ABSTRACT AND REFERENCES

ENGINEERING TECHNOLOGICAL SYSTEMS

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THE OPTIMIZATION ALGORITHM FOR THE DIRECTIONS OF INFLUENCE OF RISK FACTORS ON THE SYSTEM THAT MANAGES THE POTENTIAL OF MACHINE-BUILDING ENTERPRISES (p. 6–13)

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The lines of influence of risk factors on the system of management of financial potential of machine-building enterprises were determined. Their application makes it possible to provide enterprises with complete and reliable information on the system of the analysis component groups necessary for making optimal management decisions, improve the system of production and technological management through the use of integrated methods focused on analysis of the entire spectrum of critical parameters of the enterprise activities and maintain its financial potential at a proper functional level. Consistency comparison of expert's local priorities with regard to the elements of the second and third levels of the hierarchical model of choice of the neutralization method has been made. The consistency relation showing the degree of violation of numerical value of transitive consistency is the criterion for assessing local expert priorities. A random coherence of local priorities of matrices of various orders was obtained.

The algorithm of the strategy of optimization of the financial potential of machine-building enterprises was proposed taking into account influence of the risk factors. It is based on strategic tasks and principles and provides a tactical system set of methods, tools and concrete measures to implement the policy of optimizing the financial potential. It is characterized by various parametric indicators that take into account the risk-oriented optimization of enterprise's financial potential. Depending on situation, the strategy should be adjustable and flexible for implementation in order to obtain the most positive result.

Keywords: optimization algorithm, formation technology, managerial impacts, development system, financial potential, risk-oriented directionality.

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ANALYSIS OF THE PISTON ENGINE OPERATION ON ETHANOL WITH THE SYNTHESIS-GAS ADDITIVES (p. 14–19)

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We have conducted experimental study into parameters of the piston engine 1Ch 6.8/5.4 with forced ignition operated on ethanol with different additives of the synthesis-gas in the amount to 10 %.

We used the methods of working cycle indication, as well as registering the thermal balance of the engine, which make it possible to obtain the most complete pattern that characterizes ethanol combustion with additives of the synthesis-gas, as well as to determine the relationship and influence of the composition of an additive on the basic parameters of the engine working cycle.

We have acquired and processed experimental indicator diagrams under different modes when the engine was operated with and without additives of the synthesis-gas. It was found that the engines with spark ignition operating on ethanol with additives of the synthesis-gas in the amount to 10 % demonstrate a decrease in the indicator work and specific indicator fuel consumption. A decrease in the indicator engine performance can be resolved by using small amounts of additive of the synthesis-gas for heavy loads, and maximal amounts of additives at low loads. It was determined that significant additives of the synthesis-gas to ethanol results in an increase in the maximum pressure of combustion by up to 12 % and its shift towards the upper dead point at 7° c.s.r. Increasing the additive of synthesis-gas to ethanol by larger than 10 % requires adjustments of excess air ratio and the ignition advance angle. When using the synthesis-gas additives to ethanol, the ethanol specific effective consumption reduces by 2.5...12.4 %. The obtained experimental data can be considered with a sufficiently high degree of accuracy to be correct for engines with spark ignition and a cylinder volume of 190...250 cm^3.

The quantitative and qualitative results of experimental studies that we obtained have confirmed the effectiveness of using the additives of synthesis-gas to ethanol; they would also complement a mathematical model of the working cycle with empirical coefficients and dependences for each particular case.

Keywords: alternative fuels, synthesis-gas, thermochemical recycling, indicator diagram, combustion process.

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EXPERIMENTAL STUDY INTO ENERGY CONSUMPTION OF THE MANURE REMOVAL PROCESSES USING SCRAPER UNITS (p. 20–26)

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We have experimentally investigated the patterns in the influence of opening angle of the scraper unit, inclination angle of scrapers, and motion speed of the scraper unit, on specific energy consumption by the improved scraper unit.

We have experimentally substantiated the hourly schedule of manure accumulation and a schedule for turning the scraper unit on; it is proposed to remove manure 5 times during 24 hours: at 7, 9, 14, 18, 22, which would significantly reduce resource consumption and energy costs associated with the launch of a conveyor.

Experimental study enabled determining the structural (opening angle of the scraper unit and inclination angle of the working surfaces of scratchers) and technological (motion speed of the scraper unit) parameters, at which the improved scraper unit would demonstrate minimum specific energy consumption.

The optimal parameters for a scraper unit, at which the improved scraper unit would have minimum specific energy consumption, are the scraper unit opening angle in the range of 105 to 115°; inclination angle of the working surface of scrapers is 60°, motion speed of the scraper unit is 0.13 m/s. Based on these indicators, we assembled the developed scraper unit for manure removal.

We have conducted comparative experimental study into operation of the developed scraper unit for manure removal and the prototype, commercially available scraper unit USG-3. This study demonstrated the advantage of the developed scraper unit compared to USG-3; specific energy consumption reduces by the amount of 44 to 48 % to 0.34–0.36 kW h/t.

The established rational parameters and operating modes of the scraper unit reduce energy consumption of the scraper unit required, while maintaining the required quality for cleaning a manure channel, which confirms the feasibility of its industrial production.

The research results reported here could be applied when designing the bulldozers and other melioration equipment.

Keywords: manure removal, schedule for turning on, scraper unit opening angle, scrapers inclination angle, scraper unit speed, energy consumption.

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THEORETICAL STUDY INTO EFFICIENCY OF THE IMPROVED LONGITUDINAL PROFILE OF FROGS AT RAILROAD SWITCHES (p. 27–36)

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We have developed a comprehensive method to prolong the time of operation of frogs at railroad switches, based on the consideration of a longitudinal profile of the frog, the magnitude of dynamic forces and normal stresses.

We have improved a longitudinal profile of the frog, brand 1/11, project 1740, by the method of surfacing under field operation conditions. The slopes of a trajectory after the passage of an average statistical wheel over the proposed profile amount to 3.7 ‰ instead of 10 ‰ for a standard profile of the frog.

It was established that increasing a load on the frog to 60 % at the expense of a deflection under the frog beam leads to the accelerated disarrangement of the frog, as a result of fatigue defects at the rolling surface, while the cost of frog operation in this case increases by five times.

We modeled a dynamic interaction between the rolling stock and a standard, as well as the proposed, longitudinal profiles of frogs. Calculation of dynamic processes of the nonlinear interaction between the rolling stock and a standard profile of the frog and the profile restored by surfacing, showed that the magnitude of forces for the proposed frog at the motion speed of 150 km/h is 50 % lower compared with a standard longitudinal profile. At linear simulation of dynamic additions of forces, the magnitude of forces decreases for the proposed profile to 30 %.

We employed a graphical method to calculate the magnitudes of axial inertia moments and the moments of resistance in the characteristic cross sections of the frog. The estimation of the stressed-strained state of the frog was performed using equations of five moments for a continuous beam on elastic point supports. It was established that stresses at the static calculation of the frog are low and are much less than the maximum permissible magnitude of stresses for a given grade of steel. Therefore, we can argue that the frog works under a load at the expense of existing reserve of strength.

Keywords: frog, railroad switch, railroad rolling stock, longitudinal profile, dynamic forces, stresses.

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MATHEMATICAL MODELLING OF OPERATIONAL STABILITY OF SOWING MACHINES' MECHANICAL SYSTEMS (p. 37–46)

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This study addresses the construction of mathematical models for the operational stability of mechanical systems in agricultural seeders. The objects of research are the coulter systems of seeders with a support-packer roller and direct sowing planters, which are the disc working bodies of most sowing machines. The complexity in mathematical modeling of systems stability is due to a significant number of factors whose values are of variable and random character. To model them, it is proposed to explore the stability of systems based on their control parameters: lengths and angles of inclination, installation height of nodes and parts of a seeder, etc. The endogenous and exogenous parameters that include the following: step at sowing, soil surface depth and its properties, dimensions and weight of seeds, etc., are fixed at preset limits, in accordance with agricultural conditions. Difficulties in solving such systems of differential equations and obtaining the analytical solutions are explained by the condition for an inverse problem: the forces that act on a system must by in a constant equilibrium. The proposed modeling of system stability is based on the Lyapunov second method, which implies the construction and investigation of functions of perturbed motion at variable control parameters. We have established expressions for determining the stage of asymptotic stability of the system, which are characterized by the magnitude of time and distance that are required to return it to the unperturbed state. The obtained resulting mathematical expressions allowed us to establish significant factors: the length of a hitch, the rigidity of a spring, the inclination angle of a hitch, distance to the point of fastening a spring rod, which define the perturbed path of the coulter system. The result of modeling is the obtained damping character of the perturbed motion of the examined systems, as well as the established dependences of perturbed path of coulter systems on the above-specified parameters.

To test the adequacy of the derived mathematical expressions for determining the stability of sowing machines, to refine the ranges in the variation of significant parameters, we carried out an experimental research. We employed the procedure for a multi-factorial experiment. As a result, with the help of the developed modelling method and based on the experiment conducted, we determined the rational parameters for working bodies of sowing machines of different types, which could be applied for efficient operation and in the design process of similar machines.

Keywords: motion stability, differential equation, coulter system, perturbed state.

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DEVELOPMENT OF THE LASER-FOUNDRY PROCESS FOR MANUFACTURE OF BIMETALS (p. 47–54)

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The new highly effective method for the production of bimetal sheets was proposed. According to a thin surface layer of the functional component of the bimetal moving at a certain speed on a certain area is melted by the concentrated laser radiation. Simultaneously, the pre-prepared solutions of the bimetal base are fed to the zone of its action from a special dispensing device with a specified flow rate, resulting in a reliable connection between them when cooling.

The method is characterized by high productivity and universality of the process of manufacturing a wide range of bimetals of various purposes, the great strength of the grip of their components, the possibility of complete automation. The thermal processes occurring in the surface layer of the functional composition of bimetal from 40H13 stainless steel (AISI 420) under different laser radiation conditions are analyzed. The parameters of laser irradiation, which provide submelting of the 50 mm wide surface layer to a depth of 50–100 microns (the radiation power is 8.5 kW, the speed of the movement is 1 m/min) are determined. The conditions of feeding of the molten metal of the base of St.3 structural carbon steel (AISI A284Gr.D) (the height of the melt column 7.6 mm, the size of the outlet 50×3 mm) on the fused functional layer, which provide the formation of the bimetal with the specified dimensional characteristics, are substantiated.

The productivity of the considered laser-foundry process is determined by the parameters of scanning and power of the laser beam, the cost characteristics of the melt of one of the components, the speed of relative displacement. The fusion zone formed during cooling and relative displacement of the components of the bimetal causes the metallurgical bond between them. This allows producing bimetallic products of the required quality.

Keywords: bimetals, thermal processes, laser irradiation, induction heating, melting zone, metallurgical bond.

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DEVELOPMENT OF A METHOD TO DETERMINE DEFORMATIONS IN THE MANUFACTURE OF A VEHICLE WHEEL RIM (p. 55–60)

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The desire to anticipate and predict quality of the manufactured products, its compliance with the technical requirements of the customer at the stage of technology design leads to the development of various methods for theoretical analysis of the processes of plastic deformation. The purpose of these methods is to establish explicit patterns in the processes implemented using the intuitively clear mathematical functions.

We have formulated a method for determining relative deformations at a local change in the shape of a closed shell of rotation through radial-rotational profiling. It is shown that it is possible, based on the derived analytical dependences, to predict dimensions of a semi-finished product at the design stage of the technological process. Up to now, there have not been any analytical expressions that would estimate an unambiguous dependence of deformation on the rollers radii ratio, on a billet, and on the magnitude of feed. It is established that the magnitude of relative deformations in three mutually perpendicular directions depends on the ratio of diametrical dimensions of deforming rollers and initial diameter of a billet. Comparison of calculation results, obtained in this work, with experimental data and existing expressions allows us to argue that a given method of calculation demonstrates the accuracy acceptable for the industrial production. This contributes to the possibility to control a field of stresses and deformations in order to manufacture an equally strong wheel rim at the stage of production preparation and a technological process design. The practical application of a given method of calculation would enable technologists and designers to take into consideration the deformation strengthening after each run of profiling. As well as to determine the operational dimensions of semi-finished products and to predict thickness of a finished product in radius transitions of the profile, that is, to intensify the considered process.

Keywords: central rim well, landing shelf, radial-rotational profiling, wheel rim, deformation strengthening, local thinning.

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FORMING A DEFECTIVE SURFACE LAYER WHEN CUTTING PARTS MADE FROM CARBON-CARBON AND CARBON-POLYMERIC COMPOSITES (p. 61–72)

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We report results of theoretical and experimental research aimed at establishing the mechanisms for the formation of a defective layer at the machined surfaces made from carbon composite materials, specifically those from carbon-carbon and carbon-polymeric groups. Possessing a set of unique physical and mechanical properties, the latter are increasingly applied in aviation and space technologies. However, since the properties of a material are predetermined not only by the components applied but also by the processes to obtain products (laying of reinforcing fibers, orientation of threads), conducting mechanical tests of samples-witnesses is a compulsory stage in the operations performed.

Based on the generalization of statistical and theoretical-analytical information, we have developed a model of the emergence and propagation of cracks in a quasi-fragile material, particularly the carbon-carbon and carbon-polymeric composites, caused by the action of a cutting wedge. It is shown that the stresses that occur in a surface layer predetermine the intensity of crack growth while a direction of microcracks propagation is due to the applied force load. Therefore, control over the direction of force action, as well as the application of certain technical means, including a hydroabrasive jet, could enable the localization of microcracks in small quantities at the surface of the formed edge.

The established regularities in the formation of a defective layer at machining (including the hydroabrasive cutting) have made it possible to identify ways to improve the quality of a sample and to reduce the layer thickness to 0.05 mm. The derived dependences of the destruction zone parameters on the stresses that occur at cutting allowed us to obtain the rational sequence of machining transitions, at which the defective surface layer is the smallest.

The results obtained provide a possibility to significantly increase the accuracy of mechanical tests of carbon composite materials, thereby reducing the variance in the measurements of controlled parameters by 30–40 %.

The results have been actually implemented industrailly, and are of interest for the further research aimed at the hybridization of processes, as well as the development of technologies based on a functional-oriented approach.

Keywords: mechanical cutting, hydroabrasive cutting, carbon-containing composite material, defective layer.

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DEVELOPMENT OF THE GEARLESS ELECTRIC DRIVE FOR THE ELEVATOR LIFTING MECHANISM (p. 72–80)

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A technical analysis of the requirements for drive motors and rope driving pulleys of gearless elevator winches was performed. The possibility of application of the developed slow-moving electric motor of the bi-induction type with the unwound rotor was considered. A similar motor was produced with the rotor of the face or cylindrical type and the stator, which do not have a common yoke. The face type rotor comprises a few ferromagnetic poles fixed on a non-magnetic disk. The main design parameters of bi-induction motors for the series of speeds of the elevator car motion were generated. Recommendations on selection and compliance of the rates of elevator winches with the diameters of rope driving pullies were given. The synthesis of the system of control of the elevator electric drive was performed. It is proposed to use the microprocessor system of subordinate control of the use of the relay current controller, PI-controller of rate and P-controller of position. The results of the research revealed that there is a possibility of the exact reproduction of the assigned trajectory of the car motion and the exact stop, made on a certain floor without additional operations of approaching the assigned point. The motion is performed according to the calculated trajectory with restriction of the assigned speed at the level of the rated one, acceleration – up to 1 m/s^2 and the jerk – up to 3 m/s^2. These parameters fully meet the conditions of comfortable passenger transportation.

The difference between the experimental data and the results of modelling does not exceed 7 % in the static and 15 % in dynamic modes. The main advantages of the proposed gearless elevator electric drive were specified. In particular, it was determined that the proposed electric drive due to the design features of the quietly operating motor has much lower weight, dimensions and inertia than the traditional one in the basic option at the other similar parameters.

Keywords: elevator winch, gearless electric drive, bi-induction motor, brushless motor, lifting mechanism.

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