ABSTRACT AND REFERENCES

APPLIED MECHANICS

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ANALYSIS OF FUNDAMENTAL SOLUTIONS TO THE EQUATIONS OF STATICS CONSTRUCTED FOR TRANSVERSAL-ISOTROPIC PLATES (p. 4-12)

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In present research, we examined and analyzed the fundamental solutions of the equations of statics for the transversal-isotropic plates, which were built using generalized theory of the {m,n}-approximation. The methods for reducing the three-dimensional problems of the theory of elasticity to the two-dimensional ones are explored. In the study, we analyzed results, obtained on the basis of theory of the {m,n}-approximation, for the purpose of determining the refinement, which is introduced by the retention of a large number of terms in the expansion series of the desired functions. This theory is the most preferable for reducing the three-dimensional equations of the theory of elasticity to the two-dimensional ones since it is not based on any hypotheses, but employs the method of I. N. Vekua for the expansion of the desired functions into the Fourier series by the Legendre polynomials. This approach makes it possible to examine not only the thin plates, but also the plates of medium and large thickness, and allows us to consider transverse shearing and normal stresses. Since the classical theory of Kirchhoff–Love does not take these stresses into account, then examining on the basis of the refined theories of the stressed-strained state of transversal-isotropic plates under the action of concentrated force impacts is a relevant scientific and technical task. We carried out numerical studies that make it possible to determine the refinement, which is introduced by the retention of a large number of terms in the expansion series of the desired functions and to analyze the character of behavior of internal force factors of the zero spin stressed state and the state of bending, obtained with the use of generalized theory of the {1,0}- and {1,2}-approximation.

The obtained results play a decisive role when exploring different boundary problems of the mechanics of thin-walled elements of structures, including those exposed to the concentrated and local diverse actions.

Keywords: {m,n}-approximation, force impact, equation of statics, transversal-isotropic plate, Legendre polynomials.

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DETERMINING THE PARAMETERS OF OSCILLATION DISSIPATION IN A COLUMN OF SUCKER RODS (p. 13-18)

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In order to calculate a column of pumping rods as a mechanical system with concentrated masses, to determine dissipation coefficients, we applied a traditional method of analytical mechanics.

A mathematical model is developed of longitudinal oscillations of a three-stage conditionally vertical column of sucker rods using the functions of displacement and load of its separate stages. Dependence for determining the dissipation coefficient of oscillations is derived from the solution of the system of equations.

In accordance with the chosen set-up of a three-stage column of sucker rods, we examined a change in the dissipation coefficient of oscillations depending on the relationship between the rigidities of its stages. A change in the relationship between rigidities of the stages was carried out by changing their material.

It was found that for the selected set-up of a column of sucker rods, the use of a fiberglass stage instead of that made of steel reduces its rigidity by approximately 4 times, and increases the dissipation of oscillations almost as much. Such approach makes it possible to prevent the phenomenon of resonance in the operation of a SR column during transition modes under the action of alternating load.

Keywords: damping, dissipation, alternating loads, column of sucker rods, mechanical system, resonance.

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THE STUDY OF STRENGTH OF CORRUGATED METAL STRUCTURES OF RAILROAD TRACKS (p. 18-25)

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The analysis of the main defects of metal corrugated culverts of the railway, which arise as a result of operation, was conducted, and the problems of providing their durability and strength were highlighted. The problems of adaptation of foreign regulations for designing metal corrugated structures at Ukrainian railways and motor roads were analyzed, the results of experimental and theoretical calculations of bearing capacity of metal corrugated structures were presented.

The MCS strength at boundary loading with the railway rolling stock was analyzed by the indicator of influence of corrugation (corrugation dimensions) and the characteristics of soils on their stressed-strained state. Calculation of equivalent forces was performed by the procedure of calculation of railway strength and stability using the finite-element method. The numerical calculation of the stressed-strained state of the MCS was obtained using the licensed software FEMAP with MSC NASTRAN. An analysis of multi-choice calculations of the strength of MCS, made of corrugated structure Multiplate MR150 with thickness of a corrugated sheet of 6 mm, with dimensions of corrugation waves of 150×50 mm, showed that its bearing capacity is provided at degrees of compaction of soil backfill from 0.9 to 1.0.

Based on the obtained data, it was found that the direct cause of occurrence of residual deformation of metal corrugated pipe may be an increase in stresses in metal sheets of the pipe up to the values that exceed permissible stresses and as a result of local initiation of a plastic hinge. The condition of initiation of a plastic hinge, which takes place in the MCS arch, holds only if there is adverse simultaneous influence of two factors (causes): letting inequalities develop beyond permissible values without taking measures for its elimination and a decrease in the degree of compaction of backfill soil below 90 % (the second cause). In the absence of one of the causes, a plastic hinge might not emerge. In the joint effect of both causes, the first cause, the impact share of which is 42 %, prevails, whereas the share of the second cause is 22 %.

The obtained results of the MCS bearing capacity are needed for optimal MCS designing, establishing causes of defect emergence, timely making relevant engineering decisions in order to increase the MCS bearing capacity and reasonable use of funds for the construction or reconstruction of existing transport facilities with the use of metal corrugated pipes. The results of the study may be used by engineers of Bridge testing stations of Ukrrailway and Ukravtodor and by designing organisations involved in designing metal corrugated structures of large diameters.

Keywords: residual deformations, designing, plastic hinge, rolling stock of railways, compactness of soil backfill.

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MODELING THE DYNAMICS OF VIBRATORY SEPARATOR OF THE DRUM TYPE WITH CONCENTRIC ARRANGEMENT OF SIEVES (p. 26-35)

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In order to provide for a more efficient process of separation, we propose a new type of separator, in particular separator of the drum-vibratory type. It has a number of advantages over other separators:

1) characterized by simplicity of design and maintenance;

2) low sensitivity to the properties of the separated mixture;

3) a variety of oscillation modes;

4) possibility to automate the process of separation.

In order to design a separator, theoretical study was conducted into its dynamics for the purpose of examining the impact of its structural and kinematic indicators on the intensity of separation process of bulk mixtures. This problem was solved by constructing a nonlinear mathematical model that describes dynamics of the separator. The model is built based on a number of mathematical methods and laws, in particular the asymptotic methods of nonlinear mechanics. It is a system of non-linear analytic expressions, which in character format includes kinematic and geometric parameters of separator. Based on the model and our studies, we selected parameters for a vibratory separator of the drum type, which will provide the most effective separation of mixtures according to the selected criteria.

The developed mathematical model is uniform and parameterized. It allows speeding up the process to design a separator. It can be also used for designing and selecting the operation modes of separators of different types with a vibration drive, as well as for other vibratory processing machines.

Keywords: drum separator, debalance, nonlinear model, vibration drive, concentric sieves.

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SUBSTANTIATION AND DEVELOPMENT OF THE PROCEDURE FOR CALCULATING A HYDRAULIC BALANCING DEVICE UNDER CONDITION OF MINIMAL ENERGY LOSSES (p. 36-41)

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Here we report the procedure for calculating a hydraulic balancing device from the condition of minimum of energy losses for the accepted value of static characteristic rigidity. The procedure proposed is different from those existing by that its basis is formed by a closed system of equations by the geometric parameters of a hydraulic balancing device, which is obtained from the condition of the minimum of energy losses for the accepted value of statistic characteristic rigidity. In order to determine the energy losses on the node of a hydraulic balancing device, we received calculation formulas for energy losses in the cylindrical and face chokes of a hydraulic balancing device, using an analogy of determiining the energy losses in a cylindrical pipe with round cross section. Results of the work are represented in the form of the given procedure for the calculation of a hydraulic balancing device and proposed mechanism of its realization that make it possible to obtain a unique solution of the closed system of equations for determining the geometric parameters of a hydraulic balancing device. Geometric parameters of a hydraulic balancing device, received in this way, provide for its reliable operation at minimal energy losses on it.

The verification of the procedure for calculation and the study based on the calculation procedure from the condition of the minimum of energy losses are performed using the feed pump PE 600-300 (AO "Sumy Plant "NasosEnergoMash", Ukraine). Research results might be used for calculating the nodes of axial load of the rotor of a multistage centrifugal pump under condition of the minimum of energy losses at the accepted value of static characteristic rigidity of a hydraulic balancing device. In the present work we obtained a closed system of equations for finding the geometric parameters of a hydraulic balancing device from the condition of the minimum of energy losses for the accepted statistic characteristic rigidity.

Keywords: hydraulic balancing device of a pump, balancing of axial force, energy losses, face clearance.

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METHODOLOGY FOR THE HYDRAULIC DRIVE DESIGN BASED ON THE APPLICATION OF THE SYSTEMS ANALYSIS (p. 42-50)

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When employing the known theoretical dependences, intended for the calculation of parameters of volume of the working chamber of the pump, motor and diameter of the cylinder sleeve under condition of using the same input and output data, we identified a significant discrepancy between the obtained calculated results. The need to eliminate the differences that we detected necessitated additional theoretical research.

Theoretical studies of the design stage of hydraulic drive as the object of research are based on the application of the systems approach. Hydraulic drive is represented as a complex system, composed in the form of two or more subsystems that are functionally interconnected. Thus, one of the subsystems in the designed hydraulic drive consists of a pump and an oil tank. The second subsystem consists of a hydroallocator, pipelines and hydraulic engine with the function of translational or rotational motion, that is, consists of a hydraulic cylinder or a hydraulic engine.

By the results of conducted theoretical research, we proposed a sequence for calculating the parameters of basic elements of hydraulic drive. This sequence includes the calculation of parameters of volume of the working chamber of the pump, motor and diameter of cylinder sleeve followed by the selection of technical specification or standardized magnitudes for each element of the hydraulic drive. Results of the calculation of parameters of the basic elements of hydraulic drive according to the performed research, relative to the known ones, are approximately in be-

tween them. Based on this, we may conclude that the research results obtained are new and provide for a more accurate selection of elements for the hydraulic drive during its design.

When designing other elements of the hydraulic drive, the calculation and selection of the standardized parameters coincide with the known technique. The application of the proposed methodology contributes to the creation of modern hydraulic drive. Such hydraulic drive will match the assigned initial conditions, accepted in the course of its design.

Keywords: hydraulic drive, design, system, power, performance efficiency, pump, hydraulic cylinder, hydraulic engine.

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APPLICATION OF THE EMPIRICAL CRITERION FOR THE OCCURRENCE OF AUTO-BALANCING FOR AXISYMMETRIC ROTOR ON TWO ISOTROPIC ELASTIC SUPPORTS (p. 51-58)

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The conditions for the occurrence of auto-balancing for the rigid axisymmetric rotor on two isotropic elastic supports, balanced by any quantity of passive auto-balancers of any type, are defined.

The empirical criterion for the occurrence of auto-balancing is applied.

It is established that the dynamic auto-balancing of the rotor (in two or more correction planes by several passive auto-balancers) is possible only in the case of the long rotor. There can be any quantity of auto-balancers. The long rotor has two resonant rotational speeds. The auto-balancing occurs at above resonance speeds.

The static auto-balancing of the rotor (in one correction plane) is possible at any quantity of auto-balancers in such cases.

If the rotor is long, then it has two resonant speeds and one additional speed, located between the resonant ones. The auto-balancing occurs between the first resonant speed of rotor rotation and additional speed, and over the second resonant speed.

If the rotor is spherical, then it has one resonant speed and the additional speed, which is higher than the resonant

one. The auto-balancing occurs between the resonant and additional speeds.

If the rotor is short, then the conditions for the occurrence of auto-balancing depend on the distance between the rotor center of mass and the correction plane. If this distance does not exceed the certain boundary size, then the rotor has the only resonant speed and the auto-balancing occurs at above resonance speeds. Otherwise, the rotor has one resonant and one additional speed, which is higher than the resonant one. The auto-balancing occurs between these speeds.

The additional speed is due to the installation of the auto-balancers on the rotor. Upon transition to it, the behavior of auto-balancers changes. At slightly lower rotor rotational speeds, the auto-balancers reduce the rotor imbalance, and at slightly higher ones – increase it.

Keywords: two-support rotor, passive auto-balancer, auto-balancing, criterion for the occurrence of auto-balancing, spatial motion of a rotor.

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EMPLOYING THE SEPARATION GRADIENT AEROSOL TECHNOLOGIES FOR DESIGNING THE OIL SEPARATORS OF VENTING SYSTEMS IN GAS TURBINE ENGINES (G=200 M^3/H) (p. 59-66)

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The aim of present study was to design an oil separator for the venting systems of gas turbine engines at consumption of gaseous medium 200 m^3/h. In order to accomplish the objective, we applied separation gradient aerosol technologies, which consider all the forces and effects that influence deposition of the highly dispersed particles. A scientific base is substantiated for the intensification of gradient processes of the transfer of aerosol media in the boundary layers of multifunctional surfaces in the purification of dispersed polyphase flows for developing the technical devices that ensure an increase in energy saving and ecological improvement of power plants. We designed a section-by-section structural scheme and a three-dimensional model of the oil separator in finite elements for the calculation of hydrodynamics and separation. The calculations were conducted of the hydrodynamic situation and particle trajectory in the flow area of an oil separator. Using the calculated distribution of speed in the oil separator at G=100...200 m^3/h, it was determined that velocity in the coagulation profile does not exceed 10 m/s. It was established according to the results of static pressure distribution for G=100, 200 m^3/h that the pressure differential in the separation coagulators reaches 2.5...3.9 kPa, respectively. Results of the calculation at G=100...200 m^3/h demonstrated that the summary pulsation effect from the deposition of highly dispersed particles amounts to 25.1 %. Based on the calculations, we designed the prototype of an oil separator and tested it experimentally on the test bench in the form of an open type wind tunnel. Coefficient of the total effectiveness of purification was determined, which reaches 99.9 %. The modernization of purifiers for capturing the aerosols in different systems of power plants is possible based on the separation gradient aerosol technologies. The studies conducted make it possible to develop in the future a range of separators for gas consumption from 20 to 2000 m^3/h.

Keywords: oil separator, gradient aerosol technologies, a three-dimensional computational grid, static pressure, temperature of heater.

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