ABSTRACT AND REFERENCES

ENGINEERING TECHNOLOGICAL SYSTEMS

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A STUDY OF THE EFFECT OF ELECTROSTATIC PROCESSING ON PERFORMANCE CHARACTERISTICS OF AXLE OIL (p. 4–12)

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The effect of electrostatic processing on performance characteristics of axle oil is investigated. Axle oil is used for wetting motor-axial bearings (MAB) of locomotives. There is a pressing and urgent problem of the MAB service life, which is indirectly related to the underdeveloped reserves of anti-wear properties of axle oil. To study them, it was decided to use the method of electrostatic processing, which does not require the introduction of any additives and has proven its effectiveness in the studies of other mineral oils. It is based on the ability of electric fields to destroy micellar aggregates in oil and form a solid boundary layer of molecules on friction surfaces. In the context of solving the current problem of the MAB service life, this method wasn't considered earlier.

The research was carried out by means of the «roller-pad» friction pair, which was wetted with axle oil at different load conditions and operating times. The dependences of wear of the experimental samples under different load conditions, oil operating times and degrees of electric processing are obtained.

The results show that when using axle oil subjected to ESP, the wear rate of the experimental samples is reduced. Wear rate reduction depends on the oil operating time in the lubrication system. The greatest wear rate reduction of 1.92 times is noted for fresh oil. For the oil state after the locomotive run of 75 thousand km, the reduction is about 1.68 times and for the oil at the end of its service life, wear rate reduction is approximately 1.47 times.

Keywords: axle oil, electrostatic processing, motor-axial bearing, wheels and motors unit, wear rate.

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ESTABLISHING RATIONAL STRUCTURAL-TECHNOLOGICAL PARAMETERS OF THE MILKING MACHINE COLLECTOR (p. 12–17)

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A collector of the milking machine is the nodal element in the system of accumulation and transportation of the received milk to a milk pipeline. It was established that the structural-technological parameters of the milking machine collector influence the efficiency of machine milking. This is related to ensuring the completeness of milking and preserving the quality of the received milk. Existing designs of collectors perform their functions insufficiently and inefficiently. A delay in emptying the milk chamber disrupts operational characteristics of machine milking. It is possible to solve the problem by improving a transportation capability of the collector. For this purpose, we propose a two-section design of the milk chamber, which could eliminate the problem of milk overflow. Additional pressure gradient during the tact of compression could improve the mode of transportation and enable complete emptying of the milk chamber. The level of vacuum pressure under the nipple of a cow depends on the structural parameters of the collector's milk chamber under identical conditions of milk release. The intensity of milk release defines parameters of the transporting link collector-milk pipeline. The desired pressure gradient is established by supplying an additional portion of air from the separating chamber, through a throttle opening. The rate of establishing a pressure drop is determined by the diameter of a throttle opening and by the level of pressure in the separating chamber and the milk chamber. Losses of vacuum pressure in a flexible milk pipeline form the required transporting difference in pressures between the collector and the upper milk pipeline.

This testifies to the interrelation between structural-technological parameters of the collector's milk chamber and the modes of efficient milk transportation. A rational correlation between the volume of section of the milk chamber, the diameter of a milk hose and the diameter of a throttle opening enables effective transportation of milk while preserving its quality.

Keywords: pressure gradient, throttle opening, speed of milking, air supply, milk quality.

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ESTIMATION OF CARRYING CAPACITY OF METALLIC CORRUGATED STRUCTURES OF THE TYPE MULTIPLATE MP 150 DURING INTERACTION WITH BACKFILL SOIL (p. 18–26)

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We estimated the stressed state of a railroad structure with a large cross section spanning more than 6 m, which is made from metallic corrugated sheets of the type Multiplate MP 150. The stressed-strained state of the corrugated structure was estimated depending on the residual deformation of vertical diameter of the pipe, the modulus of elasticity of backfill soil, and the degree of compaction. The study conducted has demonstrated that maximum stresses occur on the horizontal sides of a metallic pipe, and maximum deformations – in the pipe vault.

It was established that an increase in the degree of compaction of backfill soil leads to a decrease in the stresses in a metallic pipe by almost half. The stresses grow much faster with an increase in irregularity on the railroad track. Numerical calculations have shown that the equivalent stresses exceed the permissible magnitude of 235 MPa when the degree of compaction of backfill soil is below 90 % and an operational irregularity on the track develops beyond the permissible magnitude.

Operational observations have shown that the pipe is most vulnerable, in terms of resistance against the formation of a plastic hinge, in the initial period of operation when the

backfill soil has not yet reached the standard compaction. At the initial stage of operation of a metallic corrugated pipe it is necessary to improve the level of technological control in order to timely detect railroad track's irregularities that exceed the standards, and to eliminate them.

Under normal operational conditions, a metallic corrugated structure has a rather large reserve of carrying capacity, which amounts to 80 %. However, these structures, despite their high initial strength margin, are very sensitive to an increase in external dynamic loads due to the occurrence of irregularity on the railroad track.

Keywords: residual deformation, carrying capacity, corrugated structure, modulus of elasticity, irregularity on the railroad track.

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ON THE LIMITED ACCURACY OF BALANCING THE AXIAL FAN IMPELLER BY AUTOMATIC BALL BALANCERS (p. 27–35)

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The study explores the process of dynamic balancing of the impeller of an axial fan VO 06-300 (Ukraine) by two automatic ball balancers.

The computer simulation of the dynamics of the fan in the absence and presence of automatic balancers has confirmed the qualitative results of a previously conducted field full-scale experiment. Thus, the presence of automatic balancers reduces the following:

– the mean square value of the vibration velocity in the segment from the rotor start to the beginning of automatic balancing,

– the vibration velocity values at two resonant peaks when the rotor is running down, and

– the peaks of the vibration velocities in the section of the start of automatic balancing (74 times in the 3D modelling; 5.4 times in the field experiment).

The computer simulation of the dynamics of the axial fan with the «on» and «off» gravity forces has allowed determining the following:

– the effect of gravity on the accuracy of balancing the impeller decreases rapidly with increasing the cruising speed of the impeller,

– when increasing the forces of viscous resistance to the motion of the balls, the effect of gravity on the accuracy of the rotor balancing increases;

– at low speeds of rotation (15 r/s), the impeller can be balanced not better than by accuracy class G 2.5, but at the rated speed of 25 r/s, it is balanced according to accuracy class G 1.

Herewith, the residual vibration velocities that are caused only by gravity decrease with increasing the rotor speed.

The residual vibration velocities that are caused only by the eccentricities of the raceways increase directly proportionally to the rotor speed. Therefore, fast-turning rotors need a more precise installation of automatic balancers. It is recommended to reduce the eccentricity of the raceway of the automatic balancer at least 2.5 times in relation to the maximum permissible value.

Residual vibration velocities in the automatic balancing mode (up to 3 mm/s) on the test fan are mostly caused by gravity. The probable causes of residual vibration velocities are eccentricities of the raceways of the automatic balancers, standstill of the balls (lack of reaction to small unbalances), etc. Therefore, residual vibration velocities can be reduced at the stages of manufacturing and installing automatic balancers into a fan.

Keywords: axial fan, automatic ball balancer, automatic balancing, static balancing, dynamic balancing, transients.

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PREREQUISITES FOR THE DEVELOPMENT OF HYDRO-JET TECHNOLOGY IN DESIGNING WOMEN'S HEADGEAR AT HOSPITALITY ESTABLISHMENTS (p. 36–46)

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Selection of the submerged hydro-jet as a tool for shaping volumetric headgear details was substantiated.

The experimental device for determining dynamic pressures of the submerged hydro-jet, which consists of the dynamometer, the power source, the contact group, the platform for operation of the submerged hydro-jet, as well as the top platform, was developed. The device operates so that the measurement of pressure of the submerged hydro-jet could be carried out by measuring reaction force, the module of which is equal to pressure module, and the vector is reverse. This happens due to the transfer of action forces from the fluid to the air medium with the help of the two-arm lever. Measurements are carried out at the distance of 1–30 mm between the cut of the jet-forming mouthpiece and the surface of material, treated at maximal pressure of working medium of 150 MPa.

We developed a method for determining dynamic pressures of the submerged hydro-jet depending on geometrical parameters of mouthpieces, such as: length of cylindrical and conoidal parts of the mouthpiece, inlet and outlet diameters of the mouthpiece, radius of the mouthpiece, initial section of the submerged hydro-jet with round outlet openings, radius of the jet in the transition section, semi-axes of the elliptic outlet opening of the mouthpiece, initial section of the submerged hydro-jet with elliptical outlet openings, semi-axes of jets in the transition cross-section. The method provides for determining of hydro impact power of the submerged jet depending on cross-section area at a fixed distance from the end of the mouthpiece, which makes it possible to calculate the desired parameters of pressure in the range from 0.01 to 10 MPa.

The influence of geometric parameters of conoidal jet-forming mouthpieces with round and elliptical outlet openings on dynamic pressures of submerged hydro-jets, formed by them, was explored. The experimental values of dynamic pressures of hydro-jet were found to be within specific formation effort ranging from 0.02 to 0.12 MPa. In this case, mean value of coefficient of losses is K_b=0.66–0.99 when using conoidal mouthpieces with round outlet opening, and K_b=0.42–0.99 when using conoidal mouthpieces with an elliptical outlet opening.

Keywords: hydro-jet technology, women's headgear, design, shaping of headgear details, submerged hydro-jet.

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MODELLING THE LOADING OF THE NOSE-FREE CUTTING EDGES OF FACE MILL WITH A SPIRAL-STEPPED ARRANGEMENT OF INSERTS (p. 46–54)

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A mathematical model of loading of the nose-free cutting edges of each insert of the face mill with a spiral-stepped cutting scheme was created. It was established that the size of the cut elements depends on the feed magnitude, the design parameters of the mill and the position of inserts on the contact arc. Variable factors of simulation included the feed magnitude, the clearance angle of the inserts and slope angles of the cutter assemblies. This made it possible to determine the chip thickness and width of cut, the depth of cut, the maximum value of the main cutting edge angle and the cut area at an arbitrary position of the face mill on the contact arc. Simulation in the SolidWorks Motion environment has confirmed reliability of mathematical modeling of loading of the cutting edges of the mill. The relative error in determination of the cut area was in the range from 1.8 % to 5.7 %.

Calculation of the cut elements in the arbitrary position of the cutter insert on the contact arc was made in the Maple environment. Analysis of influence of the design parameters of the cutter and the magnitude of feed on the values of the cut elements was made. It has been established that an increase in feed caused a linear increase in the chip thickness and width of cut and the depth of cut for the inserts of all steps. Optimal values of the clearance angle of the mill inserts (16°) and slope of the cutting assemblies (6°) were determined for the milling depth of 3 mm. Recommendations on the choice of rational values of design parameters of the face mill for its effective operation at various depths of cut were given.

Thus, there are grounds to assert the possibility of improving productivity of machining flat surfaces at a required quality due to the use of nose-free face mills with a spiral-stepped cutting scheme.

Keywords: face milling, cut elements, stepped cutting schemes.

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ALOE VERA AS CUTTING FLUID OPTIMIZATION USING RESPONSE SURFACE METHOD (p. 55–63)

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The fluid of vegetable Aloe Vera has characteristics as a cutting fluid, Aloe Vera cutting fluid (AVCF) has an excess of environmental reduction effects from oil-based cutting fluid (OBCF). Surface Response Methodology (RSM) based Central Composite Design (CCD) was applied as an experimental design, to predict the optimum parameters in the turning process. Because RSM is the final description of a good experimental design to improve the linear response surface model, and in determining the optimum operating

conditions. Twenty sets of experimental tests were prepared by three reversed parameter factors, feed rate (*f*), depth of cut (*a*), and AVCF three type. Roughness (*Ra*) and flank wear (*VB*) were defined as response variables and then analyzed by multiple quadratic regression to determine the most appropriate mathematical model. The combined effects of the parameters were investigated using contour plots and surface plots. HSS as a cutting tool and Steel St.42 workpiece were used to achieve 20 tests. The adequacy of the developed model was examined using Analysis of Variance. Based on the results, the optimum process is shown by the following parameters: $f=0.140$ mm/rev; $a=2.0556$ mm, and AVCF=71.8970 cSt provide optimal cutting conditions with lower *Ra* and $f=0.20$ mm/rev, $a=2.50$ mm, and AVCF=8.8050 cSt giveoptimal cutting conditions with lower VB. Therefore, the improvement of AVCF as a substitute for OBCF continued experiments.

Keywords: Optimization, Aloe Vera, Flank Wear, Surface Roughness.

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INFLUENCE OF THE PROPERTIES OF BLAST FURNACE SLAG ON CAST IRON HEATING AT PULVERIZED COAL INJECTION (p. 63–70)

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In the course of the studies at two industrial blast furnaces, we established a change in the characteristics of slag mode and cast iron heating, resulting from the transition to the pulverized coal fuel injection with a decrease in basicity of CaO/SiO_2 slag from 1.16 to 1.10 and from 1.20 to 1.12 units. It was shown that depending on a particular influence of alumina and magnesia in the slag composition, as well as on their ratio, a decrease in slag basicity can be accompanied by both an increase and a decrease in viscosity. During the research, the dependence between slag viscosity at the temperature of 1,400 °C and chemical heating of cast iron heating at the outlet was established. According to obtained data, an increase in slag viscosity by 0.1 Pa·s was accompanied by an increase in silica concentration in cast iron by 0.08–0.1 %.

The relation of physical heating of metal with slag basicity and stoichiometry was established. It was shown that a decrease in basicity of $(CaO+MgO)/SiO_2$ by 0.1 units led to a decrease in cast iron temperature by 30 °C. Such a substantial effect of basicity of metal heating indicates the need to take this influence into account not only to control the blast furnace process, but also to state the thermal balance of steel smelting.

It was shown that in the studied range of slag compositions, the influence of magnesia on heating of cast iron is limited. A slight influence of MgO on physical heating of metal was pronounced at a magnitude of the ratio Al_2O_3/MgO that is close to unity.

Results of present research could be used to improve control over blast furnace smelting in terms of taking into consideration slag influence on heating of cast iron.

Keywords: blast furnace, slag practice, viscosity, basicity, slag composition, heating of cast iron.

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