MECHANICS

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DETERMINATION OF THE TECHNICAL STATE OF BUILDINGS AND CONSTRUCTIONS AFTER FORCE AND TEMPERATURE INFLUENCES

page 4–10

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The object of research is the technical condition and bearing capacity of reinforced concrete structures of buildings and structures after power and high-temperature influences. Calculation methods, which are recommended by the current regulatory documents of Ukraine, do not always allow to correctly predict the growth of structural deformations and assess the real stock of bearing capacity.

One of the most problematic places is the calculation of structures working under forced displacements of supports and/or possible high-temperature influences. The situation is further aggravated by the fact that calculations are carried out, as a rule, using non-deformable schemes.

Strengthening of structures of buildings that have suffered damage after various impacts is usually carried out using metal elements. At the same time, the main thing remains to perform structural analysis for the justified purpose of the sections of reinforcing elements.

In the course of the study, various methods were used, primarily modeling the operation of structures using the finite element method and modern computer systems. This is due to the fact that the proposed method for solving the problem has a number of features, in particular, it allows determining the distribution of forces in the building elements after changing the stiffness characteristics or introducing additional core elements into the design scheme. In the course of solving the problem, the appearance and development of cracks is modeled by changing the stiffness characteristics of the elements.

The efforts that could have arisen in the elements of the building and reinforcement are obtained. Thanks to this, it is possible to make decisions about the possibility of further operation, reinforcement or replacement of structures. Changing the conditions of consolidation is considered as action on the part of the foundation. Compared with similar well-known calculation methods, this approach makes it possible to predict changes in the technical condition over time, that is, taking into account changes in fixing conditions and characteristics of building materials will allow a more reasonable approach to assessing the stress-strain state and the residual life of the structure or structure as a whole.

Keywords: reinforced concrete elements of buildings and structures, deflections of weakly armored elements, structural analysis, residual life.

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THE DEVELOPMENT OF A THREE-DIMENSIONAL MODEL OF THE ICE GROWTH PROCESS ON AERODYNAMIC SURFACES

page 11–18

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The object of research is the processes of hydroaerodynamics and heat and mass transfer that occur when icing the aerodynamic surfaces of aircraft during flight in adverse weather conditions. One of the problem areas in the development of software and methodological support that allows to simulate the icing processes, there

are difficulties in the transition to solving the problem in three-dimensional formulation. As well as the presence of contradictions in existing methods in describing the physical picture and, accordingly, the thermodynamics of the process of ice growth.

During the study, experimental and analytical methods were used to study the physical processes of ice growth on streamlined surfaces, based on a phased analysis of the interaction of supercooled droplets with the surface and their subsequent freezing at the wing edge. The proposed model of the process of ice growth is based on the use of the method of surface control volumes, based on the equations of continuity, conservation of momentum and energy. Based on the new experimental data obtained on the physics of icing, it is proposed to separate the processes of the formation of a bulk ice-water structure and subsequent complete freezing of this structure separately in the methodology for modeling ice growth. At the first stage of the fluid crystallization process, as part of the step on the icing time, the supercooled fluid contained in the droplets that fall on the streamlined surface passes into a state of thermodynamic equilibrium. That is, the latent heat of solidification released during the formation of an ice fraction in the ice-water structure will be equal to the internal heat required to heat the supercooled fluid from the temperature of the droplets to the temperature of the phase transition. At the second stage, the water contained in the ice-water structure will freeze due to heat loss by convection, evaporation, sublimation, thermal conductivity (minus the latent heat of solidification, kinetic and aerodynamic heating). It should be noted that the water that will freeze will also fetter the spatial ice structure. In this case, the method of successive approximations is applied to determine the direction of fluid movement along the streamlined surface.

Compared with the well-known traditional methods, this approach makes it possible to take into account to a greater extent the real physical processes of icing of aerodynamic surfaces that are extremely complex for mathematical description.

The results can be used to optimize the operation of anti-icing systems and determine ways to reduce energy costs during the operation of such systems.

Keywords: icing of aerodynamic surfaces, icing protection systems, mathematical modeling of the ice growth process.

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ELECTRICAL ENGINEERING AND INDUSTRIAL ELECTRONICS

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APPLICATION OF CASSINI OVALS FOR THE FORMATION OF THE 24-HOUR LIGHT ATTENTION OF THE RUNWAY

page 19–25

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The object of research is the process of ensuring 24-hour compliance with the technical specifications of the aerodynamic runway illumination. Under these conditions, the existence of a diffuse structure of the process of heat transfer of the working fluid and light radiation is explained.

One of the most problematic places is the complexity of manufacturing and the sufficiently large material intensity of the tungsten incandescent body and the subsequent control of compliance of the incandescent body with the requirements of Cassini ovals.

In the course of the study, mathematical analysis of eight-shaped fourth-order algebraic curves is done. Cassini oval and represent a generalization of a separate case, was made by the Bernoulli lemniscate «Bernoulli flower». «Eight-shaped» Cassini ovals form a geometric location of points whose product of distance, to two fixed points, focuses, remains unchanged. Conformity analysis was conducted to check the required diffuse structure of the heat transfer of the working fluid and the light scale generated by it, which does not take place in the known designs of incandescent lamps.

The feasibility of using the landing zone on the runways of the incandescent tungsten body in the form of a conductive «Cassini oval» is analyzed in the signal lights. Attention is drawn to the possibility of forming a diffuse structure of heat flux and light radiation. The prospects for increasing the reliability and durability of illuminating the runway signal lights are explained. The principles of choice of mass-dimensional characteristics of the working body of incandescent signal lights are substantiated.

Two further forms of Cassini ovals were obtained with the initially unchanged product being performed, in particular, the Cassini output oval deformed inside, as well as the case of the Cassini output oval falling into two autonomous ovals around the focuses.

The heated tungsten conductive «Cassini oval» emits diffuse thermal and light fluxes in all directions of the surrounding space. Due to this, the light triangles in the «Cassini oval» plane, in their totality, will outline the mosaic of radiating elements of equal brightness, and thus create a continuous radiating bright light in the form of an oval plate.

Keywords: runway, Cassini ovals, incandescent lamp, fourth-order algebraic curves.

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TECHNOLOGY AND SYSTEM OF POWER SUPPLY

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ANALYSIS OF EXPERIENCE, SAFETY AND PROSPECTS OF DIVERSIFICATION OF NUCLEAR FUEL AT NUCLEAR POWER PLANTS

page 26–33

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The object of research is the design fuel assemblies (FA-A) at nuclear power plants with water-cooled water reactors located in Ukraine. The analysis of the experience and prospects of diversification of design fuel assemblies of pressurized water reactors with alternative heat generating assemblies of Westinghouse Electric Company is carried out. The analysis is carried out on the basis of measures and results of diversification of fuel assemblies at the Temelin nuclear power plant (Czech Republic), as well as the South Ukrainian and Zaporizhzhia nuclear power plants (Ukraine). As a result of the analysis, it is shown that the diversification of design fuel assemblies by alternative heat assemblies by Westinghouse Electric Company provides the necessary nuclear safety conditions for the maximum allowable temperature of the gratings of fuel rods and the temperature of nuclear fuel.

The work determines the need for additional analysis of nuclear safety and reliability of the reactor loop equipment in relation to the conditions of critical hydrodynamic shock during the diversification of fuel assemblies. It is revealed that the known results of nuclear safety analysis during diversification of fuel assemblies by traditional accident modeling approaches are not sufficiently substantiated.

And they also significantly depend on the negative effects of «differences in the results of accident modeling by different users of the same codes» and «differences in the results of accident modeling by different codes». In addition, well-known deterministic codes do not simulate the conditions and consequences of hydrodynamic shock and various types of thermohydrodynamic instability in the reactor loop. It is shown that it is necessary to develop alternative methods for analyzing nuclear safety and equipment reliability of systems important to safety in diversifying fuel assemblies that are independent of the above negative effects. A calculation analysis of the influence of the coolant speed on the external heat transfer coefficients determined that the safety conditions for the permissible temperature of the Westinghouse Electric Company fuel rods are provided up to a maximum design temperature of 90 °C in safety heat exchangers.

Keywords: diversification of nuclear fuel, nuclear safety, reliability of the nuclear reactor core.

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REPORTS ON RESEARCH PROJECTS

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RESEARCH OF GAS CONTENT AND INTERFACIAL AREA IN THE DOWNFLOW PIPES OF A CIRCULATION APPARATUS WITH JET INJECTION GAS FILLING

page 34–38

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The object of research is an apparatus with jet injection gas filling. The studies are conducted on an experimental installation of a working medium of water-air. The distribution of gas phase bubbles is studied depending on the operating parameters of the apparatus. The value of the local and total gas content, as well as the specific surface of the phase contact, is determined. The gas content and the contact surface of the phases in the downflow pipes of the circulation apparatus with jet injection gas filling are investigated. The use of circulating apparatuses with jet injection gas filling is promising for carrying out mass transfer and reaction mass transfer processes. Due to the use of water energy for gas filling of the reaction space, the devices have advantages over airlift and gas-lift devices, bubble columns in chemisorption processes with slightly soluble gases. Experimental studies of the gas content and the contact surfaces of the phases from the operating-technological and hardware-structural parameters makes it possible to determine the optimal operating conditions. According to the results of studies, it is found that the diameter of the bubbles increases with an increase in the number of revolutions of the shaft of the mixing device. The mode of suspension of the gas phase took place at shaft rotation numbers from 600 rpm up to 750 rpm. With an increase in the number of revolutions, the resistance to the force of bubbling of bubbles increases and the suspension mode switches to the gas-liquid flow circulation mode. The ability to control the gas saturation process due to fluid circulation, regardless of the fluid load of the apparatus, is one of the advantages of the developed design. It is established that the total gas content in the downflow channels varies from 0.07...0.10 to 0.1...0.18, which is typical for gas-liquid devices. The total gas content in the downflow channels of the apparatus is in the range from 100 to 260 m^2/m^3 of the reaction volume and is typical for most gas-liquid bubblers. The results of studies of the operating modes of the apparatus with jet injection gas filling in the suspension mode of the gas phase can be used to calculate the mass transfer coefficient.

Keywords: jet injection apparatus, downflow, circulation circuit, gas content, phase contact surface.

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EXPERIMENTAL DETERMINATION OF THE SPECTRUM OF STRUCTURE VIBRATIONS UNDER THE INFLUENCE OF TECHNOLOGICAL LOAD

page 38–42

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The object of research is the process of propagation of vibrations from technological equipment to the metal structures of a building. One of the problems in the inspection and monitoring of construction objects is the assessment of the vibrational impact of technological equipment on the load-bearing elements of the building. Existing regulatory documents and methods for accounting for dynamic impact fully cover this problem, as evidenced by the presence of emergency cases of operating structures that are subject to dynamic loads.

The proposed approach, which is based on the hypothesis of considering the structure and technological equipment, has a dynamic impact as a single system with its corresponding dynamic characteristics. The implementation of this approach can be carried out by determining the integral dynamic parameters of the system with subsequent analysis and the establishment of causal relationships. During the study, records of continuous fixation of the parameters of the dynamic effect on the elements of the building structure, which are determined on the basis of preliminary analysis, were used. As a result of the analysis of the vibrograms, the vibrational spectra of the structure are constructed, from which the dominant vibrational frequencies of 3.470 and 3.625 Hz are determined. The established frequencies correspond to the main frequencies and their harmonics of the technological process implementation according to the technical characteristics of the equipment, amount to 3.670 Hz. The discovered phenomena of the internal resonance of the general construction system of the technological workshop make it possible to clearly formulate the causes of the appearance of excessive vibrations. Experimental studies of the influence of technological equipment on the frame of the structure are carried out. A finite element model of the frame based on an instrumental examination of the building is developed.

The obtained research results can be used to develop methods and technologies for diagnosing and establishing the causes of excessive fluctuations in the supporting and enclosing structures of structures under the action of a dynamic load of technogenic origin.

Keywords: survey of the structure, vibration diagnostics, natural frequencies of vibrations, mode of vibrations, dynamic load, finite element model.

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RESEARCH OF THE POSSIBILITY OF USING THERMOELECTRIC ELEMENTS (TEE) IN WELLS WITH LOW GEOTHERMAL GRADIENT

page 43–45

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The object of research is wells with a low temperature gradient of less than 2–2.5 °C per 100 m (regions of Tataria, Bashkiria, Udmurtia, etc.). In studying the layout of a device for utilizing geothermal energy, a system analysis method was used. And in the course of the study of the sucker rod pumping unit (SRPU) and the electric centrifugal pumping unit (ECPU), the comparative analysis method is used.

The paper discusses the possibility of energy savings in the exploitation of oil fields located in regions with low geothermal potential of development facilities. A method for solving the problem is considered as an option for the integrated use of not only the petrothermal energy of the subsoil, but also the hydrokinetic energy of the formation water. It is shown that the utilization of low-temperature geothermal energy due to its combination with the utilization of the hydrokinetic energy of the water pumped through the RPM system (maintaining reservoir pressure) is economically beneficial. This is due to the fact that the method proposed in the work has a number of features, in particular, production (reactive) wells are equipped at the wellhead with thermoelectric generators that convert the thermal energy of the formation fluid into electrical energy. The use of such devices will reduce the cost of electricity to power the electric drive DPE (deep pumping equipment) and other consumers of electricity in the well. Electricity generated by thermoelectric DC modules is summed from all thermoelectric converters. The received energy is sent along the line to the power supply system of the ACS-TP (automated process control system). Thanks to this, it is possible to obtain electrical energy from low temperature wells. Compared with similar known classical methods, when the gas factor of the produced products is sufficiently high (≥80–100 m^3/t), the use of associated gas is used to power electric gas and turbine generators that generate power for DPE directly at the production well. However, this method of utilization of associated gas at a late stage of development is not economically feasible, since in this case it is extremely low for its implementation.

Keywords: petrothermal energy, hydrokinetic energy, electric energy, thermal energy, reservoir fluid, complex utilization.

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CHOICE OF OPTIMAL TECHNOLOGICAL OPERATION MODE OF OFF-SHORE GAS-CONDENSATE WELLS EXPLOITED IN COMPLICATED CONDITIONS

page 46–51

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The object of research is a new method for the approach to control the optimal technological regime of gas and gas condensate wells. It is noted that in order to optimize the technological regime of the well, by extracting liquid and solid particles, it is necessary to know the minimum value of gas production or gas flow rate, which, in turn, is provided by determining the corresponding value of the bottomhole pressure. To determine the bottomhole pressure at which the well reaches the optimal operating mode, an equation is obtained that has a complex structure with respect to the bottomhole pressure (pressure in the elevator shoe), for the solution of which the graphoanalytical method was used. The proposed method for optimizing the operation of gas and gas condensate wells was tested on the basis of actual data. And it is shown that it is possible to determine the optimal operating mode of gas and gas condensate wells by determining bottomhole pressure values at which liquid and solid particles are transported from the bottom of the wells to the earth's surface. In this case, the initial data for wells (No. 652 and 704) operated on the VII horizon of the Sangachal-Sea-Duvanny-Sea-Khara-Zira (Azerbaijan) field is used to determine their technological regimes. It is shown that it seems possible to increase the productivity of offshore gas and gas condensate wells by changing the design of their lifts and the proposed method allows to extract liquid and solid particles from the trunk to the earth's surface. For each case, the particle deposition rates in the gas medium and the gas flow rate in the elevator shoe were calculated. Judging by the value of the difference in the determined particle deposition rates and gas flow in the elevator shoe, the possibility of the formation of liquid plugs in the well is established. If a situation arises when the gas flow rate does not ensure the extraction of liquid particles on the earth's surface, it is proposed to change the diameters of the lifting pipes.

Keywords: production well, optimal technological regime, gas and condensate production, gas and gas condensate fields.

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MECHANICAL ENGINEERING TECHNOLOGY

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DEVELOPMENT AND OPTIMIZATION OF TECHNOLOGY AND MODERNIZATION OF FORGING LINE FOR BEARING RINGS

page 52–62

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The object of research is the forging line L-408 (Ukraine) for the production of workpieces for rings of railway bearings. This line is installed at Kharkiv Bearing Plant (JSC HARP, Ukraine) and consists of a KIN 750 induction heating section, a P-2038A hydraulic three-position press and a KPS 250 ring-rolling unit. Based on the results of the technical audit of the line, it is revealed that the KIN 750 is produced on an outdated hardware base and has a deliberately lower efficiency. In addition, the lack of control over power and frequency during the heating process does not make it possible to optimize the process for energy costs. Also, the presses of all six lines operate from one hydraulic pump station, which provokes its obviously inefficient operation when only part of the lines is involved. In addition, the principle of operation of the P-2038A press in the absence of a hydraulic pressure control system in the executive bodies of the press does not allow for optimal control of hydraulic pumps according to the criterion of minimum electric power consumption.

In the course of the study, the finite element method is chosen as the main method of mathematical modeling of induction heating of the workpiece and forging operations. A new induction heating system has been developed and produced, which has undoubted advantages over the previously existing induction heating line, since it is made on a modern elemental base and has the ability to programmatically control power during the heating process. The press is modernized with an autonomous pump station with a capacity of 132 kW (instead of a central station with a capacity of 900 kW). The use of kinetic energy of the slider and traverse gives a radical reduction in energy consumption, especially when several or even more of the six forging lines L-408 are working.

Mathematical models and numerical methods developed for modeling controlled induction heating of workpieces and volume press operations have proved their effectiveness in calculating and optimizing the design and operating parameters of the hot forging line. The effects detected by mathematical modeling are fully confirmed during field tests, and the temperatures and pressures themselves slightly differed from the measurement results.

Keywords: induction heating, hydraulic press, hot shaping, interconnected multi-physical problem, thermoplastic deformation, finite element method.

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