ABSTRACT AND REFERENCES

APPLIED MECHANICS

FREE VIBRATIONS AND SEISMIC RESISTANCE OF THREE-LAYER NON-HOMOGENEOUS ORTHOTROPIC RECTANGULAR PLATES(p. 4-7)

Sanan Qaraisayev

The problem of seismic resistance and free vibration of three-layer non-homogeneous, orthotropic rectangular plates, which layers are made of various, continuously non-homogeneous materials, is considered in the paper. It is assumed that elasticity characteristics of the material for layers are continuous functions of the plate thickness coordinate. Using the Kirchhoff-Love hypothesis for the entire thickness of the element, the expressions for forces and moments were obtained, as well as integrated stiffness characteristics for the three-layer orthotropic plate under consideration were determined. In general form, equation systems of the plate motion in both exact and approximate formulations were obtained. In the approximate formulation of the problem, two motion equations of the problem with respect to the deflection and the stress function were obtained. For the case of the plate pin-edge fixing, the problem solution was made and the formula for determining free vibrations of the plate was found. When making numerical calculations, the elasticity characteristics of the material for layers were taken as linear in relation to the thickness coordinates.

Keywords: three-layer, orthotropic plates, non-homogeneous, elasticity characteristics, vibration, amplitude-frequency characteristics

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ON THE DYNAMIC PROPERTIES OF THE ASYMMETRICALLY MOUNTED ROTOR WITH INERTIAL ANISOTROPY (p. 8-16)

Alexander Gorbenko

The dynamics of the rotor, which has unequal moments of inertia about its transverse axis is considered in the paper. The analysis is performed considering an asymmetric placement of the rotor relative to the supports. The study is based on the dimensionless equations of spatial motion of the anisotropic rotor in a rotating coordinate system. An exact analytical expression for the critical rotation rate of the inertial-anisotropic rotor is obtained. Analysis of this expression has shown that the inertial-anisotropic rotor may have from one to four critical direct precession rates. The influence of the rotor type, its layout chart and anisotropy factor on the number and values of the critical rates is studied. To investigate the stability, the Lyapunov's method of the first approximation of perturbation equations was used. Basic necessary stability condition for the case of asymmetric mounting of the rotor in an analytical form is obtained. The analysis has shown that the main instability region is located between dual critical rates of angular oscillations of the anisotropic rotor. In general, inertial-anisotropic rotor may have up to three instability regions. The presented analytical and numerical study complements the existing dynamics theory of rotary machines. The obtained results allow more reasonably design and assign rational technological tolerances for manufacturing, assembly and erection of the rotors.

Keywords: gyrorotor, inertial anisotropy, stability, oscillations, moments of inertia, critical rates.

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NON-LINEAR VIBRATIONS OF THREE-LAYER NON-HOMOGENEOUS CIRCULAR CYLINDRICAL SHELLS (p. 17-20)

Safar Huseynov

The problem of nonlinear vibrations of three-layer non-homogeneous circular cylindrical shells is studied in the paper. It is assumed that layers are made of various heterogeneous isotropic materials, and elastic characteristics are continuous coordinate functions of the shell thickness. Taking the validity of the Kirchhoff-Love hypothesis for the whole element, the expressions for the forces and moments are obtained, and generalized stiffness characteristics for the considered three-layer circular cylindrical shell are defined. In general, all basic relations and system of motion equations of shell taking into account geometric nonlinearity are obtained. Approximate formulation of the problem is also considered. Two motion equations of the problem with respect to deflection and stress function are obtained in the approximate formulation of the problem. The solution on nonlinear vibration of three-layer cylindrical panel with pin-edge fixing is studied in detail. An analytical solution is obtained, and the dependence of the amplitude-frequency characteristics is determined. To perform numerical calculations, inhomogeneity functions of the layer material were taken as linear coordinate functions of the shell thickness. The results of numerical calculations are presented in the form of the characteristic graph.

Keywords: three-layer circular cylindrical shells, nonlinear vibrations, heterogeneous material, amplitude-frequency characteristics.

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FLOATED GYROSCOPE ERRORS ON A RESONANCE LEVEL IN THE FIELD OF ULTRASONIC BEAM (p. 21-25)

Volodimir Karachun, Viktorij Mel'nick

The nature of additional errors of a single-degree-of-freedom floated gyroscope in the field of an ultrasonic beam on the resonance level was disclosed.

A computational model of the wave coincidence phenomenon in the gyro suspension was built assuming a large wave size of the housing that enabling the provision of analytical support of the problem under consideration in the elementary, flat section of the housing frame.

A decisive influence of ultrasonic radiation on the resonance level of wave coincidence was first theoretically justified and practically proved in the bench certification of the industrial design of the floated gyroscope.

The research results can be used in the aerospace industry to take into account the risk of wave coincidence in the gyroscope suspension, manifestation of "acoustic transparency" effect of the device and the rapid growth of the measurement error.

The obtained results can form the basis of bench certification of hypersonic aircraft airborne equipment.

Keywords: wave coincidence, angle coincidence, acoustic transparency, float suspension, wave size.

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WAVE PROPAGATION IN A RECTANGULAR BAR, EXPOSED TO THE IMPACT TANGENTIAL FORCES (p. 26-30)

Nazila Rassoulova, Gulnar Shamilova

In modern technology, there are more and more cases of action of impact loads on work items of buildings, machines and constructions, therefore, the strength calculations of these items under the dynamic effects become important.

To solve the problems, arising from the dynamic effects, it is necessary to use the continuum mechanics methods and, in particular in many cases, the methods of the dynamic theory of elasticity. Analytical studies allow to find the exact problem solutions, which is very important, because the exact solutions allow to estimate the main features of the solution in general - the nature and the extent of influence of various set parameters on it. On the other hand, exact solutions are always reference and needed, in particular, for developing numerical methods for more complex cases.

This work is a continuation of the works of N. Rassoulova, G. Shamilova, dedicated to studying the propagation of unsteady waves in the prisms of rectangular cross section. Approach to solving this problem differs markedly from all previous issues of the dynamics of rectangular prisms, which mainly investigated their dispersion characteristics.

This paper deals with studying the process of propagation of unsteady waves in semi-infinite rectangular bars, exposed to impact shear forces on the face platform. System of exact three-dimensional motion equations of an isotropic elastic body is used. Applying a peculiar integration method, previously developed by the authors of this paper, exact analytic solutions to the posed problem for the final time value are found.

The results can be implemented in the production in designing special constructions, where there are impulsive effects on them.

Keywords: unsteady waves, rectangular bar, impact shear forces, Lame's equation.

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ANALYZING HYDRODYNAMICS IN HOLLOW PERFORATED SHELL OF CENTRIFUGAL OSCILLATING GRANULATOR (p. 30-35)

Maksym Skydanenko

A numerical modeling of the hydrodynamics of liquid flowing in a hollow perforated shell with a small value Re was carried out using the ANSYS CFX software, which shows the pattern of distributing its flow velocity in the granulator working cavity and before an outflow port.

The numerical research allowed specifying (correcting) the calculation of outflow velocity of a melt jet and finding the way of improving the velocity (head) of the melt flowing out from ports of the granulator basket, by upgrading the design of a rotary oscillating granulator: increasing the number of blades or selecting their geometrical shape, depending on the granulator operating parameters. By increasing the head, the probability of plugging and alteration of geometrical sizes of outflow ports decreases. This enables using the granulator for dispersing melts with solid impurities (additives).

The obtained results were analyzed and applied for developing a modified centrifugal oscillating granulator of the melt with nitrogen fertilizers, which has passed experimental and industrial tests.

Keywords: prilling, radial blades, forward-curved blades, centrifugal oscillating granulator, hydrodynamics.

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NONLINEAR BOUNDARY INTEGRAL EQUATIONS METHOD FOR CONTACT PROBLEMS OF THE ELASTICITY THEORY (p. 36-40)

Alexander Alexandrov, Yurii Streliaiev

When implementing variational methods for solving complex contact problems, there are difficulties, associated with non-convexity of minimized energy function of the system of interacting bodies and non-differentiability of this function at the desired point of its minimum. These difficulties do not allow to use gradient methods and convex analysis methods to minimize the energy function, therefore, numerical procedures for finding minimum points of such functions are cumbersome in program implementation and sometimes make it impossible to obtain the contact problem solution with sufficient accuracy. Non-variational method, based on using nonlinear operator equations with no difficulties during its implementation is proposed in the paper. Applying these equations allows to use modern achievements of nonlinear functional analysis, fixed-point theory of continuous mappings, theory of iterative methods for solving operator equations for both proving theorems of existence of solutions to contact problems, and developing effective iterative procedures for approximate solutions. Nonlinear boundary integral equations, used in this paper to simulate the contact interaction of elastic bodies, allow (unlike other similar equations) to take into account both the linkage and partial slip on the contact surface of bodies, and loading history of these bodies. Based on these equations, simple and efficient iterative procedures for approximate solutions to the contact problems are developed. A numerical solution of the contact problem on indenting the elastic sphere in the elastic half-space is obtained, and comparison of results with the known problem solution is made.

Keywords: elastic body, contact problem, Coulomb friction, integral equation, iterative method.

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SOLUTION OF CONTACT PROBLEMS OF ELASTICITY THEORY USING A DISCRETE FINITE-SIZE ELEMENT (p. 41-45)

Aleksandr Shamrovskiy, Elyzaveta Bogdanova

The paper deals with studying the possibility of solving contact problems of the elasticity theory, in particular the punch problem using a discrete model of a continuous medium. Mixed boundary value problem of statics of elastic body is solved. Namely, the elastic equilibrium of the body is found if the displacements of some part of its surface points are given. Physically, this corresponds to the case when, using the forces, applied to the surface points, the given displacements are imparted to these points, and the surface is fixed in this form. The difference of the solved contact problems of the elasticity theory is that forces are given for some surface points, and displacements - for others. This work is based on the idea of modeling a continuous medium using the finite-size element. The rectangle, in the corners of which there are point masses, connected by elastic links was proposed as a structural element of the discrete model, replacing the rectangular element of continuous elastic medium. To make calculations for this model it is proposed to use the method of successive displacements, which gave a good account of itself in calculating beam structures. The obtained discrete models allow effectively solve contact problems of the elasticity theory, including at any values of the Poisson's ratio.

Keywords: discrete model, continuous medium, discrete finite-size element, method of successive displacements.

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DESTABILIZATION OF STREAM IN A CHANNEL WITH THE LENGTH-VARYING FLOW RATE (p. 45-49)

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The flow of viscous and abnormally-viscous fluids in hydraulic systems with a curvilinear pipeline and length-varying mass, used for surface irrigation is experimentally investigated in the paper. A comparison of the hydraulic characteristics of such streams with similar results at a constant flow rate is carried out.

These studies are caused by the need to justify the design parameters of water supply and irrigation systems, which ensure their reliability. Violation of stability and reliability can be caused by unstabilized processes, constantly arising in the operation of such systems and can lead to destabilization of the equipment.

As a result of the studies, the difference in determining the hydraulic losses is found, and recommendations for calculating the pressure drop in the channels of the discrete liquid sampling along the length are given.

This will allow to forecast the operation of irrigation systems at given geometric parameters, kinematic and dynamic characteristics of the stream.

Keywords: discrete sampling, destabilization, channel curvature, transit flow rate, fictitious length.

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RESEARCH OF HYDRODYNAMIC CONDITIONS OF ENTRANCE IN CHANNELS OF PROCESS EQUIPMENT (p. 49-54)

Sergey Nosko

The obtained solutions of the equations of unstabilized flow of viscous fluid allow to take into account the influence of the hydrodynamic conditions of the channel entrance on developing the velocity field on the initial section. Research of equations in dimensionless form has expanded the physical understanding of hydrodynamic features of these flows and allowed to assess the validity of assumptions and suppositions that are used in approximate solutions of the Navier-Stokes equations.

The results of solutions are consistent with the known theoretical studies for the case of uniform velocity distribution at the entrance to the initial section (at $n_1=\infty$) and make existing adjustments to conventional calculated dependencies on determining the length of this section if the velocity profile differs from the rectangular. Thus, at $n_1=1,7$ specifications reach 85 %. Correction factors, included in the expressions for determining the length of the initial section reflect the impact of reconstructing the velocity profile during the flow.

Analytically and experimentally obtained calculated dependencies have served as the basis for developing a methodology of hydrodynamic calculation of channels and working bodies of technological equipment.

Keywords: motion equation solution, conditions of entrance in hydrodynamic initial section.

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