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Vehicle Dynamics Simulation Part 2: Presenting the Simulated Vehicle Dynamics in Virtual 3D Environment

Results of simulations done by mathematical models of driving dynamics have to be presented in a clear and appealing way. One possibility of this is presentation by animation in virtual 3D environment. For the mathematical model of vehicle dynamics, a library of low-polygon 3D geometrical vehicle models is being built. We have developed software to compose animations, based on the simulation data, and display the results in virtual 3D environment. The required vehicle-specific input data is retrieved from an existing vehicle database. A separate module for interactive driving simulation is under development. The flexible structure of the software for writing animations provides easy adaptation to future expansions of the mathematical model.

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Straightening Process Modelling of Steam Turbine Rotors Applying Tension Relaxation Method

Procedure of straightening rotors bending is complex, but it is possible to optimise it by applying the appropriate model. Application of the finite elements method at the example of straightening of the rotor for turbine TK 200-130 LMZ in power plant Tuzla. Applied method was tested by comparison with results obtained “in situ” and has shown satisfactory results. Acquired knowledge may be used in straightening of rotors and other machine parts, as well as for further research in modelling of elastic-plastic deformations.

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Vehicle Dynamics Simulation, Part 1: Mathematical Model

The field of computational dynamic is surveyed, focusing on issues relevant to develop complex and numerical efficient mathematical models. Considering the topic of mathematical model, today various formalisms are available for generating dynamical modes in the form of the linear or nonlinear differential equations. In this paper we would like to represent multibody formalism, that is applied to generate equations of motion (nonlinear differential equations) for a system of rigid and flexible bodies with arbitrary topology in a symbolic form. The formalism is general and could be used for any kind of mechanical system (vehicle, human body, gearbox, etc.), with arbitrary complexity and with arbitrary degree of freedom and therefore represents general computer support to the numerical analysis, necessary for understanding and improving design process. This general proposed tool is used to handle vehicle dynamic to demonstrate the efficiency of proposed approach.

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Tolerance Design of the Journal-Bearing Kinematic Joint. Numerical Analysis of the Effect of the Shape Variations on the Performances

In this work the authors deal with the problem regarding tolerance design of the journal – bearing kinematic joint, in which hydrodynamic lubrication conditions are realised. In particular, they propose a simplified numerical approach to analyse consequences of macro geometric variations on the performances of this kind of bearings.

The final result is numerical formulation of new abacuses to be used in the design of such kinematic joints that show how the kinematic joint performances change when the functional feature has not the ideal shape. The designer can use the abacus starting from a performance objective and evaluating the maximum allowable macro geometric error (i.e. the tolerance value) that satisfies the functional requirements.

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Fatigue Failures in Industry - Case Studies

The paper presents some typical fatigue damages in industry and transport that were investigated by FESB Laboratory for Fatigue: the fatigue cracks and failures in large gear wheel of cement mill, fatigue failure of the main engine lateral support (at bulk carrier) and fatigue cracks at large portal crane in shipyard. Each case study includes the damage analysis, stress analysis by strain gauges and FEM and repair procedures. Inappropriate design of components subjected to variable loads and stress concentration are the common sources of all presented failures, so some general suggestions for correct design and repair procedures are proposed.

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Numerical Simulation of Micro-Pitting on Gears

A two-dimensional computational model for simulation of surface pitting of mechanical elements subjected to contact loading conditions is presented. In the model it is assumed the initial crack of length 0.015 mm is initiated at the contacting surfaces due to previously thermal or mechanical treatment of the material. The discretised model with the initial crack is then subjected to normal contact pressure, which takes into account the EHD-lubrication conditions, and tangential loading due to friction between contacting surfaces. The model accounts also for the influence of fluid trapped in the crack on crack propagation. The virtual crack extension (VCE) method in the framework of finite element analysis is then used for two-dimensional simulation of fatigue crack propagation under contact loading from the initial crack up to the formation of the surface pit.

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Theoretical Improvement of the Planetary Gear Dynamic Model

The major goal in this work is to improve the planetary gear dynamic model presented in the diseration by Jian Lin presented in the Ohio State University in 2000 . A lumped-parameter model is built for the dynamic analysis of general planetary gears.
In this paper, the meshing stiffness and damping are modelled as time varying parameters. Mathematical model that consideres time-varying stiffness and viscous damping of the meshing tooth pair is proposed. Gear errors are also included in the theory and in numerical applications. A computer software in Visual Delphi was designed as well. It enable for the mathematical model on the planetary gear system to be solved.

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Damage Tolerant Design of the Aircraft Components

The closed form expression for estimation of the crack initiation life at combined HCF/LCF loading is derived in this paper, and the way of reshaping the crack growth rate formulae in the form enabling their use in fatigue design at non-stationary loading is demonstrated. This new derived formula suggests an additional damage increase when crossing from one stress block to another. For the stress history simplified in the way that it consists of one LCF stress block with NLCF = NB cycles at maximum stress and load ratio r = 0, followed by one HCF stress block with nHCF·NB cycles at maximum stress and load ratio r = (- 2)/ , the closed form expression is derived for estimating the crack propagation life at combined HCF/LCF loading.
Smith and Haigh diagrams as design tools for estimating the fatigue strengths for designed fatigue life, known load ratio and various number nHCF cycles, are obtained and presented for the parts made of titanium alloy Ti-6Al-4V and subjected to combined HCF/LCF loading.

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Grid Generation in Complex Computational Domains with the Use of Subdivision Templates

3D Numerical analyses often require volume discretization through the generation of a grid. When discretizing complex geometries, it is important that the grid fits the boundaries well. A subdivision template is a method of dividing an entire computational space (volume) into primitive subspaces. Three parts of the grid generation procedure were developed: first we define a sufficiently large volume and divide the entire domain into smaller “subspaces” and call the method of division a “template”. In the second step we transform entirely general shapes into set of B-splines by means of operators (coded functions) and enable variation of the shape of boundaries. The third step is grid optimization concerning orthogonality. The optimization is controlled by “control points”, which “slide” along “carrier geometry”.

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A System for Footwear Fitting Analysis

A shoe making industry that can offer shoes that fit consumer needs has a decided advantage over its competitors. Next to fashion requirement, shoe fitness is an important selection criterion. The proposed system for fitting measurement is intended to be installed in shops where customers' feet are scanned and then shoe database suggests best fit shoe models. We will describe the matching software part of the system which consists of a computer and a laser scanner. We propose that the scanned foot in flat position should be matched with a similar foot from the database to obtain landmark similarities for a fitness analysis. As the scanned foot has no landmarks for accurate positioning of landmarks from which fitting parameters are derived one has to rely on the registration of surfaces. A successful introduction of such a system can open several so far unfamiliar areas of e-shoe business such as design of well fitting products, lot sizing, internet shoe sales and special per customer offers.

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Prediction of 3-D Crack Growth in Thin Rim-Gears

Thin-rim gears with an initial crack in the tooth root, caused by various reasons, are dealt with in this paper. By standard procedures, it is impossible to gain a very good insight into the conditions appearing at the formation of initial damage. Bearing this in mind, a numerical model has been elaborated. The boundary element method and the theory of linear-elastic fracture mechanics have been used for crack growth simulation. By means of 3-D numerical analysis, the influence of a different position of a web (in the middle and at the edge of a rim) upon the direction of crack propagation and the remaining life is researched. The results of the research work offer a more optimal concept of gear design and dimensions.

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Four-Bar Linkage Design Using Global Optimization Approach

The paper discusses optimal synthesis of the four-bar mechanism. The general optimization problem is addressed in the form of nonlinear programming problem. The objective of this approach is to determine the optimal values of the mechanism link lengths, to minimize the hinge loads, while the difference between the prescribed trajectory and the trajectory of the arbitrary point on the mechanism coupler link has to remain within the prescribed range. A global optimization method is used in order to find the global optimal solution. The procedure uses the Adaptive Grid Refinement algorithm.

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Analytical and Numerical Analysis of Non-Symmetrical All Steel Sandwich Panels Under Uniform Pressure Load

Steel sandwich panels welded by laser can offer 30-50 % weight savings compared to the conventional steel structures. In the paper, the behaviour of the non – symmetrical all steel sandwich panels with I core under constant pressure are studied theoretically and numerically applying FEM. Non – symmetrical sandwich panels are considered to have different thicknesses of face plates. The analytical formulations include: elastic constant of shear stiffness in direction perpendicular to the core and closed form solutions for deflection of simply supported sandwich beam. Numerical finite element method (FEM) analyses are performed in order to verify the developed theoretical models.

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Optimization of Die-Bonding Process Using Orthogonal Array Experiments

The chip of power transistor with die back metallization (Ti/Ni/Ag/Au) is bonded on the lead frame (Cu:>=99.96%) using the scrubbing method. The soft solder applied is Sn-Pb alloy. Voids appear in the bonding layer and reduce the reliability of the device. The average area of the voids measured by using the X-ray radiography amount to 9.3% of the examined surface, which lies beyond the accepted limit 7%. To reduce the voids in the bonding layer, a small number of experiments using orthogonal arrays are conducted systematically, which give the optimum combination of process parameters under a specified range of die-bonding machine. The amount of voids on the average now drops to 1.73%, far below the accepted limit. The method using orthogonal array experiments can be considered as a first step for the process redesign and prerequisite for a necessary numerical simulation.

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Optimum Design of a Formula One Rear Wing Using a Genetic Algorithm

In the present paper, the possibility of optimizing the stiffness of a F1 lower-rear wing, in a shape which satisfies the aerodynamic requirements, by making use of a genetic algorithm was investigated. The aim of the optimization was to find the best laminate stacking sequences in a trade-off between stiffness requirements and weight reduction, without laminate failure due to excessive stress. It was shown that this powerful non-traditional optimization method could contribute to a considerable reduction of the composite wing weight.

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Using of 3-D Parametrical Blocking Contours for Optimizing External Cylindrical Gear Drives on a "Geometrical Level"

Always when the operating gear center distance is not specified, the modern design process of a gear drive with optimal parameters could start by creating a 3-D model of it parametrical blocking contour. It general appearance this model represent restricted multitude of limited 3-D surfaces corresponding to definite unspecified parameters of the gear drive. We can create this mathematical models automatically, using a software package, developed by us (see the picture bellow). The models includes the hole range of the admissible combinations of the center distance and the addendum modification coefficients, as well as the contact ratio, the arc-tooth thickness at the outside diameter of the gear wheels, the sliding velocities and others parameters of the gear mesh. Those models give us the possibility to find the best solution that we are looking for.

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Dynamics of Motorcycle Using Flexible Elements

In this study a model was developed for the dynamic simulation of the motorcycle in which the frame was constructed using flexible elements. A feedback control system was applied to the model so that any given trajectory could be executed. The behaviour of the vehicle was analysed, determining the significant magnitudes at the following points: centre of front hub, centre of rear hub, steering column bearing and rear suspension attachment. Trajectories passing over a sinusoidal hump, in both acceleration and deceleration, and simulating an S bend were imposed. Analyses were conducted first considering the frame to be infinitely rigid and then considering it to be flexible. Comparing the results it was possible to determine when the frame must be schematised with flexible elements.

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On Formulas and Methods for Expressing the Attitude of a Rigid Body

In many fields of mechanics there is the need of expressing the attitude of a rigid body. This paper, summarizes and compares different approaches for such purpose.
In particular, the following formulations will be considered:
1. Euler angles (different conventions);
2. Bryant angles;
3 .Cardan angles;
4. Euler parameters;
5. Cayley-Klein parameters.
The paper will also focus on the sensitivity to round-off error of a methodology for computing the attitude of a body through telemetry measurements.

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Numerical Computation of Stresses, Strains and Displacements in the Thin Plates in Plastic Range

An incremental formulation of the basic equations of the finite element method is described in this paper. These basic equations are used in stress and strain analysis in structures in which plastic strains have occurred. The elasto-plastic matrix was formed for the case of plane stress. The dependence between incremental stress vector and incremental elastic-plastic strain vector is established through the matrix . In order to illustrate a numerical procedure, a discretization of a plate quarter was performed on triangular finite elements and on isoparametric quadrilateral ones. The stress fields were computed in elastic-plastic range. The plastic zones spreading around discontinuities are also represented.

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Impact Damage Analysis of Layered Composite Plates

Material and geometrical parameters affecting structural response of impacted aircraft structures have been defined. Numerical model for the prediction of damage in layered composite panels under low velocity impact has been presented. The model takes into account matrix cracks and delaminations. All necessary numerical procedures have been performed within the frame of ABAQUS finite element software with the addition of user subroutines. Numerical effectiveness of the method has been demonstrated by the example of impact on the carbon/epoxy simply supported square plate.

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Numerical Approach for Fatigue Initiation Service Life of Mechanical Elements

The numerical model for analysing damage due to contact fatigue of mechanical elements is presented in this paper. Mechanical behaviour of various machine elements depends upon interacting influences of contact elements. Contact fatigue can be divided into the initiation of micro-cracks and crack propagation. The purpose of present study is to elaborate a numerical model for prediction of contact fatigue initiation, based on continuum mechanics. The influence of friction on the contact loading cycles and fatigue initiation should be examined. The results of loading cycles, required for initial fatigue damages to appear Ni and the place yi (on/under contact surface) where contact fatigue damage starts, were presented.

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Design Science for Mathematical Modelling of Gear Systems

The paper present our successful results of the effective implementation of engineering Design Science (DS) knowledge into the process of the engineering design of optimised gear systems (GS) from the point of view of their dynamic behaviour. We will focus especially on the third highest hierarchical level of use of engineering design knowledge i.e. on “Flexible systematic ways based significantly on system of structured knowledge” which support optimally creativity of engineering designers. By bridging between closely specialised science branches and branch of engineering design the high special knowledge on dynamical behaviour of TS was accessed to wide class of engineering designers in the praxis.

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Numerical Analysis of non Linear Thermosensible Viscoelastic Systems

In this paper will be present a numerical approach to the dynamic analysis of rubber-to-metal devices. These objects, which contain viscoelstic materials, work in extreme conditions by the point of view of vibrations and thermical shocks and their behaviour can hardly be defined in an analytical way, because of their strong non linearity properties, thermosensibility and viscoelasticity.
Analysis is performed in three stages: first is an experimental characterization of material dynamic behaviour; second is material model parameters estimation; third stage is numerical analysis of complex system model involved by an automatic calculus code. The results of this process have been successfully compared with those taken from the experimentation.

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Numerical Analyses of Mixed Mode Crack Propagation Using Virtual Crack Extension Method

Paper presents numerical simulation of crack propagation under mixed mode loading conditions. Widely used criteria for crack propagation angle include the strain energy release rate G, the maximum circumferential stress and the minimum strain energy density. All these methods are included in numerical analyses. Research work was focused on virtual crack extension method (VCE), based on strain energy release rate. CTS specimen was used for simulation of crack propagation. Results show that VCE method gives comparable results with other methods when tensile stresses around the crack tip dominate. When shear stresses dominate Sqmax criterion is the most accurate.

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Operating Bolt Load Calculation in Joints of Complex Elastic Structures

An improved method for the calculation of actual operating force on every bolt in the bolted joint has been developed. It is founded on the usage of so called “elasticity” and “stiffness” matrices of joined structures. Elasticity matrices have to be calculated separately for each part of joined structures and for every bolt position in the structure. The method is generalized and has been tested numerically and experimentally at different external structure loads and at different relative orientation of joined structures. Numerical results show considerable differences with respect to the results obtained from applying the very simplified theory. Experimental results confirm those deviations and show good agreement with numerical results.