ABSTRACT AND REFERENCES

APPLIED MECHANICS

STUDY OF THE DYNAMIC BEHAVIOR OF BUILDINGS WITH NONLINEAR DEFORMATIONS OF THE FOUNDATION AND SOIL BASE (p. 4–10)

Volodymyr Sakharov

The present level of the design of multi-storey structures in seismically dangerous conditions is virtually impossible without performing numerical studies. In the simulation of the dynamic interaction of buildings and constructions with the soil base, one of the most problematic issues is the accounting of oscillation damping processes in soils and structures. Energy losses in these environments are different in nature, character and significantly differ in values. Using viscoelastic models with different damping parameters for different environments allows to solve these problems only partially. While ignoring the nonlinear properties of soils, estimating the residual sludge and tilt of structures is impossible. Plastic deformations of soils, as well as the accumulation of local structural damage significantly affect the interaction of the elements of the "foundation – soil base – building" system as a whole.

The behavior study of the complex of multi-storey buildings (12, 18 and 24 storey) under seismic loads taking into account nonlinear deformation of foundation soils and soil base structures was given in the paper. The simulation was performed on an automated research system «VESNA-DYN» based on the modified explicit central difference method with increment by the spatial coordinates using spectral superelements that ensured high calculation efficiency. The Conclusion. The results have shown that the soil body has a considerable influence on the structural deformations. Soil bases of buildings, which differ in the number of storeys and weight have a similar oscillation frequency. The oscillation amplitude of the altitude section top is smaller (by more than 2 times) than in the other buildings and characterized by the lower (up to 2 times) oscillation period. Due to the nonlinear deformations of foundation soils, the magnitudes of residual tilts of buildings were obtained. The resulting deflection was maximum for a 12-storey building. It should be noted that plastic deformations have reduced the actual stiffness of the piles, which has significantly affected the deformation nature of soil bases. Maximum settling of buildings was about 5 cm.

Keywords: numerical simulation, nonlinear deformation, direct integration in time, spectral superelement.

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THE DEFINITION OF A TECHNICAL CONDITION OF AXLE-BOX BEARINGS ROLLING STOCK OF VIBRODIAGNOSTICS (p. 11–15)

Vassyl Ravlyuk

One of the important tasks of maintaining the rolling stock in operating condition is the diagnostics of axle-box units with roller bearings, allowing timely fault detection in all bearing elements.

For technical condition assessment of the rolling stock axle-box bearings, recognition algorithm that allows to compare a posteriori information with a priori class description by the diagnostic features language was given in the paper.

As a result of diagnostics, it was found that axle-box bearings, when making the diagnosis, may have type I and type II errors. If the feature actually belongs to the serviceable condition class, and the diagnostics system decides on the presence of defects in the rolling bearing, then there is a type I error. If the decision on serviceable condition is accepted when the roller bearing is faulty, then there is a type II error. Obviously, the result of these errors is different, so different costs are appointed to them. Therefore, the cost of risk during diagnostics is appointed by an expert operator.

Keywords: algorithm, axle-box unit, vibrodiagnostics, defect, feature, bearing, rolling stock, technical condition.

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DEVISING DIRECT REGULAR ALGORITHMS OF CJMPUTATIONAL POTENTIAL THEORY WITH COLLOCATION POINTS INSIDE THE SOLUTION DOMAIN (p. 16–25)

Dmytro Yevdokymov

Our attempts to systemize and classify the most popular direct collocation algorithms of computational potential theory have resulted in distinguishing two families of algorithms that have not yet been properly researched or used in computational practice. The first family of algorithms is the method of boundary elements with collocation points inside the solution area, while the second one is a direct regular method of discrete singularities with collocation points inside and outside the solution area. Using decomposition of the desired function in the Taylor series along the normal to the border in the vicinity of collocation, we have modified the considered algorithms and obtained significant advantages in comparison with the respective traditional algorithms.

The presented analysis was based on the plane boundary value problems for the Laplace equation. Advantages of the suggested algorithms result from their regular structure that allows to exclude the computation of singular integrals and further program implementation. In addition, the structure permits integration over the real (non-approximated) boundary, which improves the computation accuracy. Eventually, the obtained boundary integral equations are regular integral equations of the second type, which secures their stable solution.

The conclusion is proved by several series of test computation with the use three selected analytically set test functions. The suggested approach can be easily applied to solving broad classes of boundary value problems for differential equations in mathematical physics. The suggested algorithms can be mainly applied in computational mechanics.

Keywords: regular boundary integral equations, the method of boundary elements/boundary element method, the method of discrete singularities/discrete singularities method.

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MODERNIZED SUCTION BELL OF AXIAL-FLOW CHEMICAL PUMP (p. 26–30)

Marina Zaikina, Olha Matviienko

The design of the axial-flow chemical pump with the GI (guide vanes – impeller) type blade system, which provides a lower process time of the chemical reaction in the phosphoric acid manufacture was proposed in the paper.

The flow structure in the suction bell of the axial-flow chemical pump was investigated. By visualizing the calculation results, main causes and zones of hydraulic losses were found. Taking into account the results, modernizing existing suction bell was proposed, and numerical simulation of the flow in it was performed. The main condition for modernization was to preserve the flow parameters at the impeller inlet (absolute velocity, flow angle, circulation) with a simultaneous decrease in hydraulic losses. Since the losses are significantly affected by vortices which are formed on the blades, a decision on their dispersion was made. Numerical study of the flow in the modernized suction bell has shown almost double decrease in hydraulic losses. As a result of calculations, the design of the spatial flow in the suction bell of the axial-flow chemical pump was obtained.

Keywords: suction bell, hydraulic losses, axial-flow chemical pump, numerical simulation.

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CREATING THE FLOWING PART OF THE HIGH ENERGY-EFFICIENCY TORQUE FLOW PUMP (p. 31–37)

Igor Kryshtop

The paper deals with investigating the basic parts of torque-flow pumps (TFP) and searching for energy-efficient casing in the pump with high specific speed.

TFP are widely used, but in some cases it is necessary to disregard efficiency of the pump in order to ensure reliable operation in harsh conditions. Therefore, the TFP efficiency increase is an urgent task.

The methodology of designing "Turo" type TFP with the high-speed misaligned spiral casing was presented in the paper.

As a result of numerical studies, distribution patterns of velocities and pressures in the TFP flowing part, which allowed qualitatively evaluate the performance of the investigated casing structures were obtained. Analysis of the results indicates the feasibility of the casing housing of TFP with the misaligned spiral.

Full-scale testing was performed, and pressure and energy characteristics of TFP with different housing designs were obtained. Based on the tests, it can be argued that a new technical solution of the TFP housing with the misaligned spiral casing was obtained.

The results allow to design TFP with increased energy efficiency, and expand the scope of their use.

Keywords: torque-flow pump, misaligned spiral, numerical modeling, specific speed, flow non-uniformity.

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TRANSFORMATION OF THE EQUATION OF MOTION IN STRESSES FOR AN INCOMRESSIBLE FLUID (p. 38–41)

Vitaliy Budarin

The paper considers transformation of the equation of motion in stresses for an incompressible Newtonian fluid. The aim of the transformation is to obtain more detailed equations that account for the impact of vortex (rotational) and linear (forward) flows on the process of viscous friction. The transformation method is based on adding zero to the expressions for shear stresses with subsequent distinguishing of rotor velocity function and derivatives characterizing the linear flow. This approach as a form of recording the original equation does not require any additional restrictions. The transformation has resulted in new systems of equations for viscous vortex and vortex-free flows as well as three-dimensional vortex. The obtained equations allow obtaining the known exact solution for the laminar flow (Poiseuille's formula) and Euler's differential equation for an ideal fluid. We have shown that the Navier-Stokes equation is a separate case of a more general equation for Newtonian fluid motion. The obtained equations and connections between them allow improvement of the mathematical description of the incompressible fluid flow.

Keywords: general equation, Navier-Stokes, Euler, Poiseuille, vortex-free flow, 3d vortex.

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SIMULATION OF THE CHAMFERING PROCESS IN DIES (p. 42–47)

Sergii Shlyk, Vladimir Khorolskyi, Maria Naumova

Bevel cutting in special dies on the pressing equipment is a progressive method of preparing edges for welding. The basic methods of bevel cutting and chamfering before welding were considered. The principal difference between the schemes is the original arrangement of workpieces, geometry of the cutting edge and motion direction of the punch.

The purpose of the study is to determine the stress-strain state of the system "cutter-workpiece" and select a rational cutting scheme in terms of the smallest loads, acting on the tool.

A comparison of the stress-strain state parameters under various chamfering schemes was performed by modeling using the software package ANSYS/LS-DYNA. For this, calculation schemes of the models were drawn, optimal parameters of the model parts and types of their contact interaction were determined. The result of the calculations is equivalent stress-strain distribution diagrams, graphics of the stress change on the cutting edge of the tool in time, and chamfering process visualization.

The results suggest that in terms of the stability of die tooling and quality of the design elements, cutting scheme with a punch, which performs translational motion simultaneously in two directions - horizontal and vertical is more rational. As a result of numerical simulation, it was found that the stresses on the cutting edge of the punch are reduced by more than 400 MPa and workpiece distortion and burr formation are eliminated when cutting using the proposed scheme.

The proposed cutting scheme was implemented in the design of the die, used in the production cycle of PJSC "Krukovka Carriages". Persistence of the most loaded nodes of the die is hundreds of times higher than previously used die tooling.

Keywords: cutting, die, stress-strain state, sliding punch, finite element method.

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RESEARCH OF THE THERMAL AND MECHANICAL PHENOMENA AT POLISHING OF MATERIALS AND ALLOYS THAT IS APT TO FORMATION OF CRACKS (p. 48–56)

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All available information on diamond abrasive machining thermal processes simulation has been obtained with the suggestion that the materials to be ground are of uniformed structure, and doesn't take into account presence of the articles' technology strain defects. Study of causes of forming cracks as grinding defects was made within the theory of strain-stressed state of a part's surface layer qualitatively or experimentally in every single case. This article contains analysis of crack forming causes when grinding materials and alloys apt to this kind of defects. It's shown that crack-forming intensity is determined by presence of various material heterogeneities to take place at the surface layer during the detail making. Functional dependences are obtained as for technology parameters with crack-forming conditions taken into account, for the process of grinding materials apt to this kind defects to happen. When choosing machining conditions and tool capabilities, one is to take into account heat flow limits to produce when grinding to prevent forming strain defects into cracks.

With the functional dependences between physical-mechanical properties of materials machined and general technology parameters determined, technology criteria were worked out to control a process of defect-free grinding.

Keywords: crack-forming, surface layer quality, grinding, non-uniformity, heat flow, simulation.

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CORROSIVE DESTRUCTION OF PRISMATIC BAR OF CIRCULAR CROSS-SECTION UNDER PURE BENDING (p. 56–61)

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The problem of determining the time before the corrosive destruction of the straight bar of circular cross-section, which is subjected to pure bending in a corrosive medium was solved. The following cases were investigated: bar corrosion process does not depend on the stress caused by its pure bending in a corrosive medium; bar corrosion process essentially depends on its stress. The rate of the bar radius change in the corrosion process is considered to be linearly dependent on its stress during pure bending deformation. Formulas that express the dependence of stress, radius, limit wear time and cracking time of the bar on the specified corrosion process parameters and given bending moment were derived. Using the formulas obtained, the graphs of dependence of full wear time and cracking time on the bar stress at the initial time point were constructed. Also, the graph of the bar radius change (decrease) in time during the corrosion process was plotted.

Keywords: prismatic bar, pure bending, stress-corrosion cracking, corrosion rate, corrosion wear.

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