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THE ANALYSIS OF RUNNING EFFICIENCY OF VALVE UNITS IN DIFFERENTIAL MORTAR PUMP

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The object of research is a differential mortar pump with a horizontal pump column, designed for pumping construction mortars of various mobility to the places of their mechanized application to the treated surfaces. To its disadvantages should be attributed insufficiently studied mechanism of formation of return leakage of the mortar, which directly depends on the value of the angle of closure of the valves.

As methods of research, methods of physical and mathematical modeling, similarity theory, as well as a personal computer for computation and presentation of their results are used.

The issues allowing to estimate the efficiency of the differential mortar pump operation with the horizontal arrangement of the pump column for the efficiency of their valve units are considered. The possibility of estimating the operation of valve assemblies according to the angle of their operation is considered. The calculation procedure is based on the analysis of the design of the valve assemblies and the determination of the time of their opening and closing. Separately, both suction and discharge valves are considered from the point of view of the sequence of their opening – closing and minimizing their operating time. The time of their operation is usually determined based on the speed of the mortar passing through the valve assembly.

The operating angle is considered as a universal index that allows comparing pumps of different designs with different technological characteristics and allowing to improve their design, achieving a reduction of this index.

In addition, the reasons allowing to influence the reduction of the closing time of the valve without degrading the technological characteristics of the mortar pump itself are considered.

The diagrams of the mortar pump are constructed, along which the real angles of operation of the valve assemblies are determined. The results of the comparison testify to the correspondence between theoretical (16.8°) and practical (17.3°) data and the possibility of using numerical values of the valve response angle as an indicator of the efficiency of the mortar pump as a whole.

Keywords: differential mortar pump, valve actuation angle, valve assembly, valve design optimization.

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MATHEMATICAL MODELING OF VIBRATIONAL SYSTEMS FOR TRANSVERSE GRINDING BY WHEEL PERIPHERY

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The object of research is the vibrational systems of grinding processes. One of the problem areas of the research object is the determination of the way in which the regularities of mutual influence of the main parameters of the system's motion will be taken into account. The question of taking into account the energy dissipation in elastic elements in the study of the vibrations of an elastic system is quite complex, since internal friction depends on a number of factors whose influence is quite complex and practically not subject to direct account.

In the course of the work, analytical methods of research are used, based on the basic principles of the theory of mechanical vibrations and theoretical developments of scientists in this field.

Analytical dependences of the grinding system motion with longitudinal feed in the form of differential equations that take into account the dimensions of the «drive – machine – grinding tool – workpiece» system are obtained and determine their interdependence. This allows to conduct theoretical studies of processes to establish appropriate grinding modes.

With the use of Nielsen algorithm, the dependencies of the vibrational system motion are obtained without taking into account the roughness of the grinding wheel, profile which allows to predict the position of the grinding tool during processing at any time. This makes it possible to study in detail the conditions of the vibrational grinding system under various conditions and to develop measures to improve the efficiency of the grinding process by selecting the correct grinding conditions (feed rate, grinding wheel rotation velocity, grinding depth, etc.).

Keywords: vibrational grinding system, motion patterns, grinding wheel.

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INFORMATION SUPPORT FOR PROCESSES OF QUALITY FUNCTIONALS MEASUREMENT IN THE CAD OF CASTING OF STEEL CASTINGS IN SAND MOLDS

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It is shown that the design and management of foundry technology due to its multifactoriness, intensity and inaccessibility for measurements is extremely difficult, which means that a significant number of castings in real production are rejected.

A method is proposed for using instead of particular parameters the functional that unites them, which is also used as a dimensionless numerical criterion for the defectiveness of casts. The method is tested in real production with a positive technical effect.

The work is devoted to improving the quality of steel castings obtained in sand molds. An increase in the efficiency of designing and improving the management of the process of their manufacture through the development and implementation of new metrological support has been achieved. Its purpose is measurement of the functional criterion in the system «steel casting – sand mold».

To achieve this aim, an analysis of the parameter-functional «gas removal» in the system «casting – sand mold» is made. The accuracy and reliability of the use of the complex parameter-functional as a criterion of defect-free casting is estimated. The estimation of accuracy and reliability performed by the proposed method shows that the measurement error of the «gas removal» functional under the conditions of steel casting described above in sandy-resin forms does not exceed 8 %. This is quite acceptable for this type of technical applications, and also with a probability of not less than 0.85, reliably guarantees the high quality of the casting surface, both in the absence of sand burning and in the absence of blown holes.

Keywords: foundry, quality of castings, measurement of parameters, complex functional, quality criterion.

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MATERIALS SCIENCE

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INVESTIGATION OF THE MODIFICATION PROCESS OF NATURAL SEDIMENTARY CALCITE BY ORGANOSILICON COMPOUNDS

page 19–23

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The object of this research is the process of natural sedimentary calcite modification. The main problems that are solved in this research are the choice of the most suitable low molecular weight modifier among potassium methylsiliconate, sodium methylsiliconate and polymethylhydride siloxane, as well as the selection of optimal grinding regimes for the raw mineral.

It is found that during the mechanochemical activation in the presence of organosilicon modifiers, hydrophilicity coefficient of the surface of the sedimentary chalk is significantly reduced. The most effective modifier for the surface of sedimentary calcite is polymethylhydride siloxane. It is established that in the presence of modifiers, grinding and amorphization of carbonate raw materials are activated, which is confirmed by a decrease in the intensity of calcite reflections to 9 % in the case of the use of polymethylhydride siloxane and by 5–7 % in the case of methyl

siliconates. It is shown that the modification of the sedimentary chalk surface leads to a decrease in the capacity of its adsorption layer by 20 % of the capacity of the processed material. The strength of the coagulation structure in the filler-film former system also decreases: the yield point of the system with untreated material is 20 % higher than this limit for the system where chalk is modified with polymethylhydride siloxane.

Despite the advantages of the proposed technical improvement, it is likely that the use of traditional fatty acid-based materials will remain more attractive in continuous production. Since this method has advantages from the point of view of the absence of the need to change the existing composites formulations, and from the point of view of minimizing the cost price. Research results will be more interesting in those industries where improving the properties of the material plays a decisive role.

Keywords: filler-film former system, sedimentary calcite, mechanochemical activation by organosilicon compounds.

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ELECTRICAL ENGINEERING AND INDUSTRIAL ELECTRONICS

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ANALYTICAL REPRESENTATION OF SWITCHING CURRENT IMPULSES FOR STUDY OF METAL-OXIDE SURGE ARRESTER MODELS

page 24–29

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The object of research is an analytical expression for representing the switching current impulse of a surge arrester. Any current impulse (both lightning and switching) is characterized by such

parameters as the virtual front time and the virtual time to half-value on the tail. According to the standard IEC 60099-4:2014, switching current impulse has a virtual time to half-value on the tail of roughly twice the virtual front time. This requirement is one of the most problematic places in this task. The existing approaches used to represent lightning current impulses are not suitable in this case, since these impulses have virtual time to half-value on the tail of two and a half times the virtual front time.

This problem can be solved with a help of analytical piecewise continuous functions.

It is shown how to describe switching current impulses of the surge arresters with a help of analytical piecewise continuous functions. In contrast to other expressions, the resulting expressions for the switching impulse have only one parameter (angular frequency). Instead of approximate calculation, the front time of the resulting impulse is calculated by an analytically exact formula. Hence, the tolerance of virtual front time is equal to zero. The time to half-value on the tail of the resulting impulses is determined with some error that can be reduced by some complication of the original expression.

The proposed functions satisfy the requirements of the IEC 60099-4:2014 standard regarding switching current impulses of surge arresters. These functions allow representing current impulses having virtual time to half-value on the tail of roughly twice the virtual front time (30/60 or 45/90 microseconds). In such cases, minimal tolerance of time to half-value on

the tail is +3.78 %. Additional study shows that one of proposed functions allows representing current impulses having virtual time to half-value on the tail of two and a half times the virtual front time (8/20 or 4/10 microseconds). Tolerance of time to half-value on the tail for such impulses is 0.55 %. The obtained functions are intended for study of various models of metal-oxide surge arresters on personal computers.

Keywords: surge arrester, residual voltage, switching current pulse, piecewise function.

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IDENTIFICATION OF THE PARAMETERS OF THE CABLE PRODUCTION PROCESS

page 29–34

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The object of research is the process of producing electric cables with polymer insulation for ultrahigh voltages. One of the most problematic places is the presence in the contours of the regulation of the thickness of insulation layers, the noise of measuring the speeds of worms of extruders and the diameters of the insulation layers, and also the time delay. The noisiness of useful signals and the time delay adversely affect the accuracy of layer thickness control and the speed of regulation and can lead to loss of system stability. To solve this problem, a parametric identification method is proposed, which under real conditions of noisy measurements of control object variables gives an estimate close to the exact values of the parameters.

A modified least squares method is used, which in the situation of noisy input and output signals provides an unbiased estimate parameters, and a smaller spread rating than conventional least squares method. This is due to the fact that the proposed method makes it possible to reduce the spread of the quadratic functional by additional averaging on the set of quasi-static independent functionals.

In comparison with the analogous well-known least squares method, it provides an increase in the accuracy of identifying parameters in conditions of noiselessness of not only output but also input signals. The introduction of research results in systems of adaptive control of the thickness of polymer insulation layers in the production of cables for ultra-high voltage will improve product quality and improve production efficiency.

Keywords: parametric identification, integrated identification method, electrical engineering systems, electrical cables.

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TECHNOLOGY AND SYSTEM OF POWER SUPPLY

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INFLUENCE OF THE AIR FLOW VELOCITY RELATIVELY THERMOSTAT OBTURATOR ON THE EFFECTIVENESS OF INDUCED HEAT AND MASS TRANSFER

page 35–41

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The object of research is the effect of induced heat and mass transfer (IHMT), which consists in the transition of the system from unstable equilibrium to stable, which is accompanied by heat dissipation due to the transition of the liquid phase in the thermostat to the gas state. One of the problematic areas of the research object is the lack of data on the energy efficiency control limits of the induced heat and mass transfer effect by such controlling parameter as the air flow velocity moving relative to the thermostat obturator.

In the course of the research, an experimental technique is used to obtain and analyze the temperature kinetics of a colloidal capillary-porous body inside a thermostat during the IHMT effect. The method of calculating the heat balance is also used. These methods allow to reveal the effect of the air flow velocity relative to the thermostat obturator on the nature of the induced heat and mass transfer.

It is established that the work of the air flow, which moves relative to the obturator, is the controlling parameter by means of which the IHMT «start» is organized. It is determined that the intensity of the induced heat and mass transfer can be regulated within 15..20 % by the velocity of the air flow relative to the thermostat obturators.

It is established that, firstly, it is possible to control the «start» of the IHMT effect in accordance with the goal of technological processing of raw materials using this effect. And secondly, it is reasonable to change the IHMT flow rate and its efficiency by varying the airflow velocity with respect to the obturators.

Keywords: induced heat and mass transfer, thermostat obturator, air flow velocity.

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NUMERICAL SOLUTION OF THE OPTIMAL SPEED PROBLEM WITH A PHASE CONSTRAINT FOR ONE PARABOLIC EQUATION

page 42–47

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An algorithm for the numerical solution of the optimal speed problem with phase constraint for a parabolic equation describing the heat conduction processes in inhomogeneous media is proposed. To solve the problems with the use of first-order optimization methods and finite differences on non-uniform grids, analytical formulas are obtained for the components of the

gradient of the functional with respect to controllable functions. A method is proposed for selecting initial approximations for optimal controls and a step in time at each iteration, which makes it possible to accelerate the computation process. To achieve the specified accuracy, the speed problem requires 6 iterations and $T_{on} \in (0.0525, 0.06)$. Based on the analysis of the results of numerical experiments, the influence of various parameters on the iterative process is investigated and recommendations are developed on the use of the proposed algorithm. In optimal control problems, the total number of iterations in option a by the conditional gradient method is 110 and the gradient projection method is 108. In option b, the total number of iterations is CGM – 81, GPM – 64, i. e., the total number of iterations in the optimal control problem in method b the choice of the initial approximation is much less than in variant a. The optimal speed control, obtained by both methods, is close enough to test controls. Numerical experiments are also carried out in the case when the control-optimal controls have two switching points. However, the nature of the results obtained does not change. The proposed algorithm can be used to determine the optimal regime and time of thermal conductivity processes in inhomogeneous media.

Keywords: parabolic equation, speed problem, optimal control, penalty functional, gradient of the functional.

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MECHANICS

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SUBSTANTIATION OF THE STRUCTURE THEORY OF DESIGN OF TECHNOLOGICAL MACHINES AND DEVICES

page 48–55

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The object of research is the theory of the design of technological machines and devices. The main idea of this theory is the possibility of a priori quantitative evaluation of the design of machine and instrument constructions for manufacturability, unification and other indicators based on the identification of structural design features and the creation of quantitative criteria.

An in-depth study of this work has shown that the weaknesses of the research are related to the rather high influence of the heuristic component on the process of scientific and engineering search. One of the most problematic places is that the complete formalization of this process can lead to a halt in the development of scientific and technical thought. There is a risk of reducing the construction process to the reproduction of an infinite number of similar structures that differ in certain characteristics, but lie within the same constructive series.

To prevent the negative impact of the proposed theory on the rate of technical progress, it is necessary to strictly limit the field of its use, using it to optimize the design of entire products or their individual components and automate the process of searching for a better prototype for improvement in a combination of features.

To prove the main idea of the theory, methods of analysis and induction are used in the course of the research, on the basis of which, using the lemma and existence theorems, basic axiomatic theories are formulated with the subsequent completion of theorems, although the content of the considered theory is not mathematical, but technical objects.

The structure theory of design is unique, since being a model of logical computation, it makes it possible to reveal regularities

in classes and series of a set of designs on the basis of which to propose ways of optimizing and improving the productivity of the design process by establishing a connection between the features of the designs and their coding according to the chain of successive transformations. Coding of structures in place in the chain of transformations opens up wide prospects for automation of the design process.

Keywords: structure theory of design, criteria of compilation and maintainability, existence theorem for designs.

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