineering in Belgrade. Precise dimensional inspection of manufactured parts was performed at Department of Physics - University of Liverpool, UK using OGP Smartscope CNC 624 multisensor metrology system. Deviation maps were created based on measurement data which demonstrate that the machining was performed in defined specifications, verifying the applicability and pertinence of the developed system.

Keywords

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

Acknowledgement

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DESIGNING OF MANUFACTURING PROCESS OF REFORMER INTEGRATED IN SYSTEM WITH HTPEM FUEL CELL STACK

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Abstract

In this paper is shown designing of manufacturing process of reformer in polymeric electrolyte membrane (PEM) fuel cell. The process is based on reformer modelling, analyzing of reforming initial geometry and change of geometry. In addition to the numerical calculation, change of geometry is based on tool path simulation analysis in order to obtain more efficient reformer production. Before machining, tool path simulation was performed and generated by PTC Creo/Parametric software. The recommendations for geometry changing are given in order to decrease of machining costs, and are made so that did not affect the initial reformer performances. The reformer machining is carried out on a CNC milling machine and Wire EDM machine.

Keywords

Reformer, design, CNC milling

Acknowledgement

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TECHNOLOGICAL ANALYSIS FOR MACHINING OF THE REFORMERS FOR FUEL CELLS TESTING

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Abstract

Reformer is an integral component of the polymeric electrolyte membrane (PEM) fuel cell and it is used for experimental combustion testing. By analyzing the geometry of the experimental reformer, it consists of three plates, two pins for leading and a single screw for sealing. In terms of technological analysis for manufacturing of the experimental reformer emphasis was thrown on the intermediate plate which is necessary to carry out Wire EDM machining. Before the machining based on CAD models it was performed tool part generation in order to perform machining simulation. In order to minimize manufacturing costs by techno-economic analysis it was varying the wire thickness, and therefore cutting parameters. Besides the variation of the cutting parameters it was varied and the intermediate plate thickness. It was made a three sets of experimental reformer, wherein the electrical discharge machining (EDM) was performed on two machines (Mitsubishi FA-10S Wire EDM and "Ewis" EV.00.000M4) with two different wire thickness. After machining is was carried out the welding procedure, and after that re-machining in order of remove the excess material which is applied by welding process.

Keywords

Reformer, CAD/CAM systems, Wire EDM machining

Acknowledgement

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DEVELOPMENT OF THE LOW BACKLASH TORSO JOINT FOR HUMANOID ROBOTS

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Abstract

This paper presents the development of the low backlash torso joint for humanoid robots. The research was conducted within the project which develops humanoid robot Sara that should represent anthropomorphic mobile platform for research of social behavior of the robot. The research includes the interaction between humans and robots, emotions recognition and their expression, gestures and active robot operation in the immediate human environment that is dynamic and unstructured. There are two basic ways for robot torso realization. The first one is based on rigid and low backlash mechanisms whose rotation axes intersect at one point – torso/waist joint with 1-3 DOFs, and the second one on biologically inspired multi-joint viscoelastic structures that have variable flexibility with 3-15 DOFs – lumbar spine. Low backlash mechanisms provide high positioning accuracy that enable high accuracy and repeatability of movements which is essential for motion control. During the spine bending, the elastic elements generate force that opposes gravity and thereby help actuators. We propose rigid and low backlash mechanisms that require small actuators. Based on the kinematic-dynamic requirements a dynamic model of the robot upper body is formed. Dynamic simulation for several positions of the robot was performed and the driving torques for dimensioning the torso joint are determined. Realized torso has 2 DOF and enables trunk movements in the direction of flexion-extension 90° and rotation ±90°. It consists of two epicyclic gear mechanisms which are interconnected and whose axes of rotation intersect in one point. The proposed solution has a high carrying capacity and reliability, high efficiency, low backlash, compact design and relative small mass and dimensions. Further work will examine the impact of the geometric parameters on the kinematic characteristics in order to improve dynamic behavior of the torso joint as well as to reduce its mass and dimensions, which requires optimal synthesis.

Keywords

Humanoid robot, torso joint, epicyclic gear mechanism, low backlash, mechanical design

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RETRIEVING EDR DATA

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Abstract

This paper present usage of Electronic Control Unit and Event Data Recorder in nowadays vehicles. In modern vehicles, crash data can be later analyzed in forensic investigation. Nowadays vehicles, automobiles, light-weight trucks, and heavy trucks normally use Electronic Control Units (ECUs) to perform the logical control functions in subsystems which regularly embody engine, antilock braking, traction control, stability control, front/side/roof/rear restraints control, and change protection control. Once an ECU saves information associated with a crash event, which information will later be accessed for investigation functions, the ECU is usually observed as an Event Data Recorder (EDR).

In last ten years of automotive technology have seen a steady growth of electronic controller applications in automobiles, the next ten years will see an increasing sophistication in automotive network interfaces and diagnostics. The engine control unit (ECU) is the most powerful computer on a vehicle. ECU uses a sensors to monitor and control most of the engine functions in the vehicle, which means the electrical, fuel, and emissions control systems. ECU control: starting system, ignition system, spark plugs, charging system, battery, various circuits.

In addition, body electronics have a lot of growth opportunities, major applications will be in body computer, body control zones, gateway, HVAC (climate control), lighting, wipers, door module / power window, keyless entry & remote start, immobilizer, alarms, etc.

Keywords

Engine Control Unit (ECU), event Data Recorder (EDR), Reviewing data

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