XXXIV Summer School – Conference
“Advanced Problems in Mechanics”

June 25 – July 1, 2006, St. Petersburg (Repino), Russia

A P M 2 0 0 6

BOOK OF ABSTRACTS

http://www.apm.ruweb.net

General Information

APM 2006 is the thirty four in a series of annual summer schools held by Russian Academy of Sciences. The Summer school "Advanced Problems in Mechanics 2006" is organized by the Institute for Problems in Mechanical Engineering of the Russian Academy of Sciences (IPME RAS) under the patronage of the Russian Academy of Sciences (RAS).The main purpose of the meeting is to gather specialists from different branches of mechanics to provide a platform for cross-fertilisation of ideas.

History of the School

The first Summer School was organized by Ya.G. Panovko and his colleagues in 1971. In the early years the main focus of the School was on nonlinear oscillations of mechanical systems with a finite number of degrees of freedom. The School specialized in this way because at that time in Russia (USSR) there were held regular National Meetings on Theoretical and Applied Mechanics, and also there were many conferences on mechanics with a more particular specialization. After 1985 many conferences and schools on mechanics in Russia were terminated due to financial problems. In 1994 the Institute for Problems in Mechanical Engineering of the Russian Academy of Sciences restarted the Summer School. The traditional name of "Summer School" has been kept, but the topics covered by the School have been much widened, and the School has been transformed into an international conference. The topics of the conference cover now all fields of mechanics and associated into interdisciplinary problems.

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The conference is organized with help of our service agency "Monomax" (find the information further).

SCIENTIFIC PROGRAM Presentations devoted to fundamental aspects of mechanics, or spreading the field of applications of mechanics, are invited. We are particularly keen to receive contributions that *show new effects and phenomena or develop new mathematical models*. The topics of the conference cover all fields of mechanics, including, but not restricted, to

- mechanics of generalized continua (polar and micromorphic continua, mixtures, porous media, electromagnetic continua, grains, powders etc)
- solids and structures
- phase transitions
- nonlinear dynamics, chaos and vibration
- fluid and gas
- computational mechanics
- mechanical and civil engineering applications

MINISYMPOSIA AND CHAIRS

[MS1] Nonlinear Dynamics of Engineering Systems
M. Wiercigroch , E. Pavlovskaya (Aberdeen, UK)

[MS2] Fatigue of Engineering Structures
W. Eichlseder (Leoben, Austria), B.Unger (Steyr, Austria), S.V.Petinov, A.K.Belyaev (St.Petersburg, Russia)

[MS3] Nonlinear Waves in Mechanical Systems
A.V. Porubov (Saint-Petersburg, Russia), V.I. Erofeev (Nizhny Novgorod, Russia)

[MS4] Aerospace Minisymposium
M. Cartmell (Glasgow, UK)

[MS5] Stochastic Methods in Mechanics
S. Fedotov (Manchester, UK)

[MS6] Advances in Nanomechanics
A. M. Krivtsov , N. F. Morozov (Saint-Petersburg, Russia)

Four different forms of presentations are offered, namely, plenary lectures (40 minutes), presentations at minisymposia (30 minutes), short communications (20 minutes), and posters. The working language for oral presentations is English. Regrettably we can not provide simultaneous translation, and due to the international nature of the conference all the oral presentations must be in English. The working languages for poster sessions are English and Russian.

Attention: each participant may only give ONE oral presentation. The number of posters for each participant is not limited.

Registration Fee

The conference fee is:

- for participants giving a presentation: 300 EUR
- for participants not giving a presentation: 220 EUR
- for students: 220 EUR

  The fee covers invitation costs, postage, book of abstracts, proceedings, social program (excursion, get-together party), and organizational costs.

- The fee for accompanying persons is 100 EUR and covers the invitation costs, postage, and social program.
- There is a reduced conference fee of 50 EUR for participants having permanent position in NIS countries (Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgystan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan), which partially covers the postage and book of abstracts.
- There is a reduced conference fee of 25 EUR for students from NIS countries.

Time-Table Scheme

Abbreviations: Zh is session devoted to memory of P.A. Zhilin, O is the opening ceremony, PL are the plenary lectures, MS is a minisymposium, S is an oral session, PS is a poster session, C is the closing ceremony.

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Acknowledgements

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June 25, Sunday

Room A

Morning Session

Chairperson A.M. Krivtsov

10:00 – 10:30 **Opening ceremony**

Chairperson D.A. Indeitsev

Session devoted to memory of P.A.Zhilin

10:30 – 11:10 **E.A. Ivanova.** Scientific results of P.A.Zhilin
11:10 – 11:50 **V.A. Palmov.** Pavel A.Zhilin describes our future

Coffee break

12:10 – 12:50 **I.I. Blekhman.** Riddles of the theory of dynamic systems: on the borderline of mechanics, philosophy, and theology (Dedicated to the memory of Professor P.A.Zhilin)
12:50 – 13:30 **V.A. Eremeev.** The theory of shells and micropolar bodies: development of P.A.Zhilin's ideas
13:30 – 13:50 **E.F. Grekova.** P.A.Zhilin - my teacher

Evening Session

Chairperson A.M. Krivtsov

Session devoted to memory of P.A.Zhilin

15:30 – 17:10 **Round table**
17:10 – 17:50 **H. Altenbach.** On the contributions of P.A.Zhilin to the shell theory

Room B

June 26, Monday

Room A

Morning Session

Chairperson A.M. Krivtsov

9:30 – 10:10 **X. Xu, M. Wiercigroch, E. Pavlovskaia, S. Lenci, F. Romeo, M.N. Cherri.** Dynamics of Parametric Pendulum for Wave Energy Extraction
10:10 – 10:50 **N.F. Morozov, R.V. Goldshtein.** Advances in nanomechanics at the Russian Academy of Sciences (mechanical division) 2004-2005
10:50 – 11:30 **I.G. Goryacheva.** Friction in Rolling Contact of Deformable Bodies

Coffee break

Minisymposium "Nonlinear Dynamics of Engineering Systems"

Co-Chairpersons E. Pavlovskaya, M. Wiercigroch

11:50 – 12:20 **L.I. Manevitch, V.V. Smirnov, N.N. Balabaev, M.A. Mazo, K.Yu. Kosevich .** Discrete breathers in nonlinear dynamics of planar zigzag oscillatory chain and carbon nanotube
12:20 – 12:50 **E. Pavlovskaia, J. Ing, M. Wiercigroch.** Reduction of multidimensional flow to low dimensional map for piecewise smooth oscillators
12:50 – 13:20 **M. Zakrzhevsky, R. Smirnova.** Paradoxes of Nonlinear Damping in the Linear Dynamical Systems
13:20 – 13:50 **M. Zakrzhevsky.** The Fundamentals of the Theory of Nonlinear Oscillations. The New Concepts and Old Delusions

Evening Session

Minisymposium "Nonlinear Dynamics of Engineering Systems"

Co-Chairpersons E. Pavlovskaya, M. Wiercigroch

15:30 – 16:00 **A.P. Seyranian.** On classical parametric resonance problems
16:00 – 16:30 **T. Gould, C. Wang, D. Combes.** Cosserat modelling of flexible ring structures
16:30 – 17:00 **H. Ishio.** Transition from Quantum to Classical Transport through Chaotic Open Cavities

Coffee break

17:20 – 17:50 **G.V. Kostin.** Time Optimal Control of Mechanical Systems with Dry Friction under Harmonic Disturbances
17:50 – 18:20 **A. Polishchuk .** Interconnected spatial vibrations of helical springs
18:20 – 18:50 **R.A. Morrison.** Stability Analysis of the Helmholtz Oscillator with Time Varying Mass

Room B

Morning Session

Chairperson A.D. Sergeev
Solids and structures

11:50 – 12:10 **A.G. Knyazeva.** Coupling model of surface admixture redistribution at the condition of one-axis mechanical loading
12:10 – 12:30 **N.Y. Nikitina.** Investigation of stressed states of pipelines by acoustoelastic method
12:30 – 12:50 **S. Sargsyan.** Dynamic Problem of Thin Plates on the basis of Asymmetric Theory of Elasticity

Break

13:00 – 13:20 **N.A. Konchakova.** The investigation of the irreversible strain and damage in the brittle fracture materials
13:20 – 13:40 **E.L. Starostin.** Modelling elastic bands: from an anisotropic rod to a developable shell
13:40 – 14:00 **N.G. Dvas.** Stability of plain tetratomic system

Evening Session

Chairperson V.A. Eremeev
Phase transitions

15:40 – 16:00 **H. Zapolsky, N. Lecoq, R. Patte.** Numerical simulation of phase transition in Ni-based alloys
16:00 – 16:20 **A.B. Freidin, E.N. Vilchevskaya, L.L. Sharipova, M.A. Antimonov.** New phase nucleation at the initial stage of stress-induced phase transformations
16:20 – 16:40 **S.N. Gavrilov, E.V. Shishkina.** On the extension of a rod capable to undergo phase transitions
16:40 – 17:00 **S. Tokarzewski.** Bounds on effective transport coefficients from complex input data

Coffee break

17:20 – 17:40 **K.L. Muratikov, A.L. Glazov, V.I. Nikolaev, S.A. Pul'nev.** Imaging of structural phase transitions in monocrystals of Cu-Al-Ni with shape memory effect by photoacoustic thermoelastic microscopy
17:40 – 18:00 **W. Zaki, Z. Moumni.** Modeling of thermomechanical behavior and fatigue of shape memory
18:00 – 18:20 **V.F. Kuropatenko.** Hydromechanics of Multicomponent Multiphase Compressible Media
18:20 – 18:40 **A.G. Knyazeva, S.G. Psakhie, A.V. Tyan.** Masstransfer at the nonequilibrium conditions of surface high-energy treatment

June 27, Tuesday

Room A

Morning Session

Chairperson E.F. Grekova

9:30 – 10:10 **H. Bremer.** Flexible mechanism dynamics
10:10 – 10:50 **A.K. Belyaev.** A benchmark study of three approaches to waves in randomly heterogeneous elastic media

Break

Minisymposium "Fatigue of Engineering Structures"

Co-Chairpersons B. Unger, A.K. Belyaev

11:00 – 11:30 **H. Leitner, W. Eichlseder.** Interaction between surface condition and fatigue life
11:30 – 12:00 **B. Unger.** Application of Virtual Methods for the Optimization of Dynamic Loaded Structures

Coffee break

12:20 – 12:50 **F. Grün, I. Gódor, W. Eichlseder.** Tribological Studies on Sliding Bearings on the Basis of Damage Analysis
12:50 – 13:20 **I. Gódor, Z. Major, W. Eichlseder, A. Leitgeb, F. Grün.** Development of a tribological functional and failure model for PTFE-Bz Compounds
13:20 – 13:50 **S.V. Petinov.** Fatigue Analysis of Ship Structures: Application of "Strain-Life" Criterion

Evening Session

Minisymposium "Fatigue of Engineering Structures"

Co-Chairpersons W. Eichlseder, S.V. Petinov

15:15 – 15:40 **B.E. Melnikov.** Modeling fatigue crack propagation by means of continuum damage mechanics and non-local criteria.
15:40 – 16:05 **A.M. Polyanskii, V.A. Polyanskii.** Study of changes in the bond energy of hydrogen in metals under thermomechanic loading
16:05 – 16:30 **M.F. Ghanameh.** Finite element investigation of unreinforced welded tubular joints

Coffee break

16:50 – 17:20 **I.K. Korolev, A.B. Freidin, E.N. Vilchevskaya.** Modeling an interaction between a phase transforming inclusion and a fatigue crack
17:20 – 17:50 **S.V. Bobylev, N.F. Morozov, I.A. Ovid'ko and A.G. Sheinermano.** Nucleation and evolution of nanovoids in polysilicon at quasistatic and fatigue load regimes
17:50 – 18:20 **A.M. Krivtsov.** MD modeling of low-cycle high-amplitude loading of monocrystal material with defects
18:20 – 18:50 **E.L. Aero, A.N. Bulygin.** Microscopic theory of degradation of properties of crystalline material under vibrocreep

Room B

Morning Session

Minisymposium "Nonlinear Waves in Mechanical Systems"

Co-Chairpersons A.V. Porubov, V.I. Erofeev

11:00 – 11:30 **Chardard, Dias, Bridges.** On the stability of solitary waves
11:30 – 12:00 **A.B. Ezersky, V.O. Afenchenko, S.V. Kiyashko, A.V. Nazarovsky.** Spatio-temporal Dynamics of Bound States in Faraday Ripples: experiments and numerical simulations

Coffee break

12:20 – 12:50 **A. Stulov.** Mathematical models of sound generation mechanisms in grand piano
12:50 – 13:20 **V.I. Erofeyev, A.V. Sharabanova.** Elastic shear waves in bimodal materials
13:20 – 13:50 **A.V. Porubov.** On derivation of model equations for nonlinear strain waves in wave guides

Evening Session

Chairperson A.V. Zaitsev
Computational mechanics

15:30 – 15:50 **V.P. Fedotov, L.F. Spevak, V.V. Privalova, V.B. Trukhin.** Solving two- and three-dimensional elastic problems by modified boundary element method
15:50 – 16:10 **D. Savescu.** About new ball-bearings used in mechanical transmisions
16:10 – 16:30 **G. Filippenko.** On the free vibration of the cylinder shell partially protruding above the surface of the liquid

Coffee break

16:50 – 17:10 **M. Brigante, A.V. Nasedkin, M.A. Sumbatyan.** Testing of Viscoelastic Constructions: Modeling by FEM
17:10 – 17:30 **G. Partheepan, D.K. Sehgal, R.K. Pandey.** Determination of tensile properties of Chromium hotwork steel using inverse FEM and miniature test
17:30 – 17:50 **I.A. Brigadnov.** Computer simulation of sandwich sheet metal forming
17:50 – 18:10 **Ghannadi-Asl Amin, Noorzad Asadollah.** Trefftz Boundary Method for Thick Plate Bending Problems

June 28, Wednesday

Room A

Morning Session

Chairperson A.B. Freidin

9:30 – 10:10 **A.I. Borovkov, V.A. Palmov.** New approach in the mechanics of periodic composites
10:10 – 10:50 **A. Metrikine.** Wave Mechanics of Structures and Structural Materials
10:50 – 11:30 **M.P. Cartmell, M.C. D'Arrigo, D.J. McKenzie, Y. Wang.** Approximate Analytical Solution for a Motorised Momentum Exchange Tether on a Circular Earth Orbit

Coffee break

Minisymposium "Aerospace Minisymposium"

Chairperson M. Cartmell

11:50 – 12:20 **G. Radice.** Spacecraft formation control at Sun-Earth L2 point
12:20 – 12:50 **D. McKenzie, M. Cartmell.** Dynamics of Orbital Space Tethers
12:50 – 13:20 **A.A. Le-Zacharov, I. Volkovets.** Simulation of Gravitational Systems by Particle Method
13:20 – 13:50 **G. Jayanthi, P. Alagusundaramoorthy.** Finite Element Analysis of Open Isogrid Structures

Evening Session

Chairperson

15:30 – 16:10 **E.V. Lomakin, B.N. Fedulov.** Deformation and limit state of solids with stress state dependent plastic properties

Break

Minisymposium "Stochastic Methods in Mechanics"

Chairperson S. Fedotov

16:20 – 16:50 **V. Mendez, S. Fedotov.** Front propagation in reaction-random walks processes
16:50 – 17:20 **S. Fedotov, I. Bashkirtseva, L. Ryashko.** Stochastic Non-Normal Dynamical System for Subcritical Transition

Coffee break

17:40 – 18:10 **A.A. Burluka.** Closed equation for two-point pdf in mechanics of turbulence
18:10 – 18:40 **Mandeep S. Sidhu, A.A. Burluka.** Vaporisation rate in two-phase turbulent flows

Room B

Morning Session

Chairperson A.S. Kuleshov
Civil engineering

11:50 – 12:10 **W. Lu, P. Makelainen.** Fuzzy Genetic Algorithms for Design of Cold-Formed Steel Sheeting
12:10 – 12:30 **A.K. Abramyan.** On the free vibrations of an oscillator with a periodically time-varying mass
12:30 – 12:50 **L.M. Yufereva, P.N. Kot, Yu.A. Lavrov.** Influence of an annular plate on free oscillations of a spherical acoustical resonator

Chairperson A.S. Kuleshov
Fluid and Gas

12:50 – 13:10 **N.V. Nikitin.** Direct numerical simulation of turbulent wall-bounded flows: approaches, methods and results
13:10 – 13:30 **A.G. Bagdoev, A.V. Shekoyan.** The wave in gas-fluid mixture
13:30 – 13:50 **Yu.A. Ustinov.** Mathematical modeling blood motion in the arterial muscle vessels.

Evening Session

Chairperson S.N. Gavrilov
Solids and Structures

16:20 – 16:40 **R.A. Arutyunyan.** The description of deformation aging of polimers by means of modified Maxwell and Kelvin-voight materials
16:40 – 17:00 **A.V. Zaitsev, Ya.K. Pokataev.** Probabilistic methods for the analysis of random-structured fibre-reinforced composites
17:00 – 17:20 **P. Dyatlova, E. Polyakova, V. Chaikin.** Constitutive equations for soft shells with network microstructures

Coffee break

17:40 – 18:00 **M. Bournane, Y. Sadaoui, M. Nedjar.** Elasticity and internal friction of Al7SiMg hypoeutectic alloy
18:00 – 18:20 **S.G. Ivanov.** A sight at multilevel models for the design of composite laminate structures
18:20 – 18:40 **N. Kizilova.** Interaction of the steady flow of a viscous liquid with a multilayered viscoelastic wall

June 29, Thursday

Room A

Morning Session

Chairperson V.A. Eremeyev

9:30 – 10:10 **H. Altenbach.** Advanced Engineering Creep Analysis of Thin-walled Structural Elements

10:10 – 10:50 **Y. Dzenis.** Nanomanufacturing and Mechanics of Advanced Continuous Nanofibers

Break

Minisymposium "Advances in Nanomechanics"

Chairperson A.M. Krivtsov, N.F. Morozov

11:00 – 11:30 **S. Lurie, P. Belov, D. Volkov-Bogorodskii, N. Tuckova.** Theory of the interfacial interactions as particular variant of the theory for continuous media with kept dislocations

11:30 – 12:00 **V.A. Eremeev, S.E. Strochkov.** On the FEM modelling of nanofilm helical coil

Coffee break

12:20 – 12:50 **Yu.L. Raikher, V.V. Rusakov.** Diffusional and magnetic rotary microrheology

12:50 – 13:20 **S. Nath.** The Rotation-Uncoiling-Twist Energy Storage Mechanism of Muscle Contraction

13:20 – 13:50 **M.A. Mazo.** Elastic properties of clay nanoparticles via Molecular Dynamics Simulation

Room B

Morning Session

Chairperson I.I. Blehman

Nonlinear dynamics, chaos and vibration

11:00 – 11:20 **E.V. Shishkina, M. Cartmell.** On the behaviour of elastic plates under vibrational excitation

11:20 – 11:40 **A.S. Kuleshov.** On a various mathematical models of a skateboard motion

11:40 – 12:00 **I.A. Pasynkova.** Cylindrical precessions of an unbalanced flexible rotor supported in nonlinear elastic bearings

Coffee break

12:20 – 12:40 **A.G. Bagdoev A.V. Shekoyan.** The derivation of general equation for solid-electroconvulsive fluid media and waves inthem

12:40 – 13:00 **A.L. Shvygin.** On the stability of pendulum motions of a gyrostate

13:00 – 13:20 **A.A Burov.** Regular and chaotic dynamics of the orbital pendulum with the vibrating point of suspension

Evening Session

15:30 – 17:00 **Posters (PS1)**

Coffee break

17:20 – 18:50 **Posters (PS2)**

Room A

Morning Session

CHAIRPERSON E.F. GREKOVA

9:30 – 10:10 **L.Yu. Kossovich.** Hyperbolic Interfaces in Composite Shells Under Front Impacts
10:10 – 10:50 **D. Harris.** Two-phase Fast Granular Flow: Some Issues and Problems
10:50 – 11:30 **J.D. Goddard.** A general theory for the viscoplasticity of dry and fluid-saturated granular media

Break

CHAIRPERSON D. HARRIS
Mechanics of generalized continua

11:40 – 12:00 **A. Castellanos, J.M. Valverde.** Fluidization regimes of fine and ultra-fine powders
12:00 – 12:20 **M.A. Kulesh, E.F. Grekova, I.N. Shardakov.** Rayleigh waves in the isotropic and linear, reduced Cosserat continuum

Coffee break

12:40 – 13:00 **Yi-chao Chen.** Stability of Elastic Films in Proximity to a Rigid Plate
13:00 – 13:20 **J. Nitsche.** Brownian Dynamics of Continuous Deformable Macro-molecular Models in Shear Flow
13:20 – 13:40 **A.L. Svistkov.** Structural–phenomenological model of heterogeneous medium

Evening Session

CHAIRPERSON A.D. SERGEEV

15:30 – 16:10 **V.V. Beletsky.** General limited cicular three-body problem as a model for dynamics of double asteroids
16:10 – 16:50 **Ya-Pu Zhao.** Surface and size effects in MEMS/NEMS and hybrid QM/MM simulation

Coffee break

CHAIRPERSON A.D. SERGEEV
Solids and Structures

17:10 – 17:30 **V.I. Astafiev.** Damage Accumulation and Crack Growth in Metals under Hydrogen Embrittlement
17:30 – 17:50 **Z.A. Valisheva, N.B. Vovnenko, B.A. Zimin, U.B. Sudenkov.** Non-equilibrium processes influence on dynamic response in metals
17:50 – 18:10 **B.N. Semenov, Yu.V. Sudenkov, D.A. Yungmeister , A.Y. Burak.** An investigation of the process of percussive impulse formation and transference in the three bodies system

Break

18:20 – 18:40 **CLOSING CEREMONY**

Room B

List of posters
June 29

Session PS1

1. **D. Abrarov.** The Canonical Model of the Hamiltonian Systems Category
2. **A. R. Arutyunyan, Z. A. Valisheva, B. A. Zimin, Yu. V. Sudenkov.** Investigation of materials structure rearrangements during cyclic experiments
3. **M. A. Antimonov, A. B. Freidin.** On equilibrium new phase cylindrical nuclei in an uniform field of strains
4. **A. Boudjada, N. Benchiheb, L. Hamdellou, S. Ghanemi,J. Meinnel, O. Hernandez, A. Boucekkine.** Proton disorder and molecular conformation in Triiodomesitylene
5. **A. A. Bukhanko, A. Yu. Loshmanov.** Problems of technological plasticity theory
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35. **A. Gambin, A. Gaka, S. Tokarzewski.** Damage tensor based on homogenization

36. **D. A. Tushkanov, V. Ya. Shkadov.** Waves in falling films with small incline of supporting surface from horizont

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45. **V. I. Erofeyev, N. V. Kluyeva, I. N. Soldatov.** Spectra of surface displacements and H/V ratio in problems of selection of wave modes

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47. **V. Synorov, Y. A. Rossihin, M. V. Shitikova.** The impact of two thermoelastic rods

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50. **I. N. Wasserman.** Dynamic behavior of some elastic mechanical systems with set-valued nonmonotonic boundary conditions

51. **I. Yu. Zoubko, P. V. Trusov, S. A. Oglezneva, A. V. Permyakov.** Modelling of mechanical alloying process on the macro- and microlevel

CANONICAL MODEL OF THE HAMILTONIAN SYSTEMS CATEGORY

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Basing on the constructive modification of the Liouville-Arnold theorem the effective and canonical description of the whole set of analytical Hamiltonian systems (taking into account the integrable systems and their analytical perturbations) is proposed. The analytical sense of the modified perturbation theory is in the canonical generalisation of the property of the modularity for elliptic curves over the set of rational numbers. The mechanical, geometrical and physical sense of the proposed canonical model is discussed.

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A MICROSCOPIC NONLINEAR THEORY OF DRASTICALLY CHANGING LATTICE STRUCTURE AND PROPERTIES DEGRADATION UNDER TEMPERATURE AND STRESS FIELDS.

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Many complex processes of deformation are known to be accompanied by deep phenomena of change in the structure that is not introduced in the continuum theory of elasticity. This limitation of the latter theory overcomes by introducing additional model tunings and complex rheological relationships. The microscopic potential of such theories is not considerable and one has to restrict oneself only by phenomenological description of phenomena. For example, these phenomena are the degradation under irreversible deformations and temperature. The second difficulty of treating is related to the necessity of analysis of nonlinear phenomena responsible for the irreversible changes in the body. An essentially nonlinear theory of elastic and nonelastic microdeformations is developed with the help of model of mutually penetrating sublattices. A generalisation of the theory of acoustical and optical vibrations on the case of nonlinear interaction of sublattices is suggested. This interaction is introduced with account of internal translational symmetry of complex lattice, that is, the structure and energy of lattice are invariant under mutual displacement of sublattices on an integer number of periods.This principle suggests that the structure and energy of the complex lattice must also be invariant under mutual displacement of sublattices on one or more periods. This allows one to consider the force of interaction of lattices as periodic (e.g. sinusoidal) functions of the relative displacement of sublattices. In the classical Karman-Born-Huang theory these forces are linear with respect to displacements of the sublattices. The function of microdensity of the energy which is invariant with respect to mutual translations of sublattices is constructed. This enables consideration of large displacement of atoms (caused, say, critical deformation) and account of such phenomena as bond switching, change in the symmetry class of lattice, appearance defects, damage and other bifurcations; phenomena resulting in irreversible deformations. Along with macroscopic displacement U we introduced microscopic displacement of adjacent atoms u, as well as temperature field T. This allows one to account for interaction of fields of three quantities (striction, thermostriction and thermal stresses). The dynamical and kinetic equations for microscopic fields of displacements and temperature are derived. In one-dimensional case we can obtain a closed form expression for strain energy in terms of external stresses, temperature and microdisplacement on the boundary with the help of first integral. However in this simple case the theory predicts nontrivial effects of decreasing interatomic barriers at expenses of stresses and temperature. The presence of parameter of rearrangement of internal structure u allows one to model, without further complication of the model, the process of rearrangement of microstructure with overcoming internal potential barriers and describe such complex phenomena as creep, deformational aging and fatigue. This description is known to require account of accumulation of damage, which presents a problem to be tackled. For solving these problems a more detailed analysis of derived equations and generalization of the theory on two- and three-dimensional cases are needed Note, that dynamical variant of the microstructure of the evolution has also interest solution. In particularly there is a solution which describes a crack opening and moving. In a two dimensional case the developed theory predicts also the nucleation of other singular defects (dislocations, sliding, etc).

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THE COLLAPSE OF A NON-EQUILIBRIUM VAPOUR BUBBLE UNDER THE LINEAR - POLARIZED VIBRATIONS

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The behaviour of hydrodynamic systems with interfaces under the action of vibrations is a subject of a lot of papers. This attention is paid not only due to the fundamental interest, but it is also concerned with the requirements of applied researches and technologies. In particularly, the study of oscillations of bubbles [1] and drops [2] is of interest within the framework of this topic.

Both the oscillations and the collapse of a non-equilibrium (gas-) vapour bubble in an incompressible liquid under the linear - polarized vibrations are considered in present work. As it was shown in [3-4], the motion of the vapour (or gas) inside a bubble does not influence essentially neither the bubble dynamics nor the processes of cavitation or sonoluminescence. Both the presence of inert gas inside the bubble and the phase transition at the interface liquids - vapour become essential in this case. We take into account the kinetics of phase transition and apply the perfect gas law to describe the thermodynamics of both the gas and the vapour. The fluid viscosity and the heat conductivity of both fluid and gas are neglected. Interaction of a radial oscillation mode, caused by the uniform in space but time-dependent pressure, and the translation mode, generated by linear-polarized vibrations, is taken into account. The amplitude of translation motion is assumed to be small in comparison with the amplitude of radial oscillations. The dynamics of vapour inside the bubble is not considered. Such an interaction between radial and translation motions of the bubble was studied in [5] without accounting for the phase transition.

By virtue of the perturbation theory both the nonlinear equation describing the radial oscillations and linear equation, which govern the translation motion, are obtained. These equations are solved numerically. The stability of the forced oscillations with respect to the small perturbations is investigated.

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ADVANCED ENGINEERING CREEP ANALYSIS OF THIN-WALLED STRUCTURAL ELEMENTS

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The research in engineering creep mechanics is focussed on the description of time-dependent microstructural changes and the phenomenological behavior of various materials. The equations allowing the description of the material behavior and the analysis of structural elements should be useful in the case of uniaxial and multi-axial stress states. In addition, they have to reflect that the stress states can be inhomogeneous and anisotropic. Up to now one gets significant disagreements between the results of the simplified (engineering) analysis and the improved estimations [1, 2]. The performed numerical calculations show effects which cannot be described by the classical theory of Euler-Bernoulli beams or Kirchhoff plates. In addition, the calculations based on 2D finite elements are in a significant disagreement with 3D calculations. The reasons are the thickness integration, the 3D constitutive and evolution equations and the 2D structural mechanics equations [3, 4] among others. The explanation of these disagreements is the aim of the lecture.

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TERMOKINETICS FLUCTUATING PARAMETERS OF DYNAMIC SUPERPLASTICITY

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The problem the determination of the particularities the development syn phase transition observed in condition dynamic superplasticity aluminum alloy, research the functions specific heat with use. In the framework developed modelling representations with use of the equation Focker-Plank are analysed mechanisms to deformation typical for superplasticity and border metastability state. It is shown that under superplasticity main is a mechanism grain-boundary sliding, but in metastability state are added diffusive processes. The influence of the specified processes outside of conditions superplasticity becomes prevailling.

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ON EQUILIBRIUM NEW PHASE CYLINDRICAL NUCLEI IN AN UNIFORM FIELD OF STRAINS

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We study an equilibrium cylindrical nucleus of an anisotropic phase embedded into an isotropic linear elastic parent phase under an uniform external strain field. We prove that the tensor being defined by the transformation self-strain tensor, the jump in elasticity tensor and the strain tensor inside the inclusion is axially symmetric, and the axis coincides with the eigenvector of the external strain tensor. Strains inside the equilibrium nucleus must satisfy this characteristic property. We specify to the case of isotropic phases and construct the surfaces of the nucleus existence in the space of the external strains and determine the shape of the base of cylinder in dependence on external strain. We compare the cylinders nucleation surfaces with the surfaces of layers and ellipsoids nucleation. We demonstrate that the type of the new phase nucleus depends on the deformation path and material parameters.

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INVESTIGATION OF MATERIALS STRUCTURE REARRANGEMENTS DURING CYCLIC EXPERIMENTS

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In article the investigation of the changes of mechanical properties of materials due to rearrangements of structure during cyclic loading on bending of specimens made of tool steel and PMMA is presented. Using the method of optical-acoustic spectroscopy the frequency dependence of sound velocity and attenuation of probe acoustic pulses of tested specimens are measured. Then the evolution of the spectral characteristics of specimens was analyzed.

Sheets made of tool steel and PMMA were loaded with frequency equal to 15 Hz. The number of cycles to fracture were equal to $\sim 10^6$ and $\sim 2.5 \cdot 10^6$ correspondingly for steel and PMMA. The acoustic diagnostics of specimens were carried out approximately at every $5 \cdot 10^4$ cycles of loading.

It is shown that the changes of mechanical properties of materials due to rearrangements of structure during cyclic tests have no monotonous character. So the model of linear damage accumulation is a roughly approximation of fatigue fracture process.

It is assumed that the method of optical-acoustic spectroscopy of materials and structural elements allow to determine the limit of endurance of materials with a greater accuracy and predict the resource of constructions with high probability.

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THE DESCRIPTION OF DEFORMATION AGING OF POLIMERS BY MEANS OF MODIFIED MAXWELL AND KELVIN-VOIGHT MATERIALS

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Numerous publications, including monograph [1], are devoted to the experimental investigations of thermal and climatic aging of polymers. For example, in [1] the results of creep experiments on quenched and aged (4 years) specimens made of different polymer materials (40 types) in amorphous state are presented. To describe these experiments generally the principle of time temperature superposition is applied. This principle leads to the horizontal shifting of the compliance curves and describes the behavior of rheologically simple materials. To model the behavior of complex materials and deformation aging materials it is necessary to operate with the principles capable to consider both horizontal and vertical shifting. For this purpose the parameter of effective time [2] is being used. As shown in our presentation there is a principle opportunity to describe the behavior of aging materials within the limits of simple elastic-viscous models of Maxwell and Kelvin-Voight expressed through the effective time. The parameter of effective time is defined so that at instant, active loading it corresponds to the deformation time. In a condition of unloading and stabilization the parameter is reduced to the real time and considers chemical processes. Thus, in a scale of effective time the behavior of quenched and deformation aged materials are described. The elastic-viscous equations expressed in term of real time are analyzed in detail. The known physical relation between elasticity modulus, viscous coefficient and relaxation time is used and the analytical relations for the elasticity modulus and viscous coefficient with accordance to the experiments are defined. At such approach the basic experimental effects caused by factors of thermal and climatic aging are described. Taking into account the processes of deformation aging a specific differential relation for the parameter of effective time is suggested and the analytical solutions of creep and stress relaxation problems for Maxwell and Kelvin-Voight models are received. Comparison of theoretical creep and aging curves with the experimental curves of the specimens made of polyethylene films is given. It is shown, that the equation of aged Maxwell model on accuracy of description of experimental curves gives in the corresponding Kelvin-Voight equation. As to description of the stress relaxation process, only the qualitative analysis of the received solutions is presented. For a quantitative estimation additional experimental results of stress relaxation curves, received in aging experiments, are required.

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MATHEMATICAL MODEL OF NON-STATIONARY DYNAMICS OF "VIBRATION MACHINE - ELECTRIC MOTORS" SYSTEM BY APPLICATION OF ASYNCHRONOUS MOTOR DRIVES WITH RAISED STARTING PROPERTIES

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The principle of the asynchronous engines with raised starting properties is based on the current displacement effect in the bars of rotor winding. This report provides description of mathematical model of vibratory conveyer machine with self-synchronized vibration exciters asynchronous drive motors system, which allows to represent transient dynamic processes, accompanying the start-up of machine and impact loads phenomenon. There are given the differential equations for movement of vibratory machine electric motors" system in case of an asynchronous motor drive with account of the current displacement effect. This allows to model transient dynamic processes both in the machine, and in the electric motors, taking into account their mutual interaction by application of different modifications of asynchronous motors.

Results of numerical modeling of transient and steady-state dynamics are represented. The information is submitted in graphic form which enables to analyze transient dynamic processes both in the electric motors and in the machine.

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DAMAGE ACCUMULATION AND CRACK GROWTH IN METALS UNDER HYDROGEN EMBRITTLEMENT

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The process of hydrogen embrittlement (HE) in metals is not completely understood yet in despite of intense experimental investigation over the world. HE is manifested in time degradation of various mechanics parameters of materials such as elongation to failure, yield and tensile strength, fracture toughness, etc.

HE may change also the mode of fracture from ductile transgranular to brittle intergranular. HE in metals is usually caused by corrosive reaction in wet H2S containing environments. It is assumed that hydrogen enters metal continuously and interacts with defects of microstructure (dislocations, microcracks, inclusion). This is the basis of the damaging effect by HE.

The exact description of that process is represented a meaningless task. Instead of trying to describe fine details of that process we suppose more reasonable to introduce some internal variable reflecting only the main features of the damage accumulation under HE.

The objective of this paper is to establish constitutive equations with internal variables for elastic-plastic behavior of metals under HE conditions and to analyze from this point of view some features of failure both in uniaxial and multiaxial stress state.

Scalar damage parameter and damage evolution equation is proposed for description of damage accumulation process in corrosive environment. Elastic-perfectly plastic constitutive equations with yield strength and ultimate tensile strain depending on damage parameter are considered. The proposed governing equations describe such experimentally observed features of HE process as

1) the existence of threshold stress below which no failure occurs;

2) the embrittlement of material in wet corrosive environment that is referred to the loss of its ductility increasing with the increase of material strength level;

3) the change of failure mode during HE process that is reflected in changing the threshold surface in stress space;

4) the delayed bechavior of cracking that means the presence of some time to crack initiation depending on initial stress level;

5) the existence of threshold stress intensity factor K1th for macrocrack created under HE conditions.

The results obtained show that experimentally obtained value of threshold stress isn't sufficient to decide - whether or not the material tested is resisted to HE process. Only the whole experimental procedure involving both strain- and stress-controlled tests can adequately solve this problem.

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THE DERIVATION OF GENERAL EQUATION FOR SOLID-ELEKTROCONDUCTING FLUID MEDIA AND WAVES INTHEM

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For two-phase solid-elektroconducting fluid media equations of motion in Langrange coordinates are derived and are solved in connection with Maxwell equations. Linear and nonlinear dispersion relations are derived and its shoun that wave propagates with dispersion,and nonlinear phase velosity is depended from amplitude of wave. Onedimensional nonlinear waves are investigated. It is shoun that shear deformations can lead to variation of porousity. Non linear theedimensional equation of evoulution and Shrodinger equation are derived. Exact solution of last in form of narrow brams on account of nonlinear absorbsion is obtained. Soliton-like solution of evolutionary equation is found.

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THE WAVE IN GAS-FLUID MIXTUE

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In propagation of wave in two-phase media consisting from gas drops of fluid, they, under action of acoustic wave, are vibrated and influe on dispersion equation. This process is accompanied by condesation of vapor on drops, coagulation of drops, viskousity effekts. The linear dispersion equation is derived and examined. It is shoun that wave can be acculated. Graphs of dissipation coefficient frequency are construted. The formulae and graphs of variation of drops concrentation on their sizes as funktions from various parameters charcteristing wave and media are brought.

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HOW TO INVESTIGATE THE STABILITY OF PERIODIC ORBITS IN NONSMOOTH MECHANICAL SYSTEMS?

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There are many systems widely used in engineering, in which the vector field is nonsmooth. All switching circuits used in electrical engineering fall into this category. In mechanical engineering, systems involving impacting or stick-slip motion are essentially nonsmooth in nature.

It has been shown that in such systems as some parameter is varied, the dynamics may undergo abrupt and atypical bifurcation phenomena. It has also been shown that such systems give rise to piecewise smooth maps in discrete-time, and the atypical transitions are in general caused by border collision bifurcations. But in order to investigate these bifurcations in detail, it is necessary to locate periodic orbits and to estimate their stability. In systems that switch between two or more subsystems, this is no trivial matter.

There are two methods now available that achieve this end. The first is the Filippov's approach of differential inclusions by which one can construct the saltation matrix and the monodromy matrix. The second was developed by researchers at the University of Tokushima, Japan, by which one can obtain the Jacobian matrix of the Poincaré map and can follow the periodic orbits irrespective of their stability. This method has been applied very productively in analysing electrical switching systems, but is generally unknown to the mechanical engineering community even though it is quite applicable to the analysis of impacting systems and stick-slip oscillation problems.

In this talk we shall present the two approaches side by side, and will highlight their relative advantages and disadvantages in handling specific types of problems. We shall lay the mathodological framework with which the dynamics of any switching system can be investigated.

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A BENCHMARK STUDY OF THREE APPROACHES TO WAVES IN RANDOMLY HETEROGENEOUS ELASTIC MEDIA

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Three approaches to the problem of one-dimensional wave propagation in media with random elastic and mass properties are studied: (i) method of integral spectral decomposition, (ii) the Fokker-Planck-Kolmogorov equation and (iii) the Dyson integral equation. A benchmark study is performed, and merits and shortcomings of each approach are discussed. It is shown that the approaches cover actually all possible problems of the harmonic wave propagation in heterogeneous or stochastic media. Hence, by means of a preliminary analysis of a particular problem and bearing in mind the strong and weak sides of each approach, one can choose an appropriate strategy of solving the problem.

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PROBLEM OF DYNAMICS OF THE APPARATUS FOR SEPARATING SOLID PARTICLES ACCORDING TO THEIR SIZE, DENSITY AND SHAPE

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Consideration is being given to a number of problems which appear when creating and calculating the classifiers, i.e. the separators, used to classify the solid particles according to their size, density and shape: 1. Effect of the outer force fields on the rotating streams of liquid (as applied to the apparatus of a hydro-cyclic type). A possibility of the appearance of peculiar resonance phenomena has been discovered. 2. The flow of a layer of liquid on a vibrating plane (the generalization of Stokes second problem as applied to the vibrational apparatus for the gravitational concentration of ores). 3. Separation of particles according to their shape at the impacts with an obstacle, which provides the basis for the creation of a ballistic separator. 4. Calculation of the parameters of a rotating stream of small thickness (as applied to the centrifugal vibrational concentrators for the extraction of small particles of rare and noble metals). 5. Improvements in hydraulic characteristics of a pulp feed-line, working in the conditions of an unstable composition of suspension. Introduction of the recommendations made it possible almost to double the capacity of the ore concentrating factory of the Kaliningrad amber industrial complex.

The work has been performed with the financial support of RFFI (grants 04-01-00053 and 05-08-01500).

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RIDDLES OF THE THEORY OF DYNAMIC SYSTEMS: ON THE BORDERLINE OF MECHANICS, PHILOSOPHY, AND THEOLOGY (DEDICATED TO THE MEMORY OF PROFESSOR P.A.ZHILIN)

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Certain fundamental regularities of the behavior of dynamic systems are discussed here. With respect to most of them it is possible to answer the question How?, but it is difficult to answer the question Why? In particular, there is a question on the universal prevalence and basic importance of the oscillatory phenomena, of the reflection of the properties of stability in the main regularities of the real world, of the extreme properties of many of those regularities, of the phenomena of self-synchronization, and etc. A belief is stated that no perfect clue to these riddles can be found within the frames of mechanics or natural sciences. This is the field of philosophy and of religion, which, from the standpoint of the natural sciences, can be regarded as an additional hypothetical global models of the Universe. The author dedicates his reflections to the fond memory of Professor Pavel Andreevich Zhilin whose creative work combined his fidelity to the mathematical rigor, his wish to comprehend the nature of things and also his conviction of the basic role of mechanics in the construction of the physical picture of the world.

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NUCLEATION AND EVOLUTION OF NANOVOIDS IN POLYSILICON AT QUASISTATIC AND FATIGUE LOAD REGIMES

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This presentation deals with theoretical models describing nucleation and evolution of nanovoids (nanoscale cracks and pores) in polycrystalline silicon at quasistatic and fatigue load regimes. In particular, a theoretical model is suggested which describes nucleation of nanoscale cracks at triple junctions of grain boundaries in polycrystalline silicon at quasistatic and fatigue load regimes. The nucleation is intiated by intergrain sliding which is hampered/suppressed at triple junctions. Also, a theoretical model is suggested describing dislocation emission from nanoscale pores in polycrystalline silicon at quasistatic and fatigue load regimes. It is shown that the dislocation emission events crucially influence evolution of nanoscale pores.

INSTABILITIES, INTERNAL MOTION AND RADIATION EFFECTS IN DYNAMICS OF BOUND SOLITON COMPLEXES IN HIGHLY DISPERSIVE SYSTEMS

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Dynamical properties of nonlinear excitations in condensed matter are strongly influenced by spatial dispersion. In crystals and microstructured solids dispersion originates from lattice discreteness. The same situation is observed in macroscopic discrete systems, e.g. arrays of Josephson junctions, systems with nonlocal interactions, nonlinear transmission lines, etc. One of universal effects, which occur in highly dispersive continuous and discrete systems, is an existence of bound multisoliton complexes. Such a soliton complex can move radiationlessly. This phenomenon can be described theoretically in the framework of partial differential equations with higher order spatial or mixed derivatives. In this contribution a stability of the soliton complex is investigated analytically and numerically in the dispersive sine-Gordon and double sine-Gordon systems. Soliton dynamics of these models can be described by the sine-Gordon and double sine-Gordon equations with additional fourth spatio-temporal mixed derivatives. A peculiarity of the continuum wave spectrum of the dispersive models consists in its single band structure. As a result of the consideration, exact static kink and wobbler solutions are found for the sine-Gordon and double sine-Gordon systems, respectively. It is shown analytically that these nonlinear excitations are stable. Solutions for moving soliton complexes are also found exactly and they have definite values of velocities. It is shown numerically that the soliton complex can be formed as a result of interaction of two fast moving kinks. These kinks radiate and loose the kinetic energy until they form the complex, which moves further with stationary shape and velocity. Vice versa, if an initial velocity of the soliton complex is less than critical one then the bound state is unstable and is dissociated into two kinks. A separately moving kink exhibits a complex dynamical behavior. At the first stage the kink with a large velocity can cause a breather creation on its wake. Translational and internal modes of the kink appear to be bound therefore its shape oscillates slightly according to a velocity oscillation. The kink emits backward a small radiation and its velocity decreases slowly. It would be finally noted that the stability properties and propagation of a soliton complex in the dispersive double sine-Gordon system exhibit similar features but its internal dynamics demonstrates a more complex behavior including resonant phenomena under composite wobbler interactions.

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NEW APPROACH IN THE MECHANICS OF PERIODIC COMPOSITES

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We consider inhomogeneous elastic body. We suppose that it represents so called periodic composite. It means that this body is composed from very many similar periodical cells with dimensions a, b, c in directions of coordinate 0_x, 0_y and 0_z respectively. We suppose that all cells have similar complex structure. At last we suppose that all cells have full contact with their neighbours, so that displacements and stresses are continuous on the bounds of cells. Bodies of this so type - periodic composites are the subject of investigations in huge papers and books. This paper is devoted to the new technology of analysis of periodic composites. This technology is based on using of so called ”basic solutions” for one cell. We formulate mixed boundary conditions for six basic problems. We prove that their solutions are periodic ones. This periodicity permute to construct six basic solutions for whole composite. At last we make up linear combinations of all basic solutions. Due to the linearity of equations of elasticity theory, they satisfy to all of them identically. We call these combinations by the name - regular expansions. For simplification of motivations and in order to get simple results we confine ourselves by consideration of the case when any cell has three planes of symmetry, which are parallel to the coordinate planes. Now we enumerate new result which can be got using new approach and corresponding way of motivation. We use regular expansions for getting effective solutions for three fundamental problems of the mechanics of composites. Firstly, we use them for getting of effective moduli of elasticity for composite. For example, we present simple formulae for these moduli. We convince reader that we get exact values of these moduli for uniform averaged stresses and strains. Secondly, we present new motivation, which leads to the homogenized problem. We prove that ”regular expansion” represents effective solution of all equations of elasticity theory for initial nonhomogenized composite if averaged stresses and strains satisfy to the homogenized equation. Thirdly, regular expansions and the boundary layer concept are applied for such formulation of force boundary conditions for homogenized problem which permits to satisfy boundary condition for initial nonhomogenized problem.

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PROTON DISORDER AND MOLECULAR CONFORMATION IN TRIIODOMESITYLENE

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This work is a part of the study undertaken on poly-substituted halogeno-methylbenzenes [1-4] to determine more precisely the correlation between the dynamical properties of the quantum methyl rotor and variations in the methyl protons localisation of the rotor hindering potential. The conformation of aromatic molecules containing a methyl group in ortho to halogen (Br, I, Cl) substitution. The triiodomesitylene (TIM) may be considered as three times di-ortho-substitued. Our calculations of the TIM conformation using density functional theory (DFT) methods with extended basis sets show that C3h and Cs symmetry are almost equally probable for an isolated molecule. They indicate that a CH bond in CH3 group is in pseudo trans position relatively to the halogen with an increase of the exocyclic CC angle. The hindering potential of each methyl group is small with $V3 = 25cm^{-1}$ and $V6 = 28cm^{-1}$. The molecular geometry found by neutron diffraction at 14 K, has a distoreted Cs symmetry close to C2v. The DFT calculations done with a model fixing this methyl orientation and relaxing all others variables has given a geometry very close to that found by neutron diffraction. The inelastic neutron scattering (INS) experiments has also found three different tunnelling excitations for CH3. Using these observables we have proposed potentials and calculed proton density probabilities that are in good agreement with the crystallographic results. Thus it seems that crystals effects are responsible for the existence of the observed distorted geometry of TIM, so that this compound is an example of a gas phase transition state, trapped in the solid state. It is a clear example of crystalline influence on a molecular conformation.

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ELASTICITY AND INTERNAL FRICTION OF AL7SIMG HYPOEUTECTIC ALLOY

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The elastic properties study of solid materials is very important for scientists and industrialists. In order to determine the elastic characteristics of various solid materials, the Impulse Excitation Technique is very and often used. The aims of this work consist to follow the elastic characteristics evolution of the Al7SiMg hypoeutectic alloy for three states: cast, quenched and quench-annealed. The shear and Young moduli were determined by two modes of vibration: longitudinal and automatic flexion. It was shown that these moduli decrease continuously but slowly while going from the cast - quenched - annealed states. During the homogenisation (quenched state), the atoms of solid solution probably migrate towards the dislocations and the grain boundaries which constitute favourable seats for the reception of points defects. This diffusion is accentuated during the annealing. This phenomenon of displacement of the atoms towards the grain boundaries causes an impoverishment of the element of solid solution inside the grains. It is known that the shear and Young moduli are closely related to the interaction energy creates by the whole of the atoms in the material. The diminution of Si atoms in the grains involves a decrease of this interaction energy. Consequently the elastic characteristics decrease of the homogenisation to the annealing.

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FLEXIBLE MECHANISM DYNAMICS

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Flexible mechanisms, also referred to as “Elastic Multi Body Systems”; (EMBS), consist of interconnected elastic and rigid bodies undergoing fast relative motions (“rigid body motions”) with superimposed small elastic deviations. Due to the gross rigid body motions, a linearization of the elastic deformations yields some special problems to be solved. The first is the so-called “dynamical stiffening”; problem which yields an additional symmetric restoring matrix in which the zero order forces and torques enter description (acceleration reactions, centrifugal effects, gravity forces etc.). The second one results from the fact that the directional derivatives (e.g. kinetic energy w.r.t. angular velocity) may yield non-orthogonal momentum directions which makes the application of analytical methods at least uncomfortable (besides the fact that its calculation for *multi* body systems is cumbersome anyway). The proposed procedure is therefore based on the *Projection Equation* in terms of subsystems, along with nonholonomic variables for the general case. Applied to rigid multibody systems one obtains a recursive [order(n)-] solution scheme which is best suited for high accuracy and for real time applications (see APM2000). One may therefore think of to omit partial linearization and to use a “Finite-Segmentation-Model” (elastic body discretization in form of finite rigid bodies). However, such kind of modeling can not really be recommended due to the immense requested number of degrees of freedom (as will be demonstrated inspecting a chain). Considering the links elastic leads to a straight-on procedure with the aid of spatial operators. The interconnected ordinary and partial differential equations along with the corresponding boundary conditions are determined with almost vanishing effort (when compared to analytical approaches). These represent the minimal form of the dynamical problem. As for the time being there is obviously no procedure available for a direct solution, we proceed to a Ritz approach once more leading to an [order(n)-] solution scheme which is easy to implement. The drawback here is the requested number of shape functions (which, however, in case of actively controlled systems can be kept small). Nevertheless, the question on how to operate the minimal form of state equations without series expansion approximation still remains challenging.

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COMPUTER SIMULATION OF SANDWICH SHEET METAL FORMING

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Stamping of sheet metal parts by means of hard punches and dies is a standard manufacturing process. Despite its broad application in car-industry, however, sheet metal stamping technology is still an art rather than a science. Thus the design of stamping process and the selection of sheet materials for a practical product are largely done on a trial-and-error basis. In computer simulation of sheet metal forming, several finite element methods such as membrane, shell and solid model are proposed. The membrane model is the simplest one. However, the membrane model is not applicable where the bending of sheets becomes significant, for example, in drawing operations. In general, the processes where the bending effect is significant are simulated by the solid model or the shell model. For the solid model, more elements are needed to describe these shell-type structures to prevent numerical difficulty so that a large ill conditioned system of equations must be solved. The shell model is more effective than the solid one although integration in the thickness direction is still needed. The paper is presented in the following order. First, we present the results of uniaxial stretch experiments for aluminium-polypropylene-aluminium sandwich sheets named as Hylites. After that, within the framework of the shell theory, we describe the elastic-plastic 2D constitutive relation for transversely anisotropic sandwich sheet taking into account the Bauschinger effect and present a brief description of axisymmetric stamping experiments for Hylites. At the end, the punch force for Hylites is numerically investigated under the hemispherical punch stretching operation by the LS-DYNA code.

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TESTING OF VISCOELASTIC CONSTRUCTIONS: MODELING BY FEM

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It is well known that the acoustical methods of non-destructive testing can successfully be applied to analyze the strength and completeness of various objects. Thus most part of civil engineering constructions may be considered as elastic and viscoelastic materials, and its state can be evaluated by the change of some acoustic characteristics of the generated acoustic wave fields, as well as such integral characteristics as natural frequencies and absorption coefficients on resonance modes. In order to generate and measure the acoustic fields there are applied piezoelectric transducers. Such devices may be considered both as actuators and as sensors in a system generating and evaluating the characteristics of acoustic fields. The piezoelectric transducers can easily be included in electric circuits, putted on constructions, and so they are very convenient to test the strength of such civil engineering objects as colons, balconies, roofs, etc.

In the present work we construct a mathematical model, which consists of a system of piezoelectric transducers and a viscoelastic structure under consideration. We give a complete finite element model of piezoelectric devices, taking into account the damping properties by original principles accepted in the software package ACELAN. We also formulate a finite element model of the analyzable viscoelastic structures. Further, we discuss the compound models of piezoelectric and viscoelastic media, and we give a separate analysis to the case of steady-state oscillations. The final part of the work contains some results of finite element simulations for piezoelectric – viscoelastic structures. In the first example we consider the cantilever viscoelastic layer with piezoelectric actuator and sensor. For Voight's model we find the viscoelastic moduli, starting from the data on a monitoring of the impedance characteristics of the piezoelectric transducers. In the next example, again for Voight's model, we monitor by piezoelectric emitter the reinforced concrete pile with prestress effects. In the last example we give the transient analysis for viscoelastic plate with a crack, when the viscoelastic material properties are expressed in the integral form using the kernel function of the generalized Maxwell elements.

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REGIONS OF POSSIBLE MOTIONS FOR A NON-SYMMETRICAL DUMB-BELL IN THE CENTRAL ATTRACTION FORCE FIELD

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For a couple of two point masses moving in the central Newtonian attraction force field the topological classification of the regions of possible plane motions is given. This classification is based on Smale's method with using the diagram of the first integrals constants of area and energy. The obtained results are represented as atlases of the typical regions of possible motions and of the regions of stability. This material is based upon work supported by the Russian Foundation for Basic Research under grant No. 05-01-00454.

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PROBLEMS OF TECHNOLOGICAL PLASTICITY THEORY

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The purpose of the paper are rigid-plastic analysis of strain fields in the neighbourhood of the features of displacement velocities field by the example of problems about the flow of rigid-plastic material on the canal with an angular point and about pressing of rigid-plastic flat bar through an oblique die.

In the problem about canal the relations defining strain field distribution in the neighbourhood of the angular point were obtained. Calculations for cases when the angular point is at rest and moving are made. The offered approach allows to describe the residual strain field in sheet details at their straightening by an angle die.

In the problem about pressing of rigid-plastic bar were investigated strain field in the neighbourhood of rigid-plastic boundaries, they are lines of discontinuity for displacement velocities field. Were shown, that these lines has considerable influence on the changes of deformations fields of particles crossing it. Residual strain field distribution in the neighbourhood of the features of displacement velocities field were obtained.

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CLOSED EQUATION FOR TWO-POINT PDF IN MECHANICS OF TURBULENCE

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This work is devoted to a formulation of a closed transport equation for a two-point probability density function of velocity and scalar variables with a special emphasis on reactive flows. The need for such an approach is demonstrated using premixed turbulent combustion as an example. Since the early works of Damkohler, Sommerfield, Schelkin, Wohl and Sokolik it became clear that that there exist at least two different regimes in turbulent premixed combustion and these regimes are characterised with different dependencies on the turbulence rms velocity u and the integral scale l_t. Laminar flame speed u_n and thickness δ_n were parameters in this description This idea was further developed by Borghi with discerning multiple flame structures with the transition between them in terms of Reynolds and Damkohler number defined also in terms of u_n and δ_n. Identification of various regimes later became some kind of a fashion and several similar diagrams had since then been proposed in terms of the same variables. At the same time, the determination of rate of combustion was and still is quite often reduced to models describing the turbulent flame speed, or similar to it mass burning rate u_t, solely in terms of u_n and u. Again, similar descriptions became fashionable which can be seen from the fact that recent review of predictive capabilities of models for u_t by Lipatnikov & Chomiak contains 350 references. (This review emphasises the dependence u_t upon δ_n, or related to the latter molecular thermal diffusivity κ, and also suggests that there exists a self-similar regime of turbulent flame propagation).

This presentation will commence with analysis of experimental data obtained in the fan-stirred bomb and SI engine in order to assess what parameters define the turbulent combustion rate. Di-tert-butile peroxide (DTBP) thermal decomposition flame is studied in the fan-stirred bomb, this flame, unlike any other reactive medium, is characterised with a single-step chemical kinetics. Unsteady flame u_t measured for this flame for varying u are compared with the literature data for the lean ethane-air mixtures having the same u_n and Lewis number. This comparison indicates that, firstly the values of u_t measured in fan-stirred bombs differ from the values in a steady-state burner, secondly the details of chemical kinetics may be important for elevated u and thirdly there exists large temporal variability from explosion to another similar to cyclic variability in IC engines.

It is argued that any model of turbulent combustion aimed at industrial application should include molecular transport properties as well as u_n. Methods of doing this are discussed, using two probabilistic models, Linear-Eddy-Model developed by Kerstein and Reference Scalar Field model by Burluka, Gorokhovski and Borghi as examples. It is shown that the latter model is capable of describing qualitatively the transition between various regimes of combustion, however, it fails to predict quantitatively the burning rates around this transition. It is conjectured that a similar drawback would be shared by any theory limited to a single-point statistical description because of difficulty of introducing molecular transport in a way valid for different combustion regimes.

Finally, it is shown that it is possible to obtain a closed equation for two-point single-time probability density function for velocity and scalars using only formal constraints such as reduction and separation properties following the ideas proposed by Ievlev. It is shown that application of this constraints results in a very simple splitting of conditionally averaged accelerations and diffusion rates. The resulting integro-differential pdf equation has non-local terms arising from pressure field while the molecular transport coefficients are contained explicitly in the local terms.

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APPROXIMATE ANALYTICAL SOLUTION FOR A MOTORISED MOMENTUM EXCHANGE TETHER ON A CIRCULAR EARTH ORBIT

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This paper discusses the mathematical transformations necessary to convert the nonlinear equation of motion for a dumb-bell motorised momentum exchange tether on a circular Earth orbit to a form suitable for approximat analytical solution. A perturbation parameter is introduced in an algebraically consistent manner so that the equation can be solved using the method of multiple scales. The method is applied by means of symbolic solver software cowritten by one of the authors, and the solution structure is discussed, particularly with regard to the governing differential equation and the physical system upon which the model is based. Some numerical results are given in addition.

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FLUIDIZATION REGIMES OF FINE AND ULTRAFINE POWDERS

ANTONIO CASTELLANOS JOSE MANUEL VALVERDE

Some years ago we demonstrated that gas-fluidized powders may transit from solidlike to fluidlike fluidization prior to bubbling, shedding light on a long standing controversy on the nature of "homogeneous" fluidization. We show here that fine and ultrafine powders may also transit from the fluidlike state to elutriation, with full suppression of the bubbling regime. We provide a unifying description of the different fluidization regimes based on simple phenomenological equations in which particle agglomeration due to attractive forces is a key ingredient. This analysis is also applicable to the important case of liquid-fluidized beds of large beads.

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COMPACTION OF FINE POWDERS: DISCRETE ELEMENT METHOD SIMULATIONS

FRANCISCO ANTONIO GILABERT JEAN-NOEL ROUX
ANTONIO CASTELLANOS

Discrete element (or molecular dynamics) simulations are used to investigate the structure and mechanical properties of a simple two-dimensional model of a cohesive granular material. Intergranular forces involve elasticity, Coulomb friction and a short range attraction akin to the van der Waals force in powders. The effects of rolling resistance at intergranular contacts are also studied. The microstructure of the cohesive packing is shown to depend sensitively on the assembling procedure which is applied to the initially isolated particles of a granular gas. While a direct compression produces a final equilibrated configuration with a similar density to that of cohesionless systems, the formation of large aggregates prior to the application of an external pressure results in loose packings, with a structure similar to that of ballistic aggregation clusters. Specific features of force networks, coordination number, and density heterogeneities due to cohesion, and their change as function of loadind and unloading paths, are characterized.

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ON THE STABILITY OF SOLITARY WAVES

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The Maslov index is a topological property of orbits of finite-dimensional Hamiltonian systems. In this talk, a numerical scheme is developed to compute the Maslov index in the exterior algebra representation. The theory is illustrated by application to an eigenvalue problem associated with the stability of solitary waves.

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COUPLING OF TRANSLATION AND INTERNAL MODES OF SOLITONS IN HIGHLY-DISPERSIVE NEAR-DISCRETE MEDIA

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The strong spatial dispersion in crystals can change drastically dynamic properties of nonlinear excitations. A typical example of the excitations in an imperfect lattice is a dislocation, which can be considered as a soliton (kink) of the Frenkel-Kontorova model. In the system with the strong dispersion solitons exhibit a complex intrinsic structure with internal degrees of freedom. To succeed in analytical description of the novel effect a fourth-order spatio-temporal derivative is added to the usual sine-Gordon equation. This approach allows us to find exactly a total spectrum of linear excitations of the kink. It consists of a discrete set of frequencies of internal modes and a single band spectrum of continuum waves. It is shown analytically and numerically that a translational motion of a single soliton in the dispersive system is accompanied by exciting its internal dynamics and creation of the breather state, and by generation of the radiation. It is demonstrated that a fast motion of two identical solitons leads to a formation of the bound soliton complex, which is stable and can move radiationlessly in the highly dispersive sine-Gordon system.

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STABILITY OF ELASTIC FILMS IN PROXIMITY TO A RIGID PLATE

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Thin films have revolutionized the electronics industry, allowing for the development of magnetic and optical memory devices, improved integrated circuits, flat-panel displays, and a host of other inventions. With the ability to pattern substances such as silicon and polymers on the nanometer scale, thin films are now being harnessed for nano and micro-scale applications in the fields of electronics, chemistry, biology, and biophysics.

Due to the wealth of applications, the stability of thin films is important. In photolithography and coatings, for example, it is necessary to be able to deposit a stable film with uniform thickness. For such a system, instability occurs as a result of competition between the stabilizing bulk and superficial energies and the destabilizing interaction energy between the film and contactor. In general, surface instabilities are undesirable. However, such instabilities are now being used to advantage in the techniques of soft lithography and atomic force microscopy-assisted electrostatic lithography to generate precise, micrometer-sized patterns in polymers.

In this paper, we study the stability of a thin elastic film bonded on a rigid substrate, when it is brought to the proximity of a rigid plate. The attractive van der Waals forces between the rigid plate and the film surface tend to destabilize the film, giving rise to film deformations of highly complex form. We formulate the problem as the minimization of total system energy, which consists of the strain energy in the film, the surface tension potential, and the van der Waals interaction potential. The first variation condition of this minimization problem leads to the equilibrium equations for the film. The equilibrium equations have a trivial solution branch, which corresponds to homogeneous deformations. When the rigid plate is sufficiently close to the film surface, the van der Waals forces are large enough to destabilize the homogeneous deformations, and a non-trivial solution branch, corresponding to non-homogeneous deformation, bifurcates off the trivial solution branch. Such a bifurcation solution branch is studied by solving the linearized equilibrium equations. The critical value of the gap length between the plate and film surface, at which the non-trivial solution first emerges, gives the bifurcation point. Moreover, the structure of the non-trivial solution of the linearized equilibrium equations reveals the possible deformation patterns of the film when the homogeneous deformations become unstable. It is found that both two-dimensional solutions and three-dimensional solutions are possible, depending on the material properties and geometry. Finally, when multiple solutions exist, a detailed stability analysis is carried out to compare the energies associated with these solutions. The solution with lowest energy is deemed to be most stable, and thus most likely to be observed in the experiment.

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DYNAMICS OF TWO-DIMENSIONAL LONG INTERNAL GRAVITY WAVES IN A THREE-LAYER FLUID

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Three-layer stratification is proved to be proper approximation of sea water density profile in some basins in the World Ocean with specific hydrological conditions. Such a medium is interesting from the point of view of internal gravity wave dynamics, because in the symmetric case it leads to disappearing of quadratic nonlinearity when described in the framework of weakly nonlinear evolutionary models, that are derived through the asymptotic expansion in small parameters of nonlinearity and dispersion. In this situation the nonlinear transformation of the internal wave disturbances is determined mainly by the influence of the next order cubic nonlinear term in asymptotic series, and the cubic nonlinearity coefficient can have either sign depending on the layer depths (in contrast to traditional two-layer approximation, for which cubic nonlinearity is always negative). And therefore new physical effects in the wave dynamics are possible.

In the this study the analysis is presented of the dynamics of long internal gravity waves propagating in a three-layer medium, for which the Boussinesq approximation is valid. The investigation is carried out in the framework of improved mathematical model describing the transformation of internal wave fields generated by an initial disturbance or by an external forcing. The model is based on the program complex for the numerical simulation of the full two-dimensional (vertical plane) governing equations for incompressible stratified fluid; it includes nonlinearity, effect of Earth rotation and inhomogeneous bottom relief, as well as the influence of barotropic tidal flow.

One of the preliminary objectives of the present study was the modernization of the computational algorithms to make the complex possible to use on cluster consisting of multiprocessor (SMP) nodes. To solve this problem we used the hybrid programming approach: MPI technology is used for inter-node communication and OpenMP for parallelization inside of each SMP node.

In the framework of modified program complex the evolution of internal localized initial disturbances (of different polarities) is studied. Qualitatively different nonlinear wave regimes are shown. The processes of developing of long-living nonlinear localized quasi-stationary (solitary waves) and non-stationary (breathers, or oscillatory wave packets) waveforms are demonstrated. The results are compared to those following from the weakly nonlinear evolutionary models (Korteweg de Vries and Gardner equations).

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WAVE PROPAGATION IN A ELASTIC CYLINDRICAL SHELL LOADED BY A VISCOUS FLUID

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Analysis of wave propagation in an elastic cylindrical shell filled with a fluid is a classic problem in stationary structural acoustics. In the most publications on this subject, a classic thin shell theory and a standard model of a compressible fluid (an acoustic medium) are used. However, in some technical applications, the viscous effects in a fluid may be pronounced. The research reported in this paper is aimed to study the influence of viscosity on wave propagation in an elastic cylindrical shell. The theory of elastic cylindrical shells suggested in reference [1] is used for the analysis of relatively low-frequency vibrations. The theory proposed by A.N. Guz (ref. [2]) is used for description of behaviour of a viscous fluid. Unlike the standard modelling of an acoustic medium by a scalar potential, the vector potential is introduced in this theory. Therefore, dynamics of a viscous fluid is described by equations for a scalar and a vector potential. The dispersion equation is derived. The efficient numerical technique of solving this equation is developed, in which viscosity parameter is used as a small perturbation parameter. Dispersion curves are thoroughly analyzed and compared with those obtained for a duct, bounded with a Kirchhoff plate wall and a rigid one (these results are presented in [3]) as well as with those for a shell filled in with an acoustic medium. Several similarities and differences between locations of dispersion curves in various cases are identified and explained in the course of analysis. The detailed parametric study of the influence of several parameters, e.g., fluids viscosity and the parameters of elastic shell, on location of dispersion curves is performed.

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A NOTE ON AN ANALYTICAL SOLUTIONS FOR TWO-DIMENSIONAL CONVECTION-CISPERSION EQUATIO

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Introduction

We study contaminant transport which has become important for scientist working in environmental engineering. Analytical solutions of the mathematical models describing pollutant transport are rarely possible if important hydraulic/chemical processes are considered together; solutions taking into account nonlinear adsorption/desorption have been found only for a one-dimensional advection-dispersion problem.

Analytical solutions, if they are possible, are preferable to numerical ones since the latter often need correcting schemes to avoid truncation errors, which is not negligible in case of the advection-dispersion equation with reactive contaminants. In this note we give analytical solutions for the transport equation in cylindrical geometry.

The model proposed in this paper is able to predict the concentration profile without assuming infinitely large column or box and furthermore computes solute concentration in all the domain even in non-stationary case.

Problem formulation

A soluble pollutant can be transported in the groundwater system by fluid motion through the void space and dispersed by two processes mainly: molecular diffusion and hydrodynamic dispersion. Considering a chemical reaction represented by first-order kinetics, and a solute undergoing linear-sorption we have:

$$R_d \frac{\partial C}{\partial t} + u\frac{\partial C}{\partial z} = = D_R\left(\frac{\partial^2 C}{\partial r^2} + \frac{1}{r}\frac{\partial C}{\partial r}\right) + D_L\frac{\partial^2 C}{\partial z^2} - k\,C \quad (1)$$

Boundaries and initial conditions are necessary to uniquely solve the problem. We assume the impermeability of the column wall. We shall formulate three different problems for the remaining initial and boundary conditions and describing the pollutant release, in order to cover different possible experimental configurations:

Case 1 $C(r,z,0) = \frac{\sigma(r)}{n}\delta(z)$

Case 2 $C(r,0,t) = C_0(r)H(t),\ C(r,z,0) = 0$

Case 3 $C(r,0,t) = C_0(r)[H(t) - H(t-t_0)],\ C(r,z,0) = 0.$

$\sigma(r)$ is the superficial mass distribution, n is the macroporosity of the soil column and C_0 is the concentration of contaminant in the inlet section.

To solve this partial differential equation, we consider a particular Dini-Bessel series expansion of the concentration function:

$$f(r) = A_0 + \sum_{k=1}^{\infty} A_k\ J_0(z_k^{(1)} r) \quad (2)$$

1: Impulsive Pollutant Release

The concentration function in terms of the coordinates (r,z,t) is:

$$C(r,z,t) = \frac{A_0\sqrt{Pe_L}}{2\sqrt{\pi t}}\exp\left[-Kt - Pe_L\frac{(z-ut)^2}{4\,t}\right] + + \frac{\sqrt{Pe_L}}{2\sqrt{\pi t}}\sum_{k=1}^{+\infty} A_k \exp\left[-\left(\frac{\eta[z_k^{(1)}]^2}{Pe_R} + K\right)t - Pe_L\frac{(z-ut)^2}{4\,t}\right]\times \times J_0(z_k^{(1)} r) \quad (3)$$

The zero order term, represents the well known result of an equivalent one-dimensional problem.

2: Continuous Pollutant release

We analyze the effect on the solution due to a continuous inlet of contaminant into the top of the column: $C(r,0,t) = C_0(r)H(t)$.

The solution is :

$$C(r,z,t) = \sum_{k=0}^{+\infty}(A_k/2)J_0(z_k^{(1)} r)e^{(\frac{zuPe_L}{2})}\times \times\left[e^T \mathrm{erfc}(Q+S) + e^{-T}\mathrm{erfc}(Q-S)\right] \quad (4)$$

$$Q = (z/2)\sqrt{\frac{Pe_L}{t}}, T = = z\sqrt{\frac{u^2 Pe_L^2}{4} + \eta[z_k^{(1)}]^2\frac{Pe_L}{Pe_R} + KPe_L}, S = = \sqrt{\frac{u^2 Pe_L t}{4} + \frac{\eta}{Pe_R}(z_k^{(1)})^2 t + Kt} \quad (5)$$

3: Finite-Pulse Pollutant Release

We study the influence on the solution due to a pulse injection of contaminant in the top of the column.

By the superposition property of linear PDEs, we get:

$$C(r,z,t) = \tilde{C}(r,z,t) \text{ for } t < t_0,$$

$$C(r,z,t) = \tilde{C}(r,z,t) - \tilde{C}(r,z,t-t_0) \text{ for } \ t \geq t_0$$

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ANALYTICAL RESULTS FOR THE PLECTONEMIC RESPONSE OF SUPERCOILED DNA

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Mechanical properties of the DNA molecule play an important role in the biology of cell. Using various nanotechnologies, it is now possible to apply tensile [1] and torsional stresses [2] onto an isolated DNA molecule. We model the DNA molecule as an elastic rod with bending and twist rigidities, subjected to external tension and moment applied at its two clamped ends. We study the equilibrium of such a rod taking into account the impenetrability constraint, and focus on plectonemic geometries.

Numerical solutions [3] of this boundary value problem have shown that purely elastic models can reproduce the supercoiling response of the DNA molecule. Using a variational approach, we derive analytical formulae for the elastic response of the plectonemes, which extend the former numerical results and provide in addition the value of the repulsion force between the two coiled molecules. We compare this calculated repulsion force to that predicted by classical electrostatic potentials, such as Debye-Huckel's.

This variational formulation provides a natural framework to study the influence of thermal fluctuations on the behaviour of the molecule: a statistical mechanics treatment of our model allows us to reproduce the entire experimental response curve, from worm-like to supercoiled configurations.

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REFLECTION OF INTERNAL WAVES: THEORY AND EXPERIMENTS

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One often refers to the reflection of internal gravity waves on sloping topography to explain mixing phenomenon in the oceanic interior. When the incident angle corresponds to the angle of the slope, the linear theory predicts that the reflected beam has an infinite amplitude. We show analytically how this singularity can be healed when nonlinearity, dissipation and transience are taken into account.

Moreover, we will present results of several laboratory experiments to make quantitative comparisons with theoretical predictions. These experiments (standard and synthetic Schlieren or PIV) conducted either in our laboratory or in the Coriolis plateform in Grenoble allow to exhibit quantitatively the role of nonlinearities during the reflection process.

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ON THE CALCULATION OF DISLOCATION KINETICS PARAMETERS OF PLASTIC DEFORMATION USING THE RESULTS OF DYNAMIC TESTING OF METALS

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The problem on the calculation of microstructure parameters of dislocation kinetics is examined for plastic deformation of metals using results of macroscopic experiments. The diagrams of dynamic deformation of metals corresponding to various loading rates are used as initial experimental information. The tests on the attenuation of elastic precursor at the shock wave loading of plane specimens have serve as second information, which is used to control the adequacy of model constructions. The reverse approach is possible, when the first and the second experiments change the roles, but such way is more labour-intensive. The known Orowans correlation serves connecting-link between the characteristics of the dislocation motion and reproduction in the micro level and the macroscopic approach. The problem on the kinetic parameters calculation is scrutinized for two different formulations: with the using of (1) the Prandtl-Reuss model of elastic plastic medium and (2) the Godunov-Romenskii model of nonlinear Maxwell medium. In the first case, the unknown parameters of dislocation kinetics are included immediately into the equation for the plastic deformation rate, and their calculation problem is solved enough simple. In the second case, the connection between unknown parameters and the process of irreversible deformation is more complex and mediate: known parameters are included into the interpolation formula for the relaxation time of tangent stresses (or into the formula for nonlinear Maxwell viscosity), and the relaxation time appears in the coefficients of the differential equation system. In the bother cases, the way of the kinetic parameter determination is reverse problem and comes to the iteration sequence of direct problems. During each step of iteration procedure, firstly the numerical experiment of the dynamic loading of uniform roods is carried out. At the same time the tough testing machine, when the deformation history with constant rate is specified, and the loading is traceable variable. The calculation deformation curve is constructed using the results of numerical experiment and is compared with the corresponding curve obtained from physical experiment. Then in accordance with the certain algorithm, the choice is realized for new values of kinetics parameters ensuring the calculation and experimental deformation diagrams coincidence. The described process is repeated until the best meansquare approximation will be found. The globality of found extreme is controlled when various initial approximations for kinetic parameters are chosen. The comparison the numerical values of the kinetic parameters with their theoretical evaluations for some metals shows that they can differs in several order. At the same time, the calculation diagrams describe corresponding experimental curves entirely satisfactorily. Furthermore, obtained results demonstrate that the plastic deformation kinetics model accurate on the base of the first experimental data reflect far from always adequately the second experimental information.

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AL WAVES IN A ROTATING CYLINDER PARTIALLY FILLED WITH A VISCOUS FLUID AND STABILITY OF ROTOR SYSTEM

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It is well known that rotors and spin-stabilized projectiles carrying liquid payloads can suffer dy-namical instability (Stewartson K., 1959; Rumyantsev V.V., 1964). A rotating body of fluid is capable of supporting a unique type of wave motion through the

action of the Coliolis force. Such waves are usually called inertial waves or gyroscopic waves. They are found in many contexts, including the oceans and atmosphere. We conduct a theoretical analysis of wave processes in rotating layer of fluid and influence of resonant excitation of waves on stability of rotor system. The mathematical problem for flow in rotating right circular cylinder admits solution contained auto-model solution and solution as a superposition of wave modes. The wave mode can be represented as a sum of six screw harmonic: the two forms central core of flow, other forms viscous boundary layers. Dispersion relations of inertial waves in layer are studied in details. The obtained solution is used in problem of stability of a rotor with fixed point. The rotor, which angular velocity is main-tained constant by a special drive, is partially filled viscous fluid. D-curve dividing the parameters plane into domains with different degree of instability is plotted. The work was supported by the RFBR (project No. 06-01-00270).
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ABOUT ONE PROBLEM DYNAMICS MASSIVE CONSTRUCTIONS

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It is offered decision problem of the making and analysis phase portrait massive constructions, executed from concrete. Under the known incrementation displacement dependency amplitudes of the oscillations from frequency with use Fourier-analysis in condition initiated seismicity is fixed. It is shown that correlation between incrementation of the displacement and his strain has opening and closing area. Herewith opening part is conditioned elastic deformation, but opening - a deformation creep, fixing with use of the theory inherited creep solid. The calculating procedure are realized on example Toktogul hydroscheme.
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PENDULUM EQUATIONS WITH NON-MONOTONIC TWIST

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For dynamical systems with one degree of freedom which have nonlinear terms in the form of trigonometric polynomial of degree $n > 1$, period T of motion along closed phase curves may be a non-monotonic function of energy E. In this case there are energy levels for which first derivative of function $T(E)$ is equal to zero. These levels are called degenerate. Let us call the order of the first non-zero derivative of $T(E)$ as the order of degeneracy $j, j > 1$. For maximal order of degeneracy j_{max} it is shown that $j_{max} = n$, $n > 1$.

For polynomials of degree 2 to 5 the values of coefficients are presented for which $T(E)$ is a non-monotonic function and also values for which $T(E)$ has extremum of the maximal order of degeneracy.

When dynamical system of this type is under time-periodic perturbation, such extrema cause the existence of degenerate resonances. The question of the structure of degenerate resonance zones is considered theoretically using analysis of averaged systems. Numerical study of Poincaré map gives a good compliance with theoretical analysis of bifurcations.

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STABILITY OF PLAIN 4-ATOMIC SYSTEM.

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The equilibrium configurations of plain rhombic 4-atomic system are considered in the presented work. Interaction of two atoms is described by Morse potential. The dependences of the quantity of equilibrium positions and their stability on the dimensionless parameter of the interatomic potential were determined. The dependence of the force, applied to one pair of particles on the distance between them was obtained. The value of the parameter, in view of which the bifurcation occurs, was determined both theoretically and with the help of the numerical experiment. The graph, showing the relation between the dimensionless parameter and the energy, required to convert the system from one equilibrium position to another, was obtained. The values of the parameter required to stabilize the square equilibrium configuration were determined both theoretically and numerically. The coincidence of the point, where the square equilibrium configuration loses its stability, and the point of bifurcation was ascertained and explained.
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CRITERION OF DYNAMIC OPTIMIZATION OF MECHANISMS WITH NONLINEAR CHARACTERISTICS UNDER COMPLEX EXCITATION

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One of ways of decrease of dynamic loadings drive mechanisms which are carrying out periodic movement of output link, is dynamic unloading with the help of the elastic elements established between a target part and the frame of the machine [1]. In development of work [2] in given work the problem of a choice of parameters dynamic unloader is solved optimization at the account of the vibrations arising because of kinematic excitation, technological loadings and impacts at impact in clearances.

To the accepted dynamic model the following nonlinear differential equation is given in dimensionless kind:

$$q_1'' + p^2 \left[\vartheta/(\pi p) q_1' + q_1 - 0.5\Delta_1 \mathrm{sign} q_1\right] \times \times \eta\left(|q_1| - 0.5\Delta_1\right) = W(t), \quad (1)$$

where $q_1 = q/r$; $p = k/\omega$; $\Delta_1 = \Delta/r$; $W = Q/\left(mr\omega^2\right)$; q is the coordinate of input link, a stroke corresponds to differentiation on a angular of turn of the main shaft ($\dot{q}_1 = q_1'\omega$, $\ddot{q}_1 = q_1''\omega^2$), η is step function.

Then function $W(\varphi)$, proportional to the generalized force, can be submitted as

$$W(\varphi) = -(\cos\varphi + \lambda\cos 2\varphi) + g/(r\omega^2) - f(\varphi) - \quad (2)$$
$$-p_0^2(s_0 + 1 + 0.25\lambda - \cos\varphi - 0.25\lambda\cos 2\varphi),$$

where $p_0^2 = c_0/m$, $s_0 = y_0/r$, $f(\varphi) = F(\varphi)/(mr\omega^2)$, y_0 is size of preliminary deformation of an elastic element of unloader, $F(\varphi)$ is external force, g is acceleration of free falling, pulse indignation from external force we shall accept in the form of a half wave of a sinusoid $f(\varphi) = f_* \sin[\pi(\varphi - \varphi_1)/(\varphi_2 - \varphi_1)]$, at $\varphi_1 \leq \varphi \leq \varphi_2$, where φ_1, φ_2 are corresponds to the beginning and the end of a puncture; $f_* = F_{max}/(mr\omega^2)$.

For check of efficiency of the developed technique of decrease of vibroactivity the drive of needle table computer modeling was carried out on the basis of the decision of the differential equation (1) numerical method.

Optimize dynamic synthesis of unloader is multi-criterion problem. For comparison of dynamic characteristics of modes the following criteria are offered: 1) the criterion describing root-mean-square value of dynamic reaction, enclosed to needle table; 2) the criterion describing root-mean-square value of the moment, transmitted on the main shaft of the machine; 3) the criterion describing root-mean-square value additional acceleration, caused by vibrations; 4) the criterion describing relative total duration of sites of break of kinematic contact because of clearances.

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CONSTITUTIVE EQUATIONS FOR SOFT SHELLS WITH NETWORK MICROSTRUCTURES

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The network shells made of quite flexible elastic filaments are the subject of studying in the present work. The Lagrangian coordinates on the shell are introduced by means of two sets of the curves determined by cellular structure of the shell. As a strain measures of the shell the relative elongations of these curves and also changing of a corner between them are chosen. For various kinds of the cells typical for products of the textile industry, the density of potential energy of the appropriate shell is expressed as function of their deformations. The required constitutive equations are received from a condition of equality of work of interior stresses of the shell, on the one hand, and variations of its potential energy, on the other hand, at any virtual moving of the shell.

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DEFORMATION AND INSTABILITY OF HOLLOW POLYMER PARTICLES UNDER SWELLING

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The benefits of using hollow spheres in different fields, for example, as aqueous dispersions are discussed in [1]. One of the perspective methods of producing such particles is based on a core-shell technology. The procedure includes a stage which can be modeled as a swelling an elastic sphere under internal pressure. We present the results on modeling the deformation of hollow polymer particles at this stage. We study the infinitesimal instability of a thick spherical shell within the framework of three-dimensional nonlinear elasticity. The critical values of internal pressure are evaluated and corresponding buckling modes are obtained. We show that the instability depends on the presence of descending part on the tension-extension diagram of the material from which the particle is made. We discuss the mechanisms of collapse (fracture) of the hollow particle at the stage of swelling, depending on material properties.

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THE THEORY OF SHELLS AND MICROPOLAR BODIES: DEVELOPMENT OF P.A.ZHILIN'S IDEAS

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We present some recent results on the theory of shells and the $3D$ micropolar elasticity that are based on the papers by Zhilin [1, 2, 4], Altenbach and Zhilin [3, 5], and Altenbach et al [6]. In the work by Zhilin and his coauthors various problems of linear and nonlinear shell theories were discussed as well as some problems of the tensor calculus. One of the problems is the formulation of constructive definition of local symmetry group for a shell with regard for the different nature of strain measures of a shell. A closely related problem is the development of tensor invariants theory for the axial and polar tensors.

We present some results on the local symmetry group for a shell and $3D$ micropolar body as well as results in the shell theory based on the works [2, 3].

A new definition of the local symmetry group is introduced for the micropolar shell. It is based on the invariance of the elastic strain energy function with respect to such transformations of the reference configuration which are indistinguishable in terms of response during experiments. We consider only those diffeomorphisms that preserve the location of a common point of the shell and its tangent plane at this point. The relations can be written in terms of four tensors and these quadruples form a local symmetry group. The response function should be invariant with respect to such local transformations of the reference configuration that are formed by the elements of the local symmetry group. The definitions of surface isotropic and orthotropic shells are given and the constitutive equations are presented.

Another alternative definition of the local symmetry group is given for a shell where we take into account the dependence of the strain energy surface density on the structure curvature tensor. Here the local symmetry group is formed by triplets of tensors.

The $3D$ micropolar elasticity is also considered and the local symmetry group is constructed. Now we take into account that the bending measure of pseudotensor and its transformations differs from the strain measure. Note these results closely relate to the modified theory of tensor invariants developed in [4].

The universal deformations of micropolar shell are introduced. The universal deformations are solutions of a static problem which satisfy the equilibrium equations for any constitutive equation of orthotrophic or isotropic shells.

Zhilin's work [2] on the nonlinear theory of shells was preceded by his paper [1] in which a geometrically linear variant of the theory of Cosserat shells has been developed. We generalize the model [1] to the case of a shell with continuously distributed dislocations and disclinations. For this problem of mechanics of shells with defects, the statics-geometrical analogy for a case of a shell with defects is obtained and a principle of duality is formulated that establishes mathematical equivalence of two completely different in physical formulation static problems of shells.

This paper is based in part on the results [7, 8, 9].

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ON THE FEM MODELLING OF NANOFILM HELICAL COIL

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We present some recent results on the finite element modelling of of the semiconductor nanofilms, nanotubes and springs made of semiconductor nanofilms. One of the perspective method of producing such nanostructures was proposed by Prinz. One of the produced nanostructures (helical coil) is perspective for mechanical experiments. The aim of this paper is to propose several simple mechanical models for helical coil and compare these models with the results of FEM modelling by using ANSYS package. Natural frequencies of a micro-sized helical coil were investigated. The applications of proposed numerical experiment to the predictions of the mechanical properties of nanofilm is discussed.

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ELASTIC SHEAR WAVES IN BIMODAL MATERIALS

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Equations that describe dynamic processes in materials differently resistant to dilatation and pressure were obtained. It was shown that presence of damages causes quadratic nonlinearity to appear during shear wave propagation in the medium (in the case of shear wave propagation in ideally elastic medium the smallest nonlinearity for the shear oscillations would be of the third order). It was shown that bimodality of the material makes generation of second harmonic of shear wave possible. The basics of generation of second harmonic mechanism were discovered. Dependencies between amplitudes of waves that propagate with main and doubled frequencies on the parameters of material damage were established. Typical length on which energy swaps from the main wave to the second harmonic was obtained, which gives a possibility to evaluate the parameters of material damage. On the basis of the constructed mathematical model with the help of experimental researches dependence between the parameter of damage and plastic deformation was obtained. On the basis of research of the profile of Riemannian wave an analysis of plane shear wave propagation in damaged and undamaged materials was conducted. It was shown that the profile of Riemannian wave is being distorted during propagation. This phenomenon can be observed both in the medium with quadratic nonlinearity and with cubic nonlinearities. Parameters of wave turnover point for damaged and undamaged materials were found. Comparison of these parameters permits the conclusion that the damage of the material significantly contributes for the values of parameter of damage being in the range . For the values of parameter of damage less than damaged material behaves like undamaged. It was shown that in a nonlinear approximation the equation of dynamics of damaged medium with couple stresses admits solution in the form of stationary wave of deformation periodic and solitary (soliton), parameters of which greatly depend on the coefficient of material damage. Dependencies between the parameters of stationary waves on the parameters of material damage were analyzed. These discovered dependencies can be put at the basis of acoustical method of diagnostics of damaged material.

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SPECTRA OF SURFACE DISPLACEMENTS AND H/V RATIO IN PROBLEMS OF SELECTION OF WAVE MODES

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The structures of the wave field, amplitude-frequency characteristics, which are an important in nondestructive testing, are studied. Also information characterizing the structure of the wave field is useful for vibroprotection design. We consider time-harmonic wave motion generated by surface load. In simple cases such as a load applied to the faces of the free elastic layer the boundary-value problem are solved by an application of the Hankel transform technique, and an evaluation of the in-verse transform by contour integration and residue calculus. The wave field in elas-tic layer in far zone can be expressed as a sum of normal modes. In the present pa-per, an investigation of the influence of elastic and interfacial properties upon the spectrum of surface displacements and H/V ratio is presented. The effects of some parameters upon amplitude-frequency curves of surface displacements are analysed. Practical implications of the use of the horizontal to vertical component ratio (H/V-ratio) to study the subsurface structure and to select the mode are discussed. The energy balance (the energy distribution between different propagating modes) is considered in details. The work was supported by the RFBR (project No. 06-01-00270).

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SPATIO-TEMPORAL DYNAMICS OF BOUND STATES IN FARADAY RIPPLES: EXPERIMENTS AND NUMERICAL SIMULATIONS

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It was found in experiment that topological defects arising in a tetragonal lattice formed by orthogonal standing waves parametrically excited on the surface of a viscous liquid (Faraday ripples) can form bound states. It was shown that there exist two types of such bound states: a bound state of two topological charges having the same sign (type 1) and having opposite signs (type 2). Type 1 bound states appear at side walls and disappear either at side walls or as a result of annihilation with defects of opposite sign. Type 2 bound states arise when a bound state of type 1 induces in an orthogonal wave two defects having opposite charges. Bound states of type 2 are formed far from the boundaries and have limited life time. Processes occurring in the course of formation of bound states were modeled numerically by two coupled Ginzburg-Landau equations. It was found, for example, that in type 1 bound state the distance between the topological charges is determined by group velocity of the waves: with increasing velocity, the size of the bound state grows from zero to the size of the system. Exactly this dependence was observed in experiment. It was revealed that, as supercriticality (amplitude of parametric forcing) is increased, spatio-temporal chaos of bound states of two types arises in Faraday ripples. Experiments demonstrated that the number of topological defects far from side walls can be reduced by periodically modulating the frequency of parametric forcing. The motion of a single topological defect at pump frequency modulation was studied. It was found that periodic modulation of pump frequency changes the trajectory of defect motion: small-scale walks arise against the background of smooth motion. The effect of a reducing number of defects that may appear unexpected at first sight may be attributed to the fact that, due to wandering, the defects of opposite topological charges generated at side walls annihilate effectively and decrease in number in the central region.

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GENERALIZATION OF TECHNICAL THEORIES OF NONLINEAR CREEP ON AN ENDOCHRONIC CONCEPT

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The basic technical theories of nonlinear creep are analysed and generalized in an analytical kind on base of endochronic concept: the theory of ageing (time hardening), the theory of fluidity and the theory of deformation hardening with degree functions of creep by Baily and Norton. In a scale of introduced time the modified equations of creep have a canonical kind of a quasy-linear integrated equation with a determining function such as Baily. The scale (measure) of generalized time has a "simple" (not dependent on current time) degree kind with an exponent expressed through exponents of functions by Baily and Norton. Such equations give an opportunity of more full and unified description of nonlinear processes. Generalization of scale is executed by its representation as a linear integrated functional, hierarchically dependent on degree scale - function. The given generalization allows to describe the creep of media with accelerated or slowed down responses - hardening and dishardening, and, in general, enables us to describe multiphasic behaviour of media with non trivial memory.

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STOCHASTIC NON-NORMAL DYNAMICAL SYSTEM FOR SUBCRITICAL TRANSITION

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The effects of stochastic perturbations on a non-normal dynamical system near bifurcation point are investigated. By using the transformation of variables we identify a "slow" variable that determines the global evolution of the non-normal dynamical system with two variables in the subcritical case. We apply an adiabatic elimination procedure to derive a closed stochastic differential equation for the "slow" variable which dynamics is determined along one of the eigenvectors of full system. We obtain the stationary solution of the corresponding Fokker-Planck equation and show that an increase in the intensity of the multiplicative noise leads to qualitative changes in the stationary probability density function. The later can be interpreted as a noise-induced phase transition. We illustrate our results by using the model for a stochastic galactic dynamo. By a numerical simulation of the dynamical system with two variables, we show that the qualitative behavior of the "empiric" stationary pdf of "slow" variable to be accurately predicted by the stationary pdf of the reduced system.

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SOLVING TWO- AND THREE-DIMENSIONAL ELASTIC PROBLEMS BY MODIFIED BOUNDARY ELEMENT METHOD

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A modification of the boundary element method is proposed, with the technology of paralleling primordially built in on the algorithmic level. The main difference from the classical technique [1, 2] is as follows. In the boundary element method an influence point is fixed, and then the effect of each boundary element on the variation of the physical or mechanical characteristics at this point is determined by the numerical integration of the influence functions components. In the approach proposed, the influence point is taken arbitrary, and fixed is the most convenient special element over which analytical integration of the influence function components is made one time resulting in the functions of the coordinates of an arbitrary influence point. It has been evidenced that, for any boundary element and any influence point there is a point for which the integrals over the special element have a simple relation with the integrals for the initial element and the initial point. Thus, instead of going over all boundary elements with numerical integration around a fixed influence point, here one goes around influence points for the fixed special element, which are determined by the found transformation. For two-dimensional problems most convenient special element is the line segment lying on a coordinate axes with one end at the origin, and for three-dimensional problem the triangle lying on a coordinale plane with one apex at the origin. For these special elements elementary analytical formulae common for any mechanical or physical properties and for any problem have been derived as integration results. The formation of the matrix of the resolving system and then the finding of displacements, strains and stresses in the interior region is made simply by substituting different coordinates of influence points into the elementary functions obtained. These operations admit absolute paralleling. As the solutions have been obtained in the form of analytical expressions satisfying the principal equations of mathematical physics, one can correctly calculate physical and mechanical characteristics determined in terms of the derivatives of desired solutions (strains, stresses, stress gradients, heat flows etc.). A comparison was drawn between problem solutions obtained by the technique proposed and those obtained by the classical boundary element method. The computational speed proves to be much higher in the former case. By the example of elementary test problems, quick convergence of numerical solutions to the analytical one in terms of the number of boundary elements has been demonstrated.

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ON THE FREE VIBRATION OF THE CYLINDER SHELL PARTIALLY PROTRUDING ABOVE THE SURFACE OF THE LIQUID

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The problem of free oscillations of the cylinder shell partially protruding above the surface of the liquid is considered in the rigorous mathematical statement. The exact analytical solution

of the problem is constructed. The dispersion equation basing on the exact solution is obtained. The representation for the eigen functions is obtained.

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NEW PHASE NUCLEATION AT THE INITIAL STAGE OF STRESS-INDUCED PHASE TRANSFORMATIONS

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We describe an initial stage of stress-induced phase transformations due to the multiple appearance of new phase nuclei. We derive the relationships for the determination of the shape, orientation and volume concentration of the interacted nuclei. We show that even in a case of isotropic phases there is a variety of behaviors. Depending on a deformation path and material parameters, the nuclei of different shapes may appear. We consider multiple appearance of new phase ellipsoids, plane layers, and cylinders. We construct resultant transformation surfaces in strain space and average strain-stress diagrams on the path of the phase transformation. We study how the shape of the transformation surface and the type of the nuclei depend on material parameters. We relate both local and average strains in two-phase structures with phase transition zones formed in strain space by all deformations which can exist on the equilibrium interface in a body.

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RESEARCH OF NATURAL CONVECTION IN BEEHIVES

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The impact of natural convection on survival of bees in winter repeatedly was discussed in magazines ”Beekeepings”. However concrete computation wasnt executed. The first computation of natural convection showed that effects of convection are greatly [1]. The natural convection, calling calorification of bees, leads to big area with static stratification of consistense of air. There were realized enumeration of parameters and tested different models of natural convection. Computations of natural convection were executed for beehive with typical size. The sphere of bees was approximated with ball with radius 10-14 cm. The heat excretes with given consistense. Frames divide the area of beehive. The small distance between frames helps to describe flow of inter-frames area with model of Hele-Show. We used such approach. Area of bees naturally gives additional opposition to flow of air. This effect was taken approximately by decreasing of distance between frames. In this work flow in area of bees computes by two models. The first model uses cell of Hele-Show. Second model is model of porous environment.

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DAMAGE TENSOR BASED ON HOMOGENIZATION

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The notion of damage tensor based on the theory of mathematical homogenization is defined. The theoretical considerations are not restricted to periodic microstructure but numerical calculations are performed only for special periodic geometry of microstructure. The theory of mathematical homogenization is used in modeling different properties of composite materials, e.g. thermal, dielectric, magnetic conductivity, elastic stiffness, piezoelectric properties and others linear ones, cf. [1]. In the case, when one phase is approximated by vacuum, then the effective, homogenized properties exists (as the H-limit), but except multilayered structure only some bounds on the properties could be calculated. The aim of the paper is twofold. Firstly, the definition of damage tensor T is given, cf. [2]. Secondly, the numerical calculations of the tensor T are the base of the analysis of macroscopic anisotropy induced by different geometries of porous structures. The work was supported by the Ministry of Science and Information Society Technologies (Poland) through the Grant Nr 4 T07A 053 28.

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NUMERICAL ANALYSIS OF STRUCTURAL STRESSES IN PARTICULATE ELASTOMERIC NANO-COMPOSITES

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Particulate-filled elastomers (rubbers) refer to a class of composite materials consisting of a mix of a highly elastic polymeric matrix and rigid granular particles of the filler (technical carbon, silicates, etc.) which size changes from hundreds micron up to tens nanometers.

One of basic distinctions between conventional and nanocomposites is the different role that play the layers of polymer with specific features (distinct from that of matrix material) existing around carbon filler particles. The assumptions known from the literature [1] suggest that in such near surface zones it is possible to differentiate two layers of the polymer with dissimilar mechanical properties. In the first layer with the thickness about 2 nanometers (close to a particle) polymer is in condition close to a glassy state. The second layer (with thickness about 10 nanometers), containing long poorly cross-linked molecular chains, and, accordingly, softer, than the basic part of a matrix. In conventional composites the volume fraction of these layers is very small, but in nano-systems it becomes comparable to the filler concentration, and its influence must be taken into account.

The main objective of this study is numerical computer investigation of stress-strain state around filler nano-particles, surrounded by softer layers of polymer to answer the question of whether such system promotes leveling of stress gradients over the whole composite volume and, as consequence, material strengthening. In modeling the stress-strain state in nanocomposite, it was considered that the matrix and layers represent highly elastic polymeric grids consisting of freely-jointed molecular chains. That is, materials of the matrix and layers consist of the same polymer, but differ in the mechanical properties due to a different cross-link density of polymeric grid. Viscous properties of layers in the first approximation were neglected.

The uniaxial axisymmetric stretching of a chain of rigid identical spheres located in a highly elastic polymeric matrix was examined. The initial distances between them were varied so, that layers around particles could both intersect or not.

The fields of stresses and their invariants have been investigated during increase in external tensile loading, and the corresponding deformation curves of these invariants have been constructed at specially chosen points in the gap (near to a pole of a particle) and in area of sphere equator.

The investigations have revealed an interesting effect, possible only in essentially heterogeneous systems consisting of materials with well expressed nonlinear elastic properties. As the tensile load increases the maximum of the greatest principle stress can transfer from a gap between particles to the area close to particle equators. For this purpose it is necessary, that the gap be small enough, layers should intersect, and the cross-link density of the layer material should be much less, than that of the matrix. This is expected to facilitate leveling of distribution of elastic response over the volume of a composite and, finally, increase of macrostrength of a composite material.

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THE DIFFERENTIAL MODEL DESCRIBING ELASTIC-PLASTIC BEHAVIOUR OF MATERIALS AT FINAL DEFORMATIONS

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The phenomenological model of the macro-isotropic medium describing its mechanical behavior at nonlinear elastic-plastic final deformations is constructed. To obtain the constitutive equations the differential approach based on interpretation of mechanical behavior of a material with the help of symbolical circuits is used. The principal advantages of such approach are the physical clarity of each of the used mathematical expressions, the convenience of constructing the mathematical model of continuum with various complicated behavior, the absence of objective derivatives of stress tensors in the constitutive equations. The additive decomposition of the rate of deformation tensor in elastic and plastic parts is taken instead of multiplicative decomposition of a deformation gradient commonly used in the literature.

One of the evident merits of the given technique is the ability to describe not only hardening of a material at plastic flow, but also its softening (that is a descending branch of a stress-strain curve). Mathematical expressions used in the model can be essentially nonlinear, which is a necessary condition for constructing the system of constitutive equations because the considered model is aimed at describing an appreciably complicated mechanical behavior of composite materials. Such a behavior is caused by joint influence of different structural factors that show themselves at various scale levels of internal material heterogeneity.

The computational scheme of this model consists of two elements: elastic and plastic. The properties of the elastic element are defined be the expression of free energy, which can be received from the structural equilibrium models of nanocomposites or from comparison of the results of phenomenological modeling with experimental data. Description of the plastic element properties provides for the possibility of taking into account the features of continuum plastic flow in relation to the maximal deformation level during the total time elapsed from the start of the material loading. This should help to reflect a degree of structural damage accumulation.

The given approach was used for concrete applications for description of mechanical properties of polymeric nano-composites consisting of a mix of filler particles of laminated clay minerals (smectites) and a polyolefine matrix. Nano-composites of this type present new perspective technical materials combining such valuable qualities, as the improved operational properties, the ecological safety and the cheapness of manufacture. The received results have shown adequacy and effectiveness of the proposed model that opens good perspectives for its further development.

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ON THE EXTENSION OF A BAR CAPABLE TO UNDERGO PHASE TRANSITIONS

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The problem concerning extension of a bar capable to undergo phase transitions due to an external force is investigated. The infinite bar with variable cross-section is considered. The problem is solved by means of both kinetic and full dynamic approaches. The results obtained by means of these two approaches are compared.

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APPROXIMATE SOLUTIONS OF BOUNDARY PROBLEMS INCLUDING SHOCK WAVES IN NONLINEAR-ELASTIC MEDIUMS

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In this report approximate analytical solutions of some one-dimensional boundary problems including cylindrical and spherical surfaces of displacement gradient discontinuities (shock waves). For these wave processes possible types and shock waves velocities have been determined.

The velocities of shock wave propagation have been shown to be influenced by both discontinuity intensity and type of pre-deformations. According to type the waves may be classified under quasi-longitudinal wave and two quasi-transverse ones. On each wave there are both longitudinal and transverse discontinuity components, one of them predominating. It's convenient to describe such wave processes in curvilinear coordinate system. It necessitates presenting geometrical and kinematics derivatives discontinuities compatibility conditions, as well as recurrence relations for discontinuities of arbitrary order derivatives in arbitrary curvilinear coordinate system. The theory of moving discontinuity surfaces was based by Adamar, Tomas, G.I. Bykovtsev, however they confined to case of Cartesian coordinate system. The recurrence relations obtained by us [1] are necessary when forming approximate solutions of boundary problems by ray method when the motion is initially studied in curvilinear coordinate system. This report considers solutions of following problems: normal blow on inside of cylindrical and spherical hole in space, antiplane and twisting deformation in incompressible medium. The solution has form like Taylor's series but behind discontinuity surface. The series is developed with respect to either time or spatial coordinate, the latter being the distance from discontinuity surface to given space point along the ray corresponding to this point. This method is usually used for solving problems with weak waves, however in 80th last century A.A. Burenin proposed method modification which allows applying it for processes of shock deformation.

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FINITE ELEMENT INVESTIGATION OF UNREINFORCED WELDED TUBULAR JOINTS

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Offshore structures consist of a large number of tubular members connected to one another by special joints. Tubular members are jointed together at their intersections in a variety of geometrical forms. These joints represent structural discontinuities, which incur a large amount of stress concentration. The stress concentration can produce a maximum stress at the intersection as high as thirty times the nominal stress acting in the members. The combination of high stress concentration with dynamic loads makes fatigue damage almost unavoidable.

In offshore tubular structures, a typical tubular joint may be subjected to three different types of basic loadings namely, axial (AX), in-plane bending (IPB) and out-of-plane bending (OPB) through its brace members. Each type will cause a different stress distribution at the joint intersection of structures. Moreover, the actual load condition of a tubular joint can be any combination of the above three basic load cases, for this reason, a combined loading case (Com) was investigated in this paper in addition to these three basic load cases. This load is composed of an axial loading combined with a continuation of rotational bending loading obtained while rotate center of the brace around a circle. In the paper, different types of planar joints with braces subjected to combined loading; were numerically analyzed to study the effect of those different cases of loading and different types of joints, on the stress concentration zone and values.

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TREFFTZ BOUNDARY METHOD FOR THICK PLATE BENDING PROBLEMS

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These days, numerical approach to research and design is widely employed and is firmly recognized as a powerful tool. Reissner, Hencky, Mindlin and Ambartsumyan have formulated several first orders, shear deformation theories for thick plates. The method proposed by Reissner has become the standard to which all other theories. In contrast to the Kirchhoff's thin plate theory, the transverse shear deformation effect of the plate is taken into account in the thick plate theory, so that the governing equation is a sixthorder boundary value problem and in this case three boundary conditions are considered for each boundary. The aim of this paper is to present the Trefftz method for analyzing thick plate bending problems based on Reissner's plate theory. The Trefftz method can be classified into the category of the boundarytype solution procedures. The problem can be solved by the boundary discretization alone when the object is governed by and linear and homogeneous differential equation. Therefore, input data generation is much easier than the domain-type solution procedures. More over, the Trefftz formulation is regular and thus, easier than the boundary element method of singular property. In this paper, both the Trefftz direct and the Trefftz indirect methods are discussed and the results show that the present methods are effective for both thin and thick plates.

Keywords: Trefftz Boundary Method, Reissner's plate theory, Trefftz direct and Trefftz indirect methods and thick plate

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PLANE LAYER INCLINATION INFLUENCE ON THE INTERNAL HEAT SOURCES CONVECTION

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Fluids with internal heat sources appear in a large amount of applications and are investigated for a long time [1, 2]. This work continues the examination of the fluid motion stability in inclined plane layer with the heat source on the axis. The extreme cases of vertical and horizontal layers were examined earlier [3, 4] and compared with the uniform heat sources case. Here the influence of the inclination angle was under examination.

Stability maps for various parameter sets, instability parameters to angle dependencies were found. Overcritical modes numerical research was conducted.

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A GENERAL THEORY FOR THE VISCOPLASTICITY OF DRY AND FLUID-SATURATED GRANULAR MEDIA

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This paper revisits the "purely dissipative" model proposed several years ago [1] as a general continuum model for the history-dependent viscoplasticity of non-colloidal particle dispersions. Essential to the model is a positive-definite fourth-rank viscosity tensor $\boldsymbol{\eta}$ depending on the history of deformation. In the reduced form considered here, $\boldsymbol{\eta}$ is an isotropic function of a history-dependent 2nd-rank "texture" or "fabric" tensor $\mathbf{A}$, which gives stress as a tensor-valued function of fabric and strain-rate tensors. This paper considers several special cases appropriate to systems ranging from Stokesian suspensions to dry granular media.

For Stokesian suspensions, a formula for $\boldsymbol{\eta}(\mathbf{A})$ given by the analogous theory of linear elasticity, together with a corotational memory integral for $\mathbf{A}$, provides a compelling model of transient viscosity and normal stresss evolution in simple shear [5, 3]. However, one extremely rapid mode of relaxation is required to mimic the incomplete reversal of stress on abrupt reversal of shearing. This suggests that non-hydrodynamic effects are implicated, and it establishes a kinship to liquid-saturated granular media with sustained particle contact.

In the case of granular media, the isotropic version of the above model reduces to the Reiner-Rivlin form proposed previously [2], which encompasses a quasi-linear model proposed recently for dense rapid granular flow [4].

Since isotropic models cannot represent the effect of flow-induced anisotropy on yield surfaces and viscometric normal stresses, attention is given here to a more general forms, involving nonlinear dependence on both fabric and strain rate. Two important time scales are highlighted, a grain-inertia time scale for dry granular media [2, 4], and a viscous-frictional time scale that appears to be implicated in recent experiments on completely saturated granular media.

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CHARACTERISATION OF THE TRIBOLOGICAL PROPERTIES OF PTFE-BZ COMPOUNDS

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Within this project the tribological behavior of PTFE as well as of various PTFE-Bronze (PTFE-Bz) compounds was investigated. Based on the results on a component test system two compounds were selected for further detailed investigations. Failure analysis of worn surfaces as well as analysis of material microstructure allowed establishing relationships between tribological behavior and microstructure (i.e., formation of transfer film, debris, etc.). For the determination of tribological relevant material properties, a novel linear tribometer was developed and implemented. To perform a comprehensive investigation on the wear behavior of the materials, a multitude of specimens was tested and analyzed. A novel model for the description of the failure behavior was developed. The overall objective of this study was to develop a fundamental understanding of the microstructure and tribological behaviour of heterogeneous polymeric materials used as pressurized seals by applying tribological as well as thermo-physical analysis methods for both material development and component design efforts.
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DEVELOPMENT OF A TRIBOLOGICAL FUNCTIONAL AND FAILURE MODEL FOR PTFE-BZ COMPOUNDS

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Due to their high chemical and thermal resistance PTFE compounds are frequently used for seals and gaskets in various engineering applications. The thermo-mechanical properties of the PTFE (low strength and wear resistance, not sufficient heat conductivity) for tribological applications can be improved by various fillers. However, significant differences in the service lifetime and in the tribological behavior of these compounds were observed. Hence, the objective of this paper was to perform a comprehensive characterization of the tribological behaviour of dif-ferent PTFE-Bronze compounds (PTFE-Bz) and to establish a model for further simu-lation. In the first phase of this project several PTFE-Bz compounds were investigated on component level (seal) using an ASTM-standardized seal component test system. The results of the component tests and the results of the additional thermo-mechanical material characterization on specimen level (i.e., monotonic and cyclic compression tests from 20 to 200C, nano-indentation, and analysis of the micro-structure) revealed similar tendencies. Hence, based on these results several new materials were produced and provided for detailed investigations by the company partner. In the second phase, in addition to the methods mentioned above, laboratory friction and wear tests were performed using different test set-ups on various bronze filled PTFE compounds exhibiting differences in formulation and composition. To support this characterization, a novel linear tribometer was developed, implemented and ap-plied. The friction and wear coefficients, the specimen surface temperature change during the test have shown significant differences between the materials investigated. Moreover, failure analysis investigations were performed and both the compound and the counterpart surfaces were analyzed using various microscopy methods. Special emphasis was devoted to the formation and development of transfer film on the coun-terpart and on the structure of the worn debris particles. Finally, based on the results of the above investigations, a novel functional and fail-ure model was developed. The model was successfully implemented in a thermo-mechanical finite element simulation. The results of the simulations performed revealed good agreement with both the theoretical considerations and the experiences from service field applications.
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NUMERICAL PREDICTION OF EFFECTIVE VISCOELASTIC PROPERTIES OF GRANULAR COMPOSITES

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The investigation is concerned with elastomer-base composite materials of granular type with filler particles of size greater than 10 micron. Numerical simulation of viscoelstic properties of the composite was carried out using a structural cell in the form of elastomer cylinder filled at the center with rigid spherical inclusions. The height and diameter of the cylinder were equal in magnitude.

Viscoelastic properties of the matrix were described based on the creep test data. The solution of the boundary value problems of the linear viscoelasticity was constructed by applying the method of variable parameters of elasticity. The applicability of this particular method to the problem under consideration was dictated by a weak heredity of the matrix. Deformation of the cells was examined at such boundary conditions that ensured preservation of their close packing.

Investigation of the mechanical evolution of the structural cells showed that it is related to initiation and development of micro-damage involving nucleation and growth of a vacuole. The relaxation functions for the composite were derived. The performed calculation allowed us to describe qualitatively the mechanisms revealed in experiments.

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AUTOMATION OF THE ANALYSIS OF PROBLEMS OF THE MECHANICS OF ELASTOMERS WITH THE HELP OF THE SOFTWARE -COMPUTER COMPLEX MIRELA

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One of major problems arising at designing of complex engineering designs and structures, is the analysis them strengthening characteristics. Therefore is necessary to build stressdeformed states of engineering objects. Without reliable and effective automation of the decision of such problems the development of modern mechanical engineering and constructions is impossible. Now for automation of various aspects of numerical account of problems of the mechanics the plenty various universal CAD in mechanical engineering and construction, such, for example is developed, as LIRA [1], ANSYS [2], COSMOS [3] etc. However, at accounts of complex designs from elastomers, at use of universal systems can arise a number of essential computing problems [4]. For their overcoming the universal softwarecomputer complex + was developed [5]. The software architecture architecture MIRELA +, as well as logic structure of the majority others modern CAD, basing on application FEM, consists of three interconnected subsystems: of front-end processor, of processor and of postprocessor front-end processor of MIRELA + allows to automate a stage of preparation of the initial data, which consists in the description of topological model projected a construction of elastomer and discretization it on the given type of final elements. In system MIRELA + for the task of topology entrance parametrical language FORTU-3 is used [6]. The processor MIRELA + its body. Structure of the processor includes the problem-oriented program modules for the decision of linear and nonlinear problems of the theory of elasticity and viscous elasticity, problems of the mechanics of destruction, thermal conductivity, dynamics, mechanics of composites etc. Postprocessor MIRELA + allows to automate process of the analysis of the received results of account and generation of the necessary outgoing documentation on developed technical object. The important distinctive feature of system MIRELA + is its open architecture, that allows if necessary how to add modules of account of new classes of problems, and to modify already existing. Such approach allows essentially to raise a general efficiency and mobility CAD MIRELA +. The system MIRELA + has passed successful approbation at the decision of a plenty practically of important problems of the mechanics of elastomers.

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A VARIANT OF MORTAR FINITE ELEMENT FOR THREE-DIMENSIONAL CONTACT PROBLEM

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At present there are widely used algorithms for the finite element solution of contact problem. These algorithms are based on penalty method and Lagrange multipliers method. There are various variants of these approaches for the kinematically linear and non-linear cases. For these algorithms there is no substantial meaning of the material constitutive equations. Practically all implementations of algorithms works with assumed contact surfaces, which represents the parts of boundaries of finite element mesh. As a rule these boundaries are non-smoothness (there is no tangential continuity on the bounds of adjacent finite elements). This circumstance generates many computational problems, main of which are essential decreasing convergence rate or appearing divergence of Newton-Raphson solution procedure. Especially this concerns a case of contact with large relative slip displacements. The solution of these problems is one of the central themes in modern computational contact mechanics and it is a complex unsolved up to the end problem. In the literature it is possible to observe two main approaches to the solution of the present problem. The first approach is connected to construction of smooth contact surfaces. The second approach is connected with development of special mortar contact element. For the three-dimensional case the development of the first approach comes across the many essential barriers both in the mathematical and algorithmic aspects. Therefore recently attention displaces aside the second approach. In present work the simple variant of the mortar contact element being logical generalization of classic contact element in the master-slave approach is proposed for the three-dimensional case. Main advantage of the proposed element is the accounting of the non-uniformity of the contact stresses distribution within the domain of one contact element that is reached by correct application of the numerical integration procedure on Gaussian points. With usage of the regularization of contact constraints by penalty function method the stiffness matrixes and nodal forces vectors for the geometrically and physically non-linear cases are constructed. On the basis of the proposed mathematical formulation the algorithms and software for the solution of contact problems with friction at large relative slip are developed. For the lot of numerical tests the advantages of the proposed mortar element in contrast to classic contact element are demonstrated.

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FRICTION IN ROLLING CONTACT OF DEFORMABLE BODIES

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The main sources of energy dissipation in rolling are friction due to the relative slip of surfaces within the contact region arising from the differences of the curvature of the contacting bodies, and their different mechanical properties; imperfect elasticity of contacting bodies; adhesion of contacting surfaces.

The contact problems for elastic and viscoelastic bodies are considered to study the friction resistance in rolling and to analyze the contribution of each process to rolling friction for different operating conditions.

To analyze the simultaneous effect of partial sliding in contact zone and imperfect elasticity affecting the resistance to rolling the 2-D contact problems for viscoelastic (elastic) cylinder and viscoelastic (elastic) half space are investigated under the assumption that the contact region consists of two parts (slip and stick subregions) or three parts (stick subregion surrounded by two slip subregions). The dependence of the normal and tangential contact stress distribution and the friction coefficient on velocity, loading conditions, and viscoelastic properties of contacting bodies is investigated.

The approach is developed to calculate the adhesive component of friction force in rolling contact of elastic bodies with rough surfaces. It is based on calculation of the energy dissipation in an approach-separation cycle for the interaction of an asperity with the elastic foundation in the presence of capillary or molecular adhesion. The dependence of the rolling resistance on the surface energy of the interacting bodies, their elastic properties and microgeometry of the surfaces is established.

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COSSERAT MODELLING OF FLEXIBLE RING STRUCTURES

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A new technique is developed for the modelling of anisotropic, flexible ring structures. The resulting equations are presented at a number of different levels of complexity, ranging from full sets of coupled ODEs to simplified equations under specific conditions. This technique is found to agree well with selected anisotropies of particular relevance to MEMS ring gyroscopes where the physical behaviour is known or easy to predict. One important result shown is that the effect of overetching will be negligible and easily accounted for in most devices due to its symmetry. Overall, the versatility of this technique should enable application to a wide number of problems ranging from very small ring structures such as those involved in MEMS devices or molecules through to very large structures.

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MODELING OF FEATURES IS STRESSDEFORMED STATES OF DESIGNS FROM COMPOSITE MATERIALS

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The tendencies of development of modern science both engineering require creation and development of effective methods and strengthening receptions of accounts of designs. In a basis anyone strengthening account the necessity of definition is stress-deformed statuses of a design or its components lays. As a rule, the majority of designs has the complex geometrical form and while in service is in conditions to a complex is stressdeformed status. These factors interfere with use of analytical methods at accounts. Therefore wide circulation was received by numerical methods, which application does not restrain by features of geometry and complexity is stressdeformed statuses of a design. The effective utilization of numerical methods is impossible without modern computer engineering. Therefore, recently, the creation of program complexes for account of designs is carried out on the basis of various numerical methods. Among such methods have received distribution the following: variationally - differential, certainlydifferential, method of boundary elements, method of final elements. The additional difficulties at account of a design are connected to features of structure of a material and its various imperfections. So, anisotropic property of a material result in significant complication of mathematical model. The presence of imperfections as pore, cracks, cuts(sections) requires updating model and introduction in it of features connected to these imperfections. The program complex MIRELA+ allows on the basis of a method of final elements to expect designs from composite materials, which have anisotropic properties [1, 3]. At modeling the composite is represented homogeneous anisotropic material with elastic constant, dependent from elastic properties of components and from their volumetric share [4]. Then, the dependence between pressure and deformations will be described by the generalized law of Gook. The large enough classes of materials have linear properties only at small deformations. For the description is stressdeformed states of such materials use the nonlinear laws. So, for description viscoelastic properties is convenient to use hereditary theory of BoltzmannVolterra [2]. To materials with brightly expressed viscoelastic properties concern elastomers. And to composite materials, where the account viscoelastic of properties is necessary, concern rubber-cord materials. The presence of a crack in a design from a composite material results in necessity of modeling of its feature about top of this crack. It can be made by two ways: by a condensation of a grid of final elements or use of singular final elements.

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TRIBOLOGICAL STUDIES ON SLIDING BEARINGS ON THE BASIS OF DAMAGE ANALYSIS

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Hydrodynamic sliding bearings are typical tribologically loaded components. They turn comparatively high dry friction into fluid friction in order to guarantee high efficiency and to ensure the operational safety of machines. Although these machine elements have been used for hundreds of years, their exact failure mechanism remain still unclear. For selective material design, however, these damage mechanism are of special interest. The tribological system of hydrodynamic sliding bearing consists out of the sliding bearing, the rotating shaft and the lubricant film. The different desired material properties of bearing-material cannot be fulfilled by a homogeneous material. Subsequently, materials for sliding bearings normally consist of multi-phase compounds, which allow a split up of the different requirements on each specific material. To design new materials, the damage process of sliding bearings has to be investigated. In this paper it is shown that the damage mechanism of sliding bearings can only be hardly accessed by component testing. In normal operation, the sliding surfaces of the shaft and the bearing are separated by a thin lubricant film. If this lubricant film fails, the coefficient of friction rises significantly. Subsequently, the tribosystem sliding bearing fails due to a thermo-mechanical overload. This failure process is called scuffing. Because of the high energy input the failure process happens within a flash of a second. The bearing cannot be meaningfully investigated by damage analysis techniques and the failure process cannot be accessed by this ”post-mortem” analysis. Alternatively, tribological model tests can be used. These test models have to be designed carefully to lead to test results, that are analogue to component tests. Possible criteria to determine the quality of analogous models are the damage mechanisms, which must be identical to the damage mechanisms of components. In this paper a tribological test model based on the standard ASTM D 3702 (ring-on-disc) is presented. Compared with sliding bearings, the observed tribological damages are mostly the same. The advantage of this adapted test model ring-on-disc is, that, due to the lower energy input during scuffing, the failure process of the tribosystem runs in ”slow motion” compared to real sliding bearings. At different chronological steps analyses of the surfaces being at different conditions can be performed. Subsequently, an operating-model of the tribomaterial can be deduced. In this article, this damage-based analysis technique and a simulation model for a basic tribomaterial design are presented.

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THE RELATIVISTICALLY-INVARIANT FORM OF BOUNDARY CONDITIONS IN ELECTRODYNAMICS OF THE MOVING CONTINUUM

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It is known, that the Maxwell's theory of electromagnetic field essentially relativistic theory. It means, that the Maxwell's equations of electrodynamics of material continuum invariance under Lorentz's transformations group or relativistically-invariance. Mathematical expression of this invariance is four-dimensional tensor form of record of Maxwell's equations, for the first time obtained by Minkowski. Record the material equations for the linear electromagnetic continuum in four-dimensional tensor form also are obtained by him.

On an interface of various media or on a surface of medium and vacuum there are certain ratios. These ratios connect the gapes of electromagnetic field, of induction field and density of charge and current. These ratios follow from Maxwell's equations. For the moving continuum they for the first time have been obtained by Einstein and Laub in the three-dimensional vector form.

For full statement of a problem of definition of electromagnetic field in the moving continuum in invariant four-dimensional tensor form, it is necessary to have and corresponding record of boundary conditions. In the report the conclusion of the form of record of boundary conditions for fields and currents in invariant tensor form is stated.

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BOUNDARY-VALUE PROBLEMS OF LINEAR ELASTICITY FOR SCREW DISLOCATIONS NEAR CYLINDRICAL SURFACES OF NANOVOIDS AND NANOTUBES

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The fabrication of many advanced materials is accompanied by the appearance of free cylindrical surfaces. The examples of such materials are nanowires, hollow carbon and non-carbon nanotubes, and porous crystals containing nanoscale cylindrical voids, referred to as nanopipes. All these materials often contain screw dislocations, whose formation and dynamics are strongly affected by their interaction with free cylindrical surfaces. Besides individual screw dislocations, crystals with pipes frequently contain elongated inclusions of second phase, whose elastic properties may be modeled through continuous distributions of virtual screw dislocations. In particular, an analysis of the interaction of dislocated nanopipes near second-phase inclusions and flat crystal surfaces may be reduced to the analysis of their interaction with free surfaces of two cylindrical nanovoids.

To investigate the elastic interaction of screw dislocations with free surfaces of hollow nanotubes and multiple nanovoids, we have rigorously solved two boundary-value problems. The first problem concerns the stress field of a screw dislocation lying in the wall of a hollow cylindrical nanotube. The second one deals with the stress field of a screw dislocation located near two cylindrical voids in an infinite elastic solid. Despite the cylindrical shape of the voids, both the problems are characterized by the absence of cylindrical symmetry. However, their solutions may be obtained using the technique of infinite arrays of image dislocations.

In this approach, the exact solution for the stress field of a dislocation in a solid with two cylindrical surfaces is found using the following iteration process. As a first approximation for the dislocation stress field, one chooses the stress field of such a dislocation in an infinite medium. This dislocation creates a traction at both the cylindrical surfaces. At the second step, the traction at one cylindrical surface is eliminated through the introduction of two image dislocations of opposite sign into a void. The total stress field after the second step is given by the sum of the infinite-medium stress fields of the real and two image dislocations. At the third step, one eliminates the traction created by the real and two image dislocations at another cylindrical surface through the introduction of other two image dislocations in the same void (for the case of a hollow nanotube) or in the other void (in the case of a medium with two cylindrical voids). Then, at every subsequent step, two new image dislocations are introduced inside a void. These image dislocations are located so that their stress fields would eliminate the traction created by the previous dislocations at one of the cylindrical surfaces. The total stress field after any step follows as the sum of the infinite-medium stress fields of all the dislocations introduced at this and previous steps. With an increase in the number of iterations, the approximate solution approaches the exact one. Thus, the exact stress field of a screw dislocation near two free cylindrical surfaces consists of the infinite-medium stress fields of the dislocation, introduced at the first step, and those of the infinite array of the image dislocation dipoles introduced at the subsequent steps.

As a limiting case of the solution for the stress field of a screw dislocation in an infinite medium containing two cylindrical voids, we have derived the stress field of a screw dislocation in a half-space containing a cylindrical void. The solutions obtained may be used for an analysis of the formation and dynamics of cylindrical voids in crystals as well as for a study of dislocation nucleation and behavior in hollow nanotubes.

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DILATOMETRIC STUDY OF GRAPHITE PRESSED ALONG THE DIRECTION OF STRONG BINDING

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This work is a dilatometric study of thermallydilated graphite, hereafter referred to as graphite foam. The sample was pressed along the direction of strong binding. The results of this study show that the thermal expansion coefficient α_z, measured, along the direction O_z of weak binding, over the temperature range 25-500C, is significantly different from the coefficients α_x and α_y measured in the basal plane, along directions O_x and O_y, respectively. α_z values are positive throughout the whole temperature range studied. At $25C$, α_z is $20 \times 10^{-6}C^{-1}$ and reaches a maximum of the order of $110 - 120 \times 10^{-6}C^{-1}$ at $230C$, then decreases slightly down to $100 \times 10^{-6}C^{-1}$. This peak can be directly linked to a strongly amplified membrane effect. α_x and α_y vary monotonically over the temperature range $25 - 500C$. They coincide closely up to $400C$, their values being comprised between $-10 \times 10^{-6}C^{-1}$ and $-8 \times 10^{-6}C^{-1}$. Starting from $400C$, α_y increases slightly to reach $-5 \times 10^{-6}C^{-1}$ at $500C$. While there is no anisotropy under $400C$, the values measured for α_x and α_y are significantly lower than those reported in the literature. Pressing is only responsible fro the change in value of the expansion coefficient, which is not the case when sample is pressed along direction O_z. However, there is a very marked anisotropy between the expansion coefficient measured along O_z and those measured along O_x and O_y. Moreover, the values of α_z for graphite foam are several times greater than those of ordinary graphite.

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TWO-PHASE FAST GRANULAR FLOW: SOME ISSUES AND PROBLEMS

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The flow and deformation of granular materials in the terrestrial environment is inseparable from that of the ambient fluid (water or air) in which the material finds itself. If the material is confined or if gravity provides the dominant loading then the granular material is densely packed, behaving in a solid-like way (the so-called slow flow regime) with the fluid flowing through the interstices relative to the solid skeleton. On the other hand, if the material is unconfined and the fluid flow sufficiently strong the material becomes fluidised and dispersed in the fluid (the so-called fast flow regime). The granular material may be modelled in various ways, e.g. discretely, as a continuum or using statistical mechanics. Continuum models of the granular material in the slow flow-regime often assume an elastic-plastic or hypo-plastic response, while in the fast flow regime a fluid response is postulated. A commonly used constitutive framework for fast flow is a two-fluid model comprising a system of first order partial differential equations in which the solid and fluid volume fractions plays a prominent role. Two seemingly ubiquitous issues in granular flow are (a) the conditions required for hyperbolicity and its loss (and, through this, the issue of well- or ill-posedness of initial value problems); (b) the appearance in the governing equations of some terms in conservation form and some not in conservation form. These issues have a profound significance for the numerical approximation of solutions of the equations governing the model, particularly in view of the fact that the equations are sufficiently complicated to prevent easy construction of analytic solutions - for all but the most trivial problems recourse must be had to numerical methods of solution. The complexity of the behaviour of granular materials and their inadequate, to date, mathematical modelling entails an interactive approach between the modelling and numerical solution. In this lecture we discuss various modelling and numerical issues that have arisen recently in a research project on the numerical solution of the equations in both the fast and slow flow regimes.

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NONLINEAR ELECTROCONVECTIVE REGIMES OF POORLY CONDUCTING LIQUID IN A HORIZONTAL CAPACITOR

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The nonlinear electroconvective supercritical regimes of poorly conducting liquid are investigated in the electric field of the horizontal capacitor. The electrohydrodynamic approximation is used. It is supposed that electroconductive mechanism of charge formation plays significant role. The charge arising in a liquid interacts with an external electric field therefore the liquid can come into the movement.

The nonlinear evolution of convective system is analyzed with help of low mode models and method of finite differences. Low mode models are obtained by the Galerkin-Kantorovich method for the stress-free and hard boundary conditions. The time evolution of the solutions is investigated with help of Fourier analysis. The direct numerical integration of the amplitude equations demonstrates complex dynamic behavior, including monotonic and oscillatory regimes. The dependence of the Nusselt number on magnitude of supercriticality is obtained. It is determined that transition to chaotic oscillations occurred via subharmonic cascade. Map of electroconvective regimes are constructed.

On the base of method of finite differences it is determined that an electric field suppress the monotonic convection at intermediate value field, and at too large electric field (number Rayleigh) are born rigidly electroconvective oscillations of liquid. It is founded that fourth types of oscillating regimes with different spatio-temporal behaviors exist.

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TRANSITION FROM QUANTUM TO CLASSICAL TRANSPORT THROUGH CHAOTIC OPEN CAVITIES

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The system of our interest is a chaotic open cavity where the motion of coherent free electrons is ballistic with specular reflections from the Dirichlet boundaries. In such a system, classical dynamics shows rich fine structures in transport coefficients reflecting chaotic scattering in the cavity. On the other hand, quantum dynamics shows ample fluctuations in transport coefficients as a result of overlapping resonances. Our numerical investigation by solving genuine wave equations with increasing energy of scattering electrons demonstrates quantum-classical transition for electric transport through such chaotic open cavities. This gives a first numerical proof of the correspondence principle in quantum scattering problems in the chaotic open systems.
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A SIGHT AT MULTILEVEL MODELS FOR THE DESIGN OF COMPOSITE LAMINATE STRUCTURES

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Various multilevel models for composite laminate structure analysis are developed for a long time by many researchers. Composite structures are considered on several scale levels: macrolevel and structural levels unidirectional layer (mesolevel); fibers and matrix (microlevel).

Can the methods and results of structural composite mechanics be used now in engineering design practice? Can one predict deformation and failure of composite laminate structures using the properties of unidirectional layers or the properties of fibers and matrices, forming the unidirectional layer? The unique for composites community project known as the 'World Wide Failure Exercise (WWFE) or as the Failure Olimpics has been devoted to such questions. The objective of the project was to establish the capabilities of modern theories. The papers of organizers and participants of the project published in 1998, 2002, 2004 constituted the backbone of the book [1].

The participants of the project were suggested to plot failure envelopes for unidirectional layers and glass- and carbon- fiber reinforced composite laminates of various structure as well as stress strain curves for some cases of uniaxial and biaxial loading. At the first stage, were not provided with any experimental results. At the second stage the participants compared the obtained theoretical results with experimental data provided by the organizers. The majority of these test results were obtained from experiments on tubes subjected to internal or external pressure combined with axial tension or compression or torsion. The highest ranked theories were able to predict the experimental results to an accuracy of better than 50

Some aspects that have a significant influence on the predictions are whether the theory assumes linear or non-linear material behaviour and whether or to what extent the effects of thermal stresses and fibre realignment due to shear deformation are included. The most important is the way in which laminate behaviour is treated after initial failure has taken place.

It seems to be very useful to begin to study the experience obtained in WWFE and to correct the directions of further research in composite micromechanics. The methodology of the WWFE project can be used for estimation of capabilities of those theories, that were not presented in the project.

Note that the majority of the project participants took the properties of laminate layers as the basic building blocks, but only a few started from constituent matrix and fiber properties and used micromechanics to predict the layer properties, and then the properties of composite laminates. One can analyze if the methods of statistical description and modeling of structure and properties of the unidirectional composites could be useful for engineers now. What additional information about structure is needed for calculations and what it can give for engineering prediction of composite structure failure?

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BEHAVIOUR OF SOLIDS IN THE CAVITY FILLED WITH LIQUID AND SUBJECT TO TRANSLATIONAL VIBRATIONS TILTED TO THE HORIZON

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The lift force of vibrational nature acting the solid body which makes oscillations in a viscous liquid near to solid border is experimentally studied. The body oscillations occur under the action of inertial forces; the cavity filled with liquid (the straight closed channel) makes longitudinal translational vibrations under some angle to the horizon. The behavior of spherical and cylindrical bodies different in density from the liquid is considered. It is revealed that in case of inclined axis of vibrations the lift force acting the body contains a tangential component. The heavy body at some critical vibrations intensity moves upwards along the channel. It is shown that the tangential component of lift force is connected to breaking of symmetry of body oscillations. The last occur under some angle to the solid border. The lift force is formed as a result of viscous interaction of the body with the border. In case of longitudinal oscillations of the body near to the border [1] the lift force has only normal component; the body repulses from the border.

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NUMERICAL MODELING OF FLOWS DURING DETACHED BRIDGMAN CRYSTAL GROWTH UNDER AXIAL VIBRATIONS

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This work deals with numerical simulations of flows during detached Bridgman crystal growth in the presence of axial vibrations of the crystal. The study is related to the experiment planned for 2007. The mathematical model should take into account the detachment of the crystal from the ampoule wall and the presence of the additional (technological) channel in the upper part of the ampoule. The size of the meniscus near the crystal-melt interface is to be rather small (80-200 mm).

The influence of the vibrations is described using time-average approach. All hydrodynamic fields are decomposed into the quickly oscillating (pulsating) and slowly varying (average) components. Pulsating flow can be described as potential (inviscid) all over the melt volume except for the viscous boundary layers near the ampoule wall. To account for the detachment influence, we implement a simple model based on the assumption that in the absence of vibrations the meniscus is flat and horizontal. Average deformations of the meniscus and upper free surface are neglected.

Pulsating flow is calculated using collocation method. Average fields are obtained numerically by finite-difference method. Several mechanisms of average flow generation are taken into account: thermal vibrational convection, thermocapillary convection, Schlichting generation and generation of average vorticity near free surface.

The influence of vibration frequency and amplitude on average flows intensity and structure and meniscus shape is studied. The resonance frequencies of the free surface oscillations are calculated. The contribution of different mechanisms of average flow generation is clarified.

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FINITE ELEMENT ANALYSIS OF OPEN ISOGRID STRUCTURES

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Open Isogrids are used in launch vehicle payload fairings, interstage rings, and engine ducting and space station modules in Aerospace Engineering. The design of Isogrids using advanced composite materials is gaining momentum in space applications since the space structures are stiffness driven with stringent weight limits. Advanced composites materials are particularly suited for Isogrids as the typical stresses in the ribs are highly directional along the longitudinal axis of members. The main objective of this study is to develop a finite element model of vented interstage open Isogrid structure and to study the behaviour upto failure. Two types of materials like the conventional aluminum alloy and carbon/epoxy composite were considered in the analysis. An open Isogrid model was developed using the FE software ANSYS and static stress analysis was performed for the given design loads. The analysis was done for both aluminum alloy and carbon/epoxy material Isogrids and the structural safety requirements were checked. Characterization of carbon/epoxy composite was carried out in the laboratory and that were used as input in FE analysis. The collapse load of the interstage structure was also predicted using the stress analysis. Based on the factor of safety requirements, the optimization of grid elements was carried out by varying the cross sectional dimensions. Based on this study it is concluded that Isogrids made using aluminum alloy is having a low factor of safety of 1.27 on UTS, while the carbon/epoxy composite Isogrid is having a factor of safety of 1.58 on UTS.

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ANALYSIS FOR FATIGUE IN TURBINES

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High Cycle Fatigue of turbo machinery blades is a significant design problem because one of the turbine stages may operates very close to the resonant condition & this could lead to the fatigue failures. In order to assess the crack initiation life of the turbine blade, it is essential to correlate vibration to fatigue because crack initiates from the material imperfections under the combination of steady stresses and fluctuating stresses in high cycle fatigue phenomena. This work models an untwisted, non tapered cantilever beam with asymmetric cross section of turbine blade. The natural frequencies of the turbine blade were determined by using modal analysis in ANSYS. Nozzle excitation frequencies and forces were determined from the analysis of flow path field between stator and rotor blades. The critical condition at which natural frequencies are coincident with nozzle excitation frequencies were spotted from the Campbell diagram. Steady stresses and dynamic stresses were calculated in ANSYS using harmonic forces corresponding to the resonance conditions. The stress results obtained were compared with those from the analytical approach. The true stresses in the vicinity of the defect were calculated by Neubers rule with dynamic stresses as input. Local strain around defect was calculated through the formulae given by Martin et al. Crack initiation life was predicted by solving strain life equation. Finally, the turbine disc with blades is modeled and effect of twisting angle, tapered angle, the interfacial frictional forces between disc and blade and clearance in the fir tree region are considered for prediction of the crack initiation life of the turbine blade.

Flow chart for prediction of crack initiation life of turbine blade

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ON THE STABILITY LOSS OF COMPRESSIBLE BODIES AT STRETCHING STRESSES

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By means of analysis of the extreme points at the plot of dependence of the load applied upon the resulting strain the appearance of stability loss at stretching stresses is investigated for compressible nonlinearly elastic materials. Comparatively the case of incompressible materials the main obstacle at this way is the necessity of solving nonlinear boundary-value problem for the ordinary second order differential equation even for the canonical deformations. This means that for the initial state other than the affine one even the equations of neutral equilibrium can't be written in the explicit form.

The results of comparative analysis of the problems of uniaxial stretching of a rectangle, parallelepiped and solid circular cylinder are presented. For the general case of three-parameter model of Blatz and Ko material for the mentioned above problems the regions of material parameters where the dependence of load upon stretching is non-monotonic are constructed. These are the regions that allow stability loss at stretching. Despite their qualitative similarity they appreciably differ quantitatively.

As an example of non-affine initial states Lame problems for hollow cylinder and spherical shell were considered. The calculations showed that the shape of the structure under deformation essentially influenced upon critical strains. Moreover the region of material parameters where such strains exist was sharply extended with comparison to the uniaxial stretching.

The stability loss at stretching stresses can appear in the form of instability of numerical schemes applying to the analysis of some problems on the deformation of nonlinearly elastic structures. The possibility of such effect was illustrated by an analysis of the problem of constrained (plane) torsion of a ring made from compressible material. It was shown that the reason of numerical instability was connected with achievement of critical value at the stretching diagram and did not depend upon the method of numerical investigation or semi-inverse presentation of deformation.

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ON THE MICROSTRUCTURE ACCOUNT IN THE PROBLEMS OF HOLES FORMATION NEAR DEFECTS IN NONLINEAR ELASTIC BODIES

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The account of material structure seems to be very important for any problem on singular behavior especially for the holes formation. The simplest way of microstructure accounting within the framework of continuum mechanics is usage of Cosserat model of elastic media. The purpose of present paper is an analysis of influence of couple stresses upon the radius of forming hole and even the possibility of such hole formation. Two reasons of the holes formation were investigated, both connected with isolated linear defect in nonlinearly elastic cylinder.

The equilibrium of nonlinear elastic cylinder containing wedge disclination was considered. Necessary and sufficient conditions of applicability of the proposed form of semi-inverse presentation of the deformation for this problem analysis were formulated. For different types of non-compressible Cosserat pseudo-continuum potentials the account of couple stresses was found to be of no influence upon holes formation near disclination line. In the case of disclination in the classical Cosserat media the deformation was coincided with that of pseudo-continuum case, meaning that micro-rotation of the grain is identical to its macro-rotation due to elastic deformation.

The problem on screw dislocation in circular solid cylinder was much more complicated. Even in the simplest case of incompressible material it required to solve nonlinear boundary value problem to derive the field of micro-rotation. It didn't concern, naturally, the incompressible pseudo-continuum where this micro-rotation could be easy obtained analytically. The account for the couple stresses lead to the substantial decrease of the radius of the hole formed due to screw dislocation up to total disappearance of the hole.

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NUMERICAL ASPECTS OF THE STRAIN SPACE PLASTICITY THEORIES

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As a rule the deformation theory or the flow theory are used when elastic-plastic problems are formulated. In case of classic flow theory , when the general strain considered as a sum of elastic and plastic parts, as a rule it is necessary to solve constitutive relationships for increment of the stress tensor. But in that case the right part of the relationship depends on the stress tensor and increment of the strain tensor. Dependence of the modeling equation and loading conditions of stress tensor leads to some difficulties in numerical solution of elastic-plastic problems in displacements. It is connected with the satisfaction of the loading and flow conditions for loading surface considered in stress space. Usually, difficulties are eliminated by introducing an additional parameter allowing approximately satisfaction the flow and loading conditions at the any increment of the external load. But, the restrictions on the value of the increments of the external loadings are imposed. This article is devoted to the a new type of constitutive relationships without above mentioned shortcomings. Relationships of such type can be constructed considering the loading surface in the strain-space. In case of strain-space plasticity theory the constitutive equations, flow and loading conditions depends only of the strain and its increments. This dependence allows to describe uniquely not only hardening, but also softening materials. Strain-space plasticity theories allows to propose a new modifications of the numerical methods of the plasticity problems. An initial stress method and initial strain method are the basic numerical methods for elastic plastic boundary problems. It is well known, that the initial stress method, as against to initial strain method which loses convergence at small hardenings, is converging not only at small hardenings and ideal plasticity, but also for softening materials. Let's remind that the initial stress method is based on the constitutive relationships of flow theory solved concerning of the increment of the stress tensor in a combination to the Hooks law. Thus a plasticity matrix and the loading conditions depends on a stress tensor and stress tensor increments and the satisfaction of the flow criterias according to the every increments of external loading arises the certain computing difficulties. If the constitutive equations of the plasticity theory, as against the classical theories considering in the frame of Drukers plasticity postulate, to formulate on the basis of a Iliushins plasticity postulate with a loading surface in the strain space the constitutive relationship and loading conditions depend only strain tensor and its increments and satisfaction of flow criterias does not cause difficulty, that much more facilitates numerical realization of the plasticity problems on the initial stress method. The various stress space and strain space theories of plasticity and thermoplasticity for isotropic and transversely isotropic materials are offered. Are shown their validity on the basis of comparison theoretical and experimental curve for fibrous composites. The test examples about equilibrium of elastic plastic parallelepipeds and rectangular based on the various plasticity theories and numerical methods are solved.

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NUMERICAL SIMULATION OF POSSIBLE LANDSLIDE TSUNAMIS IN THE BLACK SEA

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Most tsunamis are generated by sea floor displacement by large undersea earthquakes. But also landslides, volcanic eruption, explosions, and even the impact of cosmic bodies, such as meteorites, can generate tsunamis. Although studies of landslide-generated tsunamis have a long history, events themselves are generally considered to be relatively rare. The July 17, 1998, Papua New Guinea tsunami, one of the most catastrophic tsunami in the 20th century (about 2300 casualties), appears to have been initiated not by the comparatively modest earthquake of $Ms = 6,9-7,3$, but by a local landslide triggered by the earthquake. Tsunami waves with heights reaching 26 m associated with the 1992 Flores Island Earthquake (Ms = 7.5) in Indonesia were apparently induced by local submarine landslides. Local submarine sliding and slumping also contributed to formation of destructive tsunami waves during the 1999 Kocaeli Earthquake, Turkey. All three events demonstrated that submarine slides play a substantially more important role in tsunami generation than previously thought. Though the total number of tsunami in the Black sea is insignificant (28 events), however only in the twentieth century six tsunamis were fixed, that testified to high frequency of recurrence of tsunami in this region (less than 20 years). All these tsunamis had a local character. There is no high seismic activity in this region. But it is known that landslides are often occurred here. Therefore the submarine landslides are the most probably source of tsunami in this region. Tsunami generation from submarine landslides depends mainly on the volume of the slide material and also on other factors which include: angle of the slide, water depth, density of the slide material, the speed with which the material moves, duration of the slide, etc. The results of numerical simulation of possible landslide tsunami in the basin of the Black Sea are compared. As mathematical model of tsunami generation by the underwater landslide we select two-layer hydrodynamic model, based on non-linear shallow water equations. Two events were modelled in this paper. The fist one is when the center of landslide is placed nearby the cape of Idokopas (in the region of tsunami center of April 8, 1909). And the second one is when the source of the tsunami is placed near Sochi city (in the region of tsunami center of December 4, 1970). The spatial distribution of altitudes of waves and oscillations of a sea level in fixed points are designed. Snapshots of the slide and associated tsunami waves from numerical simulations for different times after the initial slide failure for both events are performed. The results of calculations of theses events are compared to the known eye-witness data of these tsunamis. The distribution of wave heights of tsunami along coasts of the Black Sea, designed within the framework of the nonlinear theory of shallow water, is shown. Also maximum and minimum amplitude distribution of designed tsunamis is plotted. It is shown that the logarithmically normal distribution is good approximation of distribution of wave heights along the coast.

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THE DECISION OF A CONTACT TASK BY A METHOD OF FINAL ELEMENTS

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The phenomena of contact meet in daily life and play the very important role in work of designs and mechanisms. The knowledge of pressure - deformed state at contact is necessary for definition of durability and stability of details of machines and structures in places of their interaction. One of the important problem in mechanical engineering and construction is well stated mathematical theory, which can predict development of contact process and based on fundamental physical principles. Therefore the research of contact problems, the development of algorithms of account of pressure and deformations in contacting bodies represents a actual problem. There are many set of methods of the decision of contact problems now. The analytical methods allow to receive the decision in the exact closed form for the very much limited number of designs and for the simplified circuits of weighting. Therefore there is a necessity for application of numerical methods, among which most popular and universal is the method of final elements (FEM) [1, 2]. There is a number of algorithms of the decision of contact problems on a basis of FEM. One of them is the way, in which the conditions of interaction between bodies are simulated with the help of ratio of physically nonlinear tasks of the mechanics of a solid body [3]. The second way is method based on a method of Shvartz [4]. The algorithm of a buffer layer in FEM for contact problems allows to simulate contact break as a zone of the large gradients of the required decision, and is based on introduction between contacting bodies of a fictitious buffer contact layer (of contact pseudo-environment) [5]. In the work is considered the interaction of solid body with the elastic shock-absorber of elastomer. The contact interaction is simulated with help of a vector of additional loading. The given vector returns points of an elastic body, which penetrated in other body, on a general surface of contact. For different conditions of contact the vector of additional loading is various. The vector returns a points, which penetrated on a surface of contact till a straight line, which connects old and new nodes of a design, at contact to absolute coupling The vector returns points, which have penetrated, on a direct perpendicular surface of contact, at contact with slippage. Constructions of elastomers have unique properties. The classical methods of final elements do not allow to take into account these properties. Therefore was used the moment scheme of a method of final elements which takes into account rigid displacement, effect of false shift, weak condensability of elastomers. This method consists in threefold approximation of movings, deformations and function of change of volume.

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INTERACTION OF THE STEADY FLOW OF A VISCOUS LIQUID WITH A MULTILAYERED VISCOELASTIC WALL

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Nature gives us excellent examples of the optimal solutions and evolutionary optimized mechanical systems that can be used in practice and technology. The very first investigations of unique damping properties of the dolphin skin have inspired the series of theoretical and experimental work of the shear stress decrease and delay in transition to turbulence flow and stimulated development the special coating for technical applications. In the same way the steady flow stability and wave propagation in the blood vessels as multilayered anisotropic tubes with defined set of the material parameter and thicknesses of the layers gives some important decisions that can be applied to liquid flows in the tubes and channels of the technical devices and mass-exchange apparatus with distensible ducts [1]. Here the wave propagation in the multi-layered viscoelastic tube filled with a viscous incompressible liquid is considered. Navier-Stokes equations for the fluid and momentum equations for the solid layers are considered. The modified Kelvin-Voight model for the layers with different rheological parameters is used. The continuity conditions for the velocities and normal and tangential stresses at the fluid-solid and solid-solid interfaces are considered. The ratio of the radial displacement of the wall to the undisturbed inner radius of the tube is supposed to be small and solution of the coupled system is sought as power series in the small parameter. The expressions for the amplitudes of the pressures, fluid velocity and wall displacement components for the zero- and first-order approximations are obtained in analytical form. Basing on the boundary conditions the dispersion equation is calculated. Numerical investigation of the phase velocity and spatial amplification rate as the frequency functions at different material parameters is carried out. The parameters corresponding to normal and pathological arterial vessel walls as well as to some technical plastics and gels have been used for computations. The volumetric flow rate and wall shear stress are calculated. The fluid- and solid-based modes are distinguished. It is shown that Young modules, viscosities and thicknesses of the layers significantly influence the flow parameters, which is determined by the fluid-solid energy flux.

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COUPLING MODEL OF SURFACE ADMIXTURE REDISTRIBUTION AT THE CONDITION OF ONE-AXIS MECHANICAL LOADING

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The effects accompanying the solid-phase diffusion were analyzed in [1-3] etc. It was shown there that mass transfer mechanism under stress action is analogous to barodiffusion in gases and liquids. Interrelation between the diffusion and stresses should play essential role in the mechanical behavior of materials. As a rule, the diffusion problems in deformable media are analyzed in quasi static formulations, when ones are studying the surface modification of materials. And what is more, the most of known models are restricted by the calculation of stress fields accompanied the diffusion. If it is correct in some particular problems to estimate the stresses in the diffusion zone during reaction diffusion and to investigate the internal stress influence on the new phase center growth, so the quasi static approximation is no proper, when the mass transfer is modeled at the conditions of diffusion welding, acoustic or shock-wave actions and during material treatment using intensive particle beams of various types. The notions of effective diffusion coefficient are nonsensical here. Analysis shown that the items proportional to stress gradient will be prevail at the condition of external mechanical action depending on time or at the condition of essential no uniform stress field. The problem on the treatment of the material containing the alloying elements in thin surface layer by high frequency action could be regarded as the example where mass transfer under stress action will be defining. In this case, it is correct to investigate the mass elasticity equations presented in stresses in the approximation of ideal or non ideal solution with corresponding boundary conditions. In this paper, the simplest one-dimensional model, including the motion equation and diffusion equation connecting with stresses is studied numerically. It is shown that the stresses lead to diffusion zone increase essentially.

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ABOUT BOUNDARY PROBLEMS VOLUMETRIC FORMING IN CONDITIONS OF SUPERPLASTICITY

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In the framework of the theory elastoplastic processes of small curvature and the developed modelling representations some problems volumetric forming with use of superplasticity are considered. At the certain assumptions concerning a field rates displacement, fields of stresses and rates strain, and also working strength are established. From conditions of maximization of volume area of superplasticity as parts of the center deformation and minimization strengthes are constructed functions controlling by processes which optimization is caused by qualitative structural parameters of a final product. The concrete data are received for cases of manufacturing under the circuit of return expression of the thin-walled cylinder with the bottom and undraw plate drawings.

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OSCILLATORY MARANGONI INSTABILITY EVOLUTION UNDER THE INFLUENCE OF FINITE-FREQUENCY VIBRATIONS

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The influence of thermocapillary effect on the thereshold of parametric waves generation at the interface between two liquids by the horizontal vibrations was considered in [1]. The interaction of parametric and thermocapillary mechanisms of surface waves generation was also examined in [2-3]. In the present research opposite problem on finite-frequency vibrations influence on the thermocapillary oscillatory instability evolution of two-layer system of non-mixing incompressible liquids is considered. Two-layer system of non-mixing liquids, contained in the vessel accomplishing horizontal vibrations in the present of vertical temperature gradient is investigated. As thermocapillary convection is of prime interest, the interface is supposed nondeformable, capillary-gravity waves are not examined. In this case solution with flat velocity profile, temperature gradient corresponding heat-conducting regime is possible, at that the interface remains non-deformable. Investigating the problem in the absence of vibrations it was found that Marangoni instability has monotonic character, if thermal conductivity coefficient of colder liquid is less than the hotter one. In the opposite case of thermal conductivity ratio and in the absence of vibrations perturbations reduce by an oscillatory character; therefore it is possible to assume that the horizontal vibrations can result in development of oscillatory instability. In the model problem we assumed viscosity and thermal conductivity coefficients to be equal. The problem on main flow stability was solved analytically by series expansion in a smallness parameter, which is proportional to the vibration amplitude with application of multiscale method. Calculations showed that in this problem waves with frequency equal to the driving frequency are generated. Amplitude equations for disturbances were obtained, on their basis neutral curves were plotted, and dependence of vibration critical amplitude on thermal conductivity ratio of fluids was determined.

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ANALYSIS OF CONTACT TRIBOMECHANICAL SYSTEMS WITH HETEROGENEITIES AND DEFECTS APPLIED TO A PAIR WHEEL - RAIL

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The results of the finite element and analytical solutions of the contact interaction problems for various tribomechanical systems are described. The investigations are focused on the definition of the deflected mode of the complicated bodies with non-uniform properties and defects in the near-surface layers under normal and tangential forces. The specific applied problem is the estimation of the stress-strain behavior of the rail wheel with inhomogeneities and defects in the near-surface layers.

Solid models with material properties are developed in view of opportunities of subsequent condensation of finite element mesh in contact zones, assignment of inhomogeneities and defects, application of submodeling method and creation of finite element grids for modeling problems. Methods of the automated updating of material properties of finite elements for giving non-uniform material properties for the set functional dependences are developed.

For testing the numerical approaches proposed the new analytical solutions of plane and axisymmetric contact problems are constructed at presence of friction forces in initially unknown contact area and in view of the boundary effects arising on irregular areas of contacting surfaces. For these modeling problems the finite element programs are established and necessary calculations are performed. Comparison of the finite element results received with numerical - analytical results for modeling problems is carried out. For all the problems considered sufficient agreement of analytical and numerical results is obtained.

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A MICRO-POLAR THEORY FOR NON-POLAR PIEZOELECTRIC MATERIALS

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The equation for micro-polar theory of the piezoelectric phenomenon in polar mediums had been presented recently. However, the materials with non-polar structures remain uncovered. One of the most important materials of that class is α-quartz. This material has very wide sphere of application due to its unique properties. This paper consider mechanism of interaction between electric field and non-polar piezoelectric medium from point of view of micro-polar theory. The obtained equations are fitted to materials with symmetry class 32. As an example α-quartz structure is considered.

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THE INVESTIGATION OF THE IRREVERSIBLE STRAIN IN THE BRITTLE FRACTURE MATERIALS

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It is well known that compound composite materials, such as soils and rocks, while under strain, form a quasi material, where plastic deformation is realized due to fragmentation of a solid into separate parts, their displacement along the sliding surfaces and rotation so as to originate a quasi-continuum. This concept is the key idea for the synthetic theory of strength and is developed in the present work. The present research is based on the notion of irreversible strain of solids due to shear localization and formation of real sliding surfaces. Brittle fracture mechanics and the modern theory of strength formulate fracture criteria as invariant connections of critical values of strain macro parameters, and, nowadays, are more and more founded on physical methods of solids and modern branches of mechanics, which take into account material microstructure. When principal shear attains its critical value, the zone of irreversible strains starts to grow on condition that maximum tangential stress remains constant. The very moment of fracture takes place when stresses and strains achieve their critical values, while preparation to fracture (prefracture) happens near the zone of stress concentration, which is a classical region of plastic flow. Primary invariant connections serve as the fracture criterion at the moment of fracture. In case of brittle fracture, which is observed in problems on geomechanics and strain of rocks, the state of fragmentation of a solid into parts, replacing the state of plasticity, is modeled by the quadratic plasticity criterion for the stresses and strength criterion for shear strains. The issue, concerning the origin of irreversible strain in the material surrounding an excavation, is considered for an elastoplastic model in the case of excavation of a circular cross-section. Stress and strain behaviour near the elastoplastic boundary is analyzed; dependence of the position of the elastoplastic boundary on the given force values on the excavation contours is established; the strain values in the plastic region are calculated; the behaviour peculiarities of the inclination angle of the strain tensor principal directions in the prefracture zone are revealed. The issue of plasticity growth, referring to the process of additional loading and environmental stress variation while the state of material plasticity is originated, is considered as well. The author is sincerely grateful to E.I. Shemyakin, Academician of the Russian Academy of Sciences, for the formulation of the problem and assistance in work. The research is accomplished in the framework of the RFBR (Grant No. 05-01-00749).

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THE METHODS OF THE DEFINITION OF A METAL HARDENING CURVE UNDER THE EXPERIMENTAL DATA OF INTRODUCTION

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The curve of hardening is the important characteristic of the metal properties. This curve allows to find the mechanical characteristics of a material and to give an estimation of stress-strain state during the modeling of the process of detail manufacturing. There are standard tests for definition of a metal hardening curve: a tensile or a compression of specimens. However, for designs taking place in operation, for example, bridges, shell of rockets etc., it is impossible to use these methods for identification of the properties of the metal. In this case it is necessary to apply not destroying methods of experiments. It is offered to use a method of introduction of conic indenter to the surface of a product. In this test it is received the diagram of the indentation, which expresses the dependence of the effort of indenter introduction from the depth of the introduction. The curve of hardening can be found by comparing the experimental diagram of indentation with the diagram received at computer modeling of indenter introduction by the finite elements method. In finite-element model the elastic-plastic isotropic hardening medium submitting to the Hook law and the plasticity condition of von Mises has been used. Within the framework of this model the yield stress uniquely determined on a hardening curve is the unknown parameter. The curve of hardening has been defined by cubic spline approximation of the parameters. The diagrams of the indentation for specimens from Steel 3 have been received by the testing machine Instron 8801 for conic indenters with a corner at top 90 and 120 degrees for the effort of indentation equals 5 kH. The values of spline parameters were determined by minimizing of the discrepancy between the designed and experimentally received diagrams of indentation. The curve hardenings which were found from the experimental data for two corners of the indenter have coincided with high accuracy, and also have shown good concurrence from the hardening curve received for the given mark of steel from the experiments to compression of the cylindrical specimens.

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MODELING AN INTERACTION BETWEEN A PHASE TRANSFORMING INCLUSION AND A FATIGUE CRACK

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We study the interaction between fracture processes and localized structural transformations. Materials may contain inclusions which can suffer stress induced phase transformations under the process of the deformation of a body. Favorably oriented anisotropic grains in polycrystalline materials or inhomogeneities of technological nature are examples of such inclusions. Phase transformations change elasticity modules of a material and produce self-strains of a transformation. As a result, local stresses change. This in turn can initiate or block fracture processes.

This work presents the investigations of the interaction between the inclusion enduring phase transformations and a fatigue crack. We study phase transitions in a cylindrical inclusion under an external stress field transmitted by a linear elastic matrix. The possibility of phase transition in the inclusion is determined by the principle of the energy preference. We develop the finite element algorithm for the determination of the phase state of the inclusion in arbitrary stress fields. The calculations are verified by the comparison with the analytical results obtained for the case of uniform external fields.

Then we study phase transformations of the inclusion due to the stresses induced by the crack. The study is based on the calculation of the stress intensity factors. We show that the crack growth can initiate phase transitions in the inclusion. We also show that, in dependence of material parameters, the inclusion attracts or repels the crack if the phase transformation takes place. We study how this effect depends on material parameters. We mention that the effects take place when the distance between the tip of the crack and the center of the inclusion is comparable with the diameter of the inclusion, at the reasonable choice of the material parameters. We also demonstrate the competition between the external stress field and stresses induced by the phase transformations, namely, we show that increasing external stress may suppress or intensify the action of the phase transformation on the crack trajectory.

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HYPERBOLIC INTERFACES IN COMPOSITE SHELLS UNDER FRONT IMPACTS

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The paper is devoted to mathematical modeling of nonstationary wave distribution in composite shell structures. Longitudinal impacts of tangential and bending types as well as the normal impact are discussed in the paper. Asymptotic model of wave propagation in the semi-infinite shell of revolution is used. Two-dimensional Kirchhoff-Love components (tangential and bending), solutions for quasi-planar problem of the theory of elasticity, parabolic interface at the quasi front neighborhood, interface at the Raleigh wave front neighborhood and hyperbolic interfaces in the neighborhoods of expansion and shear wave fronts are applied. Boundary contact problems for incident, reflected and transmitted waves are formulated and solved on base of corresponding components. Quasi-static interface (quasi-symmetric and quasi-anti-symmetric) that satisfies the boundary conditions together with two-dimensional component is built in order to satisfy boundary conditions on the end surface in exact three-dimensional form and in the small neighborhood of the end surface contact zone. Problems for semi-infinite shell were taken as basis while investigating the problem of wave propagation in the composite shell. The first problem describes waves that are caused by the front impact. The proof of solution matching for hyperbolic interfaces and quasi-plane problem solution of the theory of elasticity is conducted in the stage of problem analyzing. The area of theory applications is also defined here. The second basic problem describes the influence of pack of waves on the joint of two semi-infinite shells and formation of the packs of reflected and transmitted waves. Contact problem for hyperbolic interfaces is solved using Laplace time and Fourier longitudinal coordinate integral transformations, method of front asymptotic and an assumption that the solution for the interface changes slightly with the normal coordinate in the scale of the contact thickness.

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TIME OPTIMAL CONTROL OF MECHANICAL SYSTEMS WITH DRY FRICTION UNDER HARMONIC DISTURBANCES

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The controlled motions of a mechanical system under dry and viscous friction and harmonic disturbances are investigated. The dry friction function of velocity is supposed symmetric piecewise constant. The time optimal control for the undisturbed point-to-point problem is applied to the system subject to a harmonic force with given amplitude, frequency, and phase. The resulted phase trajectories and periodic limiting motions for different system parameters are investigated. It was shown that the phase point of the system can reach zero position in some fixed time or tend to a limit cycle. Starting at the origin the point can return back periodically or perform an irregular bounded motion. The emergence and stability conditions of simple cycles are analyzed. For the disturbed system the synthesis and program law of time optimal control were derived. It was proved for each acceptable set of parameters that there exists a piecewise constant optimal control with no more than one switch.

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DYNAMICS OF THE PANTOGRAPH DESIGN IN ORBIT

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The object of research is transformable in orbit an elastic pantograph design. It is a component of a space vehicle and is a gravitational stabilizer and a support of solar arrays. For taking into account the elasticity of elements of the many-tier design each of them was modelled by two rigid rods connected by an elastic hinge. Elasticity of the hinge was estimated proceeding from equality of potential energy of initial and equivalent elements at identical configurations of characteristic points of the element in the deformed condition. Dynamics of relative motion of pantograph design is described by Lagrange equations. Values of rhombuses semi-diagonals, which are parallel to a centerline of all design, are chosen as the generalized coordinates. At research of such design, stabilization of a space vehicle in inertial reference frame was assumed ideal, at least during time of change of a configuration of the design. It has essentially simplified statement of a problem as in this case it is possible to consider that the centerline of a design remains straight-line. At the same time, it allows full enough to investigate dynamic behaviour of the system at various laws of program change of a configuration of the first tier, which results in deployment or retrieval of all design. The laws of a deployment are considered that varied not only under the shape, but also on duration. It is shown that depending on character of these laws the design may be either underdeployed, or opened on larger length than it would be made with absolutely rigid design.

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ENERGY EXCHANGE IN DNA DOUBLE HELIX

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We describe nonlinear localized excitation in the macromolecule DNA within the framework of the mechanical model. The model consists of two discrete oscillatory chains coupled by nonlinear springs. We take into account only one type of internal motions of DNA, namely rotations of the bases about sugar-phosphate chains, thus each base is considered as a twist pendulum and a chain as a line of connected nonlinear pendulums. After transition to complex variables [1-3] we use the multiple-scale expansions, the ratio of distance between pendulums relative to characteristic wavelength being a small parameter. As a result, we have obtained two coupled nonlinear Schrodinger equations (NSE) in principal asymptotic approximation. These equations describe, in particular, energy transfer between two oscillatory chains. It is shown that the transfer can be actually realized by nonlinear soliton-type excitation (breather) and by nonlinear cooperative waves if parameter of nonlinearity is not too large. There is some critical value of this parameter corresponding to appearance of strong energy localization on the chain (if the energy was initially concentrated on it).

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RAYLEIGH-BENARD CONVECTION SUBJECT TO TRANSLATIONAL VIBRATION OF CIRCULAR POLARIZATION

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The strengthened attention to studying convective processes in non-stationary force fields with reference to conditions of orbital flight is caused by development of various space technologies. The analysis of real conditions of weightlessness on space vehicles has shown necessity to consider influence on technological processes not only the gravitational mechanism convection, but also inertial accelerations varying in due course. Convection in conditions of variable external influences now is a subject of numerous researches. The knowledge of a picture of current and his dynamics are require for the decision of many hydro dynamical problems and is actual in connection with a wide variety of technological appendices. Performance of necessary researches on space vehicles is interfaced to complexity and dearness of experiments. Therefore it is expedient to spend laboratory modeling of the phenomena in ground conditions before first-hand experiences on space vehicles. Considering the reasons resulted above, it has been decided to lead experiments on supervision over stability and structures arising convective currents in the flat horizontal layer of a liquid which are being a field of inertial accelerations of circular polarization. The results of experiments presented in the present work, are important for understanding of interaction of the vibrating mechanism with thermogravity and also operating influence of vibrations on convective flows. Threshold curve stability concern to those in coordinates of number Rag and his vibrating analogue Rav, and also in terms of dimensionless vibrating speed a and gravity Rayleigh number at different orientation of a gradient of temperature. Results of experiment speak that the inertial accelerations polarized on a circle render destabilizing influence on stability mechanical quasi-equilibrium to a liquid at $Rag > 0$. Besides the given vibrations excite currents at heating from above, and position of threshold lines depends on frequency of external influences. Dependence of a dimensionless thermal stream - numbers Nu depending on intensity of vibrations and conditions of heating are investigated. In researched area of parameters experimental values, within the limits of an error, well lay down on one curve. The specified behaviour will well be agreed with the root dependence $Nu\ Rag1/2$ which is taking place in many convection problems. It is necessary to notice also that, number at supercriticality equal 4 accepts value 1,4. For comparison, at convection in a static gravity field the

number Nusselt for $Rag/Rag* = 4$ accepts value 1. It testifies to substantial growth heat transfer caused by the vibrating mechanism of convection in comparison with a heat transfer caused by the gravitational mechanism. Work is executed at partial financial support of the Russian fund of basic researches and Department of education and a science of Perm area Administration (grant 04-02-96038) and Fund of the USA of civil researches and development for the independent states of former Soviet Union CRDF (grant PE–009-0).
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HEAT VIBRATIONAL CONVECTION IN PLANE LAYER SUBJECTED OSCILLATIONS OF SPATIAL PENDULUM

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Thermal vibrational convection of liquid with a homogeneous internal thermal emission in a cavity subject to oscillations of spherical pendulum is studied experimentally and theoretically. The cavity has the form of a parallelepiped and models a flat layer. The layer boundaries are perpendicular to the pendulum shoulder; the rotation of the cavity concerning the shoulder is absent. The center of the pendulum is located above the layer. During the oscillation the pendulum shoulder draws the conic surface, the center of the layer moves along the circular trajectory. The lower layer boundary is isothermal; its temperature is kept constant. The top boundary - adiabatic, its temperature is determined by the intensity of internal thermal emission. This temperature distribution corresponds to stable stratification of liquid in the gravity field. Experiments find out two thresholds of critical growth of heat transfer with increase of vibrations intensity. The first (under conditions of the experiment) threshold is connected with the instability of Stokes boundary layer and manifests itself in the occurrence of three-dimensional vortical structure located in the boundary layer. It is revealed that the given instability can be found in isothermal liquid as well at the presence of density heterogeneity connected, for example, with the presence of fine firm inclusions with different from the liquid density. The second threshold is connected with the development of thermal vibrational convection itself. Convection occupies all the layer volume and is determined by the combined action of various thermovibrational mechanisms [1]. In theoretical part of the work the conditions of excitation of pendular vibrational convection in flat layer with an internal thermal emission are examined on the basis of the equations [1]. The equations are received by the method of averaging in approximation of high dimensionless frequencies (negligibly thin Stokes boundary layers). The results of theoretical analysis are in good agreement with experimental ones.

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MD MODELING OF LOW-CYCLE HIGH-AMPLITUDE LOADING OF MONOCRYSTAL MATERIAL WITH DEFECTS

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Fracture under low-cycle high-amplitude loading of 2D monocrystal material with predefined distribution of defects is studied using molecular dynamics technique. Influence of density of vacancies, lattice orientation, loading amplitude, loading period, thermal motion and interaction characteristics on the material strength, fracture process and crack topology are analyzed.
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THE SECOND VARIATION OF THE ENERGY FUNCTIONAL THAT ALLOWS FOR PHASE TRANSITION AND INSTABILITY OF PHASE BOUNDARIES.

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Phase boundaries in the Continuum Mechanics are traditionally modeled as the surfaces of the jump discontinuities of strain. It is well-known that the continuity of traction and the Maxwell rule at the interface are the necessary conditions for its stability. In this work we apply a variational procedure, which takes into account a variation of the interface, and calculate the second variation of the energy functional. From its positivity we derive new necessary algebraic conditions of stability involving the derivatives of the potential up to the second order. In contrast with the previous works on stability based on additional physical assumptions, our results follow directly from the variational formulation of the problem.

RAYLEIGH WAVES IN THE ISOTROPIC AND LINEAR, REDUCED COSSERAT CONTINUUM

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We continue in this paper the work on the modeling of rocks and soils in terms of the linear, elastic, reduced Cosserat continuum. The reduced Cosserat continuum is a continuum where each point possesses rotational degrees of freedom. Furthermore, the medium resists to rotation as well as to translation, while the couple stress is zero. The stress tensor is asymmetric. The objective of the model is to take into account the mictrostructure of rocks and soils which influences wave propagation. It was first suggested by Shwartz, Johnson, and Feng in 1984 to describe granular materials. Wave propagation in an unbounded 3D reduced Cosserat continuum was investigated by Grekova and Herman (2003–2005). In this work, we consider the Rayleigh wave for the isotropic case, using analytical and numerical methods. Instead of a straight line in the classical medium, we obtain two dispersion curves. The polarization differs both from the case of the classical medium and the case of a Cosserat continuum with couple stresses. For some frequency range, we observe a strong frequency dependence. There is a forbidden band of frequencies, lying below the analogous forbidden band for an unbounded medium. It indicates the possibility of localization phenomena. For the upper branch of the dispersion relation, there is also a forbidden domain of wave numbers: long waves may propagate only with one frequency. Far from the domain of frequencies where the microstructure influences the wave propagation, the medium behaves analogously to the classical one (as expected). We make a comparison with the classical medium and the Cosserat medium with couple stress for which the Rayleigh wave was investigated by Kulesh et al.

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SURFACE WAVES PROPAGATION IN COSSERAT CONTINUUM: CONSTRUCTION OF SOLUTION AND ANALYSIS USING WAVELET TRANSFORM

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The problem of the surface elastic wave propagation in a half-space and in a thin layer within the framework of the Cosserat medium has been considered. Medium deformation in this model is described not only by the displacement vector, but also by kinematically independent rotation vector. This model can be used for the description of the media with microstructure, for example concrete, sand, sandy-gravel mixture, soil etc.

At the same time the applications of these models almost do not exist in praxis, since there are no reliable data about the material properties in nonsymmetrical elasticity theory and in fact there are no experiments which can demonstrate the effects of couple-stress behavior in solid under deformation.

Main models of elastic waves propagation in medium with microstructure have been proposed in 50-60th. At that time many significant theoretical results have been obtained, for example the fact of Rayleigh waves dispersion. But the classical elasticity theory does not describe this effect.

The main result of presented work consists in fact, that within the framework of the Cosserat medium in the half-space besides elliptical Rayleigh wave can be in existence a shear surface wave with only transversal component. Geometrically such wave is equal to Love wave, but the existence of the Love wave as shear elastic wave is defined by presence of a layer on a half-space in classical elasticity theory, and while a layer thickness vanish the Love wave is transformed to a plane wave. The same situation we can observe in case of thin layer while besides Lamb wave can be in existence a dispersive shear wave with only transversal displacement component. Thus, in the Cosserat medium the new wave modes are found out, and there is no analogue of it in classical elasticity theory.

As a second result of presented work the method of the displacement seismogram inversion has been proposed. This method is based on continues wavelet transform and allows to restore the wave number, phase and group velocities from experimental displacement seismograms.

These results can be effectively used in possible experiments which are aimed at the detection of couple-stress effects in medium and further at the identification of material constants of nonsymmetrical elasticity theory.

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ON A VARIOUS MATHEMATICAL MODELS OF A SKATEBOARD MOTION

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In our presentation we propose several mathematical models describing the motion of the rider on a skateboard. The motion of all models is considered in assumption, that the rider control is absent. The equations of motion of each of models are derived in the form of Gibbs - Appell equations and the analysis of these equations is fulfilled. In particular, the effect of varying vehicle parameters on stability of its motion for each of models is studied.

In the present time skateboarding - the art of riding on a skateboard - is one of the most popular recreational sports. Millions of people take a great interest in a skateboarding. Nevertheless, the serious researches concerning dynamics and stability of a skateboard motion are almost absent. At the late 70th - early 80th of the last century Mont Hubbard in his papers [1,2] proposed several mathematical models describing the motion of a rider on a skateboard. However these works are written very briefly (in particular, the derivation of the equations of motion is omitted, the detailed analysis of the obtained equations is not fulfilled), that does not allow to understand the basic mathematical principles of a skateboard dynamics. In our presentation we give the further development of models offered by Hubbard.

Besides the investigations by Hubbard it is necessary to mention also the paper by Yu.G. Ispolov and B.A. Smolnikov [3] and the recent paper by M. Wisse and A.L. Schwab [4], devoted to study a various mathematical models of a skateboard motion. However the model, proposed in [3], is two-dimensional while in the papers [1,2] a more realistic three-dimensional models are studied. As regards the paper [4], it contains only the brief review of the main results obtained in [1,2]. Thus, we can consider the papers [1,2] as a keyworks on a skateboard dynamics.

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ON VIBRATIONS OF CONDUCTIVE BEAM WITH MOBILE LOAD IN MAGNETIC FIELD.

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It is considered integro-differential equation of conductive beams vibrations in homogeneous stationary magnetic field taking into account external function of excitation from given displacement of mobile load on the beam. By modified method of division of variables some partial solutions of the problem is obtained in analytical form as series under complementary restrictions for sizes of active part of the beam. For different cases of fixation of the ends of beam it is shown that action of mobile load can appear only for separate frequencies of the beam. The results are compared with solution of the problem of natural vibrations of conductive beam in magnetic field. Conditions of damping of such perturbed action of mobile load by external magnetic field were found.

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HYDROMECHANICS OF MULTICOMPONENT MULTIPHASE COMPRESSIBLE MEDIA

V. F. KUROPATENKO

Dynamic effects on muticomponent media take them out of equilibrium state and lead to relaxation processes when components interact and interchange by momentum, energy and mass if chemical reactions take place. Usually the well-known models consider the interchange processes in the frames of pair component interactions taking into account their special features (particle size, surface purity, adhesion properties, etc.). The work proves that the wide-used expression for intensity of momentum interchange between components violates the invariance of energy equation respecting to the Galilean transformation. In this place a tensor of strains external for i^{th} component is proposed and its dependence on component velocities is determined. Multicomponent medium is considered as a continuum medium with averaged values and a new type of mixture effect on each component so called cluster interaction is proposed. The conditions are studied when averaged values P, ρ, E, $\overline{U}$ satisfy the system of conservation laws as well as how these conservation laws correspond to the component conservation laws. Not only new forces $F_s i$ occur in the process of cluster interaction between i^{th} component and mixture but energy fluxes $\overline{Q}_{si}$ acting on each component with velocity not eaqual to equilibrium one. The force F_s and the energy flux $\overline{Q}_s$ acting on continuum medium are connected with F_{si} and $\overline{Q}_{si}$ by the equations

$$F_s = -\sum_{i=1}^{N} \sigma_i F_{si} \quad (1)$$

$$\overline{Q}_s = -\sum_{i=1}^{N} \sigma_i \overline{Q}_{si} \quad (2)$$

To eliminate the violence in F_s, $\overline{Q}_s$, F_{si}, $\overline{Q}_{si}$ determination they supposed to be invariant to the Galilean transformation. It is shown that after introducing new forces and fluxes the system of mixture conservation laws is obtained as a sum of component conservation laws. A conception of component non-equilibrium kinetic energy is introduced and additional equation for volume fractions is proposed which closes the system of conservation laws and equation of state of i^{th} component and does not restrict the mixture properties.

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MICROSCOPIC DERIVATION OF EQUATION OF STATE FOR PERFECT CRYSTALS

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This paper is devoted to obtaining of thermodynamic equation of state for perfect crystals. The approach based on particles dynamics method is considered. According to this approach it is proposed to analyze the simple discrete systems as models of materials behavior. Microscopic analogues of the macroscopic quantities as stress tensor, pressure, volume and thermal energy are introduced. Averaging of such quantities is conducted. In this way the desired equation of state in Mi-Gruneisens form is obtained. Analytical and numerical solutions are considered and compared. In a case of small deformations the value of the Gruneisens parameter is found. It is shown that in a case of large deformations the Gruneisens parameter depends on the thermal energy and the Gruneisens equation of state is loosing sense.

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INTERACTION BETWEEN SURFACE CONDITION AND FATIGUE LIFE

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It is well known that the surface condition influences significantly the fatigue behaviour of components. Therefore a large number of surface treatments based on mechanical, thermal or chemo-thermal effects were developed in the past. This paper focuses on the evaluation of mechanical surface treatments. Although mechanical surface treatments are commonly used in engineering practice for their beneficial effect on fatigue life, only few quantitative data is available from literature. This contribution presents results of a long-term program that aims at developing quantitative de-sign guidelines for the influence of mechanical surface treatment on fatigue life of compo-nents. For this purpose, experimental work and numerical simulations are performed in paral-lel, giving a detailed understanding of the effects of mechanical surface treatments on surface roughness, residual stress distribution, and resulting fatigue strength.

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VOLCANIC TSUNAMI IN THE CARIBBEAN SEA: THE ANALYSIS AND MODELING

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Soufriere Hills Volcano is located in a southern part of Montserrat Island. The height of a crater above a sea level about 1000 (it changes in view of activity of a volcano). This volcano represents stratovolcano with the broken central crater and cratering cupola. A diameter of a crater English 731 m, depth of 152 m. The active life of Soufriere Hills Volcano began from eruption of July 18, 1995 and proceeds till now. The eruptions of a volcano have resulted in catastrophic consequences for islands: is completely destroyed and city of Plymouth; about 8000 men have left an island, having lost habitation and work; the economy of an island is in a crisis condition.

In this work the results of field researches of traces of tsunami on Montserrat, Guadeloupe and Antigua Islands, caused by proceeding eruption of volcano on an island Montserrat in 1997-2003 years are presented. The main result of expedition is the proof that the volcanic eruption on Montserrat Island, which has happened in 12-13 July 2003, in night, has caused tsunami registered on Montserrat and Guadeloupe Islands. Height of wave on Montserrat Island makes 4 m, and on Guadeloupe Island 1 m. The chronicle of volcanic eruptions on Montserrat Island is given also, the special attention is given to eruptions in 1997 and 2003 which have brought in generation of tsunami.

For an estimation of parameters of tsunami arising at such eruptions, the mathematical modeling of distribution of tsunami is executed in the context of the nonlinear-dispersion theory. The complete system of the nonlinear equations Boussinesque, which we used for modeling of tsunami looks like:

$$\eta_t + \nabla((h+\eta)(u_a + (z_a + \frac{1}{2}(h-\eta))\nabla(\nabla(hu_a)) + + (\frac{1}{2}z_a^2 - \frac{1}{6}(h^2 - h\eta + \eta^2))\nabla(u_a)))) = 0$$

$$u_{at} + (u_a\nabla)u_a + g\nabla\eta + z_a(\frac{1}{2}z_a\nabla(\nabla u_{at}) + \nabla(\nabla(hu_{at}))) + + \nabla(\frac{1}{2}(z_a^2 - \eta^2)(u_a\nabla)(\nabla u_a) + \frac{1}{2}(\nabla(hu_a) + \eta\nabla u_a)^2) + +\nabla((z_a - \eta)(u_a\nabla)(\nabla(hu_a)) - \eta(\frac{1}{2}h\nabla u_{at} + \nabla(hu_{at}))) = 0$$

where η displacement of water surface; t time; h unperturbed depth of basin; g gravitational acceleration; u_a horizontal vector of speed on depth $z = z_a = -0,531h$, $\nabla = (\frac{\partial}{\partial x}, \frac{\partial}{\partial y})$ horizontal operator of gradient. Conservation laws for mass and angular momentum are valid for this system accordingly.

It is used for precomputations of the characteristics of tsunami at various coasts necessary for optimum planning for expedition on inspection of traces of tsunami. The data of inspections are in the consent with predictions of theoretical model. The distribution of heights of waves along coast Guadeloupe also is proved by the numerical accounts, executed by us. The detailed description of results of expedition and modeling can be found [1].

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ESTIMATION OF TSUNAMI HAZARD OF GUADELUPE ON A BASIS OF NUMERICAL MODELING

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From the point of view tsunami hazard the basin of the Caribbean sea is one of the most dangerous places in all Atlantic. The prognosis of tsunami risk of this region is extremely necessary not only in connection with high seismic activity of the given region, but also with a probable opportunity of eruption of volcanos, that, in turn, can become the reason of occurrence of tsunami, and such cases were marked in the literature.

Guadelupe Island with Maria Galanta, Desirade and Sintes Islands enter into archipelago Windward Island and are location in epicentre of the center of strong underwater earthquakes. The Guadelupe Island is located at the centre of one of the most seismically active zones of Atlantic. The tsunami on this island was registered each ten years in the past fiftieth anniversary, therefore it is extremely important in details to investigate and to estimate danger of waves of tsunami to its coast.

In the submitted work is studied tsunami danger of Guadelupe. The method of the synthetic catalogue basing on numerical modeling is applied for an estimation of risk of tsunami and tsunami zoning. The numerical modeling was carried out within the framework of the nonlinear theory of shallow water described by the system:

$$\frac{\partial M}{\partial t} + \frac{\partial}{\partial y}\left(\frac{MN}{D}\right) + \frac{\partial}{\partial x}\left(\frac{M^2}{D}\right) + \qquad (1)$$

$$+gD\frac{\partial \eta}{\partial x} + \frac{gm^2}{2D^{7/3}}M\sqrt{M^2+N^2} = 0,$$

$$\frac{\partial N}{\partial t} + \frac{\partial}{\partial y}\left(\frac{MN}{D}\right) + \frac{\partial}{\partial y}\left(\frac{N^2}{D}\right) + gD\frac{\partial \eta}{\partial x} + \qquad (2)$$

$$+\frac{gm^2}{2D^{7/3}}M\sqrt{M^2+N^2} = 0,$$

$$\frac{\partial \eta}{\partial t} + \frac{\partial M}{\partial x} + \frac{\partial N}{\partial y} = 0. \qquad (3)$$

where η - displacement of water surface, t - time, x - latitudinal and y - longitudinal coordinates, $D = h(x,y) + \eta$ - general depth of water, h - unperturbed depth of basin, g - gravitational acceleration, $m = 0.0025$ coefficient of roughness of bottom, M and N - components of the charge of water (integrated on depth) lengthways of latitudinal and longitudinal directions accordingly: $M = u(h+\eta)$, $N = v(h+\eta)$, where u and v - components of horizontal speeds of particles of water.

For modeling waves of tsunami was used batimetry of the Caribbean sea, with a step two angular minutes on breadth both longitude and including 1001×568 (568568) points. Given batimetry was given by the National Geophysical Centre of the Data (NGDC) - ETOPE2. For the account of heights of tsunami, along coast of an Guadelupe Islands, in everyone last sea point fixed maximal height of wave. Proceeding from a step of a grid distance between "basic" points, made three kilometers, and the depth was no more than 350 meters. Boundary conditions of distribution of a wave, is the wall on depth of 20 m. As the meanings of heights of waves strongly vary for various sources, owing to initial meanings and trajectory of distribution, the spatial distribution of heights of waves for each case was normalized on the maximal meaning overwash for the appropriate event.

Comparing the received results, it is possible to allocate unique area of an Guadelupe Island, not dangerous from the point of view of tsunami, is an area from 10 up to 20 tide-gauge, i.e. from cities Veuks Burg up to cities Santa Rose. This area of coast (between the specified cities along northern coast of "isthmus") are in relative safety from waves of tsunami, due to the large coral reef, which covers almost all area of a gulf Grand Cool de sak Martin. The waves of the large amplitude, lose the most part of the energy, falling on reeves by way of 2-3 kilometers from a coastal line.

In the upshot, the results of accounts show, that practically all coast of Guadelupe Island is subject to influence of tsunami behind exception only of one site, which, really, it is possible to rating to a class not dangerous - is western area of a gulf Grand Cool de Sak Martin.

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PARTICLE SIMULATION OF GRAVITATIONAL COLLIDING SYSTEM ON PARALLEL COMPUTER

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The work is devoted to computational aspects of simulation of gravitational systems using method of particle dynamics. In addition to long-range gravitational forces the short-range interaction forces for modeling of particle collisions are considered. The algorithms of integration of equations of motion and approximate force calculations are analysed. As a result of the comparison of different methods for solving N-body problem a parallel hierarchical method based on Barnes-Hut algorithm has been developed. This method has been implemented to run on supercomputer MBC-15000 which is multiprocessor system with the Message-Passing-Interface (MPI). The performance tests give satisfactory results in comparison with other Barnes-Hut algorithm implementations.

Application of the computational algorithms to the problem of planet formation is considered. In particular, problem of Earth-Moon formation as a result of rotational collapse of a dust cloud is being modeled. The area of initial conditions in which the system evolution is in agreement with the geophysical model of Earth-Moon formation has been founded.

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THE INFLUENCE INITIAL DAMAGING OF A MATERIAL AND UNLOADING WAVES

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The influence initial damaging of a material on dependence of parameter damaging from time is investigated. The experimental data for various constructional materials are considered and is shown, that the account initial damaging allows correctly describe experiments on long durability when the dependence between time before destruction and loading in logarithmic coordinates is not linear. The constant equations of Kachanov - Rabotnov for such materials are determined. Unloading waves and process of accumulation damages are shown. Process of accumulation damages connect with creation unloading waves. Appropriate wave problems are solved. Possible wave profiles are determined.

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SCALE EFFECT IN ELASTIC PROPERTIES OF NANOSTRUCTURES WITH COMPLEX CRYSTAL LATTICES

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Discrete mechanical model for nanocrystals with complex crystal lattices is considered. The complex lattices are typical for some metals and crystals with covalent bonds, such as diamond and graphite. Traditionally for description this kind of lattices many-particle potentials are used. In the current paper the alternative approach is used. In this approach the rotational degrees of freedom are taken into account and the moment contribution in interatomic interaction is allowed. In the paper the nanocrystals with different number of atomic layers is considered and scale effect in elastic properties of nanostructures is investigated.

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ELASTOPLASTIC MODEL OF IMPACT CYLINDRICAL INDENTER ON AN UFLYAND-MINDLIN PLATE

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The present paper is devoted to mathematical modeling of the low velocity impact of a sphere on a thin elastic isotropic plate, whose dynamic behaviour is described by the Uflyand-Mindlin equations taking the rotary inertia and shear deformations into account and, therefore, these equations are wave equations. They allow to assume that in a plate the transient wave of transverse shear, because of which there is a deformation of a plate material outside of the contact area, is generated with final velocity.

As a method of the decision the ray method and method of splicing asymptotic expansion received for small times in the contact area and outside of it are used. In the present work, the procedure similar to the one proposed in [1] for the analysis of transverse impact of a solid sphere upon an elastic buffer positioned on an elastic orthotropic plate, is used to the case of shock interaction of a solid body in view of a rod with a elastic isotropic plate. The local deformations in the contact region are taken into account in terms of two elastoplastic models, the Hertzs theory and the rigidplactic model.

During the interaction of the indenter with the plate, a quasitransverse waves representing the surfaces of strong discontinuity begin to propagate, and the reflected wave has not had time to return to the boundary of the contact disk before the impact process completion. In the plate of the surface of strong discontinuity represent cylindrical surfaces strip, whose generators are parallel to the normal to the median surfaces and guides locating in the median surface are circumferences extending with the normal velocities. Behind the wave fronts, the solution is constructed in terms of one-term ray expansions [2] whose coefficients are the discontinuities in time-derivatives of the required functions. To determine the desired values inside contact area the equations of motion the impactor and the region of bars contact with the plate are used. The dynamic characteristics are determined at splicing on border of the contact area of the solution for required function inside a contact disk and outside of it. As a result, we are led to a system of two linear differential equations in the dynamic displacements of plate and the quasi-static strain of the plate material in the contact region. The solution of these equations is found numerically by iteration Timoshenko scheme on computer, and the time-dependence of the contact force is obtained.

The carried out numerical researches allow to make the conclusion about influence of parameters of a construction, including plates elastoplastic properties in the contact region, on dynamic characteristics of interaction. One-term ray series for the desired functions have allowed one to calculate with the given accuracy the stresses in the contact area of the plate and the dynamic safety margin of the thin plate.

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DEFORMATION AND LIMIT STATE OF SOLIDS WITH STRESS STATE DEPENDENT PLASTIC PROPERTIES

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The plastic deformation of many materials involves not only the slip of structural elements but the growth of existing microdefects and the formation of new ones which cause the plastic dilatation of the materials. Since the behaviour of micro-damages depends on the type of external forces, the dilatation process is not of purely kinematic nature but depends on the type of stress state in solids, which can be characterized, on average, by the ratio of hydrostatic component of stresses to the stress intensity named the triaxiality of stress.

A possible approach to describe the plastic deformation of the materials under consideration is proposed. The plasticity condition is accepted in corresponding generalized form which includes, as particular cases, many of the known plasticity conditions but it gives the possibility to take into account more wide variety of material properties. The conditions for the unique solution of boundary value problem are determined. On the base of the associated flow rule, it is shown that the irreversible volumetric deformation is proportional to the intensity of the strain rate but the coefficient is dependent on the stress state type parameter. This coefficient has different values which are dependent on the correlation between normal and shear stresses in solids.

The system of the equations for the determination of the stresses and the velocities in plastic regions is obtained for the case of plane strain. The problems of the punch indentation and the tension of notched strips are considered. The dependence of the limit state characteristics on the sensitivity of material properties to the variation of the stress state type is studied. The method for the determination of continuous velocity fields characterizing the medium dilatation is proposed. The strain rates are defined completely by kinematic conditions on the boundary of a solid and they are consistent with the stress field in plastic regions.

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FUZZY GENETIC ALGORITHMS FOR DESIGN OF COLD-FORMED STEEL SHEETING

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Because of the high strength-to-weight ratio and ease of assembly, the profiled sheeting has been widely used for roofing, cladding and extended to floor systems in building constructions. Due to the variety of profiles available in the market, finding the optimum shapes is necessary. In this paper, genetic algorithms are applied to optimize dimensions of cold-formed steel sheeting. The objective of the optimization is to obtain the optimum dimensions of trapezoidal profiled steel sheeting that has the minimum weight subjected to the given constraints. In traditional optimization, these constraints are defined with crisp number. However, in practical engineering, constraints with a small certain percentage of violation can be acceptable. At the same time, for a genetic algorithm, variety is its innate nature. If some candidate solutions are thrown out because they violate one or more constraints during the early optimization process, the important information that eventually could lead to the optimal solution may also be thrown out. Although a feasible solution point should fall inside the feasible region, there can be a significant difference between the far and near solution points from the region boundary. Thus, in this research, steel sheeting is optimized to satisfy the constraints in accordance with Eurocode 3, Part 1.3 considering the fuzziness in the constraints so that the optimization is more practical from the engineering point of view.

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THEORY OF THE INTERFACIAL INTERACTIONS AS PARTICULAR VARIANT OF THE THEORY FOR CONTINUOUS MEDIA WITH KEPT DISLOCATIONS. APPLICATIONS IN MECHANICS OF MATERIALS.

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In the present research work the interphase layer an advanced continuum model is developed as a continuum media with field of kept dislocations [1]. In framework of the interphase layer model the local cohesion and adhesion effects between nanoparticle and matrix are described as the length scale effects. By the model it was found that these effects could help to understand/predict macro/micro mechanics of the material, if the boundary conditions and interphase interactions are modeled across the length scales. This approach describes the kinematics of continuum media, the formulation of governing equations (fundamentals) and the statement of boundary conditions for multi-scale modeling of the material. The general mathematical formulation of corresponding boundary-condition problem was determined by Lagranges functional and corresponding Eulers equations based on the boundary conditions. An approach and the model has been validated to predict some basic mechanical properties of a polymeric matrix reinforced with nanoscale particles/fibres/tubes (including carbon nanotubes) as a function of size and also dispersion of nanoparticles. Presented mathematical model of an interphase layer allows estimating an interaction around and nearby interfaces of nanoparticle and material matrix. It is worth noting that the local interface effects are particularly important at high defect concentrations in the material and large size of surface-to-volume ratio that increase area of contact between nanoparticle and matrix. Using these approaches the prediction methodology and modeling tools have been developed by numerical simulations and analysis of the mechanical properties across the length scales. So, the generalized Eshelbys solution is given and asymptotical averaging technique of homogenization is extended on the higher-order continuum theory of the mediums, which allow to take into account the specific properties of the interphase layer at modelling of the composites with micro- and nano- inclusions. An important aspect of the model is also investigation of multi-scale cohesion and adhesion effects at the interfaces of nanoparticle-reinforced materials that are important for stress-strain relation between material phases. The model has been successfully applied to modeling of mechanical properties (Young modulus) of nanoparticle-reinforced polymeric composites taking into account cohesion type interactions (see [2],[3]) and both cohesion and adhesion superficial interactions [4], [5]. An advantage of proposed approach is computationally effective methodology based on a fundamental theory of continuum mechanics. Using this research the prediction methodology and modeling tools have been developed by numerical simulations and analysis of the stress-strain-stress and mechanical properties across the length scales. In present work three approaches are developed: i) the integral Eshelby formula is received for matrix with isolated inclusion; ii) the generalized Eshelby solution for isolated inclusion in matrix is found and generalized Eshelby matrix is established; iii) the exact asymptotic average solution is also obtained on the base of the procedure of asymptotic homogenization (Bakhvalov, and Panasenko) for composite materials with periodic structure in framework of the gradient model of interphase layer. For the solution of auxiliary problems arising here and for numerical simulation of the stress-state in framework of the model of interphase layer the block analytical numerical method[ref5] is used. This method allows to calculate effectively auxiliary characteristics (components of stress tensor, energy in a cell, etc.).

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COUPLED DYNAMIC INSTABILITY OF COMPRESSED THIN-WALLED STRUCTURES

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Dynamic instability of various thin-walled structures under harmonic axial force has been well investigated for one-modal buckling. But in thin-walled compressed structures the spectrum of shortwave local modes is usually rather dense, and natural frequencies for overall and some local modes can be commensurable- their ratio in certain ranges of the compressive force can be close to 1:1, 2:1 and so on. Therefore the external parametrical resonance may take place simultaneously with internal resonances of various types - one-to-one resonance, autoparametrical or combination resonance.

In the paper the instability of a thin-walled bar under action of axial force $P(t) = P_0 + P_1 \cos \Omega t$ is considered with taking into account the interaction of overall and local modes. It is assumed that the bar has one axis of symmetry, and the natural frequencies for the overall mode and certain local mode are close. Equations of motion are derived with using assumption that the natural modes of oscillations coincide with the buckling modes (it is the case, in particular, for simply supported bars). The dynamic displacements field is expanded in a series in natural buckling modes (the Koiter's type expansion for the static buckling problem). The equations of motion in the first nonlinear approximation comprise quadratic nonlinearities due to the interaction of the modes. These equations have been solved by the multiple scale method. Equations of amplitude-frequency modulation have been obtained and analysed.

It is shown that the interaction of the external parametric and internal resonances gives rise to complex nonlinear phenomena. The energy exchange between different modes can lead to appearance of new steady-state coupled oscillations (which can be regarded as synchronized vibrations in the overall and local modes), and to the nonstationary oscillations. Such a complicated behavior can cause loss of stability in certain mode because of accumulation of energy on this mode.

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DISCRETE BREATHERS IN NONLINEAR DYNAMICS OF PLANAR ZIGZAG OSCILLATORY CHAIN AND CARBON NANOTUBE

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We present analytical and numerical study of short wavelength nonlinear excitations in planar zigzag chain and arm-chair carbon nanotube. Contrary to common approaches dealing with one-dimensional models, full analytic dynamical description is considered with taking into account of geometric nonlinearity. In the course of numerical study both sources of nonlinearity (geometric and physical) were present. First of all, the dispersion curves have been calculated on the basis of linearized equations of motion. The characteristic points of these curves (more definitely - of their optic branches) were selected to construct continuum equations describing slow modulation of corresponding periodic oscillations and waves. We derive three types of such equations two of which describe predominantly longitudinal and predominantly transversal displacements, third one being corresponded to more complicated coupled motions. In all cases transition to complex variables with following use of multiple scale expansions leads in the main asymptotic approach to Nonlinear Schrodinger Equation or two coupled equation of similar type. The localized envelope solitons (breathers) are particular solutions of these equations and their implicit description is presented. The obtained analytic results were confirmed by the data of computer simulation on the basis of Molecular Dynamics procedure. Besides, we studied the interaction of the breathers with thermal fluctuations. The effect of physical nonlinearity in different thermal conditions was also estimated.

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ELASTIC PROPERTIES OF CLAY NANOPARTICLES VIA MOLECULAR DYNAMICS SIMULATION

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We present the results of detailed molecular dynamics study of full elasticity tensor of clay nanoparticles in wide temperature range. The calculations were carried out with single nanoplate of pyrophyllite 2:1 clay mineral consisting of two tetrahedral sheets SiO_4 and the intervening octahedral sheet AlO_6. Considered model contains of one crystallographic cell in Z-direction and 45 similar cells in the XY-plane. Full number of atoms in the calculation cell with periodic boundary was 1800 atoms. Simulations were performed in temperature interval 100-700 K using ionic-type potentials [1]. The mechanical properties of nanoplate were calculated from force-displacement curve obtained at relatively slow rates of deformation. The influence of temperature on structural parameters (interatomic distances and angles) was analized. A special attention was paid to analysis of the structure of the tetrahedral and octahedral sheets [2]. The results are compared with data obtained with using other types of force field (but obtained for room temperature only) [3]. We have shown that calculated data are in good enough accordance with the results of the paper [3] in which the hypothesis of orthotropy was accepted. Besides, we estimated the components of elasticity tensor caused by the deflection of clay nanoplate from orthotropic crystal. Comparison of external (boundary) stresses and internal stresses and calculated with using Virial theorem in the conditions of shear loading has allowed to estimate an effective thickness of nanoplate. This result enables to obtain the explicit values of elastic modulus as well as those of elastic compliances. We studied also the structural transformations caused by loading and thermal fluctuations to distinguish the molecular mechanisms of deformation (in particular the contributions of tetrahedrons and octahedrons in the structural changes and accumulation of elastic energy).

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DYNAMICS OF ORBITAL SPACE TETHERS

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Large structures in space are an essential milestone in the path of many projects, from solar power collectors to space stations. In space, as on Earth, these large projects may be split in to more manageable sections, dividing the task into multiple replicable parts. Specially constructed spider robots could assemble these structures piece by piece over a membrane or space-web, giving a method for building a structure.

The dynamics of the space web with the spider robots crawling over the membrane are investigated, in an attempt to quantify the perturbations that the robots will impart on the structure. The equations of motion of the system will be numerically simulated to give the forces and position of membrane.

Control and stability of the space web will be critical to many applications, such as solar power generation, and this will be affected by the moving spider robots. Control strategies will be investigated to give limits on the robot motion and to find if it is possible to coordinate the robots to counteract the external forces on the space web.

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MODELING OF FATIGUE CRACK PROPAGATION ON THE BASE OF CONTINUUM DAMAGE MECHANICS AND NON-LOCAL CRITERIA

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Simulation of fatigue crack propagation is considered within the framework of non-local continuum damage concept. In the developed crack growth model both rate and orientation of crack propagation are governed by an evolution of one scalar damage variable. Non-local (integral or gradient) criteria of damage accumulation allow to take into account sensitivity of crack propagation rate to the material microstructure, that is especially actual for the short crack propagation analysis. Different variants of weight functions introduced in non-local criteria are considered. The comparison of 1D and 2D averaging for damage has been performed. The problems of fatigue crack growth at semiplane and at sharp-notched specimen are analyzed. The possibility of zigzag-like crack propagation at sharp notches is explained on the base of developed model. Comparison of numerical results and experimental data has been presented and discussed.

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FRONT PROPAGATION IN REACTION-RANDOM WALKS PROCESSES

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We consider a system with a large number of individuals which react and disperse according to a random walk. The dynamical evolution of the system is described by traveling wave front propagating with a constant speed. By using the Hamilton-Jacobi formalism, we show how to obtain the front speed in terms of the parameters related to the reaction and dispersal processes. Some biological applications are also discussed.

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WAVE MECHANICS OF STRUCTURES AND STRUCTURAL MATERIALS

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Wave phenomena play an increasingly important role in railway engineering, offshore engineering and material science. The high-speed railway lines allow the trains to move as fast as the waves propagate in the ground and in the overhead power lines. In this situation, such phenomena as wave resonance and wave-induced instability are the factors that govern the railway system dynamics. The offshore oil/gas exploration platforms move to extremely deep waters and to the arctic environment. This enhances the importance of such phenomena as the flow-induced instabilities of flexible pipes that rise the hydrocarbons and water from below the see level to the platforms. These instabilities can be due to the flow through the pipes, or due to marine currents. The latter may cause the virtually unavoidable vortex-induced vibrations, which for deep-water pipes turn into the vortex-induced waves. Also, design of offshore units capable of withstanding the arctic environment is a huge challenge, a part of which is a correct prediction of the dynamic ice-platform interaction. The new structural materials, such as on-cite compacting concrete and fiber-reinforced concrete are often subject to damaging dynamic excitations from the nearby traffic, landing planes, high-speed trains, etc. The damage can be enhanced either by external resonances or structural resonances in these highly-heterogeneous materials.

In this presentation, an overview of recent projects and results are presented of the Wave Mechanics group of TU Delft. The talk touches upon dynamics of high-speed railway lines, flow induced vibrations of flexible structures in water and modeling wave propagation in heterogeneous materials. The focus is placed on the recent achievements and challenges, namely on: (1) 3D modeling of the dynamic response of high-speed railway lines accounting for spatially discontinuous sleeper-ground contact; (2) wave induced parametric resonance of a moving current collector as it interacts with a periodically suspended contact wire; (3) early unobserved aperiodic unstable behavior of a free-hanging submerged pipe aspirating water; (4) modeling of vortex-induced vibrations of and waves in flexible structures in currents; (5) development of a dynamically consistent causal model of heterogeneous materials.

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ON THE PROBLEM OF PROPAGATION OF SURFASE WAVES IN TRANSVERSALLY ISOTROPIC MEDIUM

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The problems of propagation of elastic surface waves in a transversally isotropic half space with two variants of conditions at the boundary of half space are considered. The investigation of problems is simplified by introducing potential functions, which are analogous to the problems of plane deformations [1]. In the case when all three stress components at the boundary of half space are equal to zero the conditions of existence of surface waves are obtained. For example for Ti(Titan) the surface wave does not exist and for Be(Berilium), cd(Cadmium), the surface wave exists. Particularly, in the case of isotropic medium the known generalization of Rayleight plane deformation problem is obtained [2]. When at the boundary the normal component of stresses, one of tangential stresses and one of tangential displacements are equal to zero the new dispersion equation is obtained . When ratio of wave numbers is equal to zero the equation of first problem is obtained. Particularly, in the case of isotropic medium the equations from [2,3] are obtained.

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MODELING OF POLYDISPERSE GAS SUSPENSION BY "PARTICLE IN CELL" METHOD

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The paper is concentrated on modeling the gas suspension flow in atmosphere that describes explosive volcano eruption. We come from the premise that the products of volcano eruption are the gas suspension of polydisperse particles of dust which are spherical in shape and have heat capacity similar to solid products of volcano eruption. Accordingly gas and dust behavior in atmosphere and upper part of volcano canal during explosive eruption were modeled. Volcano eruption is examined in instantaneous destruction approximation of a partition, which divides gas suspension located in crater and heated to magma temperature from unperturbed atmosphere. Mathematical model is described by mechanics equation of polydisperse gas suspension. Unlike the models considered earlier, where gas suspension was constituted by the particles of one and the same radius (monosidperse), we take into account that particle mixture is consisted of several sorts of particles with different radius and various macrocharacteristics, such as speed and energy. At the same time we assume that density is equal for all dust particles, because the particles are consisted of one and the same material. To do a sum of nonstationary equation system we used particle-in-cell method that is widely applied to solve problems in dynamics of gases. The main point of particle-in-cell method is that it allows to split the initial nonstationary equation system into physical processes. At the same time the whole calculated field is divided into a system of large particles coincided at the prescribed time with Eiler grid cells. The calculation of every time step is divided into three stages. At Eiler stage we assume that there is no mass flow over the border, but take into account the effects determined by the forces of pressure, interface and gravity. At Lagrange stage the effects connected with mass transfer between cells are calculated. At the third, the last stage, the equation with laws of conservation of mass, impulse, and inner energy of gas and dust particles is solved. At this stage the final value of gas-dynamic parameters of flow are determined. The problem was modeled for three different cases: when gas suspension is consisted of particles with similar radius, a mixture of particles with two and three different radius. It should be noted that in the first case the equation system includes eight equations, in the second case it is consisted of 12 equations, and in the third case it contains 16 ones. Undertaken calculations demonstrate the dynamic of spreading the pressure blast over the surface of Earth depending on the distance to the place of volcano eruption. It is a common knowledge that the blast formed by eruption is the main struck reason. We determined that the form of the surface of spreading pressure blast is

close to hemispheric. It allows to predict the possible destructions from the blast formed by explosive volcano eruption. The calculation shows that the turbulences are formed during the development of gas suspension flow. The comparison of three concerned cases was also made. The dependence of the main characteristics on the initial boundary conditions of volumetric concentration of particles with different radius is observed.
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NONLINEAR WAVES IN LIQUID FILMS ON SPINNING DISK

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Nonlinear waves caused by hydrodynamic instability of a liquid film on a spinning disk are considered. The liquid is fed near the center of the disk with a constant flow rate.

The problem is reduced to a system of evolution equations. Structures of nonlinear waves and conditions of their appearance are interpreted in terms of the systems solutions. The basic set of dimensionless parameters governing the formation of the main flow and the waves is stated. The method developed can be used to find the radial coordinate of the instability origin, waves frequency and phase velocity. By this approach the nonlinear waves formation from small initial disturbance can be simulated numerically. The supporting surface shapes influence on the waves dynamics is investigated. Numerical calculations have been provided. The experimental data for wave front shapes and amplitudes and the corresponding numerical results have been compared with well enough agreement.

The research was supported by the Russian Foundation for Basic Research (06-01-00778)
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THE WEAR OF VISCOELASTIC BODIES IN ROLLING/SLIDING CONTACT

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The wear of viscoelastic bodies modelled by a body of Kelvin is considered using analytical methods of investigation. It is supposed, that the wear process is caused by the fatigue, so the dependence of the intensity of the wear process on contact pressure P is given by the relation: $\frac{dh}{dL} = Kp^{\alpha}$ where K and α parameters of frictional fatigue of material, h linear wear, L a way of sliding. In this work two cases of contact interaction rubbing body are considered. The first case is the sliding contact of the rigid cylinder and the viscoelastic substrate. The pressure distribution and the contact area, which is the zone of the viscoelastic body wear, are obtained. The influence of sliding velocity on pressure distribution is analyzed. The wear of the viscoelastic substrate is calculated. The second case is the rolling contact of the viscoelastic cylinder and the rigid substrate. It is considered, that wear process is caused by the slip phenomenon, which occurs in rolling contact, so the wear takes place only in slip zones of contact area. Two-dementional contact problem is solved to find stick and slip zones of the contact area. This investigation was supported by Russian foundational for basic research (grant No 04-01-00766 No 05-08-18204).
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EXAMINATION OF NETWORK-STRUCTURE OF CARBON BLACK REINFORCED RUBBER

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This work presents a computer model of rigid filler framework in rubber. Structural characteristics of the obtained material are examined. Algorithm of constructing single fractal carbon black aggregates and connecting them into a rigid framework, which determines the mechanical properties of the material was described. Using different filler fractions, bound rubber layer, trapped rubber and filler volumes were obtained. These results were compared with experimental data from different authors. It was shown that bound rubber layer with a thickness of 7 nanometers and more begins to play a decisive role in the mechanical properties of the material. Using uniaxial deformation of a hexagonal material cell, the minimal bound rubber volume which is drawn off to provide fourth and more ratio of elongation was estimated. It was shown that when large elongations take place, structure of filler-network in the reinforced elastomer changes greatly. The research was supported by the Russian Foundation for Fundamental Research and Perm Regional Department of Industry and Science (grant 04-01-96058).
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ADVANCES IN NANOMECHANICS AT THE RUSSIAN ACADEMY OF SCIENCES (MECHANICAL DIVISION) 2004-2005

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In the lecture an analysis of application of solid mechanics to the problems of nanotechnology is presented. A new actual aspects for research is proposed.
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STABILITY ANALYSIS OF THE HELMHOLTZ OSCILLATOR WITH TIME VARYING MASS

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The Helmholtz oscillator

$$\ddot{x} + \beta\dot{x} + x - x^2 = F \sin \omega t,$$

known to Naval Architects as the Helmholtz-Thompson equation, provides a simple archetype to study the phenomena of escape from a potential well. Following the work of Thompson [1] it has been much discussed in the Naval-Architecture literature as a phenomenological model of ship capsize in beam seas, see [2].

Motivated by the problem of a progressively flooding ship, we consider periodic time varying mass as a simple first case in progressing towards the more general problem of mass variation. In the linearised system the dynamics are equivalent to those of Ince's equation and we demonstrate that the system exhibits coexistence, see [3] and map the regions of parametric resonance.

In the nonlinear system we use the Melnikov function to provide conditions on the parameter space for homoclinic tangling and the associated phenomena of basin erosion. We show that the linear parametric instability does not have any effect on the nonlinear stability. Further we show that the frequency of mass variation is critical in determining the effect on basin erosion.

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SOME PECULIARITIES OF ELASTOMER REINFORCEMENT BY NANOPARTICLES

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The structural model of elastomeric nanoparticle-reinforced composite is offered. The basis for modeling is the assumption that the attachment between the elastomeric matrix and the filler is not absolutely rigid, and the matrix, subjected to interphase shear loading, is able to overcome the adsorption adhesion and move over the filler surface without being fractured. The proposed approach allows reverse structural rearrangement at unloading and provides an explanation of experimental observations unclear up to date: recovery of primary properties after cyclic tests at large hysteresis losses, extremely high initial elasticity moduli, and some other problems.

Mechanical peculiarities of the model are represented by: 1) an elastic spring simulating the nonlinear enthropic resistance of elastomeric molecules, and 2) effective interphase friction modeling adsorption adhesion between rubber and the surface of filler particles.

Applying the tensile force to substrates simulating the particle surface causes the elastic extension of the spring in the gap between substrates and its step-by-step sliding in the gap. The mathematical model, describing such a mechanism, allows for the structural reversibility of hysteresis and makes it possible to clarify experimental results that are still obscure.

The model indicates the availability of two mechanisms responsible for reinforcement of rubber: initial and final. The first is caused by high rigidity of short chains of macromolecules linking the neighboring particles, and the second by elastic prefracture reinforcement of elastomer macromolecules.

The three-dimensional variant of the model is developed to calculate the dependence of mechanical properties of composites on filler concentration. Numerical results are in qualitative agreement with experimental observations.

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IMAGING OF STRUCTURAL PHASE TRANSITIONS IN MONOCRYSTALS OF CU-AL-NI WITH SHAPE MEMORY EFFECT BY PHOTOACOUSTIC THERMOELASTIC MICROSCOPY

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During the last decade a great attention has been paid to investigation of materials with the shape memory effect. The interest to these materials is concerned with their unique mechanical and physical properties which gives an opportunity for a great veriaty of practical of practical applications of these materials. One of the most important mechanical properties of materials with the shape memory effect is their capability to large reversible deformations. Large reversible deformations are coupled with the spatial phase transitions of the martensite phase in these materials. Therefore, the essential efforts have been directed on investigations of structural phase transitions in materials of this type.

Optical methods are widely used at present for visualization of structural phase transitions and different phases of materials at microscopic and mesoscopic scales. To increase the contrast of these images to different phases optical methods are usually used in combination with the preliminary etching of the surface of a sample. Additionally digital processing of the obtained optical images is necessary for improvement of their contrast.

In this work the possibility to use photoacoustic thermoelastic microscopy for visualization of the martensite structure in Cu-Al-Ni crystals has been investigated. Some preliminary results in this field have been presented by us in the article [1]. In our work we had an opportunity to obtain photoacoustic images of investigated objects directly under external loading. Modifications of the martensite structure in the Cu-Al-Ni alloy were detected and imaged by photoacoustic microscopy at different external loading. It was demonstrated that photoacoustic microscopy is able to detect structural modifications in the Cu-Al-Ni alloy with the high spatial resolution. It was also shown that photoacoustic images provides better contrast in comparison with the optical ones especially at the initial stage of the phase transformations.

This research was supported by the Russian Foundation for Basic Research.

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FINITE ELEMENT MODELLING OF PIEZOELECTRIC DEVICES WITH TEMPERATURE EFFECTS

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The thermopiezoelectric problems are considered for analysis of piezoelectric transformers and smart-devices with temperature effects. In classical coupled system of thermopiezoelectric equations the damping components are added. The finite element formulation of coupled thermopiezoelectric problems in general case and in the case of partial relatedness is obtained.

For finite element analysis of piezoelectric devices with temperature effects in computer package ANSYS we propose the special techniques. As it was mentioned, ANSYS piezoelectric finite elements do not have properties, which are necessary for carrying out coupled thermopiezoelectric analysis. Meanwhile, in ANSYS it is possible to solve successfully the static piezoelectric problems with thermal stresses using coupled-field analysis technique.

In more complicated way using additional macros in ANSYS it is possible to solve practically important problem about dissipative initial heating of piezoelectric devices under harmonic vibration. In particular, having solved in ANSYS the harmonic piezoelectric problem by standard way one can find the displacement field. Using this field we calculate averaged dissipative function. This dissipative function is further considered as additional thermal source in heat flow problem, which is solved in ANSYS/Thermal.

This work is partially supported by grants of the Russian Foundation of Basic Researches (No 05-01-00752).

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THE ROTATION-UNCOILING-TWIST ENERGY STORAGE MECHANISM OF MUSCLE CONTRACTION

SUNIL NATH

Considerable effort has been spent during the last 100 years to understand the physicochemical basis of energy conversion and force generation in muscle; yet the molecular mechanism of muscle contraction remains an enigma. Here I propose a novel, comprehensive molecular mechanism (The Rotation-Uncoiling-Tilt Energy Storage Mechanism of Muscle Contraction) that explains all the biological and mechanical data to date without exception, and is in consonance with all the known laws and principles of mechanics and dynamics. These insights elucidate the functioning of this amazing acin-myosin nanomachine. It is also shown that currently believed mechanisms (e.g. the lever arm model) contradicts the known principles of mechanics and hence needs revision. The proposed mechanism is a step in this direction.

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INSULIN FIBRILS INTERACTION MODELING AND INVESTIGATING.

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In the current work insulin fibrils behavior and possible ways of fibrils organizing are modeled and investigated. The aim of the present study is to determine whether any forms of fibrils organizing are possible and what these forms may look like.

In the current work standard methods of molecular dynamics are used. We represent fibrils as thin stiff beams with weight concentrated in their ends. Computer simulation in C++ is used to model interaction between ”fibril beams”. We apply in turn two different types of potential functions to represent Van der Waals interactions between fibrils endings. By putting our objects of investigation into electrical field (fibrils dipole moment given) we are taking into account electrostatic interactions as well.

Having subject of investigation biological objects (which fibrils no doubt are), their modeling is supposed to involve many different aspects. But due to their complexity we should choose to highlight not all aspects at the same time, but only some of them, so our modeling cannot pretend to give complete picture of the situation. By trying different approaches we're aiming to come nearer to our goal - finding any forms of fibrils organizing.

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DIRECT NUMERICAL SIMULATION OF TURBULENT WALL-BOUNDED FLOWS: APPROACHES, METHODS AND RESULTS.

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During the last decades, direct numerical simulation (DNS) has been recognized as a powerful and reliable tool for studying turbulent flows. Numerous studies showed that results obtained by DNS are in excellent agreement with experimental findings, if the latter are reliable. DNS-based studies are advantageous to experimental methods in that a practically unrestrained, far more detailed study of the flow field structure can be achieved. Another, perhaps even more important advantage is that DNS allows exposure of new important physical mechanisms of turbulence production and self-sustainability. However one major difficulty that arises with a numerical investigation of turbulent flow is the presence of a vast, continuous range of excited scales of motion, which must be correctly resolved by numerical simulation. DNS of turbulent wall-bounded flows requires order $\mathrm{Re}^{7/2}$ work to resolve dynamically significant velocity fluctuations at large Reynolds numbers. That is why most of direct simulations are restricted to low-Reynolds-number and simple-geometry flows. Existing approaches and methods for turbulent flow simulations in ducts of different cross-section are discussed in present paper. A brief overview of numerical algorithms developed by the author is presented. The results of several particular simulations are analyzed. The mechanism of near-wall turbulence sustenance is explained as well as the reason of turbulent secondary flow appearance in the ducts with noncircular cross-section. The work was supported by RFBR under the grant No 05-01-00607.

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INVESTIGATION OF STRESSED STATES OF PIPELINES BY ACOUSTOELASTIC METHOD

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In time revealing of weak high-stressed parts of engineering constructions provides the earlier prediction of their destruction and elimination of further damage. It is strongly important for such objects as ships, submarines, airplanes, railways and trains and other multielement structures. Some problems of relevant prevision of dangerous stressed states of large-sized engineering constructions may be successfully solved on a base of precise ultrasonic measurements of materials acoustoelastic properties [1]. The great importance of nondestructive evaluation of stressed states of bridges, power stations, gas and oil pipelines is evident, because the failure of those civil engineering constructions leads to great amount of human victims and deterioration of environment.

The reliability of acoustoelastic manner for applied biaxial stress evaluation in magistral pipelines of large (820 1420 mm) diameter was proved experimentally. So, the diameter of steel pipes used in our experiments was 1020 mm and thickness from 9 to 14 mm. The pipes were closed by special steel bottoms and were exposed to inner pressure of water with additional control by ultrasonic method. The precise measurements of time-of flight of shear and longitudinal waves propagated across the plane of stress acting were made before and during the loading.

Special compact device IN-5101 produced by ENCOTES engineering company was using in the experiments. IN-5101 realizes the acoustoelastic effect, e.g. linear dependencies between elastic wave velocity and mechanical stresses, and provides reliable measurements of uniaxial and biaxial stresses in different engineering materials under long-term load and different climate environments. The operation of IN-5101A is user-friendly in comparison to devices based on other physical principles (e.g. X-rays). The advanced technology for nondestructive testing of mechanical stresses in engineering materials and pipelines was used in our investigations.

The values of stresses acting along and across the pipe axes (axial and circumferential stresses, correspondingly) were automatically evaluated in real time by the special computational block, based on the theoretical studying [1] and placed inside the experimental equipment. The elasticity theory predicts for the thin pipe walls that the normal stresses are essentially smaller than axial and circumferential stresses. So, the stressed state of a small part of a thin envelope of the pipe is performed as in-plane stress. The results of our investigations show that the observed data are quite closed to the results of the solution of a problem which was founded by Habriel Lame in 19th century. The difference between stresses evaluated by ultrasound and by theoretical computations, is not exceed 5-10

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BROWNIAN DYNAMICS OF CONTINUOUS DEFORMABLE MACROMOLECULAR MODELS IN SHEAR FLOW

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This talk addresses the manner in which non-simple (nonspherical, deformable) models of dissolved macromolecules rotate and deform in shear flow of the suspending solvent. To date, the element of deformation has been modeled using dumbbell and other bead-spring models that arbitrarily and artificially discretize the molecular mass. We apply a new kinetic theory of continuous deformational Brownian motion to study the more realistic problem of a sphere that can stretch through a continuous family spheroidal shapes and bend through a continuous family of kidney shapes. Hydrodynamic and energetic calculations respectively determine the deformational diffusion coefficient and macromolecular self-energy as a function of configuration, and define the orientational-deformational diffusion equation. Asymptotic and numerical procedures are applied to solve this transport equation, and thereby determine the distribution over angular and deformational coordinates, at arbitrary values of the Péclet number. Average rheological stress coefficients are also computed. Although the elongational component of shear flow especially excites the stretching mode, interesting analysis is also presented for a bending mode.

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ESTIMATION OF TENSILE PROPERTIES USING FINITE ELEMENT SIMULATION OF MINIATURE TEST

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The present paper is aimed at determining the mechanical properties such as elastic modulus, yield strength and the post yield or flow behaviour of the material in a virtually non-destructive fashion. Generally these properties are obtained by conducting the tensile test on the required materials as per the standard specifications. However to assess the present healthiness and condition of a in-service component, large size samples for carrying out the standard test cannot be taken out without destroying the component. In order to overcome this situation miniature specimen test technique has been evolved. The miniature specimen test techniques provides a way of obtaining these mechanical properties of components by consuming very small amount of material than that required for a conventional test. This has attracted the attention of many researchers in sub-size and miniature test techniques such as tensile, Microhardness, small punch, bend, fracture toughness, impact and fatigue etc. [1] In the present study a new dumb-bell shaped miniature specimen has been designed. The proposed miniature specimen is very easy to fabricate. It also has additional advantage in finite element modeling with respect to computational time and memory space. The miniature specimen is designed such that it experiences in-plane tensile load through the loading pins. A simple experimental setup is also designed to perform the test on the miniature specimen.

Finite element simulation of the miniature test is also carried out for a specimen made from a die steel. Finite element analysis was performed by using commercially available ABAQUS implicit code [2]. The comparison of load-elongation diagrams obtained from the finite element and from the miniature test is also done. It is observed that there exist a good agreement between the finite element and miniature test results. Like wise finite element analysis is carried out on number of materials having different material properties and a data base is created using different input parameters (tensile properties) and the corresponding output load-elongation diagrams obtained from finite element analysis. Now for an unknown material, miniature test is conducted on miniature specimen is fabricated from the unknown material using the developed test setup. The resulting miniature test load-elongation diagram is obtained. Now by comparing the miniature test load-elongation curve with the finite element data base the mechanical properties of the unknown material is obtained.

The proposed scheme for prediction of material properties could be very useful where the amount of available sample volume is less or at locations where adverse condition prevails or at situations where the standard testing technique is not feasible.

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CYLINDRICAL PRECESSIONS OF AN UNBALANCED FLEXIBLE ROTOR SUPPORTED IN NONLINEAR ELASTIC BEARINGS

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The forward synchronous whirling motion of a statically and dynamically unbalanced rotor supported in non-linear elastic bearings has been studied. The rotor is assumed to be a four-degrees-of-freedom Jeffcott model, i.e. a rigid body with axial symmetry carried by a flexible massless shaft. Rotation occurs at constant spin speed. The behaviour of the shaft is assumed to be linear. The elastic bearings are isotropic and the Hertz's contact is considered. Viscous external and internal damping are taken into account. Self-centring effect has been confirmed and limiting radii for the shaft ends and mass centre's orbits have been computed. It has been shown that for a special set of parameters the forward whirling motion could be cylindrical, as the surface traced by the "non-deformed" shaft is a cylinder. The amplitude frequency response has been obtained and ranges of stability and instability have been found out.

The problem of stability loss of a cylindrical whirling moion has been investigated, too. It has been shown that different scenarios of stability loss could take place. For some range of the spin speed, jump phenomena and bi-stability occur, but the steady-state motion remains to be the forward synchronous cylindrical precession. For some other values of the angular velocity stability loss is accompanied by inducing hyperboloidal precession, when the surface traced by the "non-deformed" shaft is one-sheet hyperboloid. The threshold angular speed for autovibration has been found. By computational modeling the limit cycles have been built. It has been shown that the chaotification of the limit cycles could take place. The results of numerical integration reveal the transition "chaos to chaos".

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REDUCTION OF MULTIDIMENSIONAL FLOW TO LOW DIMENSIONAL MAP FOR PIECEWISE SMOOTH OSCILLATORS

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Dynamics of the piecewise smooth nonlinear oscillators is considered, for which, general methodology of reducing multi-dimensional flows to low dimensional maps is proposed. This includes a definition of piecewise smooth oscillator and creation of a global iterative map providing an exact solution. The global map is comprised of local maps, which are constructed in the smooth sub-regions of phase space. To construct the low dimensional map, it is proposed to monitor the points of intersections of a chosen boundary between smooth sub-spaces by a trajectory. The dimension reduction is directly related to the dimension of the chosen boundary, and the lower its dimension is, the larger dimension reduction can be achieved. Full details are given for two systems: a drifting impact oscillator, where the five-dimensional flow is reduced to one dimensional (1D) approximate analytical map, and a piecewise linear oscillator with symmetrical amplitude constraints, where 2D map is constructed and verified experimentally.

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TSUNAMIS IN FRENCH WEST INDIES (LESSER ANTILLES)

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The historical data of tsunami manifestation in the French West Indies is collected, analyzed and discussed. The data of tsunami in French West Indies can be found in various literature sources [1] [4].In total, more than 50 events were recorded in this area for the last 300 years; seventeen (17) events of tectonic origin, seven (7) events of volcanic origin, two (2) teletsunamis and more than 20 meteotsunamis. Highest values of the tsunami heights have been recorded in the northern Guadeloupe (Basse-Terra Island). This study constitutes a preliminary analysis of tsunami risk in the French West Indies.

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FATIGUE ANALYSIS OF SHIP STRUCTURES: APPLICATION OF ”STRAIN-LIFE” CRITERION

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The Strain-Life criterion is applied to assess fatigue life of a fast ship hull structural details of the family frequently affected by fatigue. The criterion-based approach operates with fatigue life measured by initiation of fatigue crack at a stress concentration, with the local stress flow intensity characterized by the scale factor of the long-term statistical distribution of an arbitrary (nominal) stress, and with theoretical stress concentration factor representative for the geometry and local modes of loading. For convenience of analysis, a ”AS - Kt - N/No” diagram is developed. Key words: Fatigue crack initiation, Local strain approach, Strain-Life fatigue failure criterion, Hull structural details, Fatigue design

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INTERCONNECTED SPATIAL VIBRATIONS OF HELICAL SPRINGS

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Interconnected spatial vibrations of helical springs are analyzed on the basis of Kirhhoff-Klebshs equations by small vibration superposition on terminal displacements. The features of thin helical beam allowed constructing the fundamental solution matrix for all three characteristic equation roots variation ranges. Two types of end conditions are realized: the fixed ends and the pivot ends that corresponds to sinusoidal vibrations. The preliminary compression and spin of a spring are taken into account. To find the natural frequency the characteristic and boundary equations must simultaneously be inversed into zero. The calculation of frequency spectrum and its analysis is fulfilled by using 5 problems: frequency spectrum at sinusoidal vibration type (generating solution), the calculation of local extreme points of characteristic equation (they correspond to nonpropagating modes that have zero group velocity), the calculation of frequency spectrum for fixed restraint at symmetric and antisymmetric vibrations, construction of mode forms. All types of special vibrations can be achieved on the basis of two elastic deformation waves which correspond to two branches of characteristic equation. The low branch of characteristic equation corresponds to spatial longitudinal vibrations. The presence of two fundamental mode forms couples are found at the place of characteristic equation local maximum overbending (along upper and low branches) their mode forms envelopes are half-waves; the first harmonics modes by forms can be found below their following fundamental modes by forms. Nearly coinciding natural frequencies have been analyzed, e.g. transverse and longitudinal. The cases of two and three close frequencies are given. The hypothesis of resonance problem forming at nearly coinciding of special vibration fundamental frequencies. The author calls this phenomenon resonance interruption. This phenomenon was found during testing the front wheel suspension unit spring of car Izh-2126 whith close fundamental frequencies of transverse and torque vibrations. During testing for resonance (in March 1985, Renoult company) resonances at the range of $1-50Hz$ were not detected. The comparison of frequency calculations made by the author with the experiments of other authors was done. It is shown that at the range higher the lower fundamental frequency and lower the characteristic equation local maximum of upper branch the multiple resonances are not formed. The transition of Euler buckling failure into the local one with regard to preliminary spring spin was achieved by dynamic method.

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OBJECTORIENTED MODELS AND METHODS OF SOLVING CONTACT MECHANICS PROBLEMS IN ELASTICITY-PLASTIC STATEMENT

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Developing technologies bring to the foreground one of the main problems of modern Mechanics of Deformable Solid Body, being the one of contact interaction. Complexity of these problems stands for the variety of approaches and mathematical methods used to solve them [1, 3, 4]. When designing complicated engineering constructions a number of different computer-aided design complexes are used. System FORTU-FEM is a universal computing system of computer-aided design (CAD) of complex engineering constructions and installations which enables computerization of all design stages [2]. The analysis of contact bodies interaction including plasticity phenomenon specifies the research, thus making it substantially different form the one aimed at researching bodies interaction including other phenomena. The main aspect of solving contact problems in elasticity-plastic statement is the necessity of calculating nonlinear correlations. FORTU-FEM system enables effective solving contact problems of solid body mechanics both in linear and physically nonlinear statement. The solution is reached by way of substituting initial physically nonlinear statement with iterative succession of linear problems. Moreover, iteration is organized both for zone precision as well as defining the zones of plasticity. The research describes the object-oriented model of numeric calculations of mechanics contact problems in elasticity-plastic statement using finite element method, that is implemented basing on FORTU-FEM, a universal computer-aided design system in machine building and construction industries.

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IMPACT OF AN INERT BODY INTO A SOFT SHELL

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Motion of an inert flying body after its impact in a soft environment, and also calculations of deformations and the stresses arising in the shell are considered. It is supposed, that in an initial condition the environment has the spherical form and the body, further, moves along its radius. It is supposed also, that the shell is indefinitely thin and does not resist to bending. The body is considered as a inert point. As a result of the body moving the shell in its vicinity becomes covered by axially symmetric wrinkles. The number of these wrinkles is indefinitely great, while their depth is negligibly small. It allows taking into account only meridional stresses of the shell and simplifies calculations. Rather simple analytical results are received in a case when inertness of an environment is not taken into consideration.

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STUDY OF CHANGES IN THE BOND ENERGY OF HYDROGEN IN METALS UNDER THERMOMECHANIC LOADING

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A method for analysis of experimental dynamical curves of high-temperature vacuum-extraction is developed, which allows determining the binding energy and diffusion constants of hydrogen in the probe under study. The experimental data have been obtained using the measuring complex, which allows conducting the absolute measurements of the dynamical curves of high-temperature vacuum-extraction of hydrogen from a solid probe. The measuring complex was applied for studying the defect structure of materials undergoing fatigue cracking and uniaxial tension.

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PLAIN AND SPATIAL INSTABILITY OF A COMPOUND ELASTIC CYLINDER CONTAINING INITIAL STRAIN.

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The problem of stability of a compound pipe-in-pipe cylinder under external pressure is investigated within spatial theory of elasticiy. The cylinder contains initial strain due to the difference between outer radius of the inner pipe and inner radius of the outer pipe.

The equations of neutral balance, linearised boundary conditions and conditions at the border of two pipes are derived using the model of an isotropic incompressible material. The subcritical state solution is obtained from the exact solution of a nonlinear Lame's problem for such a compound cylinder. Both plain and spatial instability of the cylinder are studied. The problem of finding the critical values of external pressure yields homogenius boundary-value problem for ODE-system.

For a number of popular material models in a wide range of geometrical parameters the numerical results are obtained. These results make it possible to conclude on the influence of initial strain values on the critical values of external pressure.

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ON DERIVATION OF MODEL EQUATIONS FOR NONLINEAR STRAIN WAVES IN WAVE GUIDES

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An approach is developed to obtain the model equations for nonlinear strain waves using the boundary conditions on the lateral surfaces of the wave guides. It allows us to reduce the dimension of an initial statement of the problem without use of any ”physical” hypothesis. As a result the governing equations are obtained with required precision. The approach may be employed to describe both the longitudinal and shear waves.

Instructive examples are considered, including free lateral surface rod and the rod interacting with an external medium. Also the equation for the rod with a microstructure is studied. Two dimensional problems are considered on an example of a plate interacting with an external medium.

More information about the approach may be found in the book [1].

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EFFECT OF THE ADDITIONAL DEGREES OF FREEDOM OF THE SYSTEM ON SELF-SYNCHRONIZATION OF MECHANICAL VIBRO-EXCITERS

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Consideration is being given to self-synchronization of two similar mechanical vibro-exciters, placed symmetrically on a softly-vibro-isolated platform. It is known that in the case the platform is a flatly-oscillating solid body, at Mr2/J (M being the mass of all the bodies of the system, r being the shift of the center of mass of the rotors from the axis of rotation, J being the moment of inertia) it is only the counterphase synchronous rotation of the rotors of the exciters that is stable. Consideration is given to the possibilities of providing a cophase synchronous rotation by means of introducing additional degrees of freedom either to the rotors of the exciters or by changing the number of the degrees of freedom of the platform.

The problem was solved by means of numerical simulation. As a result, conditions have been obtained, under which the synchro-cophase rotation of the rotors is stable. The simulation specifically confirmed the result, obtained by means of analytic solution: the stability of the indicated regime is of the type of a temporary stability.

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SPACECRAFT FORMATION CONTROL AT SUN-EARTH L2 POINT

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The coordination and control of a constellation of spacecraft, flying a few meters from one another, dictates several interesting design requirements. During formation deployment, re-sizing and re-orientation the spacecraft must reach their desired positions without incurring in collisions or interfering with each other. The method presented here, based on Lyapunov’s second theorem on stability, hinges on defining a potential function from the geometric configuration of the constellation together with any collision avoidance requirement. Large angle slews have been incorporated into the control algorithm as well as plume impingement avoidance. Reduction of fuel consumption, while taking into account the attitude and position constraints will be demonstrated.

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DIFFUSIONAL AND MAGNETIC ROTARY MICRORHEOLOGY OF COMPLEX FLUIDS

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Recent years are marked by bursting interest towards microrheology (MR) as a tool to explore complex fluids at the mesoscopic scale. In a MR experiment, small (micron or nanometric) solid particles (tracers) are embedded in a tested sample and then the info on their dynamic behavior is collected and analyzed. If the external forces are absent, the only mechanism inducing the tracer motion is its Brownian diffusion. Sometimes, MR is termed as ”rheologic microscope”. Temperature-driven diffusion MR is being developed in both translational and rotational variants. In the latter, one needs: (i) that the center of mass of the observed probing particle should be kept in place and (ii) that the particle should have an orientation-dependent ”identificator” to monitor its rotation. Both conditions are exhaustively fit if polarized laser tweezers technique is used with disk-like micron-size particles, see [1], for example. The light reflected from the disc edge is employed to register the chaotic rotation of the tracer. Correlation analysis of this signal contains information on the complex elasticity modulus of the tested fluid. However, to extract correct material data from the signal processing one needs an adequate theory of the particle rotary motion. In the present work we describe a new model for MR of a Brownian particle in a viscoelastic fluid. The model takes into account the two essential factors: the particle inertia and the impediment of its rotations imposed by the orientation-dependent potential of the tweezers. For illustration we use the real data of Ref.[1]. Application of an external force considerably modifies the tracer motion, and one may easily benefit from that. One of the prospects is to use the probes made of a ferromagnetic or superparamagnetic substance. Then a regular motion is imposed on a nanoparticle contactlessly via an AC magnetic field, the response to analyze is the dynamic magnetization of the tested sample. In a natural way the task of interpretation of these data virtually coincides with the theory of dynamic magnetization of ferrofluids at high dilution. We note that for the linearly viscous matrices the problem is already solved. Meanwhile, a ubiquitous interest for physics, material science and biophysics is the rheology of complex media, e.g. those possessing a dynamic memory (polymeric solutions) and/or equilibrium elasticity (gels). Here the experiment as well as theoretical investigations are yet at the start. In the talk an overview is given of the state-of-art in theoretical magneto-microrheology. In the set of appropriate models we distinguish two main classes. For the tracers of micron size the particle inertia is essential. Here a number of strong and surprising effects challenging experimentalists are predicted, see Refs. 2,3. For smaller particles applicable is the inertialess limit, where strong simplifications making the consideration very clear are possible [4]. We present the viscoelastic analogues of the magnetic relaxation times, linear and quadratic dynamic susceptibilities, and field-dependent rotary magnetoviscosity coefficients. Financial support on the part of RFBR (grants No 04-02-96034 and No 05-02-16949) and CRDF (Award No PE-009-0) is gratefully acknowledged.

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MESOMECHANICAL ANALYSIS OF DEFORMATION AND FRACTURE IN HETEROGENEOUS MATERIALS WITH EXPLICIT CONSIDERATION FOR 3D MESOSCALE STRUCTURE

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In this contribution, a mesomechanical approach to simulate the mechanical behavior with explicit consideration of the three-dimensional structure is applied to study the elasto-plastic response of polycrystalline and composite materials under loading (tension, compression, and shock wave loading). A procedure of a step-by-step packing (SSP) of a finite volume with structural elements has been used to design the composite structure consisting of an Al(6061)-matrix with Al2O3-inclusions and polycrystalline aluminum structure. A three-dimensional mechanical problem of structure behavior under quasistatic and dynamic loading has been solved numerically, using an explicit finite-difference code. Stress-strain evolution during loading has been investigated, with a comparison of meso- and macro-scale processes. The analysis of stress and strain distribution in the bulk of the specimen has been provided on the base of the mesomechanical concept, with special attention paid to the quantitative estimation of local characteristics on the mesoscale level. Deformation patterns in planes oriented parallel and perpendicular to the axis of tension have been studied. Particular emphasis has been paid on the investigation of individual contributions from different components of the stress and strain tensors to local and global response of the material. It has been shown that, due to its structural heterogeneity, material on the mesoscale level exhibits a complex stress-strain behavior, with the stresses and strains in local areas (e.g. in the vicinity of interfaces) deviating from their average level by several orders of magnitude. The question how far two-dimensional models can be used for the description of heterogeneous material behavior on the meso-scale level has been studied, using the metal matrix composite material as an example. The computational analysis has shown that in the case under study there is no reasonable qualitative and quantitative agreement between 2D and 3D stress-strain distributions on the mesoscale level. The main reason of the difference between three- and two-dimensional results is a complex deformation behavior observed in the vicinity of interfaces in the 3D-case so that all components of stress and strain tensors deviate widely from zero, and, thus, make their contribution to the local values of the stress and strain tensors.

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MATHEMATICAL MODEL OF TRANSPORTED PARTICLE - VIBROTRANSPORTING MACHINE INTERACTION

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Mathematical model of mechanical system including vibration transport machine with self-synchronised vibration exciters and material particle moving on its working surface is considered. The model describes steady movement and transient dynamic processes caused by machine start and impact loading. The differential equations of this mechanical system movement are derived. The results of numerical simulation of transient and steady processes of particle are presented as plots that allow to analyse transient dynamic processes in machine and their influence on dynamic parameters of particle.

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DYNAMIC PROBLEM OF THIN PLATES ON THE BASIS OF ASYMMETRIC THEORY OF ELASTICITY

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Lately, in connection with the modern problems of mechanics of bodies with the microstructure micro and nanomechanics, the interest in momental mechanics of solid spheres and in the construction of simplified models on their basis grows significantly. The problem of the construction of the general theory of elastic thin bars, plates and shells on the basis of asymmetric (momental, micropolar) theory of elasticity plays a particular role. One of the main methods of the construction of the general theory of thin bars, plates and shells on the basis of the classical theory of elasticity is asymptotic method. The present work is on the construction of the general dynamic theory of micropolar plates on the basis of asymptotic method [1] of integration of the initial-boundary problem of asymmetric theory of elasticity in thin three-dimensional sphere of the plate. Three- dimensional equations, boundary and initial conditions of the linear dynamic theory of asymmetric elasticity with the independent fields of displacements and rotation in three- dimensional thin sphere of plate are considered. Dimensionless coordinates and time are entered. Dimensionless parameters characterizing elastic momental properties of micropolar body are entered too (these dimensionless parameters are of the type of physical-geometrical parameters as they contain one of the geometrical sizes of the plate). The main small parameter is the relative thickness of the plate. Depending on the values of the mentioned dimensionless physical parameters of the defined dynamic problem of the asymmetric theory of elasticity three different asymptotes are stated on the basis of which three different applied two-dimensional dynamic theories of micropolar plate (with the corresponding quasi-static boundary theory) are constructed. The first of these theories is the general applied two-dimensional dynamic theory of micropolar plates with free rotation, the second is the general applied two-dimensional dynamic theory of micropolar plates with the constraint rotation, and the third is off-beat force-shear theory (with a small shear-momental rigidity) of the micropolar plates. The corresponding quasi-static boundary value problems of micropolar plates are constructed and studied. The problem of matching of the applied two-dimensional theories and boundary layers of micropolar plates is studied. The boundary and initial conditions of the constructed applied two-dimensional dynamic theories of micropolar plates are stated. The spheres of applicability of each of the constructed theories of micropolar dynamic theories of plates are defined.

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EFFECTS OF THE SUBSTRATE IN THE ELASTIC RESPONSE OF A THIN FILM IN INDENTATION TESTS

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In thin-film technology the study of the effect of the substrate in film elastic response is important to determine the elastic properties of the film by indentation tests; recently, the growing importance of the nano-microscale materials studies has rekindled the interest about this topics. When a solid thin film is deposited over the substrate, the indentation problem become more complex with respect to the homogeneous semi-space problem and the elastic response of the film can be categorized according to film/substrate material properties. If the film is soft in comparison with the substrate stiffness (soft-film), usually the substrate is approximated as rigid and the analysis may be simplified. On the contrary, if the film and the substrate elastic properties are comparable or the thin film properties are stiffer respect to the substrate (hard-film), a correct evaluation of the mechanical behavior of the indentation problem requires knowledge of the effects of elastic properties of both the film and the substrate (Maugis 1999) . In the present report an elastic tridimensional solution for an isotropic film coated on an isotropic elastic substrate subjected to an axisymmetric loading condition which simulates the presence of an indenter of assigned form in a quasi-static indentation test is proposed. To find the solution in explicit way, two main assumptions are introduced; firstly, in view of the local character of the indentation problem, we introduce a suitable parameter b representing the radius in which the contact phenomenon is contained. In such a way, we write the components of the displacement field by means of Dini and FourierBessel expansions, so avoiding the use of the Hankel integral transforms and, consequently, the problem of their inversions (Yu, Sanday and Rath 1990). It is possible to show, from a numerical point of view, that, under suitable conditions, the specific value assumed for the parameter b is not relevant. Further, since the original mixed boundary value indentation problem leads to dual integral equations which, due to their complexity, can be solved only numerically by means of a Fredholm integral technique, we have changed the boundary conditions by assuming a pre-assigned distribution of traction on the free surface; this assumption is also introduced in the paper of Li and Chou (1997) within the framework of the Hankel integral transform technique (Watson 1944). So doing, we solve the elastic problem of a thin film coating/substrate systems under prescribed axisymmetric load by using a Dini and Fourier-Bessel expansions for the radial and the vertical component of the displacement field respectively. The elastic response of the film is analyzed with two different interface conditions between the substrate and the film to bound the real case: frictionless contact and perfectly bonded. We get an explicit analytical form for the displacement and stress fields in terms of Fourier-Bessel expansions depending by some coefficients related to the form of the indenter and to the pre-assigned pressure distribution suitable to model the interaction film-indenter. Acknowledgements. This work was supported by MIUR Cofin Prin 2005: Models for interfacial problems in multi-layer structures.

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CONVECTION IN A ROTATING CUBICAL CAVITY

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Convection in rotating systems has received much attention in recent years because of its unusual properties. An important discovery has been made by [1] who demonstrated that the onset of convection in a horizontal layer heated from below and rotating about a vertical axis occurs at much lower Rayleigh numbers in the presence of side walls than in their absence provided the rotation rate is sufficiently high. This property contrasts with the case of a non-rotating convection layer enclosed by side walls where the critical value of the Rayleigh number is always larger than in an infinitely extended layer.

A characteristic property of side wall supported convection is its propagation as a wave. The direction of propagation is given by $\Omega \times \vec{n}$ where $\vec{n}$ is the normal of the vertical side wall pointing into the fluid. The convection pattern travels uniformly as a sinusoidal wave along a circular side wall as assumed in the analysis of [1] or along a straight wall as assumed in the boundary layer analyses of [2]. But the question of the propagation of waves along inhomogeneous side walls has not been analyzed until now. Convection in a cubical box has become a standard configuration for the investigation of the dynamics of convection in the presence of inhomogeneous side walls. Numerous studies have been performed on convection in cubes in the absence of rotation ([3]; [4]).

In the present paper we are focussing on this question by considering the onset of convection and its nonlinear evolution in a cubical box heated (cooled) on its lower (upper) horizontal side and rotating about a vertical axis. The detailed numerical study of the natural convection in a rotating cubical enclosure at moderate Rayleigh numbers has revealed the existence of three different flow structures with their intrinsic behaviour depending on the values of the governing parameters. The critical Rayleigh numbers for the onset of convection in the cubical cavity and the associated frequencies have been determined. Of particular interest are the transitions from the oscillatory regimes of convection to the steady regimes. It should be possible to observe these in laboratory experiments.

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AN INVESTIGATION OF THE PROCESS OF PERCUSSIVE IMPULSE FORMATION AND TRANSFERENCE IN THE THREE BODIES SYSTEM

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The results of experimental research and theoretical analysis of the impact process in the three bodies system (shank-striker-percussive piston) are given in this work. The results of experimental research of the collision process between two and three bodies at an average speed of 5-15 m/s are shown. The experimental method allowed us to register with high time resolution the shock-wave processes at the block and to then analyze them. Also the method provided data about spectral and integral characteristics of the impulse processes, which are produced during the complex impact. It is shown, that in such an impact system the efficiency of impulse transmitting from the shank to the ore body is much higher (30The results of research are proved by the theoretical analysis of the solid bodies impact process taking into account the contact interaction according to the Hertz theory and the results of finite element modeling using the ANSYS/LS-DYNA programme. We also note that the full-scale investigation of such a system, applied at a standard perforator, proved the results of scientific investigations and gave almost twice as high an ore drilling speed (170

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ANALYTICAL SIMULATING OF THE TROLLEY-AND-WIRE DYNAMICS FOR HIGH-SPEED RAILWAYS APPLICATIONS

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We study theoretically a traditional engineering problem how to achieve the optimal combinations of contact net parameters for a reliable contact between a high-speed current collector and contact wire. Today semi-empiric standard-looking discreate models are used for that. They allow solving some special questions for operative devices, but if one need to vary the properties of a device purposefully, it is very difficult, because of the necessity to work up and analyze a lot of data.

We propose a model to solve this problem in analytical style. Ignoring some small terms in the strict mathematical description of the system "contact wire–trolley" the introduced model we obtain important analytical integrals. It allows to describe the motion of the system by the equation of the Mathieu type equation. The most important coefficients, responsible for the contact net properties in the model, do not require an experimental correction. It is well known that such equations have self-oscillationg solutions. So the new model gives a possibility to study dynamics of the Trolley-and-Wire system by semianalitical methods.

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ON CLASSICAL PARAMETRIC RESONANCE PROBLEMS

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In the paper several classical stability problems are considered: the problem of a swing, the problem of a system with varying moment of inertia, and the problem of stability of an inverted pendulum with vibrating support. These problems have been discussed in the well-known book on stability and vibrations [1]. In all problems the periodic excitation function is assumed to be arbitrary and small damping is taken into account. New analytical formulae for stability and instability (parametric resonance) regions are obtained in three-parameter space. For some examples it is shown that analytical and numerical results are in a good agreement between each other.

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EDGE WAVES IN A PRESTRESSED INCOMPRESSIBLE ELASTIC PLATE

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We study flexural edge waves propagating along the free edge of a semi-infinite, homogenously prestressed, incompressible elastic plate. This waves are localized near the edge, i.e. they decay exponential in the direction normal to the free edge. They have similar properties to Rayleigh surface waves that are travelling waves propagating along the surface of an elastic half-space.

Investigations in this area are often devoted to two problems. The first one is the existence and uniqueness of the waves, and the second one is derivation of explicit secular equations for the wave speed and efficient computation of the wave speed.

Existence of edge waves was first noted by Konenkov (1960) for a homogenous isotropic semi-infinite thin plate, and later confirmed by many authors, see, e.g., Thutston and McKenna (1974), Sihna (1974), Lagasse and Oliner (1976), and Kaufmann (1998) for isotropic plates, and Norris (1994) for orthotropic plates. Thompson et al (2002) considered edge waves on a thin orthotropic plate where the edge is inclined at arbitrary angle to a principal direction of the material and demonstrated numerically that a unique edge wave existed for all values of angles and material parameters.

In the case of general anisotropy, and when the mid-plane of the plate is a plane of material symmetry, Fu (2003) with the aid of a Stroh-like formalism proved the uniqueness of edge waves and suggested an algorithm to test its existence and to compute the edge-wave speed. Application of a Stroh-like formalism in this work makes it possible to use ideas developed for the surface-wave problem (Fu and Mielke 2002, Mielke and Fu 2003). The Stroh formalism is a powerful tool in solving two-dimensional anisotropic elasticity problems. The foundation for the theory was laid down by Stroh in his papers in 1958 and 1968, a good description and development of the theory can be found in Ting's book (1996).

In our paper, we return to the assumption of isotropy but adress an aspect of edge wave propagation that does not seem to have been discussed previously, namely the effects of prestress on the edge wave speed. We assume that the prestress is a state of plane stress and that the wavelength of edge waves is large comparing with the plate thickness. As a result, we find with the aid of a standard asymptotic expansion procedure that the flexural motion is decoupled from the in-plane motion and the former can be described by the Kirchhoff hypothesis.

As an application of the theory, the edge-wave speed is computed for a plate composed of a Mooney-Rivlin material that is subjected to a combined pure homogenous strain and simple shear. It is shown that there are strain states that made the edge wave speed vanish that corresponds to the bifurcation condition and edge wrinkling of the plate.

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ON THE BEHAVIOUR OF ELASTIC PLATES UNDER VIBRATIONAL EXCITATION

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The problem concerning the influence of longitudinal vibrational excitations on the stability of transversal oscillation within a rectangular plate is under consideration. The plate is pre-compressed with constant force applied to two parallel edges. The problem is solved by means of the method of direct separation of motions. This is one of the most powerful approaches for the investigation of the behaviour of mechanical systems subjected to high frequency vibrational excitation. As a result of the treatment the generalized formula is derived for vibrational correction to the critical load. The formula is valid for certain types of boundary conditions, when the loaded sides of the plate are simply supported and other edges are clamped, simply supported, free, etc. The influence of boundary conditions on the resonant effects in vibrationally excited plates is also discussed. The results that are obtained allow one to control the stability of the system by choosing appropriate excitation parameters.

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DEVELOPMENT OF THE NOVOZHILOV APPROACH TO THE DESCRIPTION OF LOW-CYCLE FATIGUE

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In V.V.Novozhilov and O.G.Rybakina's work [1] the opportunity of creation of criterion of durability on the basis of the information about plastic loosening for the first time has been proved. This criterion has received the development in a lot of works basically for cases of uniaxial cyclic loading. The formulation of this criterion supposes invariant representation that gives the basis for application of the given criterion and for cases of complex cyclic loading. For this purpose the exact description of all effects appearing at such loading is necessary. In the present work on the basis of the theory of the plasticity considering microdeformations [2], the variant of the theory which due to updating the local law of deformation is capable to describe complex cyclic deformation, including a relaxation of internal microstresses (ratcheting) is offered. It, in turn, has allowed to distribute criterion of Novozhilov low-cicle fatigue strength to any processes of complex cyclic loading.

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VAPORISATION RATE IN TURBULENT TWO-PHASE FLOW.

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Average vaporisation rate is modelled for turbulent two phase flow over a range of pressure and temperature conditions. Experimental data from a premix duct with a flat-bed atomiser is used, in which turbulent intensities and scales is a common feature. Based on Eulerian model, it is assumed that small-scale turbulence is responsible for vaporisation. In place of droplet diameter, average liquid surface area is considered in this expression. This alternative formula, to classic Spalding-Godsave theory, predicts vaporisation and Sauter Mean diameter in agreement with experimental results.

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EXPERIMENTAL STUDY AND SIMULATION OF RHEOLOGY OF METALS UNDER HIGH-TEMPERATURE PLASTIC DEFORMATION

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Metals under high-temperature plastic deformation are presented as elasticviscoplastic medium, witch harden under effect of plastic deformation and soften under recrystallization and recovery. In literature for the medium are presented constitutive relations which including kinetic equations and they describe recovery and recrystallization in different forms. Analysis has shown that appropriate describing of rheology of metals under complicated and wide range of change of speed of deformation it is necessary to improve the received earlier constitutive relations. The installation for experimental definition of dependence of resistance to deformation from history of development of deformation is created in the Institute of Engineering science of the Ural Branch of the RAS. The installation allows deforming specimens up to 1200°C. The experiments on compression or tensing of specimens are carried out in the installation. In the first case specimens are heated up in the chamber electric furnace, in second - contact electro heating. method of realization of experiments and computer program of processing of experimental data has been developed. elasticviscoplastic model of resistance to metal under large high-temperature plastic deformations with reference to processes of metal forming has been constructed. It was suppose that elastic deformations are small and the Hooke's law realize and plastic deformation - large takes place. The metal is plastically incompressible and the plastic strain rate is submitted to the associated plastic-flow law having a loading surface that meets the condition for the von Mises criterion. A required functional in constitutive relations for the von Mises criterion is yield stress. The speed of change of yield stress is assembled of speed of hardening and softening. For these components have been offered differential equations describing of rheology medium. The hardening, static and dynamic recovery and dynamic recrystallization is simulated. The viscous properties have described by nonlinear dependence from strain rate. The experimental data for some steel and aluminum alloys in a wide range of change of strange rate have been received. On these data the identification offered of rheological model of medium has been executed. The influence of a deformation history on structure of alloys after deformation has been investigated.

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THE PROBLEM OF SPATIAL BENDING OF THE NON-LINEAR ELASTIC TUBE AND ITS APPLICATIONS IN BIOMECHANICS

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Within the framework of the large deformation theory the problem of spatial bending the tube, which is loaded by the inner pressure, is developed. The material is assumed to be incompressible and transversally isotropic with the curvilinear axis of the material symmetry. The hypothesis of the additive decomposition of the strain energy function to isotropic and anisotropic parts is employed. Spatial bending deformation is specified in the form of the two-parameter class of deformation, proposed by Professor L.M. Zubov. It is proved, that the achievement of mentioned deformation of the elastic tube under inner pressure requires presence of outside force and outside torque on the faces of the tube. Directing vectors of this force and torque is orthogonal to the axis of the tube in the undeformed state. The task being investigated is reduced to the system of PDEs with respect to three functions on two independent variables. The solution of this problem is of interest in connection with description of the mechanical behavior of human large arterial vessels in the physiological range. The hypothesis of the elastic potential additional decomposition leads to the certain simplification of the material parameters identification process for the large blood vessels in the specified range of deformation. This research was supported by RFBR (05-01-00638).

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MODELLING ELASTIC BANDS: FROM AN ANISOTROPIC ROD TO A DEVELOPABLE SHELL

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A thin and narrow elastic band in equilibrium is modelled as a solution to a variational problem with a functional which only depends on the shape of the axial curve. The equilibrium equations are presented for a general form of the geometric functional which involves the curvature and torsion of the axial curve as well as their derivatives with respect to the arc length. The model is then specified to the case of a thin anisotropic rod and asymptotic equations are obtained by letting one of the two bending stiffness coefficients go to infinity. This corresponds to identification of the principal axes of bending and torsion of the material with the Frenet frame of the axis. While the arc length is conserved along the axial curve, the rest of the band's ruled surface can be stretched or contracted. In the other model, the band is assumed to be an isometric embedding of a rectangle into 3D space. It means that the band is a piece of a developable surface. A limiting case of an infinitesimally narrow strip is analysed first and then the band of finite width is discussed. Results of numerical solution of the boundary value problem are presented for a range of parameters and comparison of the models is performed.

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NUMERICAL INVESTIGATION OF CRACK DYNAMIC AND STRAIN LOCALIZATION IN GEOLOGICAL MEDIUM

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In this work the development of bands of localized deformation and the formation of cracks in geomaterials under various quasistatic and dynamic loading conditions have been simulated numerically. Patterns have been obtained on the formation of systems of cracks around a fractured inclusion. The emergence of Riedel bands of localized shear in a medium layer has been modeled. The sandstone specimen fracture in compression were study. Interaction of a tensile, shear and incline compress waves with the surface and tips of the crack and emission of elastic waves accompanying the crack growth are simulated. Wave effects on the crack behaviour and stress state at the tip are shown. Supershear crack growth are obtained. To describe inelastic behavior of pressure-sensitive materials, the concepts of plasticity theory were employed. In the computations the Nikolaevskii model with a non-associated flow rule is used. In the course of plastic deformation damages are accumulated and volume changes. Macrocrack opening and material fracture are described explicitly. For this purpose the node-splitting technique is used and the free-surface conditions are given on newly formed boundaries.

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EIGENSPECTRA AND EIGENSOLUTIONS OF STRESS FIELDS NEAR THE CRACK TIP FOR POWER-LAW MEDIA

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Hutchinson [1], Rice and Rosengren [2] have derived the well known HRR stress field in the vicinity of Mode I and Mode II crack tips in a power-law harderning material. They solved the governing nonlinear ordinary differential equations for the stress function by a numerical procedure. Now the investigation of the damage creep, damage elasticity, damage plasticity coupled boundary value problems requires the thorough analysis of the whole set of the eigenvalues of the stress field in the neighborhood of the crack tip in non linear power-law materials. Up to now the eigenvalues for Mode I and Mode II crack problems are not known in the literature in an analytical form. It is obvious that the antiplane shear crack problem can shed light on the more difficult and important from a practical point of view Mode I and Mode II problems. In this contribution singular fields and higher order fields near a crack tip in power-law media under antiplane shear are studied. Using the hodograph transformation [3] and the perturbation method [4] the whole set of eigenvalues is determined. Here the comparison of the techniques considered is given. It is shown that these approaches allow to obtain the analytical formulae for all the eigenvalues of the stress field near the crack tip in power-law materials. Moreover, the perturbation method allows to find the eigenvalue for an arbitrary hardening exponent value if the eigenvalue for the linear material is specified. It is also demonstrated that the numerical integration of the governing nonlinear differential equation by the Runge-Kutta method and the shooting procedure gives us the same eigenvalue set. One can conclude that unlike the hodograph transformation the perturbation technique can be used for estimation of eiqenvalues of Mode I and Mode II crack problems.

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MATHEMATICAL MODELS OF SOUND GENERATION MECHANISMS IN GRAND PIANO

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The sound of the grand piano depends mostly on the soundboard vibration energized through piano bridges by detailed motion of strings excited by the impact of the hammers. Therefore, the creation of good theoretical models of the hammer, the hammer-string interaction, and the proper description of the conditions of string termination on the bridge are the important problems for determining the sound produced by a piano. Starting from physical models describing the piano hammer, string, and bridge, this presentation is focused on the numerical simulation of interplay of those parts of the piano. Based upon the large number of experimental data obtained using a special piano hammer testing device, it has been shown that all the present-day piano hammers have as a quality the hysteretic type of the force-compression characteristics. Two mathematical hysteretic models were derived to describe the dynamical behavior of piano hammer. The both models are based on an assumption that the hammer felt made of wool is a nonlinear microstructural material possessing history-dependent properties. The experimental examination of the waves traveling along the string, and modeling the string excitation by nonlinear hammer with memory demonstrate that the real piano string is an almost ideal string, and can be considered as a perfectly flexible. The observed phenomenon of the wave dispersion can be explained by the influence of the frequency-dependent characteristics of the bridge admittance. The effect of the duplex scale and its tuning on the treble bridge admittance was also investigated. It was found that the amplitude of the longitudinal motion of the treble bridge depends on the lengths of the parts of the strings passing the bridge and attached to the hitch-pin rail of the frame. The mechanism caused the transformation of the transversal string vibrations to the longitudinal bridge motion has been also considered. This project was supported by Estonian Science Foundation through grant No. 5566, and Tallinn Grand Piano Factory.

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ANALOGIES IN ELECTRO, MAGNETOSTATIC AND ELECTROCONDUCTIVITY PROBLEMS

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There exist the close analogies between the problems of electro, magnetostatics and electroconductivity. All of them let to the similar equations about unknown field functions expressed through potentials. Meanwhile the certain differences exist at the terms of electro and magnetomotive force. The usage of permanent magnets in magnetic circuits lets to difficulties in modeling, while the practical importance demands simple and reliable calculating models. The technique for handy account of the permanent magnet properties is proposed. It is shown how both magnetic and electric complex problems can be easily simulated with the usage of electroconductivity theory.

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STRUCTURAL - PHENOMENOLOGICAL MODEL OF HETEROGENEOUS MEDIUM

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The algorithm based on use the scheme of mechanical behavior of continuum for constructing a system of constitutive equations is applied to model mechanical properties of polymeric nano-composites at finite deformations. The circuit consists of horizontally located elastic, viscous and plastic elements. For construction of the circuit one can also possible use transitive elements. Their physical meaning is consists in the establishment of interrelation between structural and macroscopic deformations of continuous medium. The use of transitive elements allows us to model more precisely the mechanical behavior of materials, taking into account the processes at the structural level of nano-composites (such, as movement of polymeric chains in layers around filler nano-particles, etc.).

The condition is adopted according to which the performed work is independent of the type of stresses and strains (macroscopic or structural) in material elements used in calculation. For elastic and viscous elements the equations of the classical theory of nonlinear elasticity and viscous liquid are used. The theory of plastic flow is applied to the description of properties of plastic elements and proportional dependence between the rate of deformation tensor of the plastic element and the rate of deformation tensor of medium is postulated.

Each of mathematical expressions in system of the constitutive equations is responsible for quite specific mechanism of nanocomposite properties formation at the structural level of material. It can be selected by a phenomenological way from the condition of the best agreement with experimental data or be determined from the structural models of the examined material.

The capabilities of the proposed approach have been illustrated for the case of description of filled polymer mechanical behavior at cyclic loading under finite deformations. The following proposals form the basis of this model: the hypothesis about the existence of glassy and viscous layers around the particles, the information about structure of particle and the hypothesis of formation of uniaxially oriented fibers of high durability in gaps between the particles under deformation.

Universalization of this model on the case of a mixture of deformable and liquid continuums is developed for investigation of mass transfer processes in complex medium under final deformations.

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MODELING OF BEHAVIOR OF POLYMERIC CHAINS NEAR FILLER PARTICLES OF POLYMERIC NANOCOMPOSITES

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In polymeric materials, the regions, in which polymeric chains exist in the oriented state (have well-defined orientation) play an essential role in the development of mechanical properties of the composites. These regions may occur near the filler particles forming the layers with specific properties, or exist in the form of supramolecular structures in the bulk of the polymer. In nanocomposites the volumes of polymeric material involved in the layers near the filler particles are comparable with the volume of the filler itself or even greater. The oriented regions of a crystalline polymer are rigid inclusions, which, in themselves, play the role of the material filler. Therefore, the analysis of mechanisms responsible for the formation of the oriented regions in the bulk of the polymer due to introduction of the filling agents, variation of temperature and deformation is an important problem of the materials science.

The problem on modeling the layer formation near filler particles due to potential interaction of the filler surface with the links of the polymeric chains was considered. It was shown that thickness of such layers could be greater than 1 nanometer.

A hypothesis was made suggesting that the appearance of layers near the filler particles as large as 5 nanometers and more is the sequel of the orientation effects. This phenomenon can be explained by the fact that owing to the interaction of the polymeric chains, the orientation of the polymeric chain links can be transferred from the oriented regions of the material to the neighboring regions. A mathematical model was developed to describe this phenomenon. It was based on the assumption that time variation of the orientation tensor is determined by three factors: mutual orientation influence of the polymeric chain links locating in neighboring regions, thermofluctuation growth of the chaos in the orientation and preservation of part of already existing orientation. The analogous mechanism may control the growth of lamellae in spherulites of polyolefins.

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THE IMPACT OF TWO THERMOELASTIC RODS

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The problem on collinear collision of two thermoelastic rods possessing the same rheological parameters but of different length and temperature is considered, in so doing before the impact the rods move unidirectionally along a common longitudinal axis with distinct constant velocities. Lateral surfaces and free ends of both rods are heat insulated, and free heat exchange between the rods occurs within contacting ends. The rods' thermoelastic behavior is described by the Green-Naghdy theory [1]. The ray method [2] is used as the method of solution allowing one to obtain the longitudinal coordinate dependence of the desired values at each fixed instant of the time beginning from the moment of rods' collision up to the moment of their rebound. It is shown that the duration of rods' contact depends not only on the initial velocities of the impact, but also on the initial temperatures of the rods. The findings for the problem of the longitudinal impact of two elastic rods made of the same material with plane ends and of equal cross-section are presented in detail in [3]. To the authors knowledge, similar investigation for two colliding thermoelastic rods has not been carried out, although the problem of impact of a thermoelastic rod against a rigid heated barrier was considered repeatedly using different theories of thermoelasticity [4-6].

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ASYMMETRICAL GRAVITY FORCE MODULATION INFLUENCE UPON THE CONVECTIVE EQUILIBRIUM STABILITY IN A LAYER

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The first calculations of natural convection in a closed cavity heated from below with an asymmetrical modulation of gravity force are showed complex features of branching [1]. The next steps were fulfilled for discovery of the situation. A similar modulation was tested for mechanical systems with one degree of freedom. Review of these investigations was made in the paper [2].

In the article a stability of convective equilibrium state of fluid heated from below in a layer (Rayleighs problem) was investigated for the case a asymmetrical modulation of gravity force. The modulation was created by oscillations of the layer along the gravity force. The asymmetry of the modulations was caused by different intervals of moving the layer up and down. A relation of this intervals gives a value of the asymmetry parameter A_c. Influence of modulation with $A_c = 1$ (absent of the asymmetry) was investigated properly in [3].

Maps of stability were constructed for different values of the asymmetry parameter, an amplitude of modulation and a constant part of gravity force. It was found that the asymmetry parameter gives a vital reduction of a critical Rayleigh number which determines a threshold of stability of the equilibrium state. Non linear regimes of unsteady convection were investigated by means of a mesh method for the case of the Rayleigh number grater a critical one. Integral properties of solutions (a middle value of the Nusselt number, a kinetic energy) were found for different values of the asymmetry parameter, the amplitude of modulation and the Rayleigh number.

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COMPUTATIONAL EXPERIMENTS FOR RANQUE-HILSCHS VORTEX TUBE

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Ranques effect is a separation of rotated flux to two, one of them has lower temperature, than entering flux, and the other higher. Processes in vertex tubes are difficult to study, because complete description is based on movement and heat transfer of compressible liquid.

The flow is considered laminar and axisymmetric. The solution is obtained from evaluation of Stocks equations. Calculations were made in terms of velocity components, pressure and temperature. The variable mesh is used to obtain steady solution.

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PARTICLE DYNAMIC SIMULATION OF 2D DYNAMIC FRACTURE

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Spall fracture experiments allow obtaining high dynamical tension and fracture for various materials. The particle dynamic method is convenient to analyze kinetic processes in the fracture zone. This analysis is very difficult to perform using continuum methods. In the presentation a 2D problem of a plate impact interaction is solved using the particle dynamic method. An ideal single-crystal particle packing with Lennard-Jones and Morse pair potential is used. Dependence of the deformation velocity on the system geometry for computer and real materials is investigated.

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BOUNDS ON EFFECTIVE TRANSPORT COEFFICIENTS FROM COMPLEX INPUT DATA

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Composites are prevalent in both nature and amongst engineered materials. Common metals, reinforced concretes, fiber glasses, colloidal suspensions, ceramics, bones et cetera are examples of natural and man-made composite media. Hence, the prediction of a macroscopic behavior of composites, if properties and microstructures of their constituents are known, is one of the most important problems of classical physics. The aim of this paper is to predict the effective dielectric constant $f_1(z(\omega))$ of a two-phase medium with coefficients $\lambda_1(\omega)$ and $\lambda_2(\omega)$ as a function of a frequency ω, where $z(\omega) = \lambda_2(\omega)/\lambda_1(\omega) - 1$. By starting from truncated power expansions of an effective dielectric constant of two-phase composite we establish the best bounds on it as a function of frequency. To this end we use the new C-continued fraction technique developed by us. Numerical evaluations of the C-estimates of the effective dielectric constants of checkerboard composite are provided.

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MATHEMATICAL MODELING BLOOD MOTION IN THE ARTERIAL MUSCLE VESSELS

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The vessels in which muscular tissue as helical spiral is predominant are called muscle type vessels. Helical spiral of the mechanical property is created by spiral position of the muscular fibers. This fact provides a number of features in blood motion and in the wall of arterials deformation. Within the bounds of suggesting mathematical model problem of the pulse wave transmission is considered. And new features which illustrated by calculations are obtained.

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NON-EQUILIBRIUM PROCESSES INFLUENCE ON DYNAMIC RESPONSE IN METALS

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Experimental results and theoretical analysis of dynamic displacement of metal surfaces as well as acoustic driven pulse forms by short pulse heating of laser are presented here. Analysis of two thermo-elasticity problems has been carried out. The semi-space surface was affected originally by a pulse in the form of heat current in the first case and by temperature pulse in the second one. It should be noticed that characteristic feature of these problems solution structure is function delay. Consequently, transition time of stress compression to stress extension coincides with heating time, i.e. laser impact at the distance from semi-space surface. Laser affected displacement reaches its maximum value during pulse heating time. In contract to the problem solutions, on practice significant inertia of thermomechanical response both for stress and strain was found. The transition process time found experimentally is evaluated as s. Comparing theoretical and experimental results it can be suggested that in case of sub-microsecond heating rate we face a non-equilibrium process in which thermalization absorbed energy time period exceeds standard values and its parameters cant be framed within a linear problem of thermo-elasticity.

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EFFECT OF THE ADDITIONAL DEGREES OF FREEDOM OF THE PENDULUM WITH A VIBRATING AXIS OF SUSPENSION ON THE STABILITY OF ITS EQUILIBRIUM POSITIONS

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We consider here the behavior of a pendulum with a vibrating axis of suspension which differs from the classical one by the additional degrees of freedom: the pendulum contains a certain mass, fixed on a spring, which can transfer with respect to the main mass in two mutually perpendicular directions. The analytic solution of the problem in the special case of the purely longitudinal oscillations of the additional mass had been obtained before by I.I.Blekhman and L. Sperling by method of direct separation of motions, i.e. on the basis of considering the so called equations of slow motions of the system. Unlike that, here, along with the indicated approximate equations, we have also solved the numerically initial ("exact") equations of the system, believing that the additional mass can transfer not only in the longitudinal direction, but in the transverse one as well. Besides, an experimental investigation has been made of the model of the pendulum on a vibrating stand, and in this case we have also studied a model with a double-sided catch of the course of the longitudinal oscillations of the additional mass, i.e. a system with impacts. The results of the investigation displayed a good agreement with the numerical solution, and both of them - with the solution, obtained by method of direct separation of motions. In particular, it has been confirmed that the presence of an additional degree of freedom of the pendulum leads, under certain conditions, to the instability of the equilibrium positions which had been stable before, and vice versa. It has also been confirmed that the stability region of the upper vertical position can be essentially widened.

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TRANSIENT DYNAMIC PROCESSES IN TWO-MASS VIBRATIONAL TRANSPORT MACHINE

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Transient dynamic processes in two-mass vibration transport machine G.V. Vasilyeva, S.A. Rumyantsev

The system of differential equations describing the transient processes of movement of two-mass vibration transport machine with self-synchronized vibration exciters is considered. The results of numerical simulation (modeling) of transient processes of machine movable and damping parts are obtained. The dependence of transient processes on the ratio of forced and natural oscillation frequencies and on the correlation movable and damping parts masses are shown. The effectiveness of machine vibration isolation is evaluated. The results are illustrated as plots for analysis of transient dynamic processes.

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THE INVERSE COEFFICIENT PROBLEMS IN THE THEORY OF ELASTICITY

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Statements and research methods for the inverse coefficient problems of definition of elasticity modules as functions of coordinates (including prestress) in the theory of elasticity within the framework of stationary vibrations are discussed. As initial data are components of a vector of the displacements, measured on a part of a boundary in some range of frequencies variaition, are taken. The basic problems coming on at research of these problems are discussed:

1) the formulation of the operational formulas binding given and unknown functions; 2) development of numerical techniques for solution of occurring operational equations with compact operators on the basis of a combination of modern computational technologies (finite-element and boundary-element) and regularization methods; 3) the formulation of the conditions providing uniqueness of the solution of the problems being investigated.

The considered type of problems demands the approaches based on iterative procedure of the solution of some direct problems with variable modules of elasticity. So, a way of construction of the linear operational equations for which both a method of the integrated equations and finite-element technology can be used for kernels determination is proposed. Examples of reconstruction of various types of discontinuities (inhomogeneities) such as cavities and cracks and examples of identification of the module of elasticity and prestress for canonical domains are considered.

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DYNAMIC BEHAVIOR OF SOME ELASTIC MECHANICAL SYSTEMS WITH SET-VALUED NONMONOTONIC BOUNDARY CONDITIONS

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The study of the systems, undergoing the loads, described by the set-vaued relations, is one of the actual and intensively developing fields of mechanics. In these problems zero value of velocity is mapped on the set of the force values. The structures which undergo dry friction forces and some pump systems, can be considered as examples of these problems. In the simplest case , such as Coulomb friction law, the force value during the sliding phase is constant. In this case (and also for monotonic velocity-force relations) we come to the solution of the dynamical variational inequality. The solution of this inequality can be reduced to minimization of convex nonsmooth functional on each time step. However, for the actual friction law tangential force depends on sliding velocity. As a rule, this velocity-force relation is nonmonotonic. The nonmonotonicity of the friction law leads to additional computational difficulties. In this case, inequality to be solved is hemivariational, and functional to be minimized in each time step is non-smooth and non-convex. In this work hemivariational inequality is solved by sequential iterative solution of variational inequalities. The algorithm developed is used for study of longitudinal vibrations of sucker rod string. The results show, that nonmonotonicity of friction law leads to amplification of vibration. The case of dragging this structure with a constant velocity is also considered. In the last case nonmonotonicity of friction law leads to the stick-slip oscillations at the low velocity of drugging. This work was supported by Russian Foundation for Basic Research under grant 04-01-96048, regional program ”Ural”.

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DEFORMATION WEAKENING AND FAILURE PROCESSES IN DEFORMABLE SYSTEMS, METHODS OF SURVIVABILITY AND SAFETY ANALYSIS

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The statements of mechanics of stable post-critical deformation and failure in damaged solids with weakening zones and

items of formulation and substantiation of appropriate boundary value problems are analysed. The importance of taking into account the properties of loading systems is marked. Information about these properties is introduced to the problem formulation owing to use of special boundary contact conditions. The appropriateness of non-local failure criteria use is substantiated using the post-critical deformation stability conditions of medium that are written with regard for properties of a surrounding material as a loading system. The questions of competence of the description of a final stage of deformation and failure of inhomogeneous media with the help of effective characteristics have been considered on the basis of solution of model boundary value problems. The obtained results testify to connection of weakening characteristics with length dimension parameters that permit to describe strength scale effects. Problems for rod systems illustrating the behaviour on post-critical deformation stage as a result of individual element failure are presented. The stabilizing role of loading systems with sufficient rigidity and the possibility of realization of load-bearing capacity reserves in deformable systems due to formation of the stable deformation weakening conditions for individual elements has been demonstrated. Problems of complex advanced strength analysis including load-bearing structure safety estimation based on the analysis of factors that influence the character of processes of initiation and evolution of defects are considered. The estimation procedures of deformation and strength reserves, the results of survivability and reliability analysis, the results of investigation of failure processes control potential have been illustrated on the basis of numerical modeling of main-line crack formation and development processes in deformable solids at plane stress state. The scale effect of strength caused by change of hardness of loading system has been demonstrated. The work is supported by Russian Fund of Basic Research (grants RFBR-Urals 04-01-97503, and 04-01-96067).
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DYNAMICS OF PARAMETRIC PENDULUM FOR WAVE ENERGY EXTRACTION

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In this study a new concept for the extraction of energy from sea waves for the purpose of generating electrical power is examined. The concept is based on the conversion of vertical motion of sea waves into rotational motion of a parametric pendulum rigidly mounted above a floating structure, where the generated pendulum's rotational motion will provide the driving torque for an electrical generator. As a first approximation of such system a parametric pendulum driven by an electrodynamic shaker was considered. Detailed experimental investigations and mathematical modelling and analysis of this system have been carried out and they will be presented during the lecture. In particular, the influence of the dynamics of an electro-dynamic shaker on the behaviour of a parametric pendulum will be shown and accurate predication of rotational orbits will be given. Finally, the investigations from a newly built experimental rig operating in a wave tank will be presented to validate the original concept.
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SIMULATION OF SYNCHRONIZATION OF MECHANICAL VIBRO-EXCITERS IN OSCILLATORY SYSTEM WITH THREE DEGREE OF FREEDOM

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The problem of self-synchronization of unbalanced vibro-exciters placed on carrying moving body with one or three degree of freedom. Numerical integration of nonlinear differential equations was carried out by means of standard package of computer programs Maple 9.

The results of solving the equations are presented in the form of plots of change of integrated coordinates, carrying body displacement, phase difference between exciters and plots of synchronous and partial angular velocities of exciters during the period in question (40sec) and during one period of oscillations. Mechanical trajectories of centres of mass of carrying bodies are obtained.

Numerical simulation of the problems on self-synchronization of two and four unbalanced vibro-exciters placed on rigid body with linear oscillations, the problems on self-synchronization of two, three and four exciters placed on rigid body performing plane oscillations was carried out.

The simulation of problems on double and triple synchronization was carried out. It is shown that in spite of existence of vibration link between exciters the practical realization of multiple synchronization effect is rather difficult since vibration moments of multiple synchronization are small compared with corresponding moments of simple synchronization. At the same time using the devices providing elastic connection of exciters with the object to which vibration is imparted or between each other enables to increase vibration moment. The possibility of increasing moduli of vibration moments by means of using the mechanism of universal joint is shown.

The carried out numerical simulation of self-synchronization of vibro-exciters shows the accordance between numerical and the obtained before analytical and experimental results and enables to investigate the influence of the parameters of oscillatory system on self-synchronization as well as to determine parameters of devices recommended for intensification of multiple self-synchronization effect.
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PROBABILISTIC METHODS FOR THE ANALYSIS OF RANDOM-STRUCTURED FIBRE-REINFORCED COMPOSITES

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Prediction of the effective elastic modules and definition of the statistical characteristics of random stress and strain fields at the components of fibre- and particle-reinforced composites are connected to finding the solutions of stochastically nonlinear boundary-value problems. The conditional and unconditional correlation functions (CF) of the second, third, fourth and fifth orders for elastic modules, which characterized collective multiparticle interaction in the ensemble of inclusions, are required for construction of approximate solutions (the total correlation approximation, for instance) of these problems. CF are determined by the central moments of the corresponding orders for the random indicator takes value 1 or 0 depending on belonging to reinforcement elements or matrix consequently.

Calculation of the conditional and unconditional multipoint CF of different orders for the random-structured composites follow the 'traditional' algorithms used to plot these functions experimentally by employing microsections of fibreglass plastics. Realization of the algorithms is supposed to usage of an additional co-ordinate net and definition of belonging each point of the net to one of the phases and required significant hardware and software cast even in the case of reduction of the calculation the CF to the problem of finding geometric probabilities as well. Application of parallel computational procedures could be solved this problem partially. The results for plotting CF of the second order (which carried out on the multiprocessing system MVS–1000) have shown, that usage of 10 processors is reduced the total solution cast up to 5 times and further increasing the number of processors is inappropriate.

The analytical relationships in the form of finite number series for conditional and unconditional multipoint CF of the different orders for the random-structured fibre- and particle-reinforced composites are obtained on the basis of the new approach to defining geometric probabilities. The detailed convergence analysis of these series allows to investigate such regularities of composite structures as localization and the presence of the order parameters, i.e. periodic terms in the random fields.

The analytical relationships for the derivatives of unconditional CF of the second and third order at the points corresponding to zero values of the arguments, which are defined by the ration of the measures for the interphase surface and for the fragment, are obtained. It is shown, that the derivatives for the correlation moment of the second order with any void fractions have a negative sign. But the derivation for the CF of the third order takes always negative or positive values if void fractions of inclusions are smaller or greater than 2/3 consequently. Lack of the relation for the derivatives on angle co-ordinates proves a local statistical isotropy of random fields of composite structures under approximation of the 'small distances'.

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MODELING OF THERMOMECHANICAL BEHAVIOR AND FATIGUE OF SHAPE MEMORY MATERIALS

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In this paper, we propose a unified thermomechanical model and a low-cycle fatigue criterion for shape memory materials. The model is capable of simulating all major aspects of the material behavior under general three-dimensional thermomechanical loading conditions. Typical examples include superelasticity, orientation of martensite, thermoelasticity, and one-way shape memory effect. A generalized version of the same model addresses the training of shape memory materials, and the two-way shape memory effect.

Based on experimental results, we establish a low-cycle fatigue criterion in the superelastic case by showing that a relation exists between the number of fatigue cycles to failure of the material and the amount of dissipated energy per cycle represented by the area of the stabilized superelastic hysteresis loop of the stress–strain curve. The dissipated energy, and as a consequence the number of cycles to failure, can be numerically estimated by the present model.

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NUMERICAL SIMULATION OF PHASE TRANSITION IN NI-BASED ALLOYS

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An important feature of the current study is to analyze coarsening data in ternary Ni-based alloys. The morphological evolution and coarsening kinetics of ordered intermetallic precipitates with coherency stress in Ni-Al and Ni-V alloys were studied using the diffusion equations and three dimensional atom probe (3DAP) analyses. The emphasis is on the effects of precipitate volume fraction. Specifically, we predict the variation of the rate constants of coarsening with precipitate volume fraction in Ni-Al alloys and the suppression of two from three orientational variants in Ni-V systems. Comparison of numerical simulation results with experiments shows good quantitative agreement.

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SHOCK PULSE SPECTRUM INFLUENCE ON CHARACTER AND THRESHOLD OF CLEAVAGE IN PMMA.

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Shock pulse spectrum influence on character and threshold of cleavage in PMMA.

Experimental researches of cleavage in PMMA at microsecond shock loadings have found out temporal structure of a shock pulse influence on character and threshold destructions. Experiments were spent on electric explosion installation with characteristic duration of shock loading about 1-2 micro seconds. The plane shock wave was initiated by explosion of aluminum foils, Shock loading was delivered to a sample through PMMA a waveguide. Sizes and a time structure of shock loading were registered either with the laser interferometer or piezosensor. Thus the form of shock loading could change due to change of a mechanical impedance of a thin layer located between a waveconductor and a sample. It is found out that character and a threshold of cleavage considerably differ for different time forms of shock loading. The Conclusion: apparently this dependence is caused by correlation of scales of a mesa structure with spatially time spectrum of shock loading.

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DYNAMICS OF MANY INTERACTING BODIES ON MACROLEVEL AND SOLID DIFFUSION ON MICROLEVEL IN THE MODELING OF MECHANICAL ALLOYING PROCESS

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Mechanical alloying is a way to produce a solid solution of many crystal materials and their compounds as an ultra fine powder. A method of the process is high energy action on powders of initial components by milling balls in special devices (a planetary mill or an attritor). It is very far from equilibrium process which is accompanied by dissipation of supplying energy on three scales: macroscale over complex vortical motion of the milling balls, mesoscale over repeating process of fracture and welding of the powder particles, microscale over evolution of defect structure of particles including solid diffusion of components. For many materials mechanical alloying is the only way to produce their solid solution. The main problem is to find out meanings of the process parameters (frequencies, sizes of devices and balls, temperature conditions) that allow obtaining new materials with prescribed properties.

Interactions in the balls-powder system on macrolevel include repeating collisions and long-continued contacts with friction between balls. The last is a motion with non-holonomic constraints and its description for a system of more than two bodies is rather hard to solve problem. In present work we used a method like hard sphere dynamics, in which all types of balls interactions are reduced to sequences of pair nonelastic collisions with friction. Such approach is applicable to simulation of motion of any granular media. Here the method has been used to describing of milling balls dynamics in a planetary mill. Analytical solution for nonelastic collision with friction was obtained for pair of balls with different masses. For changing of normal component of the relative velocity was used Newton relation with constant restoring coefficient. For changing of tangent component was obtained analytical solution takes into account possible stopping of relative sliding of the balls during the collision. A powder motion is not explicitly described, but its presence is taken into account by additional restoring and friction coefficients. This method was shown to describe rolling of a ball along with any moving or immovable surface with arbitrary approximation to an analytical solution with decreasing of time intervals in a sequence of collisions. The method of dimensional analysis was used to write a common form of dependence of kinetic energy dissipation rate on parameters of the process for a planetary mill. Coefficients of this dependence are improving by numerical experiments. Statistics of balls actions on a powder is obtained from simulation as distribution of proportion between normal and tangent components of collision impulses and distribution of their quantities.

The problems of solid diffusion between two micro-blocks of a powder particle and gas diffusion from pore to a bulk of material with presence of dislocations are solving by use of local equilibrium thermodynamics approach. External impact action is corresponded to distributions obtained on a macroscale. Here diffusion along with dislocation lines is modeling by setting of very large diffusion coefficient on a dislocation line in compare with bulk diffusion coefficient. Solutions of these problems allow finding answers on the following questions: 1) how deep may penetrate solute atoms in a bulk of material in dependence on external loading parameters, 2) in which conditions is possible a process of gas diffusion from pore and an inverse process.

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