ABSTRACT AND REFERENCES

APPLIED MECHANICS

IDENTIFICATION OF THE GEOMETRY AND ELASTIC PROPERTIES OF RIGID INCLUSIONS IN A THIN PLATE (p. 4-9)

Nataly Guk, Natalia Stepanova

The presence of inclusions in thin-walled structural elements in the course of their operation under mechanical and thermal loads gives rise to the material damage. In publications on this subject, the problem of defect identification is considered in two directions – the location and shape of the defect or the physical properties of rigid inclusions are determined.

The paper proposes a method for simultaneous determination of the location of rigid inclusions and their elastic properties (Young's modulus) in a thin plate. The mathematical model of a plate with the inclusion is built in the framework of the linear theory of elasticity. For quantization of unknown functions, the finite element method is used. The geometric inverse problem is formulated in the conditional-correct statement.

The parameters of rigid inclusions are determined by minimizing the quality functional. Additional conditions are attached to the functional using the Lagrange multipliers. The results of the identification of one or several inclusions of different sizes by the proposed method are presented. In solving the problem for a plate with one rigid inclusion, the error of restoration of the inclusion location does not exceed 3 %, the error of determination of the Young's modulus of this inclusion – 2 %. The error of determination of the Young's modulus for a group of several rigid inclusions is in the range of 4–7 %.

Comparative analysis of numerical experiment results shows that the proposed method allows identifying the location and properties of several rigid inclusions of various sizes.

Solution of the problem of identifying the inclusions, determining their size and elastic properties allows more accurate estimation of the strength characteristics of elements and prediction of the service life of structures.

Keywords: thin plate, rigid inclusion, geometric inverse problem, finite element method.

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RESEARCH OF THE STRESS-STRAIN STATE OF THE CONTAINER SHIP DECK ELEMENTS USING THE KARMAN DIFFERENTIAL EQUATION SYSTEM (p. 10-19)

Valerij Maltsev, Anatoliy Nyrkov, Sergei Sokolov

The current stage of development of the shipbuilding industry is characterized by the emergence of new types of ships, structurally significantly different from the traditional ones. In this connection, it is necessary to build more rigorous physical models describing the behavior of ship structures under the action of external loads.

Structural mechanics of the ship, as an independent science, began to form at the beginning of the XX century. The founder of this science according to the rule can be considered a Russian scientist and shipbuilder, professor of the Naval Academy and the shipbuilding department of Petrograd Polytechnic Institute. Based on previous knowledge of the theory of elasticity to them the first rules of allowable stresses have been proposed for surface ships, the methods for evaluating the strength and stability of ship floors and reinforced plates were developed.

Currently, structural mechanics of the ship faces a number of problems requiring urgent solutions, such as the desire for maximum reduction of body materials consumption, the emergence of new, more advanced manufacturing processes of the hull. To solve these problems, it is necessary to turn to the theoretical research and use the knowledge gained during the last three centuries, various scientists involved in various developments in the science of strength of materials, theory of elasticity, and theory of plasticity and structural mechanics of the ship.

The importance of building effective and reliable calculation methods to predict the impact of the loading process on the long-term strength of structural materials is caused by the need to ensure long-term durability of structures in the conditions of insufficient and costly experimental studies.

Container shipping today is the most convenient and the most universal means of transportation. A wide variety of types of containers (dry cargo, refrigerated, insulated, flat track, tank containers) ensures not only fast loading and unloading, but also the opportunity to use the maximum vessel capacity.

The software system was studied and defined, which allows determining the deformation of the upper deck of the ship while loading and on the resulting chart voltages to determine possible locations of damage with the aim of preventing them, because any accident on the ship can not only cause human and material losses, but also major environmental disasters.

The practical value of the results of the work lies in the fact that these studies make it possible to assess the actual loading of shipbuilding structures in terms of their operation.

Keywords: ship plate, stress-strain state, Karman differential equation system, finite difference method.

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AN EXPERIMENTAL AND THEORETICAL METHOD OF CALCULATING THE DAMPING RATIO OF THE SUCKER ROD COLUMN OSCILLATION (p. 20-25)

Ivan Steliga, Jaroslav Grydzhuk, Andriy Dzhus

Despite the massive use of dynamograms to identify possible faults in downhole sucker rod pumps (DSRPs), frequent analysis of the deviation of the pumping mode from the optimal mode, and attempts to determine the column load of the sucker rod (SR), little if any attention had been given before this study to oscillation processes that significantly affect the column's durability. In view of the expedience of considering the SR column as an oscillation model, the objective of the study consisted in developing a method of determining the column oscillation damping ratio on the basis of the obtained DSRP dynamograms. The study considered the nature of the dissipative forces and their impact on the character of the SR column damping. It has proven a reasonable possibility of studying the intensity of oscillations' damping in defferent sections of the dynamograms. This was done by analysing real estuarine and abyssal dynamograms and approximation of oscillogramed sections in the form of periodic changes in the load factor of oscillations' damping for particular column layouts. The developed method can be applied to analysing dynamograms of a particular well, whereas the determined damping ratios facilitate assessment of the SR column dynamism and establishment of the best modes of the DSRP operation to prevent resonance under actual operating conditions.

Keywords: sucker rod column, dynamogram, oscillation coefficient, load, damping, oscillogram, approximation.

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ANALYSIS AND COMPARISON OF EXPERIMENTAL RESEARCH OF PUMP WITH CENTRIFUGAL-VORTEX STAGE (p. 26-31)

Maxim Naida

The paper is aimed at investigating the operation of the pump with combined centrifugal-vortex stage. The constructed power characteristics show that the pump has rather a high pressure (H=12 m) and low power consumption (N=0.27 kW) with low fluid supply (Q=27 m^3/day).

To determine the combined stage usefulness, comparative power characteristics of the pump with combined centrifugal-vortex stage with centrifugal and vortex pumps, having similar geometric dimensions are obtained. The comparative analysis shows that the pressure of the pump with combined centrifugal-vortex stage is 2.5 times higher than that of two pumps.

This data allows a greater understanding of the further study of pump operation with combined centrifugal-vortex stage.

The results of the tests allow concluding that the application range of pumps with combined centrifugal-vortex stage is quite limited: the oil industry, pressure boosting systems, fire suppression systems, as well as washing and sprinkler systems.

Keywords: pump, centrifugal-vortex stage, impeller, pressure characteristics, power, pressure.

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A MATHEMATICAL MODEL OF THE HYDRAULIC SYSTEM OF THE UNIVERSAL HOSED CONCRETE PUMP (p. 32-42)

Denys Chayka, Inga Emeljanova, Pavlo Andrenko

The paper presents a scheme of a new-design universal pistonless concrete pump with a hydraulic drive and provides a basic diagram of its hydraulic system. To maximize energy efficiency, the designed hydraulic circuit is implemented through the following hydraulic devices: high-torque hydraulic motors, a gear pump, a hydraulic cylinder, hydraulic spreaders, a filter, a safety valve, anticavitation and check valves, a flow controller, and pipelines. The key element in the hydraulic circuit of the pistonless pump is high-torque hydraulic motors that have low rotation frequencies and thus would ensure the necessary torque on the rotor of the concrete pump to push the concrete mix. The designed nonlinear mathematical lumped-parameter model of the hydraulic system of the universal hosed concrete pump is based on its decomposition into individual structural elements and a detailed account of variables of the working fluid, which ensures a more precise assessment of the output parameters of the concrete pump. The mathematical model allows determining static and dynamic characteristics of the entire system and its individual components, studying the parameters, and setting new rational parameters.

Keywords: universal hosed concrete pump, hydraulic diagram, mathematical model, high-torque hydraulic motor, working fluid.

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THE METHOD OF CALCULATING THE VELOCITY FIELD AND SHEAR STRESSES IN INCOMPRESSIBLE FLUID (p. 43-48)

Vitaliy Budarin

The velocity field calculation method is based on the use of two special cases of the Newtonian fluid motion equations, not including the Navier-Stokes equations. Two shear stress calculation methods are considered. The first method is the differentiation of the velocity field equation, and the second one requires the solution of the first-order differential equation. The second method provides the distribution of shear stresses for any continuous medium, including the Newtonian fluid.

Calculation equations for a laminar flow in a round pipe are found. It is shown that a parabolic velocity distribution along the radius is a special case of a more general equation.

The factors affecting the shear stresses for the three flow models are found. Stresses are determined by the linear velocity gradients in the laminar flow. In the 3D vortex, they can be found by various equations, which include vorticity. Total stresses for the averaged turbulent flow are calculated by summing the previously found stresses.

The equations of the method are incomplete and may be used for the accurate solution of simple problems.

Keywords: incompressible fluid, Poiseuille, flow regimes, velocity gradient, vorticity.

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INVESTIGATION OF THE PROCESS OF STABILIZATION OF THE ROTATIONAL AXIS OF THE LIFTING BODY BY THE PENDULUM AUTOBALANCER (p. 49-63)

Vladimir Pirogov

The paper investigates the conditional stability of the basic steady motions of the spatial model of an isolated system, consisting of a rotating lifting body, a particle, creating its static unbalance and two identical mathematical pendulums, mounted on a longitudinal axis of the lifting body and moving in the plane of the static unbalance, the relative motion of which is hindered by the viscous resistance forces. It is found that in the case where unbalance is present and pendulums can correct it with a certain margin, there is one basic motion. In the absence of unbalance, there is a one-parameter family of basic motions. In the case of maximum unbalance, which can be corrected by pendulums, there is one basic motion, but it generates a pseudo family of basic motions. Also, it is revealed that some basic motions, if isolated, or a family or a pseudo family of basic motions is conditionally asymptotically stable. In the absence of unbalance, the presence of a single zero root of the characteristic equation does not affect the stability of a one-parameter family of basic motions and is responsible for the transition from one steady motion of a family to another. In the case of maximum unbalance, the presence of a single zero root of the characteristic equation does not affect the stability of the basic motion and is responsible for the transition from one steady motion of a pseudo family to another. Transition processes are oscillatory-damped.

Keywords: lifting body, pendulums, motion stability, spacecraft, passive autobalancer, damper.

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IDENTIFICATION OF A MIXTURE OF GRAIN PARTICLE VELOCITY THROUGH THE HOLES OF THE VIBRATING SIEVES GRAIN SEPARATORS (p. 63-69)

Leonid Tishchenko, Sergei Kharchenko, Farida Kharchenko, Vadym Bredykhin, Oleg Tsurkan

The research of the process of sieving of grain mixes in vibrating sieves of grain separators is given. The generalization of theoretical research allowed obtaining a mathematical model of grain mix dynamics in vibrating sieves, which is based on hydroanalogy and improved by the introduction of bubble fluidized medium. This model is the equation for determining the grain mix velocity components, taking into account the structural and kinematic parameters of sieves and properties of the mix. This identified the possibilities of intensifying the mix sieving in vibrating sieves through the use of epicycloid-shaped holes. The model is tested on the example of the pea mix sieving, resulting in the constructed velocity field and volume efficiency variation patterns in the series round-hole sieves and the developed five-petal epicycloid-shaped hole sieves. It was found that an important parameter in the dynamic processes and the grain mix sieving process is the velocity of its passage through the holes. To increase the modeling accuracy, the technique of identification that was to determine the flow rate of granular medium through the sieve holes was developed. The measurements of the velocity of the mix passage through the sieve holes were carried out. To do this, the flow of the sieved grain mix was determined and attributed to the area of the sieve holes. The load, structural and kinematic parameters of the sieve, including the type of holes was varied. The studies found a significant increase in the velocity of passage of the grain mix through epicycloid-shaped holes of the developed sieves in comparison with series round-hole sieves, which confirms their efficiency. Using these methods provides the real variation ranges of the velocity of passage of the grain mix of different crops through any type of sieve holes.

Keywords: sieving process, efficiency, velocity field, holes, fluidized medium, pea mix, hydroanalogy

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INFLUENCE OF LOW RUBBER COMPRESSIBILITY ON THE SEALING ELEMENT OF A DOWNHOLE PACKER (p. 70-78)

Vasif Talibov Mamedov, Seyfulla Ramiz oglu Gurbanov

The variational Lagrange principle and the Kantorovich method are applied in calculating the downhole packer sealing process with the influence of low rubber compressibility. The dependence between the sealing ratio and the stress ratio on the geometric parameters of the sealing element of the downhole packer is determined. It is found that the sealing effect of end faces leads to a significant difference in the stress-strain state of the packer seal assembly from uniaxial compression. Rubber is an elastic material in the entire load range. However, with increasing strain there is increasing deviation from the linear relationship between stress and strain, despite the fact that rubber remains an elastic material, and the relationship between stress and strain becomes nonlinear.

The incompressibility should be considered as the property of rubber to maintain a constant volume under any strain. Volume decrease under higher strain is associated with the change in the physical state of rubber due to crystallization. The compressibility effect may become noticeable only in special structures, in downhole packers, so in this case the problem is divided into two: 1) the solution of the problem in the case of an incompressible material; 2) the solution of the problem, corresponding only to the three-dimensional compression, when the strain E_{ij}=const, if loads are large enough and the rubber compressibility has to be taken into account. It is shown that strain in many designs of downhole packers should be written based on precisely this dependence, because the lateral strain in the seals appears constrained so that a large volume of rubber is under uniform compression. In this case, the assumption of absolute incompressibility of rubber can lead to a significant overestimation of the seal rigidity.

Keywords: low-compressibility rubber, downhole packer, Lagrange principle, toughening factor, normal and shear stresses.

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RESEARCH OF COMPETITIVENESS OF VIBROWAVE INFRARED CONVEYOR DRYER FOR POSTHARVEST PROCESSING OF GRAIN (p. 79-85)

Igor Palamarchuk, Oleg Tsurkan, Vladislav Palamarchuk, Sergei Kharchenko

The expediency and necessity of competitiveness evaluation of new equipment for manufacturers and users are proved. This will help consumers in selecting the right product and encourage manufacturers to produce energy-efficient equipment.

The method and example of the technical level evaluation of the vibrowave infrared conveyor dryer for grain drying in the post-harvest processing by two types of general indicators are presented.

Two types of general indicators are identified according to the criteria of performance, efficiency and steel intensity of the developed machine and grain dryers of the same class.

The research revealed that the developed vibrowave infrared conveyor dryer is competitive and outperforms existing dryers for two types of general indicators. This result is achieved through the use and implementation of continuous processing mode with the minimum power and materials consumption with ensuring the layer-by-layer grain processing uniformity.

The technical level evaluation of the developed machine by several criteria makes it objective and assists consumers in making the right decision when choosing new equipment to improve production.

Keywords: post-harvest processing, infrared dryer, vibrating dryer, grain drying, competitiveness evaluation, general indicators.

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