ABSTRACT AND REFERENCES

APPLIED MECHANICS

SIMULATION OF COLD ROLLING OF BEARING RINGS TAKING INTO ACCOUNT THE TEMPERATURE FACTOR (p. 4-8)

Ludmila Avtonomova, Eugene Grozenok

To ensure the manufacturing accuracy of the bearing rings it is necessary to predict cold rolling process parameters (tool feed rate, forces in the contact area between tool and workpiece, cooling modes, etc.). Therefore, at the process design stage to determine their values, correct mathematical model of the rolling process, which is a related thermoelastoplastic contact problem is needed. The problem of modeling the process of cold rolling of bearing wheels taking into account friction in the contact and influence area of the temperature factor is considered in the paper. Numerical implementation of the 3-dimensional heat conduction problem and the problem of calculating the parameters of thermal stress-strain state of the bearing ring, made of steel SHKH-15 was carried out based on the finite element method using a computer complex DEFORM-3D. Defining relations were set by processing families of deformation diagrams and took into account plastic state of the material in an appropriate range of strain rates and temperatures. Calculations of three-dimensional related contact problem at the two different cooling modes – convective heat transfer with the free air and liquid conducted. The distributions of stress fields, rolling forces and temperature field were obtained. Comparison of the results has shown a significant change in the total force on the tool at different problem statements. Taking into account the temperature factor allows more adequately describe the physical processes in cold rolling of the bearing rings.

Keywords: bearing ring rolling, plastic deformations, temperature, contact pressures, rolling forces.

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DESIGN AND OPTIMIZATION OF THE SHAPE OF THE ROLLER GENERATRIX OF DOUBLE-ROW RAILWAY ROLLER BEARING (p. 8-12)

Valeriy Khavin, Dmitriy Yahudin

The paper considers constructing a parametric model of the double-row railway roller bearing and determining the optimal shape of its roller to reduce contact pressure.

Solution of problems of one-and two-parameter roller shape optimization, ensuring maximum uniform contact pressure distribution, is achieved by forming the roller geometry by varying the radius of curvature of the roller generatrix, or by varying the two radii that describe the change in the generatrix curvature. The level of maximum contact pressure was considered as the objective function.

To determine the contact pressures, finite element method in the formulation of the contact problem of elasticity theory was used. Numerical solution of the contact problem was performed by expanding Lagrange's method; ANSYS software package was used.

Solution of problems of one-and two-parameter roller surface shape optimization was carried out by applying the penalty function method in combination with the alternating-variable descent method and the golden section search method.

Optimal radii of curvature of roller generatrix of double-row railway roller bearing CRU 150x250 in the formulation of one-and two-parameter optimization problem were obtained.

It was revealed that the roller generatrix geometry in the form of two conjugated radii of curvature ensures maximum contact pressure level by 8 % lower than in forming the roller surface curvature by a single radius of curvature.

The results show the possibility of a significant reduction of the contact pressure for a pair of roller - bearing race due to the optimal profiling of roller generatrix, which will allow proportionally increase the durability and life of the product.

Keywords: bearing roller, contact pressure, optimization, radius of curvature, finite element method.

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SOLID MODELING OF MACHINING CENTRE SVM1F4 IN KOMPAS 3D (p. 13-18)

Oleg Krol, Ivan Sukhorutchenko

A three-dimensional solid model of a special-purpose mill-drill-bore machine VM1F4 with CNC in CAD KOMPAS-3D was developed. A study of the design performance by strength and stiffness criteria using the finite element method within an APM FEM module, integrated into the KOMPAS-3D system was carried out. A three-dimensional model of the turntable of the considered machine using the original embodiment of sliding supports and anti-backlash worm gear was presented.

The need for such works is caused by, on the one hand, the requirements of an integrated approach to creating competitive machine tools, including the construction of a three-dimensional representation of complex design and optimization of the product according to the metal intensity and stiffness criteria. On the other hand, the implementation of an integrated approach is reasonable to carry out using low-cost CAD, which corresponds to the financial capabilities of small and medium-sized design divisions. Version of an integrated CAD KOMPAS-3D with integrated SAE – ARM FEM module is the most appropriate.

As a result of investigations, the rational structure and shape of the machine complex that includes machine spindle positioning device and turntable device with a vertical and a horizontal axis for implementing complex shaping movements was determined. A new approach to improving the accuracy of dividing movements of the turntable due to using a new method of clearance compensation in the worm gear was proposed.

The obtained results allow to outline the ways to improve the design, by determining dangerous sections and implementing a version of the spindle, approximated to full-strength part. In conditions of the long operation, the option of maintaining the accuracy characteristics of manufactured products by reducing the errors of dividing movements of the turntable of the machine with the workpiece mounted thereon was proposed.

Keywords: machine, 3D-model, spindle, stiffness, worm, turntable, anti-backlash gear.

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THE GENERALIZATION OF THE RESULTS OF RESEARCH OF DYNAMIC BEARING CAPACITY OF HYDRODYNAMIC THRUST BEARINGS (p. 18-24)

Igor Sydoryka

The analysis of traditional and developed calculation methods of dynamic bearing capacity of hydrodynamic thrust bearings of various technical systems was conducted. Due to generalization of existing data and the results of the research, it was found that each of the operational factors, affecting the TB reduces its dynamic load capacity. The combined impact of these factors can deplete the dynamic load capacity of the thrust assembly and lead to the destruction of the lubricating layer, which will cause the breakdown of the TB and the failure of the technical system. This problem is particularly acute nowadays because of an increase in service life of ship machinery and a decrease in the number of planned preventive maintenance.

The mathematical model was developed and calculation method of the dynamic bearing capacity of the thrust assemblies of fluid friction, which allows to determine the

allowable amplitude of forced longitudinal vibrations of the shaft, face motion variation of thrust collar and allowable misalignment of the bearing housing was improved. At the design stage, improved calculation method allows to perform vibration calculations to assess the dynamic bearing capacity of the TB of various technical systems.

Keywords: dynamic bearing capacity, calculation method, thrust bearing, operational factors.

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THE HYDRAULIC RESISTANCE OF MESH DIVIDERS OF PHASES IN THE NON-STATIONARY LIQUID STREAM (p. 25-29)

Anzhelika Davydova

The flight program of modern aircrafts includes multireclosure of propulsion system in practically zero gravity conditions. Normal start of engines in zero gravity conditions is ensured by fuel continuity means, which are an integral part of the fuel system. Today, mesh dividers of phases, the basic working element of which is a woven metal mesh with micron-sized cells are the most widely used as such means. One of the main design parameters of mesh dividers of phases is pressure loss that occurs during the passage of the fuel flow through the phase divider cells in the course of flight mission of the aircraft.

The effect of the nonstationarity level of the fuel stream, flowing through the cells of the mesh at the transient operation stages of the propulsion system on the amount of pressure losses is investigated in the paper. Using an operational method, applied to the differential equation of the accelerated motion of a viscous fluid in a finite-length cylindrical tube, an equation, describing the value of hydraulic resistance coefficient of mesh divider of phases depending on the Froude and Reynolds numbers is derived.

As a result, it is found that using the values of hydraulic resistance coefficient of mesh dividers of phases without considering fuel consumption nonstationarity when performing design calculations can lead to significant errors in determining pressure losses on the mesh divider of phases at transient operation stages of the propulsion system.

Using the results of the work in engineering practice allows to optimize the design parameters of fuel continuity means and increase the efficiency of the fuel system of spacecrafts in various flight conditions.

Keywords: spacecraft, fuel tank, mesh dividers, hydraulic resistance, rocket engine.

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INFLUENCE OF SPACE–CHORD RATIO OF THE AIRFOIL CASCADE ON THE FLOW «CHOKING» REGIMES IN THE BLADE CHANNEL (p. 30-33)

Yuriy Tereschenko, Ekaterina Doroshenko, Tehrani Arash

Gas turbine engines are a major part of propulsion systems of different aircrafts. Gas-dynamic stability of compressors of aircraft GTE is achieved by using various compressor regulation methods to ensure unstalled flow of blade rows in all operation modes of the engine. The loss of gas-dynamic stability of the compressor is caused by flow separation in blade rows and critical flow regimes (flow "choking" regime) in the blade channels of separate stages. So far, flow "choking" regimes in the blade channels are not fully investigated. The effect of the cascade space–chord ratio on flow "choking" regimes in the blade channels of the airfoil cascade was studied in the paper. The authors have proposed a theoretical relationship, allowing to calculate flow "choking" regimes with different space–chord ratio of the airfoil cascade. The authors have performed a series of calculations of flow in airfoil cascades in "choking" regimes using numerical simulation. To close the averaged Navier-Stokes equations, the Menter's SST model was used. Adaptive irregular computational grid was selected to solve this problem. For the calculation, second-order design scheme with the local use of the first-order design scheme was used. Results of studying the flow in airfoil cascades have shown a significant effect of the stall zone behind the front edge of the blades at negative angles of attack on the flow in the blade channels. Decrease in the actual minimum flow area of the blade channel leads to a reduction in the value of the Mach number M_{max}, at which flow "choking" regime in the blade channels by the air consumption occurs. The results have shown that the greater the space–chord ratio of airfoil cascades, the larger the relative influence of the boundary layer thickness on the critical flow regime. Generalized characteristics of "choking" regimes of compressor cascades can be used for calculating "choking" regimes of the axial-flow compressor stages in determining the boundaries of gas-dynamic stability and "choking" boundaries of multi-stage axial-flow compressors.

Keywords: choking, airfoil cascade, cascade space–chord ratio, simulation, stall, compressor, flow.

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RELIABILITY EVALUATION OF AUTOMATED MONITORING OF ROCK CUTTING TOOL CONDITION (p. 34-37)

Ihor Chyhur

When drilling oil and gas wells, the problem of reliable detection of time of rock cutting tool replacement because of its wear remains unsolved. To solve it, the automated control system of the rock cutting tool condition with the functions of identifying, recognizing, predicting and selecting the strategy of monitoring the exhaustion of the tool was developed. To increase the system performance, the analysis of its subsystems in terms of their impact on the overall control reliability index was carried out. It was found that recognition and prediction subsystems are the most responsible. To implement the algorithms of these subsystems, it is proposed to use neuro and fazzi- artificial intelligence technologies that have proven their efficiency in such tasks. The results obtained are important since they indicate the effective ways to solve the problem, moreover they can be also applied to other problems of this type.

Keywords: control, system, condition, drilling, identification, recognition, prediction, rock cutting, chisel, reliability.

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DESIGN OF IMPULSE JET GENERATORS BASED ON STRUCTURAL SYNTHESIS (p. 38-45)

Valery Gulin, Tatyana Ustimenko

Experience in designing devices that generate impulse jets, mainly for the mining industry for working thin coal seams, well-boring, formation of stables allows to perform some generalizations, create a block diagram with its sufficiently detailed description. Basic elements of this diagram are systemized and have a mathematical description. In order to combine the elements into a system, the connection equation is developed. A mathematical model of the system is the motion equation of masses (pistons, valves, plungers, distributor components, etc.), the wave equation of unsteady flow in the connecting lines, the ratios for variable hydraulic resistances and equation of the pressure ratio in the connected hydraulic chambers of the system. Based on the mathematical model, the simulation model, reflecting the main hydrodynamic processes in all the system elements was developed. In order to verify its adequacy, a bench experiment is held, and comparison of the data obtained is performed. The comparison was carried out by both time indices of the workflow (depending on pressures in the characteristic points of time), and basic integral indicators – equivalent pressure in the impulse, impulse repetition rate, system efficiency. Analysis of the results has shown that the prediction error of the workflow using the mathematical model is in the range of from 10 % to 15.4 %, which is acceptable for engineering studies. The data obtained allow to use the block diagram, schematic diagrams of a set of possible elements, its components and their mathematical description for the system of computer-aided design of impulse jet generators. This is the basis for selecting the optimum and rational parameters when creating new diagrams for different applications of impulse jets.

Keywords: generator, impulse jet, structural synthesis, element, mathematical model, experiment, adequacy, design

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EXPERIMENTAL STUDY OF MASS EXCHANGE CHARACTERISTICS OF VORTEX SPRAY MASS EXCHANGE DEVICES (p. 46-50)

Al Hayat Mohammed Nadim Qasim

During the study, the theoretical bases of the experimental determination of mass exchange characteristics of VSCMED were investigated, stand for this was designed and manufactured. Graphical dependencies, illustrating the change in the target substance concentration under different hydrodynamic regimes were obtained. The study is aimed at optimizing the geometric dimensions of the vortex mass exchange chambers. The conditions for fine-dispersed spraying of liquid in VSCMED that has a positive effect on increasing the mass exchange surface were considered. Based on the data obtained, we recommend maintaining the speed in the entrance slits of at least 24 m/s while gas velocity in the spray zone will be more than 60 m/s. These conditions allow to obtain the mass transfer coefficient more than 0.00085 mol/m^{3}c and minimal geometrical dimensions of the device.

As a result, recommendations for designing devices that allow to develop an engineering calculation methodology of the mass exchange characteristics of the absorption process and geometrical dimensions of VSCMED were obtained.

Keywords: vortex, device, mass exchange, experiment, countercurrent calculation, phase, criterion, drop entrainment.

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