ABSTRACT AND REFERENCES

ENGINEERING TECHNOLOGICAL SYSTEMS

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PROGRAMMING SPINDLE SPEED VARIATION IN TURNING (p. 4-9)

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A mathematical model for the turning process is developed, which considers the oscillations of technological machining system (TMS) in a 3D space, along all three coordinate axes simultaneously. The model accounts for the influence of natural feedback on the depth, feed and cutting speed; moreover, the effect of machining by chatter marks is introduced into the model by two directions – depth and feed. It is established that the main factor, which determines the origin of regenerative oscillations, is the machining by chatter marks. That is why a change in the spindle speed with the help of the SSV option (Spindle Speed Variation) on the machine tool with CNC leads to a change in the trail frequency and its noncoincidence with the natural vibration frequency of TMS, which calms the system.

The created applied simulation software makes it possible to conduct a purposeful search for the best parameters of harmonic law when changing the spindle speed for each particular machining case. We propose as the criterion the minimum time of oscillation damping by amplitude per one entire revolution of the billet. Thus, a procedure is developed and a tool is created for programming the variable speed of the spindle in the turning operation on the machine tool with CNC. We experimentally proved effectiveness of the proposed solution.

Keywords: mathematical model for the turning process, regenerative oscillations, spindle speed control.

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SPECIAL FEATURES IN THE APPLICATION OF FRACTAL ANALYSIS FOR EXAMINING THE SURFACE MICRORELIEF FORMED AT FACE MILLING (p. 9-15)

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A method of fractal analysis is applied to describe the relief surface area, which is formed at face milling of plates at different values of the workpiece feed. Microphotographs of the samples' surface served as input data for calculating the fractal parameters of the microrelief surface area. Here we

discuss the most favorable conditions for obtaining photographic images of the samples.

The implementation of the method of fractal analysis was achieved in accordance with the rough partition method by the standard procedure. Data on the relief surface area of real samples, which composed the base set of measure for the fractal analysis, were calculated by the interpolation method based on data on the chromaticity of different pixels in a photograph.

We obtained dependences between the magnitudes of fractal parameters for the surface area at the rate of feed for the workpieces made of steel 35 and alloy D16T. It is demonstrated that an increase in the feed from 50 mm/min to 400 mm/min leads to an increase in the values of Hausdorff dimensions for surface relief area of the articles at the area of its analyzed surface of 5×5 mm^2 from 2.55 to 2.68, and at the area of 1×1 mm^2 – from 2.43 to 2.51.

A proposal is put forward on the possibility of using fractal characteristics to quantitatively describe the surface microrelief of samples after face milling.

Keywords: fractal analysis, surface roughness, face milling, surface relief area.

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MODELING OF THE CORROSION PROCESS IN STEEL OIL PIPELINES IN ORDER TO IMPROVE ENVIRONMENTAL SAFETY (p. 15-20)

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Experimental studies demonstrated that the main role in the corrosion processes on a steel pipeline in the fracture of an insulation coating exposed to aggressive solutions belongs to the work of macro galvanic couples pairs «metal of pipe in the fracture – metal of pipe under an insulation coating». The current of given galvanic couples is a universal indicator for calculating the loss of metal in fractures.

Modeling of the electrochemical corrosion of steel in an oil pipeline section in the fracture of an insulation coating is reduced to determining the stationary electric field that occurs during work of a macro galvanic couple. Distribution of electric field potential is determined by solving a two-dimensional Laplace differential equation. Calculations by the model allow us to predict corrosion losses of metal in a pipeline in the fractures of an insulation coating exposed to aggressive electrolytic solutions regardless of their chemical composition.

The benefit of the technique developed is the possibility to predict the development of corrosion over time and obtaining the required estimated parameters on structures under operation by a non-destructive method.

Keywords: steel oil pipeline, electrochemical corrosion, galvanic element, corrosion model, rate of corrosion, environmental safety.

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THE STUDY OF INHIBITING STRUCTURAL MATERIAL CORROSION IN WATER RECYCLING SYSTEMS BY SODIUM HYDROXIDE (p. 21-28)

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Influence of sodium hydroxide on the rate and nature of corrosion of St3 carbon steel and SCh 18–36 grey cast iron in highly mineralized recycling water was studied. The nature of the corrosion damage was determined and the weight index of corrosion of these alloys was calculated. By means of polarization measurements, the electrochemical indices of anodic processes on steel and cast iron were determined. The effect of the circulating water pH on behavior of steel and cast iron under anodic polarization has been studied by cyclic voltammetry. It has been shown that the effective impact of pH on characteristics of the anode processes occured at pH≥11.4. At these pH values, the metal steady-state potential shifted to a region of positive values which was an indication of

inhibition of the anodic process itself. At pH≥11.4, the pitting potential significantly shifted to the positive side: the process of healing pits was faster than their formation. It has been established that steel and especially cast iron tend to pass into a passive state at pH>10. The corrosion rate values did not exceed this index for the studied alloys in distilled water and were in the range of acceptable values. Thus, it is possible to effectively inhibit the rate of steel and cast iron corrosion, especially in the waterline zone by shifting the pH of the circulating water to the alkaline region. As a result of the conducted studies, optimal working conditions for iron alloys as the most technically important structural materials for designing closed cycles of circulating water supply systems have been established.

Keywords: circulating water, corrosion, carbon steel, grey cast iron, mineralization, sodium hydroxide.

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RATIONALE FOR THE PARAMETERS OF EQUIPMENT FOR PRODUCTION AND USE OF BIODIESEL IN AGRICULTURAL PRODUCTION (p. 28-33)

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Available and future equipment for production and use of biodiesel does not fully ensure the process efficiency in agricultural production. Therefore, it is necessary to increase the energy efficiency of biodiesel by improving technical means for its production and consumption.

The mathematical model of energy-efficient emulsion stirring in circulation mixers-separators is improved. The model allows determining the geometric parameters (length and diameter in cross-sections) of the emulsion jet with the turbulent regime of stirring. The use of injectors for creating the turbulent motion regime of the emulsion jets in a biodiesel production unit is proposed. The emulsion passage through injectors also provides uniform layer-by-layer emulsion stirring. The emulsion is pumped out from the mixer bottom, the mixed emulsion layer is lowered. Turbulence decreases, higher reaction completeness is achieved. The high quality of biodiesel and reduced energy consumption are achieved. The geometric

dimensions of mixers of various capacities are determined, energy consumption for biodiesel production are substantiated. The agro-industrial technology for biodiesel production using mixers for all production stages is proposed. It is found that the biodiesel temperature rise increases the fuel spray angle at the exit of injectors, which improves emulsification and combustion efficiency of biodiesel. The flowchart of biodiesel use in tractor engines with the two-stage heating system is proposed. In the proposed system, biodiesel is heated in the fuel tank and immediately before injection into the engine cylinders. Experimental verification of the machine-tractor unit, equipped with a diesel heating system is performed.

The use of circulation mixers-separators allows biodiesel production by the simplified technology in agricultural production. Application of the developed two-stage biodiesel heating system extends the temperature range of using pure biodiesel and reduces its consumption.

Keywords: biodiesel, transesterification, mixer, machine-tractor unit, heating system.

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RESEARCH INTO EFFECT OF ULTRASONIC, ELECTROMAGNETIC AND MECHANICAL TREATMENT OF BLENDED BIODIESEL FUEL ON VISCOSITY (p. 34-41)

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A combined ultrasound and ultrahigh frequency electromagnetic treatment of the blended fuel, which consists of diesel mineral fuel (DF) and methyl ester of rapeseed

oil (MERO), allows reducing viscosity of the biodiesel fuel. We experimentally examined the influence of ultrasound, ultrahigh frequency electromagnetic and mechanical treatment of blended biodiesel on its viscosity.

It is established that the optimal treatment period for the blends of biodiesel fuel with ultrasound is 5 minutes that makes it possible to reduce viscosity of the product by 20 % on average. We also found a positive effect of UHF electromagnetic field on the blends of diesel fuel with methyl ester of rapeseed oil during for 5 minutes, which allowed us to reduce viscosity of the product by 5.6 % on average. A treatment of the blends of biodiesel fuel in a mechanical homogenizer did not lead to improvement in the fuel viscosity and, after 60 days of observation, viscosity remained at the same level as prior to the treatment.

It was established that the combined effect of a 3-minute ultrasound and ultrahigh frequency electromagnetic treatment of the blend with 90 % DF + 10 % MERO and with 80 % DF + 20 % MERO made it possible to reduce viscosity of the biodiesel fuel by 16.3 % and 15.8 %, respectively, relative to the untreated blended fuel. Viscosity in the given blends, relative to the mineral diesel fuel, decreased by 9.3 % and 1.2 %, respectively.

Keywords: ultrasound, electromagnetic treatment, diesel fuel, methyl ester of rapeseed oil, biodiesel viscosity.

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EXPERIMENTAL STUDY OF THE PROCESS OF THE STATIC AND DYNAMIC BALANCING OF THE AXIAL FAN IMPELLER BY BALL AUTO-BALANCERS (p. 42-50)

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The process of the static and dynamic balancing of the impeller of the axial fan by ball auto-balancers is experimentally investigated. The influence of auto-balancers on sections of the racing and the run-out of the fan and the efficiency of the auto-balancers in the cruising sections are studied.

It is shown that the vibrations of the impeller occur with the frequency of its rotation. This means that the usual and aerodynamic unbalances are the main sources of vibrations and they are similar to each other; both unbalances give rise to vibrations with the rotor frequency.

It is shown that the impeller has two resonant frequencies (although the impeller itself is a short rotor and has one resonant frequency). This is because the impeller is mounted into a massive corps and dynamically it behaves like a long rotor. The larger resonant frequency of the impeller is almost 2 times lower than its operating frequency. Therefore, it falls into the area of the beginning of balancing with a margin.

It is shown that the presence of one auto-balancer does not worsen the racing process of the fan.

It is shown that in the run-out when the rotor passes through the resonant velocities, the value of the vibration accelerations and the duration of the passage of the velocities:

– in the presence of one auto-balancer are decreased insignificantly by 20–40 %;

– in the presence of two auto-balancers are decreased significantly by 60–80 %.

These are explained by the following: in auto-balancers at the run-out there is retention of the balls and balls are retained in the balancing positions almost until the rotor stops.

It is shown that dynamic balancing occurs faster than static balancing.

It is shown that on the cruising steady motion:

– one auto-balancer, mounted from the side of the impeller (the shank), significantly reduces vibration accelerations in its plane and almost does not reduce vibration accelerations from the side of the shank (the impeller);

– two auto-balancers significantly reduce the vibration accelerations of the impeller in all planes.

It is shown that the attachment of additional masses to the fan protective casing reduces its vibrations, but does not reduce the loads on the bearings.

Keywords: axial fan, aerodynamic unbalance, vibration acceleration, auto-balancer, dynamic balancing, transition processes.

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MODELING OF FRACTURE SURFACE OF THE QUASI SOLID-BODY ZONE OF MOTION OF THE GRANULAR FILL IN A ROTATING CHAMBER (p. 50-57)

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Large-tonnage processing of granular materials is carried out in drum-type machines. Utmost simplicity of the design solutions of such equipment is paradoxically combined with the behavior of machined medium that is extremely complex to describe.

The efficiency of working processes in drum machines is determined by the mode of motion of the fill of a rotating chamber. The character of this mode is predetermined by the position of a transition surface of quasi solid-body motion zone to the zone of fall and subsequent shift, which determines dynamic activity of the filler's movable part.

A traditional hypothesis on the implementation of processing granular materials in the drum machines is based on the concept of a separate element of the fill in a rotating chamber isolated from the surrounding medium. According to this hypothesis, the fracture surface of a solid-body zone is of cylindrical shape with a diameter that depends only on the rotation speed. Therefore, performing numerical calculations is associated with insurmountable computational difficulties. Obtaining experimental data is hampered due to the complexity of hardware control. That is why results, obtained recently, approach real motion modes of the examined medium only by qualitative characteristics.

We constructed an analytical model of behavior of a granular fill in the transition from the circular, during ascent, to the quasi-parabolic, while non-free falling, trajectory of motion in the cross-section of a cylindrical chamber that rotates around a horizontal axis. Equation of a slip line coordinates in parametric form is received. They make it possible to approximately determine the shape and position of the transition surface depending on the kinematic, geometric and rheological parameters of the system. A granular fill is considered as a whole medium with parameters that are averaged by volume. We employed the plastic rheological model.

Based on the modeling performed, we formalized a stress field in the mass of fill in the cross-section of a rotating chamber by using a system of differential equations of flat boundary equilibrium of a granular medium. A condition for the boundary equilibrium is obtained. It is demonstrated that disequilibrium is accompanied by sliding layers of the fill. We defined position of the slip lines in stress field. It was found that the motion zone transition is accompanied by the destruction of a quasi solid-body zone at the border that is a slip line in the motion picture of plastic medium in the cross-section of a chamber. It is established that the position of transition limit depends not only on the angular velocity. It is a function of radius and degree of filling the chamber, specific weight, angle of friction and ascent angle of the fill.

Keywords: granular fill, rotating chamber, quasi solid-body zone, fracture surface, slip line.

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DETERMINING THE DEPENDENCES FOR CALCULATING A CONVERSION SCALE OF PROFILE HEIGHT OF THE CONTROLLED PACKING SURFACE (p. 58-62)

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Based on the shadow projection method, we obtain an initial image of the surface of a textile packing with the purpose to digitize and subsequently analyze it by the methods of technical vision. We received dependences of the scale of conversion of the shadow size at the surface of a packing, caused by the deviation of its shape from the specified one, into a digitized image. The assigned packing shape is determined by the conditions for its processing during subsequent transitions in textile production. The images received with a sufficiently high frequency of observation are the data for consequent construction of a volumetric model of the packing. Using this model, it is possible to establish deviations in the packing shape form the required one, caused by a violation of conditions in the formation of packing.

The impact of design elements in a device for the registration of initial data on the magnitude of conversion scale is established. As a result of research, we received dependences that allow us to reasonably approach the selection of design parameters of a device. The device to control the shape of packing in the process of its unwinding makes it possible to eliminate design defects at the stage of adjusting the mechanism of a bobbin winder and to formulate requirements for its operation.

Keywords: shadow projection method, conversion scale, profile height, error estimation, defects in winding, stationarity of process, thread tension.

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