ABSTRACT AND REFERENCES

ENGINEERING TECHNOLOGICAL SYSTEMS

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SUBSTANTIATION OF DIAGNOSTIC PARAMETERS FOR DETERMINING THE TECHNICAL CONDITION OF TRANSMISSION ASSEMBLIES IN TRUCKS (p. 4–13)

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We have conducted a selection of diagnostic parameters to control technical condition of the gear box. Development of technical operation of transportation vehicles is aimed at examining and predicting a technical condition with the formation of a rational diagnostic base being a key direction.

Solving the tasks in a given scientific-technical field was based on the theory of relative sensitivity. This involved a theoretically substantiated relationship between diagnostic parameters and the indicators of reliability for the assemblies of transportation vehicles based on their parametric dependence that we proposed. The implementation of theoretical research was conducted by determining a technical condition based on the express diagnosis of transmission oil in the gear box of the family of trucks KamAZ. We have performed express control and examined the working transmission oil for the following parameters: alkaline number, the content of mechanical impurities, dielectric permittivity. The dependences of their change on the run of transportation vehicles were obtained, as well as the corresponding criteria of sensitivity over different intervals of the run. We selected diagnostic parameters and formed a rational base using the criterion of relative sensitivity, establishing the run and the required diagnostic parameters. Control over diagnostical parameters of the gear box should be executed for the following indicators: the content of mechanical impurities in transmission oil – within intervals of 0...12 and 48...60 thousand km of the run; the dielectric permittivity of oil should be controlled within 48...60 thousand km of the run; the alkaline number of transmission oil should be controlled within 12...24 and 48...60 thousand km of the run of the examined transportation vehicles. Based on the compiled rational diagnostic base, it is possible to run an analysis and predict technical condition of the gear box, as well as establish supporting operations in technical operation.

Keywords: diagnostic parameter, reliability indicator, relative sensitivity, transportation vehicle, transmission assembly.

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ANALYSIS OF THE PREFORM BLOWING STAGE WHEN OBTAINING A POLYMERIC PRODUCT USING THE EXTRUSION BLOW MOLDING METHOD (p. 14–21)

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It was shown that the process of blowing a polymer preform has two characteristic stages. We obtained analytical dependences that link geometric parameters (diameter, wall thickness) of a molded polymeric preform and parameters of the finished molded product to technological parameters of the process of extrusion blow molding of a polymeric product (tangential drawing rate, polymer melt viscosity, internal blowing pressure, tangential drawing factor, molding time). The illustrations of modeling different technological modes are presented. Basic calculations were carried out for the modes of internal blowing pressure from 1 kPa to 3 kPa for a polymeric preform made of high density polyethylene at a temperature of 200 °C, with effective viscosity 8,300 Pa·s, an average diameter of a polymeric preform of 0.05 m, and a thickness of its wall of $5 \cdot 10^{-3}$ m. In this case, stage 1 is characterized by moderate modes of deformation and is limited to tangential drawing factor $k=2.5$. Stage 2 has an intensive character of deformation, which can lead to defects of the molded product. It was shown that one of the ways for preventing defects is to reduce internal pressure when blowing a polymeric preform. In this case, the main factor that limits the rate of blowing a polymeric preform due to an increase in internal blowing pressure is the maximal dimensional diameter of the molded product.

Keywords: polyethylene, extrusion blow molding, polymeric preform, drawing ratio, drawing rate, molding time.

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STUDY AND DEVELOPMENT OF THE TECHNOLOGY FOR HARDENING ROPE BLOCKS BY REELING (p. 22–32)

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The study of the efficiency of hardening the parts working in spalling conditions through reeling with rollers were performed with the help of physical simulation and showed the high effect of hardening cast steels (a 10- to 14-fold increase in durability). The depth and degree of work hardening during plastic deformation of the surface layer were studied by the method of regression analysis. It was found that the 95-% confidence intervals for the depth of work hardening calculated from the results of measurements of yield strength make up 11–36 % of the hardening depth and 32–75 % by the hardness measurements. Electrography examination has shown that an increase in the degree of work hardening when reeling with a needle roller manifests itself in a higher dislocation density and cell size decrease in the substructure of ferrite grains. Diffusion of chemical elements in the surface layer in the process of surface deformation was studied with an analysis of the change of the surface microhardness. It was established that the content of Cr and C decreased by 20–30 % in the transition zone and increased to 10–15 % in the hardened layer. The main mechanism of diffusion during SFW is the dislocation density gradient. The process of the contact friction surface wear during reeling with consideration of slippage was investigated. It was proved that roughness of the friction surfaces affects the coefficient of friction and the rate of tribo-contact wear during reeling with slippage. For example, with a decrease in surface roughness after reeling with rollers, coefficient of friction for the lubricated surfaces decreases.

A procedure for determining conditions of reeling with a wedge roller was developed. A method, technology, and a device for reeling the rope blocks with a wedge roller were developed to provide low roughness and high degree of work hardening of the surface. Optimal reeling conditions were found due to experiment planning using the steep convergence method.

The obtained results of calculations will serve as initial data in designing working elements of the reeling devices and developing technological processes for strengthening parts. The conducted studies will find their future use in evaluation of the wear processes taking into account slippage of the «rope block – rope» friction couple.

Keywords: contact strength, wear, surface plastic deformation, wedge roller, rope block.

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DEVELOPMENT OF A PROMISING SYSTEM FOR DIAGNOSING THE FROGS OF RAILROAD SWITCHES USING THE TRANSVERSE PROFILE MEASUREMENT METHOD (p. 33–42)

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We have developed a system for diagnosing the frogs of railroad switches, based on the application of modern microcontrollers of the type ESP with high technical characteristics and the simultaneous use of the information technology IoT (Internet of Things). The proposed system has advantages over mechanical systems in terms of the accuracy of data, their operational processing and submission to user in order to analyze technical condition of frogs at railroad switches. The results of measuring the transverse profile of frogs at railroad switches make it possible to take scientifically-substantiated decisions regarding the need for recovery repair of frogs by the method of surfacing and for control over gradual decrease in their carrying capacity, for establishing their actual technical condition and residual resource.

We carried out experimental-theoretical research into longitudinal profile of frogs at railroad switches laid on the reinforced concrete bars. It was established as a result that after passing 50–65 million tons of cargo (that corresponds to the medium degree of wear) the trajectory takes the shape of a bump. We observe sharp hollows on the reinforced concrete base in the zone where a wheel rolls from a rail wing onto the core, characterized by significant total inclination. Subsequently, when the passed cargo increases, the number of sinusoidal irregularities grows. At wear close to maximal (80–95 million tons passed), the percentage of unfavorable trajectories (sinusoidal and hollows) grows; at low wear, they make up 49.8 %, at a wear of 5–6 mm and larger – 88.3 %. Sometimes there is a transformation of the sinusoidal irregularities into the wave-shaped ones.

We have established characteristic motion trajectories of the center of mass of the wheel over the frog depending on the wear of rail wings and the core of a frog and the passed cargo. A mathematical model was constructed for predicting the wear of frog profile depending on the total weight of passed cargo.

Keywords: frog, railroad switch, longitudinal profile, motion trajectory, rolling stock of railroads.

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MINIMIZING THE MASS OF A FLAT BOTTOM OF CYLINDRICAL APPARATUS (p. 42–50)

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In the bodies of cylindrical apparatuses that operate under pressure, one of the weak elements is a flat bottom whose thickness is increased by 4...5 times in comparison with the wall thickness. This is due to the fact that the bottom is exposed to a more unfavorable bending deformation compared to the wall that «works» on stretching. In order to reduce specific metal consumption for the bottom, we propose the optimization of the shape of a radial cross-section by a rational redistribution of the material: to increase thickness of the bottom in the region of its contact with the wall and to significantly reduce it in the central zone. To describe a variable thickness of the bottom, we applied the Gauss equation with an arbitrary parameter that determines the intensity of change in the thickness in radial direction.

We have obtained a general solution to the differential equation of the problem on bending a bottom at a given law of change in its thickness, which is represented using the hypergeometric Kummer's functions. A technique for concretizing the resulting solution was proposed and implemented, based on the application of conditions of contact between a cylindrical shell and a bottom. The solution derived was used to minimize the mass of the bottom. We have designed a zone of transition from the bottom to the wall whose strength was verified by the method of finite elements under actual conditions.

Keywords: bottom of variable thickness, hypergeometric Kummer's function, contact between a shell and a round plate.

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DEVELOPMENT OF A TECHNOLOGICAL APPROACH TO THE CONTROL OF TURBINE CASINGS RESOURCE FOR SUPERCRITICAL STEAM PARAMETERS (p. 51–56)

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A comprehensive model for evaluation of the resource of HPC of the turbine K-800-240-2, which includes calculation of thermal, stressed-strained state, cyclic and static damageability, is presented here. The numerical studies conducted with the use of modern methods of mathematical modeling showed a high impact of forces of pins' tightening on the stressed-strained state of the casing elements (the stress level increased by 17.7 %). A technological approach to resource control, aimed at a change in pins' tightening efforts, was proposed. It was established that this method decreases static damageability of basic metal of casings (by 9.7 %), improving its long-term strength. When taking into account tightening forces, the maximum stress intensity decreased by 9.3 %, while the stress level in the flange joint decreased by 11–41 %. These positive moments are accompanied by an increase in individual resource of the casing by 10 %. The developed concept and recommendations have significant importance for ensuring long-term operation of steam turbines with the initial pressure of hot steam at 24 MPa.

Keywords: turbine casing, pins, tightening, stressed-strained state, long-term strength, resource control.

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THE ANALYSIS OF FRICTION EFFECT ON EQUAL CHANNEL ANGULAR PRESSING (ECAP) PROCESS ON ALUMINIUM 5052 TO HOMOGENEITY OF STRAIN DISTRIBUTION (p. 57–62)

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In the current study, the effect of friction coefficient on strain distribution and deformation was investigated with the computer simulation providing a better understanding of the material flow mechanism and deformation behavior in the ECAP. The 10×10 mm and 50 mm-long rectangular billet was used as the geometry of aluminum material. The geometry of dies is 105° channel angle, 0 mm inner fillet radius, and 5 mm outer fillet radius. The dies were modeled as rigid bodies, and the specimen was assumed as a bilinear hardening model. The effect of friction was investigated with the three-level variation coefficient of friction (0.01; 0.025 and 0.05). Based on the result, it can be shown that the friction affects the strain distribution condition. The friction of 0.05 produced more uniform strain distribution, better homogeneity, and smaller corner gap. The experimental study of modeling results was done with MoS2 lubricant while the strain distribution was verified by the microhardness test. The microhardness distribution test result was similar to strain distribution from modeling.

Keywords: die, aluminum, ECAP, friction, homogeneity, simulation, strain.

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DETERMINING RATIONAL PARAMETERS OF THE CAPACITIVE ENERGY STORAGE SYSTEM FOR THE UNDERGROUND RAILWAY ROLLING STOCK (p. 63–71)

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An approach was proposed for determining rational parameters of the on-board capacitive energy storage for the underground railway rolling stock with recuperation systems. The essence of the approach is to determine the maximum power and energy intensity of the on-board CESS based on the analysis of the payback period of the storage systems. The main distinctive features of this approach include taking into account a number of operating conditions and technical features of the underground railway rolling stock.

Using this approach, rational parameters of the on-board capacitive energy storage system for standard operating conditions of the experimental rolling stock with the recovery systems were determined at the Sviatoshyno – Brovary line of the Kyiv Metropoliten. Based on the analysis of diagrams of the payback period of the chosen storage systems, it was

established that for the given conditions of operation of the underground railway rolling stock, it is rational to introduce a capacitive storage with a maximum power of 1,000 kW and a working energy intensity of 3 kWh. It was calculated that for the given operating conditions, introduction of a storage system with rational parameters will save 16.1 % of the quantity of electric energy consumed for traction of the underground railway rolling stock.

Keywords: transport mechanics, energy saving, energy efficiency, capacitive energy storage, underground railway rolling stock.

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