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1st International Symposium on Machines, Mechanics and Mechatronics - Current Trends

Belgrade, Serbia

July 1-2, 2014

UNDER THE AEGIS OF:

University of Belgrade, Faculty of Mechanical Engineering

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TRADITIONAL AND EMERGING TECHNIQUES FOR PRACTICAL RANDOM VIBRATION ANALYSES

PLENARY TALK

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Abstract

The lecture will focus on available tools for conducting random vibration analyses for practical engineering problems. An inherent aspect of this theme is the simultaneous existence of elements with linear behavior, and of elements of nonlinear behavior within the system. In this regard, techniques both for linear and nonlinear random vibration analyses, will be discussed. Attention will be focused on traditional techniques such as statistical linearization/quadratization, and Monte Carlo simulation. Further, emerging techniques, such as wavelets as a tool for signal and response localization, and fractional calculus as a tool for capturing non-local behavior will be discussed. Pertinent examples of the application will be considered.

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STANDARDIZATION OF MECHANISM AND MACHINE SCIENCE TERMINOLOGY

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Abstract

The paper deals with history, activities, methodology and results of standardization of terminology within International Federation for the Promotion of Mechanism and Machine Science (IFToMM). The constituent meeting of the Permanent Commission for the Standardization of Terminology (Commission A) was held on September 18, 1971, in Kupari, Yugoslavia. Its objectives were to establish a unitary terminology for Mechanism and Machine Science (MMS). Unification of terms on the international level became important for teaching, communication and also for research associated with the development of new fields of science and engineering. Unifying of terminology primarily has to have analytical character - to select terms existing in established fields, to keep proven ones and to define them in order to make possible comparison of different systems or methods [1]. Another important task is to accompany and to control the terminology in rapidly developing fields. The main work in terminology consists in classification and definition. Both of them are standing in a certain interrelation as either presumption or result of a terminological process. Even at the stage of setting up the list of terms to be defined the rules of classification derived from the predicative logic are to be considered. The Commission A reached an agreement on several rules and guidelines - a definition may neither contain nor cause logic contradiction; the terms to be defined may not appear in the definition; the predicate of definition should not be negative; definitions should be concise, etc. Initially, a master version in English was set up and published in the IFToMM journal Mechanism and Machine Theory (MMT), Vol. 18, No. 6, 1983. Cooperation inside IFToMM (e.g. TC for Non-linear Oscillations, TC for Gearing etc.) were established with remarkable results. The 3rd edition of the MMS terminology appeared in MMT, Vol. 38, Nos. 7-10, 2003. This last printed edition contains a basic core of 771 terms and definitions in the English, French, German and Russian languages and a "supplement" of 823 terms and definitions in English. About 10 years ago the Commission A started the development of an electronic version of the four-language dictionary. It offers additional possibilities of browsing by means of links in the alphabetic index part and in the explanation part. At present it contains 13 chapters - from general, Structures of Machines and Mechanisms, Kinematics, to Vibrations and Non-linear Oscillations, Stability, Biomechanics and Mechatronics. This paper is also an invitation towards the entire MMS community, within and out of IFToMM, to join the future efforts of the Commission A.

Keywords: Terminology, Standardization, Commission A, Mechanism and Machine Science, IFToMM

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CORRELATION BETWEEN STRUCTURAL DAMAGE AND DYNAMIC RESPONSE OF THE STRUCTURE

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Abstract

This paper presents one approach in damage detection using frequency response functions data. In order to detect, locate and quantify the damage of the beam like structure, the method based on damage detection and relative quantification indicator is investigated. This method uses measured FRFs as characteristic of dynamics response of the mechanical system, from which the damage detection and relative quantification indicators are calculated. The goal of investigation is to determine effectiveness of the method based on damage detection and relative quantification indicator to detect, locate and quantify damage of the beam, from the standpoint of independency of the method to the previously built FEM or analytical model. Experimental investigation was done on the cantilever beam using hammer excitation and "roving hammer" modal testing. Described damage detection method shows good performance even for the hammer excitation and one response transducer available, which is important considering the practical implementation of the method in the frugally equipped laboratories.

Keywords: damage detection, modal testing, experimental FRF, modal frequencies, cumulative generalized damage index.

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DYNAMIC GROWTH OF AN INTERFACIAL CRACK BETWEEN THE TWO ANISOTROPIC MATERIALS

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Abstract

In this paper is considered behavior of the stress field around the tip of a crack that propagates dynamically along the interface between the two anisotropic materials. The emphasis is set on application and extension of the existing concept of the interfacial fracture mechanics to problem of a crack that propagates dynamically. The angular distribution of the stress is presented. The behavior of the oscillatory index, force resolution factor and energy factor in terms of the crack tip speed and ratio of materials' stiffnesses was studied. The oscillatory index value increases with increase of the crack propagating speed and it tends to infinity when the speed approaches the Rayleigh wave speed of the softer of the two materials. The force resolution factor strongly depends on the crack tip speed, but weakly on the stiffnesses ratio. The opposite is valid for the energy factor. In this work, the dynamic stress intensity factor was determined of the anisotropic bimaterial combination for several basic configurations. Result obtained in this paper can serve as a guide in materials mathematical modeling.

Keywords: Interface, crack, dynamic growth, anisotropy

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INTELLIGENT CONTROL LEGO NXT 2.0 MOBILEROBOT WITH NONHOLONOMIC RESTRICTIONS, ACCORDING TO PREVIOUSLY BEEN DRAWNING TRAJECTORY IN UNDEFINED ENVIRONMENT

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Abstract

The theme of this work is to manage the systems with nonholonomic restrictions (details processed on a mobile robot LEGO NXT) . Nonholonomic systems are most mobile robots because there is no limit on the rolling motion, and that the problem is motion control of mobile robots has attracted a considerable number of researchers due to the complexity of the problem. All management structure which will be developed based on the kinematic model of the movement. Thus, the resulting structure is very easy to expand the mobile robot with differential drives inc their kinematic model is identical to the kinematic model of the wheel. This paper describes the management structure for the trajectory tracking as well as for the stabilization point in a two-dimensional cartesian space without barriers. All these structures are tested on computer simulations with the use of dynamic models of mobile robot, and the experimental on really mobile robot .LEGO NXT 2.0

With obstacles in the area in which the mobile robot moves, tasks can be grouped to move from point to point (stabilization point), and the follow-up given trajectory. From the standpoint of management, due to the specific structure and behavior an helonomic system, it is easier to solve the problem of tracking trajectory in relation to the problem shifts from point to point, and will first be processed.

Keywords: MobileRobots, Nonholonomic, LEGO NXT 2.0

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SYNCHRONIZATION IN NON-LINEAR CHAINS OF MATERIAL PARTICLES

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Abstract

The paper presents the marvelous possibilities of identical synchronization in the chains of material particles. The nature of coupling elements between particles has got damped, linear and non-linear elastic properties. The one or more particles are periodically forced. Depending of coupling elements features and the positions of excitations the synchronization effect is less or more present. The multi-parameters analyses were done by presentation of numerical simulation in the phase space of output variables of coupled particles, like as through synchronization error diagrams. Concluding remarks consider synchronization threshold in a sense of necessary strength of coupling coefficients for full synchronization in the particular chain system.

In chains with non-linear coupling the nonlinearity brings the properties of exponentially divergence of trajectories of particles that starts from very close points in phase space, nevertheless even in that systems on may find synchronization, which is rather surprising detail [1, 4]. In the general sense the synchronization consider the correlation or mutual response in time behavior of two or more processes. In other words, regimes of subsystems have to coincidence after some period of time [2, 3]. From all different cases of synchronization the identical synchronization (IS), as a particular case of general synchronization, was been of interest in this paper. The most simply case of IS could be bring off when the particles are coupled with sufficient coupling strength so that their states are equal after transient changes.

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MATHEMATICAL MODELING AND SIMULATION OF TOOL HOLDER ACCELERATION DURING TURNING PROCESS WITH EXPERIMENT APPLYING

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Abstract

Planning of the modern manufacturing systems that would be suitable for the most demanding cutting processes requires analysis of all technical and technological process parameters by applying scientific methods, modeling and optimal conditions of machining process and systems defining. In order to secure the planned functioning of machine tools they need to be sufficiently resistant and stable at all influences which are exposed in the cutting process. The primary objective of the development of new machine tools is that their concept of production minimizes any external factors to ensure their increased productivity, production without pauses and extraordinary expenses. Researches in domain of the machine tool design and behavior in working conditions show necessity to create more complex models. To increase productivity, efficiency, quality of products, decrease material consumption and tool wear, adequate algorithms to obtain optimal parameters of cutting process have to be used. Because high number of influence factors to the cutting process, it is very difficult to determine most influence parameters of the cutting process by analytical model. For this reason it is necessary to apply the experimental measurements and analysis of the results which is indispensable in the development of new machine tools and improving existing machining systems. Objective of this paper is to find mathematical algorithm of tool holder acceleration ($a_{NA} = f(\sigma_z, v, \delta)$) in function of machined material strength, cutting velocity and depth of cut and perform analysis of influence of these parameters to tool holder acceleration. For the reasons mentioned in this paper experimental investigation of tool holder acceleration during turning process has done for three different types of steel: 9SMn28, S355JOG3 and C45E, with different depths and cutting velocities. Based on the experimental results mathematical modeling of tool holder acceleration during turning process was carried in function of strength of material, cutting speed and depth of cut, while the other parameter were not considered in the modeling than we assume them as constants. A mathematical model of tool holder acceleration in the function of these processing parameters was obtained because mathematical modeling of machining processes is the basis of optimization and defining optimal conditions for the design of modern manufacturing systems.

Key words: machine toll, turning, modeling, acceleration, tool holder

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FATIGUE OF SHAFT FLANGE BOLTED JOINTS UNDER PRELOAD FORCE AND DYNAMIC RESPONSE

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Abstract

The bolted joints are used for flange connections which are subjected to preload forces and dynamic loads. This combination of static and dynamic loads in threaded joints result with complex interaction of high mean stresses, high notch effect, thread flanks contact forces and moments, and contact surfaces slippage which leads to fatigue damage. Multi-body system dynamic model of shaft was used for assessment of dynamic behavior. Finite element model of shaft flange connection, with detailed thread joints made of heat treatable steel 30CrNiMo8 under preload condition and nonlinear thread flanks contact, was created. Rainflow cycle counting was used as cycle count method for describing the load cycle with local stress-strain hysteresis loop. Influences of mean stresses, bolt diameter, and stress gradients were taken into account according to FKM guidelines. The most critical fatigue locations were obtained at thread roots.

Keywords: thread fatigue, joint integrity, flange bolted joint, thread flanks contact, thread forces and moments, FKM guidelines, multiaxial fatigue

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COMPUTATION OF EFFECTIVE BENDING STIFFNESS OF RC TELECOMMUNICATION TOWERS BASED ON EXPERIMENTAL DATA

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Abstract

Optimization approach, combined with experimental data, is used to derive equations for the effective bending stiffness of cross-sections of reinforced concrete (RC) structures. The objective is to determine equations of the unstressed sections for the correct computation of the displacements of these structures and possible applications of structural failure theory, using the results obtained here to predict what section is more probable to fail. The experimental data from tests with 30 and 40 m long RC telecommunication towers, having circular cross-section with 50 cm diameter for the 30 m structure and 60 cm diameter for the 40 m structure, are used. For cross-sections along the axis of the structure, the effective stiffness equation is derived. To accomplish structural analysis, the structures are discretized and the differential equation of the elastic line integrated to obtain the rotations and displacements. Optimization problems are defined where the objective functions are the approximation errors, while the design variables are the coefficients of the effective bending stiffness equations of the cross-sections. Two different formulations are used to compute the effective stiffness. The first one gives one equation for each section and the other formulation provides one equation for the entire structure. The effective stiffness is presented in graphs as function of a ratio between the characteristic bending moment and the ultimate moment of the cross-section. The sections where the largest stiffness loss was obtained were the sections that indeed collapsed in real similar structures. Directions for future research are presented.

Keywords: Stiffness tests, experimental data, lateral displacement, concrete structures, cracking, optimization models

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CONDITIONS FOR DYNAMIC BALANCE OF A RIGID BODY WITH HEAVY FOOT

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Abstract

The model of a rigid body and heavy foot joined by the revolute joint in the constant gravitational field is described. The rigid body moves in the vertical plane, whereas the heavy foot lies on the flat, very rough horizontal support. Conditions for the dynamic balance of this system are mathematically expressed by using the ZMP method. It is shown that they determine an area in the phase space in which the state of the system should be in order that its dynamic balance may be kept. It is also shown by appropriate simulations of motion of the system in the dynamic balance that these conditions are not sufficient to keep it in the upright position, but affect its controllability. It is briefly discussed what are the necessary conditions for this system in dynamic balance to keep its upright position.

Keywords: dynamic balance, upright posture, zero moment point, controllability, rigid body

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DISPERSION RELATION FOR SYMMETRIC DEFORMATION IN ELASTIC PLATES REINFORCED BY ONE FAMILY OF STRONG FIBRES

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Abstract

Here we are concerned with a fibre-reinforced composite materials which have an important property that they are anisotropic, and in many cases this anisotropy may be very strong, in the sense that mechanical properties are strongly dependent on direction. Such materials are highly resistant to deformation by extension in the fibre direction compared to other deformation modes. Thus we treat the material as a transversely isotropic for which the extensional modulus in the fibre direction is much greater than that in a direction perpendicular to the fibres. We are going to consider problem in three dimensions, but restrict attention to linear elasticity theory.

Constitutive relation for fibre reinforced materials are extensively examined in wide range of papers, which are mainly based on article given by Spencer [1]. Wave propagation in plates reinforced by one family of the fibres, for symmetric deformation, are given by Green and Milosavljevic, in [2], and bulk wave propagation is given by Milosavljevic et al, in [3].

This article examines extensional waves propagating in an infinite plate reinforced by one family of strong fibres. The fibres are parallel to the stress free faces of the plate. The dispersion relations for symmetric deformations, relating the phase velocity to the wavelength, for specific carbon fibres - epoxy resin composites are examined. Expressions are also obtained for the variation of stress through the thickness of the plate. Corresponding results are obtained for the idealized material which is inextensible in the direction of the fibres. A comparison of the results shows that the inextensible material behaves quite differently from the anisotropic material in the long-wavelength region.

Obtained dispersion relations give possibilities for examination distribution of displacements and stresses throughout the plate thickness for both very strong fibres and for idealized case when fibres are considered as inextensible, that is as material with constrains.

Keywords: Extensional waves, Plates, Fibre reinforcements, constrains.

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FINITE ELEMENT MODELING OF WING BIRD STRIKE

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Abstract

Bird strike events are a potential dangerous problem faced by flight safety nowadays. These events are usually simulated through numerical approaches due mainly to the technical difficulties and high costs associated with experimental tests. The consequences of bird impact can be severe and, therefore, the aircraft components have to be certified for a proven level of bird impact resistance before being put into service.

Bird impact poses serious threats to military and civilian aircrafts as they lead to fatal structural damage to critical aircraft components. The exposed aircraft components such as windshields, radomes, leading edges, engine structure, and blades are vulnerable to bird strikes.

Among a large number of structural tests an aircraft structure needs a certification requirement for a proven level of impact resistance against bird impacts. Bird strike experiments are very expensive and henceforth explicit numerical modeling techniques have grown importance [1,2]. Parts of aircraft construction are intensively vulnerable to damage during flight by bird impact. The theoretical approach and results of numerical simulations of dynamic response of the wing loaded by the bird impact are presented. The numerical simulation is carried out using smooth particle hydrodynamics (SPH) method running in the nonlinear explicit finite element code ANSYS AUTODYN. The focus is given to the validation of the stress, strain and deflection of wing on the impact zone. The dependency of given parameters on the variation of ellipsoidal bird aspect ratio, impact velocity and wing design details was discussed. As well, some results of experimental data were given.

Keywords: aircraft wing structure**,** impact birds, numerical simulations, SPH model, FEM

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TRAJECTORY AND BASIC MULTYBODY DYNAMIC ANALYSIS FOR FIVE-AXIS CNC MACHINES

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Abstract

This paper presents basic trajectory and dynamic analysis for 5-axis CNC machines, that have been most widely used in machining freeform surfaces.These machines that have three translational motions in the X, Y and Z directions and two rotational motions, pose two different types of problems. The first one can be described as geometrical that relates to the tool path calculation, while the second type is mechanical and relates to both speed and acceleration calculation. The geometrical problem of the trajectory, and velocity, acceleration and jerk limits of the five axes CNC machines, are considered in finding the most optimal feed along the toolpath.

Keywords: multy body dynamic, CNC machines, trajectory, velocity, acceleration

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GEAR TOOTH ROOTH STRESS AND FILLET RADII DEPENDENCE

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Abstract

Real gears are statically undetermined systems and tooth root stress concentration depends of many parameters. Optimal gear form relative to a stress concentration is one of the main problems of gears design. Stress state at the gear tooth root and its analysis is a contemporary topic of scientific investigations. Gear stress state depends to a large extent on main gear profile configuration parameters, which made it one of the key areas of interest for scientific analysis. Tooth root form and fillet radius have a great influence on gear tooth root strength that is one of the primary subjects of this analysis. Special attention is given to analysis on impact of gear tooth fillet radius at the critical cross section on stress value and distribution. Stress intensity factor and gear working life depends directly on tooth root stress. A first initial crack appears at the gear tooth and it is affected the most by root stress concentration. Hence, this research topic is focused on finding the optimal fillet tooth root radius to minimize the tooth root stress intensity. Author analysed critical stresses at tooth root with only one fillet radius ρ_F . However, in order to get less tooth root stress concentration one more fillet radius as a "disencumber notch" is involved. So, special attention will be dedicated to comparison of stress values in gear tooth root with one and with two fillet radius ("two level approach" in a root). Research results are achieved by application of numerical methods - finite element method (FEM) and real working conditions simulation. The results of this analysis are presented as figures and tables of Von Mises stresses as well as charts against different values of tooth root fillet radius ρ_F. The results are analyzed in order to form an effective numerical model for tooth root geometrical discontinuity phenomena at static loading. Although both mashed gear teeth critical stresses are analysed, this research shall present only driven gear stress results.

Keywords: finite element method-FEM, tooth root stress concentration, tooth root fillet radius.

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VIBRATIONAL STABILIZATION OF STATICALLY UNSTABLE INVERTED TRIPLE PENDULUM

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Abstract

There are a lot of works devoted to the stabilization by parametric excitation of otherwise statically unstable systems, see recent papers [1-4]. Most of these studies, however, have been devoted to high-frequency stabilization. Here the stabilization of statically unstable elastically restrained triple inverted pendulum under its own weight is investigated for general excitation frequency.

The solution of the problem is pursued by the Multiple Scale perturbation Method, as perturbation of a critical Hamiltonian system, possessing a zero- and two real frequencies. Different asymptotic expansions are carried out, which are able to capture the long-term behavior of the system, for generic (non-resonant) values of the excitation frequency, resonant relations of 1:2, 2:1 and 1:1 type, between excitation and a selected natural frequency and combinations of natural frequencies.

It is shown that a proper ordering of the control parameters must be performed and proper use of integer or fractional power expansions must be made, according to the resonance under study. A comprehensive scenario of the stabilization regions is given in which lower-bound as well as upper-bound curves are evaluated.

Asymptotic solutions are validated by comparison with exact numerical results furnished by Floquet theory of ordinary differential equations with periodic coefficients. Agreement between the two results appears to be excellent at low excitation level, and qualitatively good at moderately high levels.

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VIBRATION CONTROL OF RESONANT VIBRATORY FEEDERS WITH ELECTROMAGNETIC EXCITATION

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Abstract

The vibratory feeders with electromagnetic excitation are commonly used for performing gravimetric flow of granular and particulate materials in processing industry. This mechanics drives offer easy and simple control for the mass flow conveying materials. In comparison with all previously developed drives (pneumatics, inertial, centrifugal,..), these have a more simple construction and they are compact, robust and reliable in operation. The absence of wearing mechanical part, such as gears, cams belts, bearings, eccentrics or motors makes electromagnetic vibratory feeder's (EMF) most economical equipment. Application of EMF in combination with power electronic converter provides amplitude-frequency vibration control and flexibility during operation. By means of such a mechatronics system, in addition to amplitude control, can provide operation in the region of the mechanical resonance. Resonance is highly efficient, because large output displacement is provided by small input power. On this way, the whole vibratory system has a behavior of the controllable mechanical oscillator. Standard power electronic output stages intended for control of vibratory feeder using SCR devices thyristors and triacs. This implies phase angle SCR control i.e. constant frequency of vibration, given that these electronic elements must be synchronized to the mains supply frequency 50(60)Hz. Phase angle control can only accomplish tuning amplitude of vibration, but vibratory frequency cannot be adjusted by this way. Since the conventional SCR controller operates at fixed frequency, the vibratory mechanism must be retuned. Application of transistor (IGBT of MOSFET) switch mode power converters enables accomplishing the amplitude and/or frequency control. Their use implies the excitation of a EMF independent of the mains supply frequency. In addition, the frequency control ensures operation in the region of mechanical resonance. Change of the mechanical resonant frequency, due to change of the conveying material mass, or even change of the spring stiffness, reduces efficiency of EMF drive. An optimal and efficient operation requires tracking of resonant frequency. Consequently, complicated mechanical tuning is eliminated and electronics replaces mechanical settings. Previously mentioned facts were motivation for simulation

model formulation of the both, phase angle control and switch mode control, for resonant vibratory feeder with electromagnetic excitation. In addition to simulation results, in this paper are presents a possible solution of the amplitude-frequency control of EMF and corresponding experimental results. The experimental results are recorded by the practically implemented IGBT power converter and control system based on a PC104 module. A comparison the simulations and experimental results confirm effectiveness of the proposed vibration control and corresponding switch mode power controller.

Key words: Vibration control, vibratory feeder, mechatronics, electromagnetic drive, resonance, power electronics, power converter, SCR, IGBT, power control,

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THE EFFECTS OF NOISE AND INTERNAL DELAY ON COHERENT OSCILLATIONS IN TWO STOSCHASTICALLY PERTURBED DELAYED DYNAMICAL SYSTEMS

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Abstract

We numerically study the effect of noise and internal delay on coherent oscillations induced by external noise driving in two stochastically perturbed excitable delayed dynamical systems. It is shown that both, the noise and internal time delay in some domains of values can substantially increase, and in some domains decrease values of induced coherence oscillations. This dependence can be explained by considering bifurcations of the analyzed system.

Keywords: Noise, internal delay, coherent oscillations, delayed dynamical system.

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ANALYSIS OF MINIMUM REQUIRED SLIDING FRICTION COEFFICIENT IN THE THE BRACHISTOCHRONIC MOTION OF A MECHANICAL SYSTEM WITH NONLINEAR NONHOLONOMIC CONSTRAINTS

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Abstract

This paper analyzes the problem of brachistochronic motion of a mechanical system with nonlinear nonholonomic constraints. The nonholonomic mechanical system is represented by two Chaplygin blades [3, 4, 5, 6] to which a nonlinear restriction is imposed in the form of the perpendicularity of velocities. The brachistochronic motion is considered in both horizontal and vertical plane between two specified positions with unchanged value of mechanical energy during motion. Differential equations of motion, where reactions of nonholonomic constraints and control forces figure, are obtained according to the general theorems of dynamics. It is here more convenient to use them instead of some other methods of analytical mechanics applied to nonholonomic mechanical systems that require subsequent physical interpretation of the multipliers of the constraints. The formulated brachistochrone problem, with a corresponding choice of the quantities of state, is solved, for this case, as the simplest task of optimal control by applying Pontryagin's maximum principle [1]. A corresponding two-point boundary value problem of the system of ordinary differential equations is obtained, which, in a general case, has to be numerically solved [2]. The numerical procedure for solving the two-point boundary value problem is performed by the shooting method. Based on thus obtained brachistochronic motion, active control forces are determined as well as the reactions of the nonholonomic constraints. Using Coulomb's laws of friction, a minimum required value of the sliding friction coefficient is determined, so that the considered system is moving in accordance with nonlinear nonholonomic bilateral constraints.

Keywords: Brachistochrone, Nonlinear nonholonomic constraints, Pontryagin's maximum principle, Coulomb friction, Optimal control

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AERODYNAMIC DESIGN OF AIR COOLED GAS TURBINES

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Abstract

This paper describes the development of a new method for the analysis of axial multistage turbines with cooling by air from compressor bleed. The method is based on a stream function approach and a finite element solution procedure. It includes a high-fidelity loss and deviation model with improved correlations. A radial distribution model of losses and a new spanwise mixing model are applied to simulate 3D flow effects.

The calibration of the models is performed by calculation of a number of test cases with different configurations, with the aim of achieving high accuracy and optimum robustness for each of the test cases considered.

Various types of cooling air injection were encompassed: film cooling, trailing edge injection and disc/endwall coolant flow. There are two effects of air cooling: (i) increase in mass flow downstream of the injection surface and (ii) reduction of the gas total temperature connected with total pressure losses. For both of these effects, the appropriate 2D models were developed and applied.

The code was applied to flow analysis and performance prediction of a newly developed industrial gas turbine. Comparison of the predicted results and measured test data for a number of parameters showed good agreement.

Keywords: Gas turbines, air cooling, aerodynamic design, flow losses

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INVESTIGATION OF HEAT-AFFECTED ZONE BY SIMULATIOHN AND IN WELD JOINTS

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Abstract

The finite element method (FEM) is frequently used by design engineers to evaluate characteristics of a product including deformations, stresses, strength, stiffness, vibration and fatigue analysis, etc. The tools used for this kind of analysis are well developed, but generally do not account for the effects of the manufacturing process. The increasing pressure to decrease product development time has led to the need for efficient tools to predict not only the behavior of the finished product, but also the effect of the manufacturing process on the final shape. Mechanical properties and crack resistance of welded joints can be crucial for welded structure as basically depended on the heterogeneous microstructure of the WM and HAZ.

Keywords: Simulation, Welding, HSLA steel, Crack growth rate.

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AIR SPRING DYNAMIC MODEL WITH FREQUENCY DEPENDENT CHARACTERISTIC

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Abstract

Air springs are well-known for their low transmissibility coefficients and their ability to vary load capacities easily by changing only the gas pressure within the springs. This paper presents improvements of the classical model with a new dynamic model of an air spring with frequency dependent characteristics. Air springs are used in a mechatronic approach in suspension design because of their ability to provide a controlled variable spring rate and they offer simple and inexpensive automatic levelling. It is shown that connecting an additional volume to the air spring gives two values of the stiffness property and the design parameters of the surge pipe that connects two volumes influence the frequency dependence of the stiffness properties. Despite the fact, that the air springs for passenger cars are commercially available, there is not enough research devoted on their dynamic characteristics. Quaglia and Sorly [1] discuss the vehicular air suspensions from design aspects, but not from control viewpoint. In [2], detailed overview of the constructive characteristics and the theoretical assumptions for the processes in air springs is given. Presthus [3] develops few dynamic air spring models for rail vehicles.

The development of the new mathematical model for airs spring in passenger vehicles incorporated the stiffness and the damping characteristics of air spring. The change of the effective area was neglected, because for the air spring the experiments were made for, this change is very small. The theoretical background and the details about the experimental setup could be found in [4]. Analyses of the vehicle vertical dynamics show special interest around the frequency domain from 0 to 20 Hz. Classical dynamic models, as well as the manufacturer's technical data is for very low frequencies from 0 to 1 Hz. The difference between the classical and new dynamic model is presented on figure 1 which shows that the classical model is only valid for low frequencies.

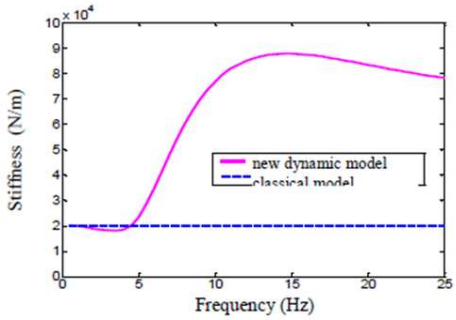

Fig.1. Comparison of classical and new dynamic model

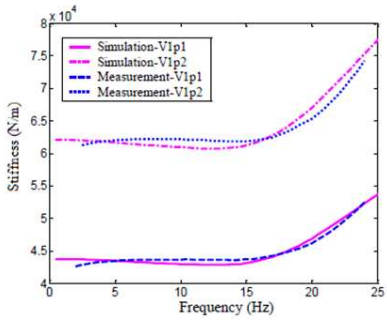

Fig.2. Frequency dependent stiffness

Experimental results and results obtained by simulation in Matlab/Simulink are compared in figure 2. The diagrams show that the simulation results match the experimental results for verification of the new dynamic model for air spring suspension system.

The proposed air spring with additional volumes has two main benefits: possibility for vehicle level control and possibility for suspension stiffness control. With the design of surge pipe that connect the volumes a possibility is given to tune the frequency range where the additional volume is operating.

Keywords: air spring, dynamic model, vehicle suspension system, mechatronic.

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MODEL BASED VIBRATION CONTROL OF FLEXIBLE BEAM

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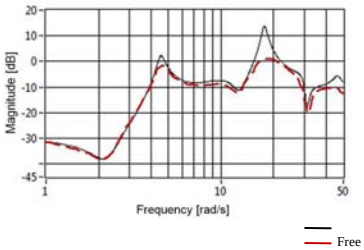
Abstract

The application of piezoelectric transducers for active vibration control of flexible structures is presented in this paper. Considering the fact that the research area of vibration control has brought a lot of intention to itself in the last decade, different systems for vibration suppression has been developed, analyzed and implemented in many technical fields [1]. The trend in design of mechanical systems has the tendency to lean towards more light structures in favor of flexibility, but also vibration. Light structures which have the distinctive feature of having sensors and actuators that are often distributed and have a high degree of integration inside the structure are called smart structures [2]. When smart structures are analyzed, basic components of any active vibration control system are the mechanical structure influenced by disturbance, sensors, controllers to intelligently make use of the signals from the sensors and to generate the appropriate control signals, and actuators which counteract the influence of the disturbance on the structure. The rapid developing technologies in sensors, actuators, real-time controllers and measuring techniques has pushed the limits of vibration control systems to a complete new level introducing the mechatronic approach with high level of integration [3].

The research presented in this paper includes modeling, simulation and experimental results for an aluminum beam with distributed piezoelectric patches, disturbed by external shaker excitation. The experimental setup is given in detail in [4]. Model based control of flexible structures has been enabled with the development of real time and FPGA targets. In figure 1 a bode plot of measured sensor signal of free vibration and controlled vibration response is presented. The first and the third vibration modes of the beam are considerable damped using model predictive control (MPC) algorithm running on a NI cRio real time and FPGA target. MPC algorithm is suitable for piezoelectric smart beam because it takes in consideration the constraints of the system [5]. Piezoelectric actuators work in predefined range and a control algorithm that takes in the consideration the voltage limits is expected to be more effective. Comparison of actuator effect in a linear quadratic regulator (LQR) and MPC is given in figure 2.



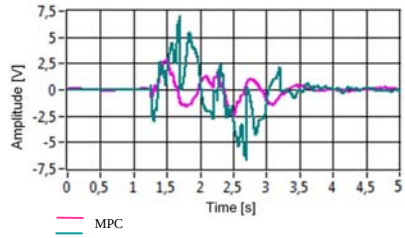


Fig. 1. Frequency response of free and controlled vibration

Fig. 2. Actuator effect comparison of LQG and MPC control

This paper contributes to the application of piezoelectric transducers in the flexible beam vibration control engineering concept. LGR and MPC model based control algorithms have been designed and applied to the experimental setup, and it has been concluded that the MPC is more effective by taking in consideration the constraints of the piezoelectric actuators.

Keywords: vibration control, piezoelectric elements, mechatronic system.

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VIBRATION BASED DAMAGE DETECTION IN MECHANICAL STRUCTURE USING PIEZOELECTRIC TRANSDUCER

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Abstract

Damage detection techniques in mechanical structures and their application are becoming more important in recent years in the field of structural health monitoring. Mechanical systems with ability for detection of interpret adverse changes in a structure can improve their future reliability and reduce life-cycle costs. The main objective for structural health monitoring is the detection and characterization of damages that may affect the integrity and the functional operability of the mechanical structure. Conventional inspection techniques and methods can be expensive and time consuming. These issues can be considerable overcome by development and implementation of methods and techniques based on equipment that can effectively detect the existence of damage and can provide information regarding the location and the severity of damage in the structure. Therefore piezoelectric transducers, as both sensors and actuators, are commonly used for damage detection in systems for structural health monitoring [1]. These devices have capability for utilization of the converse piezoelectric effect to actuate the structure in addition to the direct effect to sense structural deformation. Piezoelectric transducers are small, lightweight, reasonably priced devices and can be produced in different geometric forms. Piezoelectric sensors and actuator can be bonded onto the surface or can be embedded in to the structures, hence they have great potential to improve significantly structural health monitoring and damage detection by nondestructive evaluation.

Health monitoring of the mechanical structure is very vast field and exist variety of methods, techniques, strategies for damage detection which all are tending to achieve one common goal of knowing the state of structural integrity, damage presence and even remaining life [2]. In this paper, frequency response analysis of aluminium beam with bonded piezoelectric transducer is presented by using finite element method in commercially available software package ANSYS. The piezoelectric actuators were driven by harmonic signals and the beam vibration response are analyzed. Results of undamaged one-dimensional beam model are compared to different scenarios of damage presence in structure.

Technique is based on the idea that modal frequencies, mode shapes and modal damping as model properties of the structure can be determine as function of physical properties [3]. In addition, if a fault appears in mechanical structure, this can be recognized as changes in the physical properties, which leads to cause changes in the modal properties of the structure.

Keywords: damage detection, vibration analysis, piezoelectric transducers, structural health monitoring.

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SOFTWARE AND HARDWARE SYSTEMS FOR ABDOMINAL AORTIC ANEURYSM MECHANICAL PROPERTIES INVESTIGATION

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Abstract

The main goal of this paper is to describe two different systems that were developed for the purpose of abdominal aortic aneurysm mechanical properties investigation and to present the results of the measurements. The first system is based on the "Bubble Inflated" method and it increases the pressure of physiological saline which affects blood vessel tissue and causes mechanical deformation. The system provides recording the data about the current value of the pressure in the physiological saline by using the appropriate pressure sensor. The second system makes stretches of the vessel tissue in uni-axial direction and save the data about the force and the elongation. Both of these systems use cameras for assessment of the deformation. Obtained results from both systems are used for numerical simulation of computer model for abdominal aortic aneurysm. It gives a new avenue for application of software and hardware systems for determination of vascular tissue properties in the clinical practice.

Keywords: Abdominal aortic aneurysm, bubble inflated method, uniaxial stretch, pressure sensor, force sensor

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CROSS CORRELATED MODAL ANALYSIS AS A POWER TOOL FOR CIVIL STRUCTURES INTEGRITY IMPROVEMENT

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Abstract

In the last thirty years there was diligent work on how to set clear criteria and conditions for the application of methods that relateto a change of modal parameters. Regardless of the great progress that is made in this area, especially the leap forward in the area of acquisition equipment, the principles on which the method is based remained the same. Modal parameters that are commonly monitored (natural frequency, vibration mode shapes, damping) are functions of the physical properties of the structure (mass, stiffness and damping). Therefore, changes in strength, due to the damage (cracks) in the structure can be detected by the monitoring of the modal parameters fluctuation.

The conclusion of current research is that the monitoring of structures dynamic behaviour can be reliable for an integrity assessment, but not for localization of possible damage. The problem whichmostof the authors find is that two similar cracks of different size and different location on the structure can cause almost the same change in natural frequency of the structure.

Former researches of damage detection by modal analysis experiments were mostly conducted under controlled laboratory conditions [1-3]. Justvery few were performed on real structures in operation (tests usually involve a scale model or segments of full scale structures [4-7]). That is why this article offers a new approach based onfull scale measurements and detailed 3D model finite element analysis.

The subject of investigation is a floor construction at a power plant control room. The bundle of steam pipelines is suspended to the under-structure of the control room. Pipeline vibrations are transmitted to the floor via suspending tendons. Main goal of the investigation was to determine which one is the source of increased vibration on the floor. The analysis of 3D finite element model provided set of natural frequencies of the structure. Full scale measurement defined the characteristics of the excitation and the response of the floor. Cross correlated analysis of these two spectral signatures showed obviouslythat the excessive vibration in the control room is just a reflection of the dynamic excitation, which is introduced by a distinct pair of steam pipelines.

Keywords: modal analysis, finite element method, structural integrity

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EXPERIMENTAL INVESTIGATION OF SPILLOVER EFFECT IN SYSTEM OF ACTIVE VIBRATION CONTROL SYSTEM

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Abstract

Piezoelectric actuators are widely used in structural systems for active vibration control with the aim to enhance the performance of systems. The developed system of active vibration control consists of active structure, controller and high voltage amplifier. The composite beam is host structure for sensor platform (strain gages) and actuator platform (dual layer PZT piezoelectric actuator). In order to improve the dynamic characteristics of active system the coefficients of PID controller are changed [1]. The effectiveness of active vibration control system at mode of interest can be grown with change of PID coefficients but the stability of system can be reduced. The instability of the active structure is often perturbed by spillover effect [2]. In this paper the importance of considering spillover effects in closed loop of piezoelectric active structures is demonstrated and shown the importance of change the PID coefficients in stability of active vibration control system. Experimental results corresponding to the

developed active vibration control system are presented and affirmed stability on proposed active structure.

Keywords: Active vibration control, piezoelectric actuators, strain gages sensor, spillover effect

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VISUAL FEEDBACK IN ROBOTIC WELDING BASED ON STRUCTURED LIGHT TRIANGULATION

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Abstract

Robotic welding is by its share in industrial practice dominant field of application of industrial robots. However typical robotic welding cell operate as an open system, with a very rudimentary or without any robot interaction with its environment, i.e., task space.

The main requirement for successful robotic welding is an ability of the robot control system to recognize deviations from the nominal geometry of the assembly that is being welded and the geometry of the surrounding workplace (various fixtures and similar dedicated equipment). In general, these deviations can be grouped into four main groups: Type 1 - location errors of the assembly relative to the coordinate system of the robot work space (shown on the left figure); Type 2 - macro geometry errors of the assembly, including completeness of assembly; Type 3 - relative location of the joint/seam errors in relation to the local coordinate system of the assembly; Type 4 - micro-geometry errors of the joint/seam. Depending of the type, the geometrical deviations can be recognized by: contact sensors, optical (noncontact) sensors, as well as other special purpose sensors which are based on measuring variations in welding current or acoustical emission.

Currently, the most widely present sensor technology is based on laser triangulation sensors, point or line type. Although very accurate and robust, these sensors have a significant disadvantage in terms of speed of acquisition of the weldment geometry. Alternative technology which can potentially cope with this weakness is based on special kind of machine vision sensors which are also based on optical triangulation, but with one very important difference. Instead of dots or lines, the light source emits spatial light map, which contains a certain logical structure, i.e., coded pattern. Such kind of sensory system is capable to perform massively parallel triangulation. Time consuming scanning is no longer necessary. Acquisition of the weldment geometry can be achieved just by a set of sufficient number of static views. Parallel triangulation achieves an extremely fast and inherently robust spatial digitization, which can be effectively used in robotic welding process. It is worth to mention that structured light triangulation is in general much more complex then point or line triangulation in laser proximity.

This paper presents the basics of the concept of coded structured light machine vision, which is adapted for robotic welding application (shown on the middle figure). Besides the conceptual and theoretical aspects, this paper presents the first laboratory findings carried out on dedicated experimental installation (shown on the right figure) which is developed at the Cyber Manufacturing Systems Laboratory at Faculty of Mechanical Engineering, Belgrade University, within the project: Smart Robotics for Customized Manufacturing, supported by Serbian Ministry for education, science and technology development, under the grant No.: TR35007.

Keywords: Robotic Welding, Adaptive behavior, Triangulation, Structured light.

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INVENTION AND DEVELOPMENT OF OMEGA DEFORMETER

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This kind of invention is aimed for the precise displacement measurement. It is conceived as a leaf spring of omega (Greek alphabet capital letter Ω) shape with the strain gage on it. Relative displacement between end points of the omega-spring is detected throughout the deformation of the bonded strain gage. Introduced displacement is proportional to the strain gage deformation. Novelty with this item is an improved linearity due to a specifically designed omega-shape. Unlike the renown solutions,the omega deformeter enables a better motion-to-strain conversion. Search for the best technical solution started with the set of computer simulations. Among a large variety of different 3D models the omega shape is selected as an optimal concept. Based on its design an original prototype is developed and manufactured. Laboratory examinations confirmed the ultimate sensitivity and linearity of the omega deformeter. Currently the transducer undergoes the site measurement tests.

Keywords: displacement measurement, finite element method, structural integrity

ACTIVE COMPLIANCE CONTROL OF KINEMATICALLY REDUNDANT ANTHROPOMORPHIC ROBOT ARM WITH SOFT JOINTS

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Abstract

This paper presents theoretical and experimental results of the recent research efforts carried out in the domain of the robot generalized stiffness control. In particular, we are interested in kinematically redundant robotic manipulators and their nullspace compliant behaviour. Although the nullspace of redundant robots is deeply studied in the kinematical domain, this is not the case with their compliant behaviour. In our research we have discovered that the kinematical redundancy can be very efficiently used to control compliant behavior, i.e., desired robot generalized stiffness (1) properties, by its internal motion within the nullspace associated with a given vector of the robot TCP Cartesian coordinates $X_0 \in R^m$. Since the robot generalized stiffness is dominantly influenced by the compliance of its joint actuation system, generalized stiffness matrix K_X can be easily transformed into actuation stiffness matrix Kq, using congruent transformation.

$$F_E = K_X (X - X_0) = K_X \delta X \quad (1); \qquad K_X \rightarrow K_q = J^T(q) K_X J(q), \;\; K_q \in R^{n \times n} \quad (2)$$

where $F_E \in R^m$ is the external contact force acting on the robot TCP, $K_X = K_H \in R^{m \times m}$ is the desired generalized stiffness, $X \in R^m$ is the true position vector of the robot TCP, $\delta X \in R^m$ is the TCP displacement vector, induced by its interaction with the environment, and J(q) is the Jacobian matrix operator.

The actuation stiffness matrix is always symmetric (congruent transformation preserves symmetry), positive definite, and generally non-diagonal. Actuation redundancy can generate these non-diagonal members, but such kind of actuation is very difficult to be achieved practically (actuation redundancy of this type is widespread in biomechanical systems, and also in the human body). Instead of actuation redundancy, we have used kinematical redundancy, which can be easily achieved practically. Starting point of using the kinematic redundancy to satisfy the relation (2) is based on the following hypothesis: within the null space of kinematically redundant robot with k degrees of freedom can be simultaneously satisfied: 1) nominal trajectory of the robot's tip of the task space domain, 2) nominal generalized stiffness of the robot tip K_{X0} and 3) canonical

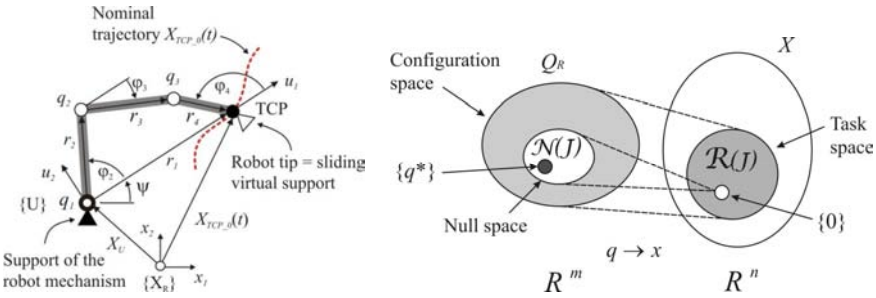
form of the actuation stiffness matrix. This hypothesis is based on the assumption that the increased mobility of the robot can be used effectively for generation of required generalized stiffness on technically acceptable way.The null space (3) provides internal motions of the redundant robot mechanism that does not cause any movement of the robot TCP in the task space. Internal mobility (motions) allows finding at least one vector (4) such that reduce Kq matrix to its quasi-canonical form.

$$\mathrm{N}(J(q)) = \{q : J(q)\partial q = 0\} \quad (3); \qquad q^* \in N(J(q)) \quad (4)$$

In addition, in our research, we include compliance control for every joint of the robot sturucture (soft joints - variable stiffness actuators). This provides desired stiffness generation of the robot joints within a possible physical range, which allowing the generation of desired K_X matrix, or more general, robot behaviour in the task space.

For evaluation purposes, kinematically redundant planar anthropomorphic robot with 3 degrees of freedom is used.

The robot configuration subspaces and motion in its null space is modelled using equivalent four-bar linkage mechanism, as shown in the figure below, so that the robot TCP is represented as a virtual support that slides along the nominal trajectory. In parallel, Yaskawa SIA10F 7dof antromorphic robot arm is used for experimental evaluation purposes.



This research is carried out the Cyber-Manufacturing Laboratory - CMSysLab, Faculty of Mechanical Engineering, within the project: Smart Robotics for Customized Manufacturing, grant No.: TR35007, supported by the Serbian Ministry of education, science and technology development.

Keywords: Generalized stiffness control, Kinematic redundancy, Nullspace motion, Soft Joint.

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ANALYSIS OF THE HCR INTERNAL GEARING AGAINST WARM SCUFFING DAMAGE

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Abstract

The issue of design and dimensioning of HCR gearing, especially of the gearings with an internal engagement, it nowadays, especially in the design of hybrid cars drives, highly topical. This kind of gearing has many advantages in operation, but at the same time it is more complicated in stage of its design and load capacity calculation. In the HCR gearing is load shared a minimum between two pairs of teeth what means better load distribution and decrease the noise generating in the mating gears. The HCR gearing has longer line of contact what leads to grow of the flanks slide velocities what in the same time means the higher danger of flanks damage with warm scuffing. It is valid for both - external and internal types of teeth meshing. Authors in this contribution present some results of warm scuffing research of internal HCR gearing. There are given the equations for calculation of warm scuffing resistance of internal HCR gearing derived according to integral temperature criterion and also the results of optimization of the geometry parameters such gearing.

Key words:HCR gearing, temperature scuffing, integral temperature

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ENERGY ANALYSIS OF DYNAMICS OF A MULTI-DEFORMABLE BODY SYSTEM WITH FRACTIONAL ORDER DISCRETE CONTINUUM LAYERS

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Abstract.

Hybrid system contains multi deformable bodies (beams, plates or membranes), same boundary conditions, coupled by discrete continuum layers. Discrete continuum layers are built by standard elastic and inertia properties and fractional order elements homogeneously distributed between each of two adjacent deformable bodies. During the dynamics of deformable bodies in transversal direction each of standard elastic, and inertia, and fractional order elements obtain extension or compression equal to difference between two displacements of the corresponding body points for which are coupled its ends: $\Delta w_{k+1,k}(x,y,t)=w_{k+1}(x,y,t)-w_k(x,y,t)$ for plates and membranes, and $\Delta w_{k+1,k}(x,t)=w_{k+1}(x,t)-w_k(x,t)$ for beams and belts. Energy analysis of dynamics of definrd multi-deformable body system with elastic, and translator ind rotator inertia properties, and fractional order discrete continuum layers is presented. Sries of theorems are defined and proofed. One of theorem is:

Theorem 1. Generalized forces $Q_{w_k}^{elem-sloja}$ and $Q_{w_{k+1}}^{elem-sloja}$ of interaction between two deformable bodies coupled by standard discrete continuum layer with known kinetic $\mathbf{E}_k^{elem-sloja}$ and potential $\mathbf{E}_p^{elem-sloja}$ energies and known Rayleigh function of energy dissipation $\mathbf{\Phi}^{elem-sloja}$ and generalized function of fractional order element energy dissipation in the form:

$\Phi_{0<\alpha<1}^{element-layer}=\frac{1}{2}c_{0<\alpha<1(k,k+1)}\left\{\mathsf{D}_t^{\alpha}\left[w_{k+1}(x,y,t)-w_k(x,y,t)\right]\right\}^2$, where where $\mathsf{D}_t^{\alpha}[\bullet]$ is fractional order differential operator of the α^{th} derivative with respect to time t in the following form: $\mathsf{D}_t^{\alpha}[\bullet]=\frac{d^{\alpha}[\bullet]}{dt^{\alpha}}=\frac{1}{\Gamma(1-\alpha)}\frac{d}{dt}\int_0^t\frac{[\bullet]}{(t-\tau)^{\alpha}}d\tau$ $\Gamma(1-\alpha)$ is Euler Gama function, $c_{\alpha(k,k+1)}$ are rigidity coefficients expressing fractional order dissipation properties, and α a rational number between 0 and 1, $0<\alpha<1$, expressing dissipation properties of

standard fractional order element, for generalized coordinates $w_k(x,y,t)$ and $w_{k+1}(x,y,t)$ displacement of deformable bodies at the point of contacts with discrete continuum elastic, inertia and fractionaL order layer are in the following forms:

$$Q_{w_k}^{elem-layer} = -\left\langle \frac{d}{dt}\frac{\partial \mathbf{E}_k^{\,elem-layer}}{\partial\left(\frac{\partial w_k(x,y,t)}{\partial t}\right)} - \frac{\partial \mathbf{E}_k^{\,elem-layer}}{\partial w_k(x,y,t)} \right\rangle - \frac{\partial \mathbf{E}_p^{\,elem-layer}}{\partial w_k(x,y,t)} - \frac{\partial \Phi^{elem-layer}}{\partial\left(\frac{\partial w_k(x,y,t)}{\partial t}\right)} - \frac{\partial \Phi_{0<\alpha<1}^{element-layer}}{\partial\left(\mathrm{D}_t^{\alpha}[w_k(x,y,t)]\right)} = Q_{w_k(x,y,t)}^{elem-def.bodya}$$

$$Q_{w_{k-1}}^{elem-layer} = -\left\langle \frac{d}{dt}\frac{\partial \mathbf{E}_k^{\,elem-layer}}{\partial\left(\frac{\partial w_{k-1}(x,y,t)}{\partial t}\right)} - \frac{\partial \mathbf{E}_k^{\,elem-layer}}{\partial w_{k-1}(x,y,t)} \right\rangle - \frac{\partial \mathbf{E}_p^{\,elem-layer}}{\partial w_{k-1}(x,y,t)} - \frac{\partial \Phi^{elem-layer}}{\partial\left(\frac{\partial w_{k-1}(x,y,t)}{\partial t}\right)} - \frac{\partial \Phi_{0<\alpha<1}^{element-layer}}{\partial\left(\mathrm{D}_t^{\alpha}[w_{k-1}(x,y,t)]\right)} = Q_{w_{k-1}(x,y,t)}^{elem-def.bodya}$$

expressed by energies and energy dissipation which posses discrete continuum layer.

Other theprems are related to the change: * of total mechanical energy of one eigen amplitude mode and generalized function of fractional order energy dissipation; * of a total mechanical energy of a eigen time mode of eihrn time function correspond to one eigen amplitude mode. Transiet of enegy between defrmable bodies in the hybrid system is analyzed.

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FIRST-PASSAGE OF STOCHASTICALLY DYNAMICAL SYSTEM WITH FRACTIONAL DERIVATIVE AND POWER-FORM RESTORING FORCE UNDER GAUSSIAN EXCITATIONS

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Abstract

In this paper, the first-passage problem of stochastically dynamical system with fractional derivative and power-form restoring force subjected to Gaussian white-noise excitation is studied in detail. Based on the Fourier expansion, power-force restoring force is expressed by the slowly-varying amplitude and phase process, and the fractional derivative with Caputo definition is approximated by a series of periodic functions. After that, the system can be governed by a Markov process by applying stochastic averaging method for reduced terms. Backward Kolmogorov equation associated with reliability function and Generalized Pontryagin equation associated with averaged first-passage time are built and solved. Moreover the influence on system reliability caused by the order of fractional derivative and the power of power-form are also examined respectively. Numerical results show that reliability function is decreased with respect to the time. The figures derived from numerical method are all good agreement with Monte-Carlo simulation.

Keywords: First-passage; fractional derivative; power-form restoring force; reliability

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MODELING OF IMPACT OF A TENNIS BALL WITH COURT: AN OVERVIEW

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Abstract

The dynamics of a ball bounce from the plane surface is investigated for a long time. During the history outstanding scientists deal with this problem [1]: for example, Sir Newton in his publication in 1672, and two hundred years later, Lord Rayleigh [2] in 1877. The most intensive investigations date from 1990, when a significant number of experiments on physics of impact of the ball with the unmovable surface are done. The most usual the tennis ball – court system are treated. The tennis ball is assumed to be with fixed geometric and physic properties, while the characteristics of the court are varied. Using these results, the analytical description of the problem is developed. In this paper various types of models of tennis ball – surface impact are shown, where real physical parameters of the system are introduced and applied. Bounce of the ball after impact is analyzed according to sliding and rolling friction coefficients. The coefficients depend on deformation properties during impact [3]. The output characteristics of the ball after impact depend on the inputs: velocity and angular of the ball before impact and its angle position. It is concluded that the sliding and rolling friction coefficients and restitution parameter altogether with the input kinematic values have a significant influence on the output values. If the friction is high ('slow court') and the ball is with top spin, the horizontal component of output velocity decreases and the high of the bounce and it angular velocity increase [4]. If the sliding friction is small ('fast court') and the rolling friction is significant, the horizontal component of output velocity become longer while the bounce high and topspin are smaller. If the ball has the backward spin and impacts a surface with certain physical parameters, after impact the output angle may be negative, and the angular velocity changes it direction into forward spin [5].Namely, if the ball is projected on a hard horizontal surface at oblique incidence with sufficient backspin, it bounces back in the direction from which it came, i.e. with a negative angle of reflection. Furthermore, the angular velocity of spin is reversed. The change in horizontal ball speed directly is proportional to the coefficient of friction if the ball incident is at small angle to the horizontal. If the angle is higher, the ball will roll during the bounce [6]. Finally, the question is whether tennis players could improve their performance by knowing more about this physics.

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MECHANISM FOR AN ERGONOMIC CHAIR

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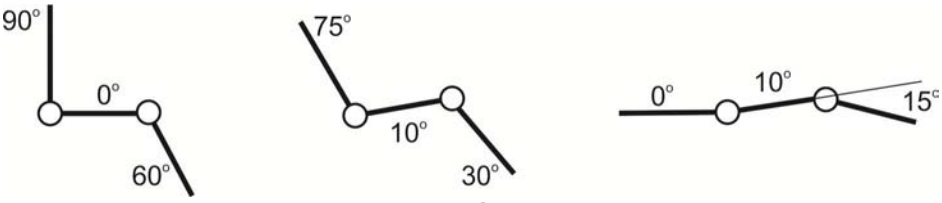
Abstract

In today's society, a lot of people spend their whole day sitting down – either in office environments, operating machines or at home. Although sitting requires less physical effort than standing or walking, it still puts a lot of stress on the lumbar area. Combined effects of a sedentary lifestyle and a job that requires sitting can lead to many health problems. The selection of a suitable chair design is a critical step in preventing health problems for people who spend the majority of their time sitting down.

The common user positions while sitting are: upright position (Fig1.a), reclined position (Fig 1.b) and supine position (Fig 1.c.)



a. b. c.

Fig.1. Typical ergonomic chair configurations and dimensions

A novel design of the mechanism for ergonomic chair positioning is presented in this paper. It is a planar six-bar mechanism with third class kinematic group and one degree of freedom . The application of a high class kinematic group enables the realization of precision positions as well as smooth movement when changing positions. Synthesis has been performed and mechanism dimensions were obtained. The solution is presented on Fig.2.

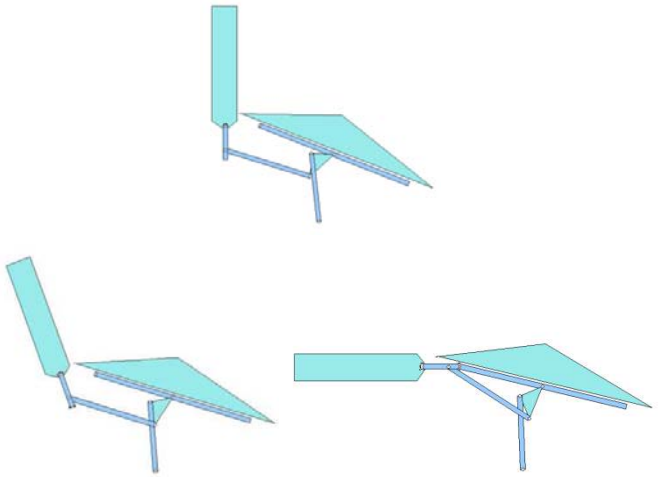


Fig. 2. Structure of the proposed mechanism

Keywords: ergonomic chair, high class kinematic group, mechanism design

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ANNEAL HARDENING EFFECT IN SINTERED COPPER- PALLADIUM ALLOY

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Abstract

This paper reports results of investigations carried out on sintered copper and copper-palladium alloy (with 4at%Pd). The Cu-Pd alloy and pure copper for the sake of comparison were subjected to the same thermomechanical treatment with finally reduction of 25 %, 50 % and 75 %. Annealing up to the recrystallysation temperature was performed, followed by hardness and electrical conductivity measurement. This investigation shows that the hardness and electrical conductivity of cold deformed Cu-Pd alloy increase after annealing in the temperature range of 160-450^{o}C due to anneal hardening effect. It is shown that the amount of strengthening, caused by anneal hardening effect increase with increasing degrees of finally deformation.

Palladium alloys are important for catalysts, automobile exhaust gas cleaning, thermocouples, electrical contacts, capacitors, permanent magnetic alloys, and for the production of high purity hydrogen [1] because of its high activity and excellent chemical stability. Palladium is expensive so researchers have been focused on decreasing the Pd content. Alloying of less expensive metal such as copper with noble metals like palladium is a potential way to achieve this goal [2] The Cu-Pd system has recently received a lot of attention because of the existence of three particular superstructures (Cu_3Pd, 1D-LPS and 2D-LPS) and order–disorder transition between the ordered structures and f.c.c. solution [3].

This hardening effect cause a considerably increase of mechanical properties, where solute locking to dislocations has the most important role, although solute segregation to stacking faults has important role [4,5]. Bader, Vitek and Warlimont [4,5] studied anneal hardening effect in copper-based binary systems with Al, Au, Ga, Ni, Pd, Rh and Zn and confirmed the increase of spring bending limit (measure of annealing hardening intensity) in the Cu–Pd system.

The goal of this paper is to study the effect of anneal hardening in the alloy of the Cu-Pd system, and investigation of the alloy properties improvement in the comparison with pure copper. The properties of Cu-4at%Pd alloy after thermomechanical treatment are significantly improved in comparison with pure copper. This and the others copper base alloys can be applied for the electrical contacts [6,7,8].

Keywords: copper-palladium alloy, anneal hardening effect, thermomechanical treatment,

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DIFFERENT METHODS IN THE ANALYSIS OF ECCENTRICALLY PATCH LOADED STEEL I-GIRDERS

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Abstract

Thin-walled steel I-girders loaded over flange by patch or concentrated load that has a certain eccentricity regarding the web plane are wide spread in engineering practice. The problem is rather complex. It is a special case of elasto-plastic bending with geometric non-linearity noticeable even at low extent of loading.

Experimental analysis initiated in late 1980s, in USA and Czech Republic, combined with FEM analysis by specialised computer softwares [1-3], revealed that behaviour, collapse mode and ultimate load of eccentrically patch loaded steel I-girders depend on geometric parameters, load eccentricity and load applying manner. Collapse mode of most (but not all!) eccentrically loaded girders is quite different than collapse mode of centrically loaded girders. In case of eccentric collapse mode the reduction in ultimate load with the increase in load eccentricity is obvious. However, clear border between behaviour of centrically and eccentrically loaded girders had not been defined. The reliable procedure of ultimate load calculation for eccentrically loaded girders had not been formulated. Key questions had been open: For which combinations of influential parameters do the eccentrically loaded girders lose carrying capacity the same way as centrically loaded girders? Where is the border between centric and eccentric collapse modes? Is there mixed collapse mode which is combination of centric and eccentric collapse modes? What would be appropriate procedure for calculation of ultimate load in eccentrically loaded girders?

Extensive experimental-theoretical-numerical research (started in 1998 at the University of Montenegro, joined in 2005 by University of Granada)successfully and satisfactorily answered aforementioned questions[4-7]. Different methods were applied, compared and combined. Experimental testing as essential part of this research provided valuable database for all theoretical and numerical methods. Experimental data were used for creation and validation of numerical/FEM models. Database consisted of experimental and FEM results was used for formulation and fitting of empirical expressions for

calculation of load reduction factor, that relates ultimate load of eccentrically loaded girder to the ultimate load of geometrically identical centrically loaded girder.Artificial neural networks (ANN) were created and trained on experimental database and ANN forecast models for collapse mode and ultimate load of eccentrically patch loaded girders were offered.

Apart from current work on improvement of numerical methods results, particularly ANN forecast models, further research work in defining reliable, universal procedure for calculation of ultimate load in eccentrically patch loaded steel I-girders, should go into direction of defining mathematical model based on collapse mechanism. Although this is usual procedure in case of centric patch load, there are no such mathematical models and definitions of collapse mechanism for eccentric collapse mode in the available literature.

Keywords: Steel I-girder, patch loading, load eccentricity, collapse mode, collapse load, experiment, numerical analysis, empirical expression, finite element method (FEM), artificial neural network (ANN), forecast model.

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SOLVING STOCHASTIC DIFFERENTIAL EQUATIONS OF GRAPHIC PROCESSING UNITS

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Abstract

In this short paper we are describing some methods to solve stochastic differential equations which appear in mechanics. We are concerned with solutions of mechanical oscillators which are subject to random excitation. We are primarly interested in solving stochastic differential equations excited with white noise. We rewrite the random mechanical

oscillator equation in the form suitable for applying numerical procedures for solving it. Finally, we give some design notes on the methods used to implement numerical simulation of the graphical processing units.

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EXAMINATION OF THE 3D MODEL OF SATELITE ANTENNA DISH- FLUID FLOW AIR ANALYSIS

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Abstract

The paper made a 3D model of a satellite antenna dish, and then the test is conducted technical functionality of the system. Assembly of satellite antenna dish, a 3D CAD model which is derived reverse engineering was studied in the framework of the exercise of their functions. Taking into account the function technical assembly which is directly related to the transmission of waves, it was deemed necessary to analyze fluid flow of air around the antenna. In this type of circuit is very important that the effect of air currents can carry out its function. The simulation model is based on a factor of the airflow according to the data that are valid for the area in which the device is used.

To be the analysis of fluid flow, it is necessary to define the climatic conditions in which a technical system has to perform its function. According to the Bureau of Hydrometeorology Serbia "is one of the characteristics of the climate of Belgrade is southeast wind, Koshava, whose strength is 25-43 km / h, and its hit single can be up to 130 km / h. due specification of winds and air currents". The Koshava is one of the strong or very strong winds with hurricane gusts.

Satellite antenna dish in this study was designed in a software tool SolidWorks2011. and passed through a simulation tool flow SolidFlow. The results of the simulation were later compared with the results of tests of the real model satellite antenna dish that is made in Air-Technical Institute in Belgrade. Due to the volume of work in this study contains a few iterations, which were tested on real model and simulation is performed only in some specific parameters. For the same reasons, comparison of the results obtained are not displaced persons located within this work.

For certain angles of azimuth and elevation an analysis of fluid flow in a computer tool SolidFlow. This view has streamlines that impressive and give accurate values when testing the real models are in tabular and graphical displays a large scale. According to the chart, the color that the user specifies for its aesthetic necessary data on the

examined technical system. Graphical display of fluid flow dish and anaglyph 3D display in the work.

It is shown that the method of the test flow in virtual reality is very effective, and not too demanding. Equipment used in the real experiment is cumbersome, requires a serious level of preparation of the experiment and the final result set. Testing the system in SolidFlow software package requires only certain skills that must be mastered to the designer who makes the development of technical systems. Of course, a prerequisite for getting quality and correct results of testing the proper formation of the 3D model.

Keywords: 3D Model, Satelitte antenna dish, Air flow.

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