Final Scientific Conference of Federal Research Center

«Kazan Scientific Center of Russian Academy of Sciences», 2017

Sub-forum of Mechanics and Engineering

(Kazan, 2018)

D.A. Gubaidullin

Institute of Mechanics and Engineering of FRC Kazan Scientific Center of RAS

2/31, Lobachevsky str., Kazan 420111 Russia

Reports on the achievements in the fields of thin-walled structures nonlinear mechanics, hydroaeroselastic and wave systems, dynamics of multiphase multicomponent media in porous structures and procssing units; non-linear stability theory of control systems with changeable structure were presented at the Final Scientific Conference. Abstracts of the reports are presented below.

February 15, 2018

D.A. Gubaidullin, A.A. Nikiforov (IME FRC KazSC RAS)

Acoustic waves in viscoelastic bubble medium

The propagation of acoustic waves in a viscoelastic bubble medium is studied theoretically. A linearized differential equations system for the disturbed motion of such a medium is presented, the dispersion relation is derived. Based on the example of a viscoelastic bubble medium, which is a polydimethylsiloxane with embedded polydisperse air bubbles, the dependences of the phase velocity and damping coefficient on the oscillation frequency are calculated, a comparison with known experimental data is given.

D.A. Gubaidullin, Yu.V. Fedorov (IME FRC KazSC RAS)

Acoustic waves in a liquid suspension with gas bubbles and solid particles

The mathematical model is proposed, which determines acoustic wave propagation in a liquid with gas bubbles and solid particles. The differential equations system is written and the dispersion relation is derived. Low and high-frequency asymptotics of the phase velocity in the considered mixture are found and illustrated. The effect of solid particles and gas bubbles on acoustic wave dispersion and dissipation is described. For the mixture of fluid with solid particles the speed of sound is compared with available experimental data.

D.A. Gubaidullin, R.N. Gafiyatov (IME FRC KazSC RAS)

Reflection and transmission of acoustic waves through a layer of multifractional bubbly liquid

The mathematical model is presented, which determines the reflection and transmission of acoustic waves through the medium containing a layer of multifractional liquid with vapor-gas and gas bubbles. The influence of the bubble layer thickness and the bubbles vapor concentration is shown. For the layer of water with air bubbles a comparison between the transmission coefficient theoretical dependence with wellknown experimental data was made.

D.A. Gubaidullin, E.A. Teregulova (IME FRC KazSC RAS)

Acoustic waves dynamics in multifraction gas suspension

The acoustic waves propagation in mixtures of gas, vapor, drop and particles of different materials and sizes is studied. The mathematical model is presented, the dispersion relation, equilibrium and frozen speeds of sound, low- and high-frequency asymptotic behavior of the linear attenuation coefficient are obtained, dispersion curves are calculated. The influence of the dispersed phase parameters on the dissipation and dispersion of sound waves is analyzed.

D.A. Gubaidullin, Yu.V. Fedorov, R.R. Zaripov (IME FRC KazSC RAS)

Reflection of an acoustic wave from the boundary of a two-fraction gas suspension with polydisperse inclusions

The results of the study of acoustic wave incidence on the interface between a pure gas and a gas suspension are presented. The case is considered where gas suspension consists of two polydisperse fractions, each of fractions is described by a definite distribution function of the size inclusions. It was found how the inclusions mass content and size distribution functions effect on the reflection coefficient dependence on the disturbing frequency

D.A. Gubaidullin, P.P. Osipov, A.A. Abdushev (IME FRC KazSC RAS)

Simulation of aerosol particles distribution dynamics in hyperbolic resonator

The aerosol particles distribution dynamics in acoustic field inside a hyperbolic plane resonator is numerically studied. The exact value of the first resonant frequency, as well as the amplification of gas velocity amplitude are found. The existence of acoustic flow in the form of four Rayleigh and four Schlichting vortices is revealed at first resonant frequency. The dynamics of initially uniformly distributed particles and their drift at the first resonant frequency are simulated. The five convergence zones of aerosol particles (acoustic traps) are observed. The particles drag coefficient influence on their distribution dynamics is analized.

D.A. Gubaidullin, P.P. Osipov, I.M. Almakaev, R.R. Nasyrov (IME FRC KazSC RAS)

The calculation of acoustic waves in a closed resonator using various numerical methods

The numerical study of acoustic waves is performed using various methods based on the 1D Lagrange approach, alternating directions and CFD Fluent software. The shock wave arising at frequencies close to the first resonant was investigated. The experimental results are compared with analytical results of other authors based on 2D-simulation. It’s found that the 1D Lagrange approach is in a good agreement with 2D simulations results of other authors as well as with results obtained using other methods as part of this work. Due to the accurate boundary condition formulation, high computational speed and minimum memory consumption, the 1D Lagrange approach can be effectively applied to solve a number of two-dimensional problems, as well as to verify the other numerical methods reliability .

D.A. Gubaidullin, D.A. Tukmakov (IME FRC KazSC RAS)

Numerical simulation of disperse phase spatial distribution influence on the nonstationary processes in gas suspensions

This work is devoted to numerical simulation of the nonuniform mediums dynamics consisting of the solids weighed in gas - gas suspensions. Significant parameter of a gas suspension disperse phase is the geometrical distribution of solid particles concentration in the explored flow region. The experimental study of such flows is presents severe difficulties, so the numerical simulation is necessary. Calculation results are obtained using the numerical solution of a set of heterogeneous environment dynamics equations in Euler statement taking into account phases power and thermal interactions.

D.A. Gubaidullin, R.G. Zaripov, L.A. Tkachenko, L.R.Shaidullin (IME FRC KazSC RAS)

Experimental study of the aerosol dynamics in closed tube near resonance шт going to the shock-wave mode

The features of the aerosol coagulation are revealed in case of nonlinear gas oscillations in the tube at different frequencies and amplitudes of the piston stroke. Induced aerosol oscillations cause a time-dependent decrease in the droplets number concentration. This process occurs 5-15 times faster than with the natural precipitation of droplets. The coagulation time and aerosol droplets deposition dependence on the frequency is nonmonotonic with a minimum at the first natural frequency.

T.S. Guseva (IME FRC KazSC RAS)

Numerical simulation of the various shape jets impact on a solid surface

Some results of numerical study of the jet end shape influence on the features of the high-speed jet impact (250 m/s) onto a solid wall are presented. It is shown that when the end of the jet is sharpened in comparison with the hemispherical one, the impact pattern does not change qualitatively. In case of increasing the jet end blunting, the region with tensile stresses, arising in the jet, starts to interact with the wall earlier and the integral load maximum on the wall increases.

A.I. Davletshin, T.F. Khalitova (IME FRC KazSC RAS)

Calculation of a shock wave in the cavity of a nonspherical cavitation bubble when compressed in a streamer

Convergence of a shock wave in the cavity of a nonspherical cavitation bubble when it compressed in a streamer is calculated. A mathematical model of bubble dynamics in a streamer and a model of single axisymmetric bubble dynamics are used. A possible scenario of the bubbles expansion and strong collapse is presented. It was obtained with taking into account the hydrodynamic interaction of bubbles, their deformations, liquid compressibility, vapor heterogeneity, shock waves focusing in bubbles.

N.A. Khismatullina (IME FRC KazSC RAS)

ENO-schemes for calculating the dynamics of perturbations in a body

A method for calculating the dynamics of an elastic-plastic body is presented, based on UNO and TVD modifications of the second-order-accurate Godunov method. Method efficiency is shown by an one- and two-dimensional problems of the waves propagation in the body, their interaction with its surface and localized impact onto the body. Compared with Godunov method, UNO and TVD modifications allow to significantly reduce the computational costs: the RAM - more than an order of magnitude and the CPU time - more than two orders of magnitude.

A.I. Davletshin (IME FRC KazSC RAS)

Spatial interaction of gas bubbles in an acoustic field

Dependence of gas bubble dynamics in liquid in the standing ultrasound wave pressure antinode on the neighboring bubbles is considered. The bubble is central among three, five and seven bubbles located on one, two and three mutually orthogonal straight linesб respectively. In all the cases, the distance between the bubble and its neighbors is the same. It is shown that in the second case the bubble deforms larger.

L. A. Kosolapova, V.G. Malakhov (IME FRC KazSC RAS)

Cavitation bubble dynamics in the advanced toroidal phase of motion

The cavitation bubble dynamics in a liquid near a plane rigid wall is considered. The possibility of converting a simply connected bubble into a toroidal one is taken into account. A numerical technique is used, based on the Euler method and the boundary elements method. Two calculating methods of the liquid pressure are compared. In the first method, the time derivative of the potential is calculated using finite-difference equations. In the second method, this derivative is calculated using the boundary elements method. It is shown that the difference in the results is only observed at the beginning of the toroidal phase.

I.A. Aganin, A.I. Davletshin (IME FRC KazSC RAS)

Hydrodynamic interaction of bubbles in an ultrasonic travelling wave

Some results of the investigation of the two micron bubbles dynamics under the influence of a plane ultrasonic wave propagating along a straight line connecting their centers are presented. The bubbles are initially spherical and equal, the distance between their centers is equal to six their radii. The ratio of the bubbles initial sizes is varied when their total volume is constant. Three interaction scenarios are possible: bubbles collision, destruction of bubble due to large deformations and bubbles divergence.

M.S. Ganeeva, V.E. Moiseeva, Z.V. Skvortsova (IME FRC KazSC RAS)

Numerical study of of the ellipsoidal burst disks nonlinear bending under the pressure and temperature of the working fluid

Nonlinear bending of the thin oblate ellipsoidal segments is investigated under the pressure of heated or cooled working fluid to their concave surfaces. The numerical analysis of segments stress-strain state has been performed in terms of their use as bursting disks. The numerical simulation results were obtained depending on the environment temperature level and bursting rod height above the unstrained membrane pole. The results obtained for ellipsoidal and spherical segments having the same bases and the height of the pole above the base have been compared.

February 16, 2018.

Elesin A.V., Kadyrova A.Sh. (IME FRC KazSC RAS)

Usage of the spline surface for the identification of reservoir absolute permeability on the pressure measurements on the wells

The identification problems of reservoir permeability field in the form of a spline surface are studied under the conditions of single-phase fluid filtration. The values of identification parameters are determined during the residual function minimization. The residual function is constructed on the known pressure measurements on the wells.

A.V. Tsepaev (IME FRC KazSC RAS)

Solution of two-phase nonisotherhermal fluid flow problems in the reservoir penetrated by a well.

The work is devoted to solving two-phase nonisothermal fluid flow problems, based on decomposition methods. The nonlinear Forchheimer law is used in regions with high filtration rates. To determine the temperature, the energy conservation law (the first law of thermodynamics) was used for reservoir systems, while the temperature of the fluids and the skeleton was assumed to be the same. Calculations are performed on heterogeneous computer systems.

A.I. Nikiforov, R.V. Sadovnikov (IME FRC KazSC RAS)

About waves effect on the particles removal by filtration flow from a porous medium

A mathematical model of the wave action on the process of particles removal from a porous medium (suffosion) by a two-phase filtration flow is developed. It is shown that the particles removal under wave action is increased due to the action of inertia force, which reduces the influence of the force holding the particles on the pore surface. The obtained results can be used for simulating the bottomhole well zone cleaning processes under vibration wave action.

G.A. Nikiforov (IME FRC KazSC RAS)

Influence of the water injection intensity on the oil displacement process

The future of oil production in the Republic of Tatarstan and in other oil-producing provinces of Russia is high-viscosity oil and oil deposits in low-permeability reservoirs. However, while developing such deposits, oil exhibits non-Newtonian properties, which can lead to the washed zones formation within the reservoir in the form of narrow "corridors" washed with a displacing liquid. In this paper, the such zones formation is modelled by the example of the five-point flooding system element and the water injection intensity effect on this process is studied.

P.E. Morozov, M.Kh. Khairullin, M.N. Shamsiev, A.I. Abdulin (IME FRC KazSC RAS)

Analytical model of SAGD process in the element of the super-viscous oil reservoir development

A new analytical model is developed based on nonlinear filtration law with limiting gradient to estimate the horizontal well productivity in the element of the super-viscous oil reservoir development by SAGD method. The effect of limiting pressure gradient on the horizontal well production rate and CSOR is studied.

B.A. Snigerev (IME FRC KazSC RAS)

Numerical study of the hydrodynamics and heat-mass transfer of subcooled liqud bubble boiling in vertical heated pipes

The results of numerical simulation of hydrodynamics and heat-mass transfer of subcooled boiling flow under conditions of forced flow in vertical heated pipes are presented. Comparison of numerical simulation results with experimental data showed that the proposed approach allows to simulate bubble boiling regimes in a wide range of pressures, flow rates, heating modes.

I.V. Morenko (IME FRC KazSC RAS)

Mathematical modeling of fluid flow with a free surface in an axisymmetric reservoir

The results of fluid flow numerical simulation with the free surface in an axisymmetric reservoir are presented. The influence of the basic physical properties and geometric parameters on the liquid column sinking are analyzed.

V.L. Fedyaev, A.R. Siraev (IME FRC KazSC RAS)

The influence of external factors on the polymer coatings spraying

The main external factors affecting the polymeric materials deposition are described. The influence of side wind and low air temperature on the effective powder consumption and quality of the coating is considered. Recommendations to minimize the negative impact of external factors are presented.

N.M. Yakupov (IME FRC KazSC RAS)

Diagnosis of thin-walled and thin-layered structural elements

The history of the laboratory from 1946 and achievements for the last 30 years are presented. The studies on the effect of scratches, media and solar radiation on the rigidity of thin-walled and thin-layered elements; influence of surface deformation, magnetic field, ultraviolet radiation and vibration on the corrosion wear of thin-walled elements were undertaken. A spline version of the FEM in 2D and 3D applications and an experimental-theoretical method for studying thin-walled elements and a method for determining the mechanical properties of nanocoating are noted.

N.K. Galimov, S.N. Yakupov (IME FRC KazSC RAS)

Experimental - theoretical approach to determine the mechanical properties of elliptical shape membranes in plan

The stress - strain state of an elliptical membrane fixed on a contour and loaded with uniformly distributed pressure is studied. Due to the small membrane thickness bending stiffness is not taken into account. Deformations are assumed to be plastic. The problem is solved by the Bubnov-Galerkin method (at a first approximation). An example of determining the conditional elastic modulus of an elliptical membrane is considered from experimental data. The results analysis is performed, errors are determined.

S.N. Yakupov, N.M. Yakupov (IME FRC KazSC RAS)

The effect of vibration on corrosive wear

Experimental studies of thin-walled samples from steel housed within water tanks on a vibrating platform have been performed. The control group of samples in water tanks is located in a calm area. Samples are kept in an water medium for a predetermined time. It has been found that vibration affects the samples corrosion: samples being affected by vibration are subject to greater corrosive wear in the water environment than samples not being affected by vibration. This is of great theoretical and practical importance, given the working conditions of many structures and structures made of metal.

S.N. Yakupov, L.U. Kharislamova (IME FRC KazSC RAS)

Change in the mechanical properties of membranes in a liquid medium

The influence of the water contact period on the mechanical properties of two groups of membranes was studied experimentally and theoretically. The first group consists of porous nylon membranes used for the transportation of liquid biologically active compounds. The second group is a bitumen-polymeric waterproofing membrane roof of a complex structure. It is established that the samples retained in the liquid change the mechanical characteristics of complex composite structures.

R.R. Giniyatullin, N.M. Yakupov (IME FRC KazSC RAS)

Study of thin deformed samples in a medium under the action of a magnetic field

The known studies on the magnetic field influence on a corrosion wear are reviewed. An experimental facility based on a permanent magnet is described. A curved sample in a medium under the influence of a magnetic field was investigated. It is found that the corrosive wear of deformed samples in the presence of a magnetic field varies depending on the deformations sign. The presence of a magnetic field provides to reduce corrosion. Corrosive wear of samples with a stretched surface occurs faster than for samples with a compressed surface.

L.I. Khasanova, I.I. Bikmukhametov, N.M. Yakupov, Kh.G. Kiyamov (IME FRC KazSC RAS)

Stress distribution in the rod fastening area depending on tensile forces

The development of modern calculation methods and the growth of the computing capabilities make it possible to refine the calculation schemes. The stress-strain state of the rod depending on tensile forces at various Poisson's ratio values is numerically studied, and also in case of the local defect in the fastening region. There is a concentration of stresses in the region of the ribs in the fastening zone. The local defect occurrence in this region leads to a significant increase in the stress concentration value.

A.F. Kashafdinova, N.M. Yakupov (IME FRC KazSC RAS)

Stress-strain state of a beam-rod system

The stress-strain state of beam-rod systems depending on tensile forces is numerically investigated. In the first case, the core system lies on the upper fibers of the beam and is fixed at three points. In the second case, the two vertices of the rod system are raised above the beam surface. One end of the rod system is hinged to the support, and the other end and one of the central nodes of the system are pivotally connected to the beam. Various values of the rods stiffnesses and the rods inclination angles are considered.

A.A. Abdyushev (IME FRC KazSC RAS)

Application of elastic spheres made-up of a locally isotropic material for the analysis of the metal atoms interaction potential

A method is known for simulating the microobjects behavior based on paired energy potentials. There is also an Embedded Atom Method, which estimates the microobjects energy, based on the "density of the electron cloud". Having connected these two concepts, the author suggested that the energy of interaction of two or more atoms can be determined by the accumulated potential energy of elastic deformation in solving the nonlinear contact problem of elastic spheres. Numerous experiments have been performed.