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SEARCH FOR THE WAYS TO IMPROVE THE OPERATIONAL RELIABILITY OF THE ROLLING MILLS

page 4–8

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The object of research is the hinge unit of the universal spindle of rolling mills. The most common for such conditions are used hinges with anti-friction liners with sliding friction. One of the most problematic parts of the hinge with sliding friction is the uneven distribution of pressure on the contact surface of the segments, which reduces the wear resistance of liners and operational reliability of the spindle. To identify the causes of uneven pressure and determine areas of significant excess of torsion loads, studies are carried out on the developed mathematical model of the hinge.

In the course of the research, a mathematical analysis of the influence of the parameters of liners on the magnitude of pressure on the contact surfaces under the working loads of the roller blades and segments of the hinge liners is used. The parameters of the zones of high pressure in the contact liners typical forms in the form of a continuous segment with flat and cylindrical surfaces. It is established that it is necessary to change the liner section plane along the length and width of the segment.

Analytical dependences of the hinge parameters on the active loads and pressure are obtained. The formulas for determining the geometric dimensions of the hinge segments with regard to its radius and rigidity are derived. The study of the hinge with inserts, in which bevels on a flat surface and slopes to the ends along the length and from the middle to the side faces, indicates the possibility of uniform distribution of pressure along the length and width of the segments of the inserts.

Thus, research on the mathematical model and in the laboratory has shown that it is advisable to use the developed design of the liner with a variable section plane along the length and width of the liner. The uniform distribution of contact loads is confirmed by pressure plots along the length and width of the segments. This makes it possible to increase the wear resistance of the hinge joint of universal spindles of powerful rolling mills. Compared with the known designs of hinges, the operational reliability of the spindles and the period of trouble-free operation of states are significantly increased.

Keywords: rolling mill reliability, universal spindle, contact pressure, wear uniformity.

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EXPERIMENTAL STUDIES OF FORMING DESIGN AT DYNAMIC LOAD

page 8–13

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The object of research is the movement process of forming structures of a vibration unit with spatial oscillations. The main disadvantage of such vibration systems is the lack of data on the mutual influence of machines and media. Experimental vibration unit is developed and manufactured. The unit is equipped with two asymmetrically mounted vibration exciters that are attached directly to the forming surfaces. A new technique for measuring the motion of forming structures with the location of sensors in the areas of dynamic load is proposed. The basis of their location is the premise of determining the contact forces of the interaction of the subsystems with each other. As well as an assessment of the ratio of time of action and time of wave propagation. This approach is new, because it takes into account the real relationship of the dynamic parameters of the machine and the environment between them and the degree of interference. In the course of research, records of continuous fixation of the distribution of active oscillations of forming surfaces are used. A fundamentally new result is obtained,

which consists in the fact that the transition process is envisaged to take into account when determining the parameters and locations of vibrators. Due to this, the forms of natural oscillations of the system with large amplitudes of oscillation and correspondingly lower frequency are realized. Compared with similar known designs of vibration units, this can significantly reduce the energy intensity of the causes of the vibration machine. The use of pneumatic generators in real factory conditions reduces the noise level and accelerates the speed of the process of compacting concrete. Practical recommendations for the rational constructive design of sections of forming structures are developed. Technological parameters of oscillations with new values of the output numerical values of the amplitude-frequency mode of the exciter of oscillations are determined. To construct such forming structures, the sites for vibration units are determined. The obtained results can be used in related processes, for example, in the mining industry, as active surfaces for transporting ore, for moving suspensions and solutions in the chemical industry.

Keywords: experimental model, forming structure, spatial load, stress-strain state.

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STABILITY ASSESSMENT OF 30XHMЛ STEEL MELTING PROCESS IN ELECTRIC ARC FURNACES ON THE BASIS OF TECHNOLOGICAL AUDIT OF SERIAL MELTINGS

page 14–18

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The object of research is the process of 30XHMЛ steel melting in two electric arc furnaces with a capacity of 6 tons. Technological audit of the process is carried out on existing furnaces in the steel foundry of a machine-building enterprise specializing in the manufacture of large shaped castings for products of transport engineering. The audit is aimed at analyzing the compliance of the performed main technological melting operations with the required regulated technological instructions.

On the basis of carrying out serial meltings, a sample of experimental and industrial data is obtained to determine the tensile strength of steel samples 30KhNML. It has been established that according to the actual production data of serial heats it is impossible to postulate the distribution law, in particular, to speak of a normal distribution. Therefore, the use of statistical sampling functions to assess the melting stability is not advisable. It is proposed to use the stability coefficient (η), based on the calculation of entropy (H), as a criterion for assessing the melting stability. It is proposed to use a fuzzy description of these values for practical use in assessing the melting stability. In this case, it can be assumed that the calculated values of entropy and melting stability coefficient for each sample separately and the total sample form the left (α_{jp}) and right (β_{jp}) fuzziness boundary. It is proposed in the fuzzy description to use the membership function of (L–R) type. In a specific case, it can be assumed that $\alpha_{jp}=2.63$, $\beta_{jp}=2.71$ (for a fuzzy number H) and $\alpha_{jp}=0.22$, $\beta_{jp}=0.24$ (for a fuzzy number η).

Thanks to the proposed method for assessing the melting stability, it is possible to obtain objective data without relying on the assumption of a normal distribution law. The proposed method is invariant to the type of technological process in the blank production. These can be metal forming, heat treatment and other metallurgical

processes. The importance of the proposed method is related to the fact that the quality of further technological operations for the production of finished parts depends on the inheritance of the quality of blank production as the previous technological stages of production.

Keywords: electric arc furnace, steel melting, melting stability coefficient, membership function, fuzzy number, fuzziness boundary.

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OPERATION OPTIMIZATION OF HOLDING FURNACES IN SPECIAL CASTING SHOPS

page 18–22

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The object of research is the melting and casting system of special casting shops. The process is considered on the basis of simulation modeling of the requirements of chill or melts pressure casting machines and the capabilities of the melting and holding furnaces to meet this need. The modeling is carried out on the basis of typical solutions for the used brands of furnaces for the manufacture of aluminum alloys in non-ferrous casting shops of a machine-building enterprise specializing in the manufacture of casting in metal molds for engineering products.

As a result of simulation modeling, a description is obtained of the influence of the intensity of applications on the melt on the part of chill machines or injection molding machines, and the time taken to complete these applications for the total costs of the implementation of the technological process. It is proposed to determine the total costs as the sum of the costs associated with the consumption of technological electricity, and the costs associated with the likely downtime of machines due to lack of metal. Moreover, the second component reflects the requirement for the performance of machines in terms of their actual operation. Therefore, the total cost of the process of chill casting or casting under pressure in terms of the consistency of the elements of the melting and casting system is chosen as the criterion for optimizing its operation.

It is proposed to consider the melting and casting system as a queuing system (QS) with failures. Such a presentation is the most stringent in terms of requirements for ensuring a given performance. Using the study of the response surface, the optimization problem is solved according to the consistency of the intensity of requests for the melt and the time of their execution, which minimizes the total costs of the implementation of the technological process. Local optimal technological solutions are obtained that enable technologists to choose the most rational decisions for conducting a melting campaign using transfer furnaces with a capacity of 0.16–0.25 tons. Such solutions will provide the possibility of reducing the cost of manufacturing aluminum casting.

Keywords: special types of casting, injection casting, holding furnaces, melting and casting system, queuing system.

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MATERIALS SCIENCE

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EFFECT OF THE MODIFIER ON THE THERMOPHYSICAL PROPERTIES OF FIREPROOF ETHYLENE-VINYL ACETATE COPOLYMER COMPOSITION MATERIALS

page 23–28

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The object of research is the thermophysical processes of fireproof composite materials: ethylene-vinyl acetate copolymer, which contain fire retardant fillers and a modifier. In order to ensure the incombustibility performance, polymer compositions have a high degree of filling up to 60 % by weight. A copolymer of ethylene with vinyl acetate is used as a polymer matrix. Inorganic fillers-flame retardants are aluminum oxide trihydrate with an average particle diameter of 1.5 μm and 3.0 μm, magnesium oxide dihydrate with an average particle diameter of 3.0 μm and 3.7 μm and hydromagnesite with an average particle diameter of 1.4 μm. One of the most problematic places is the process of processing such compositions.

Aminosilane is used as a modifier. Using the method of thermogravimetric analysis and TGA/DSC differential scanning calorimetry, the melting and decomposition temperatures, the crystallinity degree, the specific heat, and the mass loss are determined.

The results show that the melting points decrease with increasing modifier content for all samples. A significant decrease in the melting point is observed when using fillers with a large average particle diameter. The temperature of the decomposition beginning increases for all polymer compositions in which the modifier is introduced. The crystallinity degree increases with increasing content of the polymer composition modifier. The specific heat capacity of all polymer compositions increases with an increase in the amount of modifier. This is due to the influence of fillers-flame retardants and modifier on the formation of the structure of polymer compositions.

This makes it possible to reduce the melting point by 1.2–16.2 degrees, depending on the chemical composition and dispersion of the flame retardant fillers in the presence of a modifier. The crystallinity degree increases and the specific heat capacity increases with an increase in the modifier content. The decomposition beginning temperature of polymer compositions increases significantly from 20 to 45 degrees.

The results will be useful in the development of fireproof formulations of polymer compositions for cable products, taking into account their thermal characteristics.

Keywords: composite materials, effect of modifier, ethylene-vinyl acetate copolymer, fillers-flame retardants, thermophysical properties.

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IMPROVEMENT OF THE METHOD OF DRILLING AND BLASTING OPERATIONS AT THE USE OF EXPLOSIVE SUBSTANCE «UKRAINITE» IN UNDERGROUND MINING WORKS

page 29–35

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The object of research is a rock massif of iron ore, which is destroyed by an explosive located in deep wells. One of the most problematic places is ensuring uniform grinding of the rock massif during underground mining of mineral deposits at great depths. In the Kryvyi Rih iron ore basin (Kryvyi Rih, Ukraine) in underground mining let's use the Ukrainian-made Grammonite 79/21 explosive, which provided an opportunity to obtain high-quality grinding of the ore mass to a depth of 1200 m. With a decrease in mining, these indicators deteriorate significantly, due to the manifestations of rock pressure, which leads to the overcoming of wells and increased specific charge for blasting.

A comprehensive method is used based on an analysis of existing methods that affect the specific charge of an explosive. According to practice data, it is found that when using an emulsion explosive in mining operations, the specific consumption of an explosive decreases, while the cost of extraction decreases and the quality of grinding of the massif improves. However, due to the lack of a methodology for calculating the parameters of drilling and blasting operations, the «Ukrainite PP-1» emulsion explosive is not widely used. The development of the methodology taking into account the characteristics of the «Ukrainite PP-1» emulsion explosive will improve the extraction of ore mass.

It is shown that the use of «Ukrainite PP-1» emulsion explosive leads to a decrease in the total length of wells by 35 %, and a decrease in production costs. This is due to the fact that the proposed method of calculation has the peculiarity of taking into account the specific costs of emulsion explosives obtained by pilot tests, in particular, the efficiency coefficient of emulsion explosives.

Due to this, the costs of drilling and blasting work are reduced and it is possible to obtain a calculated economic effect from the introduction of this technology at the level of 0.6 c. u./t. The proposed pattern of drilling the massif by the downward fans, compared with similar known, can reduce the time for drilling and improve the grinding of the rock massif without changing technology.

Keywords: least resistance line, specific explosive charge, well diameter, rock strength factor, explosive.

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TECHNOLOGY AND SYSTEM OF POWER SUPPLY

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AN EXPERIMENTAL STUDY OF THE WAVE EFFECT IN FUEL EQUIPMENT USING HYDROGEN ADDITIVES TO DIESEL FUEL

page 36–41

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The object of research is the hydrodynamic wave effects in the fuel equipment of high pressure diesel engines. One of the most problematic phenomena when using hydrogen additives to diesel fuel is the change in the maximum fuel injection pressure, which leads to deterioration of fuel separation parameters.

For research on the nature of hydraulic oscillations in the fuel equipment, an experimental booth has been created that allows the study of the wave effect with the use of small additives of hydrogen to the main fuel. In the development of an experimental stand, modern precision measuring instruments were used. According to the results of experimental studies, it is established that in the high pressure fuel line a characteristic «wave effect» of oscillations appears. This effect is caused by the landing of the pressure valve on the saddle in the fuel pump of high pressure, as well as the landing of the needle nozzle. The nature of the oscillation depends on factors such as the length of the pipeline between the pump and the nozzle, the maximum injection pressure of diesel fuel, the speed of propagation of the pressure wave. This speed, in turn, depends on the frequency of rotation of the crankshaft of the engine. The frequency of rotation of the fuel pump shaft is changed with the help of an inverted regulator and frequency meter of the drive motor.

As a result, the fuel injection characteristics are obtained, which reflect the nature of the change in the pressure wave, depending on the presence of hydrogen additive. It is determined that the hydrogen additive in the amount of 0.1 % of the cycle fuel supply (by mass) leads to the suppression of wave oscillations and the shortening of the oscillation region by 12...20. The characteristics of absorption of hydrogen by diesel fuel are obtained. The amount of hydrogen additive depends on the pump rotation frequency, the injection pressure and the supply pressure of the additive. This kind of hydrogen consumption is explained by the time frame of the restriction of the absorption process, the difference in the minimum value of the «pressure wave» of the excess pressure of the additive. The resulting data can be used to confirm the mathematical model of hydrogen absorption when used as an additive to the fuel line.

Keywords: internal combustion engine, hydrogen consumption, hydrogen addition.

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BUILDING A LOAD CHARACTERISTIC OF THE FUEL INJECTION SYSTEM OF A SHIP'S MEDIUM-SPEED ENGINE DIESEL IN DYNAMIC TESTS CONDITIONS

page 41–49

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The object of research in the work is hydrodynamic processes in the high pressure fuel system of the ship's medium-speed engine on variable modes. Variable regimes constitute a significant part of the operational time of a number of types of ships (tugs, fishing vessels, etc.), and for transport fleets they are characteristic for maneuvering. In the latter case, reliability and environmental safety for sanitary control zones are of particular importance. Studies of fuel supply processes in variable modes are important, since they largely determine all the operating characteristics of a diesel engine and are not well studied

The article presents an experiment in which the task is obtaining the load characteristics and the study of transients in the fuel equipment of the ship's medium-speed diesel engine under dynamic testing conditions. In the course of the research, a developed hardware and

software complex is used to ensure the implementation of the experiment plan, fixation, processing and oscillography of the obtained data. An electromechanical system is developed by rack displacement of a high-pressure fuel pump with programmed computer control. The experiment program provides for changing the rack position in the whole range covering the operational load characteristic. The discrete displacement includes five fixed rack positions with a step transition between them. During testing, the high-pressure fuel pump completes 80 injection cycles over 44 s. The transition time between the individual fixed positions of the racks is 0.44 s. The stabilization period of hydrodynamic processes in the fuel supply system is close to 0.22 s. In the investigated range of rack positions m_r=25–5 mm the main parameters of the fuel injection are as follows: $p_{n.c}$=474–232 bar; $p_{n.i}$=457–222 bar; p_p=445–162 bar.

The possibility of obtaining load characteristics by dynamic tests is shown, which significantly reduces the test time and increases the reliability of the data, eliminating the influence of the time trend parameters.

Keywords: medium-speed diesel, fuel equipment, hardware-software means of non-motorized dynamic tests, load characteristic, variable modes.

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ALTERNATIVE AND RENEWABLE ENERGY SOURCES

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RESEARCH OF THE SPATIAL ASPECTS OF USING RENEWABLE ENERGY SOURCES FOR SUSTAINABLE DEVELOPMENT OF THE TERRITORY

page 50–58

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The object of research is renewable energy sources as the basis for the development of renewable energy in Ukraine. Problems in the implementation of objects in this industry are the need to apply measures for their safe operation and less profitability of renewable energy sources compared to traditional ones. This is due to the high cost of equipment and significant costs to ensure technological processes. Increasing the share of renewable energy sources in the total energy balance will require government subsidies to the industry.

It has been proven that the application of the cartographic approach allows determining the optimal locations of renewable energy facilities from an economic point of view and taking into account a number of equally important factors, in particular, social and environmental impact. The next methods are used:

– cartographic – when applying modeling techniques for building maps of renewable energy resources;

– geo-informational – in the process of collecting and processing information about resources, objects and factors for the development of renewable energy;

– statistical – at the stage of calculating the energy potential of wind energy, solar energy, geothermal and hydrological resources.

The maps for the above-mentioned renewable energy directions are presented, recommendations on the optimal areas for the construction of energy facilities are given on the example of Kharkiv region (Ukraine). So, location:

– wind power plants are recommended in Vovchansk, Kharkiv, Velykyi Burluk regions;

– solar power plants – in Blyzniuky, Pervomaiskyi, Balakliia, Izium, Lozova and Borova;

– geothermal power plants – in the south of Barvinkove and Blyzniuky, southeast of Izium, Borova and Lozova districts.

Perspectives for locating small hydropower stations within the study area are sections of the Siverskyi Donets, Udy, Berestova, Mzha, Merla rivers.

The dependence of the economic efficiency of wind, solar, geothermal energy and small hydropower facilities on factors such as:

– distance of transportation of energy raw materials and finished energy to consumers;

– heat loss;

– cost of investment in the construction of infrastructure (power lines, electrical substations, heating networks).

Keywords: renewable energy sources, spatial aspect, economic factors, cartographic approach, sustainable development of the territory.

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