METALLURGICAL TECHNOLOGY

DOI: 10.15587/2706-5448.2024.310424

DETERMINATION OF THE INFLUENCE OF THE SURPLUS CONSTRUCTION ON THE PARAMETERS OF THE SHRINKAGE SHELLS IN THE «BODY»-TYPE STEEL CASTINGS WHEN CASTING IN SINGLE SAND MOLDS

pages 6–10

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The object of research is the technology of manufacturing «Body»-type shaped castings of the from medium carbon steel in one-time sand molds.

The existing problem is that the design of the casting and foundry equipment significantly affect the formation of internal defects in castings. This especially applies to steel castings, the technology of which is more complicated than the technology of cast iron castings due to much worse casting properties of steel.

To determine the influence of the location of surpluses on the «Body»-type steel castings of the on the formation of shrinkage shells, computer modeling was used, in the process of which 5 computer experiments were conducted with different sizes and geometries of surpluses.

According to the simulation results, it was found that with some technological options, there is a risk of the shrinkage shell penetrating into the casting body. The use of a cylindrical surplus of a rectangular cross-section with fillets ensures complete absorption of the shrink shell in the place of surplus installation. Using an excess round section at the installation location does not guarantee absorption of the shrink shell. The determining factor affecting the coefficient of increase in the depth of the shrinking shell is the excess volume. This influence can be described by a functional dependence of the logarithmic type with the coefficient of determination R^2=0.82.

It was determined that the ratio of the diameter of the inlet to its height does not affect the coefficient of increase in the depth of the shrinking shell. The resulting functional dependence allows to set the excess volume that provides a minimum growth factor while simultaneously preventing excess metal consumption.

The presented study will be useful for machine-building enterprises that have foundries in their structure, where shaped castings are made in one-time sand molds.

Keywords: steel shaped castings, surplus, shrink shell, design and technological solutions.

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DOI: 10.15587/2706-5448.2024.309790

THE EFFECT OF NOISE ON RECURRENT DIAGRAMS OF ENERGY CONSUMPTION OF A METALLURGICAL ENTERPRISE

pages 11–16

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The most common problem faced by modern metallurgical enterprises is the improvement of their energy efficiency, which is based on the management of energy-saving projects. The paper deals with the analysis of the impact of external noise on recurrent diagrams based on short-term time series of daily energy consumption of a metallurgical enterprise. The object of this study is short time series of energy consumption of a metallurgical enterprise. The time series of energy consumption of PJSC «Electrometallurgical Plant «Dniprospetsstal» (Ukraine) for 2018–2021 were used as data. The subject of the study is the method of recurrent diagrams of short time series.

In the process of research, methods of short time series analysis based on recurrent analysis were used to study the characteristics of the system state on the example of a metallurgical enterprise. An analysis of the influence of external noise on recurrent diagrams of short-term chaotic time series was carried out using the developed software in the Matlab environment for constructing recurrent diagrams of energy consumption of a metallurgical enterprise.

The following tasks were solved in the work: software was developed for constructing recurrent diagrams in the Matlab package with the possibility of analyzing changes in the magnitude of quantitative indicators of recurrent diagrams under the influence of different levels of noise in time series.

The obtained results are recommended to be used to characterize the state of the system and analyze the influence of external noise. The practical value of the performed work is determined by the proven usefulness of recurrent analysis for estimating electricity consumption and the improvement of modeling of this process, which will allow increasing the accuracy of forecasting future dynamics verified by empirical data.

Keywords: recurrent analysis, network traffic, time series, recurrent diagram, energy consumption, nonlinear dynamics, metallurgy.

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MECHANICS

DOI: 10.15587/2706-5448.2024.310428

DEVELOPMENT OF THE STICK-SLIP FRICTION MODEL FOR DISCRETE ELEMENTS MODELING

pages 17–25

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The object of the research is an intergranular friction model for use in discrete-element modeling of the mechanical behavior of granular materials under static and dynamic conditions. As in this approach grains are modeled by independent elements interacting through contact forces, the selection of contact force models, and in particular for the tangential component (friction), represents the most important task in obtaining the most realistic macroscopic behavior. There are many friction models that work well in dynamic regimes, but fail to model mechanical behavior in static or quasi-static regimes. In this work, an intergranular friction model is proposed based on Coulomb's regularized friction model, which takes into account the stick-slip phenomenon that appears at low sliding speeds at the contact. Three different examples are designed and modeled in order to demonstrate the robustness of the model in different situations including static, quasi-static and dynamic regimes. The first is a basic example consisting of the translational motion of a grain on a planar surface with a relatively low constant velocity. This example allowed to capture the stick-slip phenomenon. The second represents a grain subjected to its own weight and supported essentially by frictional forces. This example shows

that the model works well in both quasi-static and static regimes. The third example consists of a grain sliding on a plate and subjected to accelerated motion. It showed the effect of friction velocity on the occurrence of stick-slip, as well as the evolution of friction force with sliding velocity. The obtained results demonstrated that the model effectively captures shear behavior in the different regimes. It could therefore be used in discrete element modeling of granular materials under both static and dynamic conditions. As in this work, the model is formulated in 2D, it would be interesting to develop a general 3D formulation so that it can be easily applied in 3D modeling.

Keywords: Coulomb friction, static, dynamic, stick-slip, discrete element method, soft contact, shear rate.

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DOI: 10.15587/2706-5448.2024.310802

DETERMINATION OF THE DENSITY OF THE SURFACE WHICH IS EXPOSED TO VARIOUS WORKING BODIES OF THE VIBRATION PLATE VP-10

pages 26–31

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The object of research is a vibrating plate with interchangeable working bodies developed by the authors. Vibrating plates are an integral part of small mechanization equipment and are mainly intended for layer-by-layer compaction of various materials, such as sand, gravel, bituminous mixtures, etc. Vibration compaction methods are widely used in the construction of road surfaces and other infrastructure facilities. Self-propelled vibrating slabs are also used effectively in other construction processes such as compaction, trench reinforcement, land work and laying paving slabs. They ensure effective compaction of materials due to vibration.

This paper is aimed at determining the optimal equipment for compaction of materials during the construction of small objects. Analyzing the characteristics of the machines that most affect the quality of compaction, it is also necessary to evaluate their influence in specific conditions. Studies show that for each type of material, a special working body should be selected, taking into account the specific conditions and requirements for compaction, to ensure optimal quality of work.

The authors seek to consider the selection of vibrating plates and their working bodies that best meet the requirements and needs of compaction of various materials on limited construction sites. The analysis of different types of working bodies for different surfaces helps to improve the compaction process and provides optimal conditions for different types of building materials, taking into account their unique properties.

The paper examines the influence of the working body on the processed environment, in particular, analyzes the ability of various factors to influence the quality of material compaction. Special attention is paid to the influence of the geometry and size of the contact area on the sealing efficiency of each material type. Overall, this analysis can significantly improve material compaction strategies in the construction industry, contributing to improved construction quality.

Keywords: vibration, vibration installation, vibration amplitude, vibration exciter, mathematical analysis, vibration machine.

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TECHNOLOGY AND SYSTEM OF POWER SUPPLY

DOI: 10.15587/2706-5448.2024.309965

SYNERGISTIC PREDICTION OF PENETRATION RATE IN BOUKHADHRA MINING USING REGRESSION, DESIGN OF EXPERIMENTS, FUZZY LOGIC, AND ARTIFICIAL NEURAL NETWORKS

pages 32–42

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The comparative analysis of predictive methodologies highlights the original contribution of this study in optimizing the prediction of Rate of Penetration (ROP) in mining drilling operations. The emphasis on employing advanced Artificial Neural Networks (ANN), fuzzy logic, and linear regression models provides new insights into enhancing predictive accuracy and operational efficiency in mining practices. This study aims to quantify the effects of three pivotal drilling parameters: compressive strength, rotational pressure, and thrust pressure on the rate of penetration, a critical performance metric in mining drilling operations. Additionally, the study seeks to develop and evaluate advanced predictive methodologies for predicting ROP. The effects of compressive strength, rotational pressure, and thrust pressure on the rate of penetration were investigated through a Design of Experiments (DOE) approach. Initially, the main effects and two-way interactions among these variables were identified using DOE. Subsequently, three predictive methodologies: linear regression, fuzzy logic, and artificial neural networks, were developed and evaluated to predict ROP based on the identified factors. The evaluation of predictive methodologies revealed that the ANN model demonstrated superior accuracy in predicting the ROP, achieving over 95 % accuracy. Additionally, the fuzzy logic model provided effective handling of non-linearities in the data, while the linear regression model offered initial insights into the relationships between the variables. The application of advanced predictive methodologies: artificial neural networks, fuzzy logic, and linear regression to optimize the prediction of rate of penetration in mining drilling operations offers precise insights into drilling parameter interactions, enhancing operational efficiency and supporting informed decision making in mining practices.

Keywords: drilling, mining, rate of penetration, design of experiments, fuzzy logic, artificial neural network.

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DOI: 10.15587/2706-5448.2024.310699

SELECTION OF OPTIMAL SCHEMES FOR THE INERTING PROCESS OF CARGO TANKS OF GAS CARRIERS

pages 43–50

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Recommendations are given for choosing the optimal schemes for the process of inerting cargo tanks of ships carrying liquefied gases. It was determined that one of the tasks that arise during the transportation of hydrocarbon cargoes (crude oil, petroleum products, and liquefied gases) is to ensure fire safety and prevent accidental explosions of cargo vapors in cargo tanks. Processes that occur during cargo operations on ships transporting oil products and liquefied gases are considered. The critical composition of the mixture of oxygen (entering the cargo tanks with air) and cargo vapors (remaining in the tanks after the cargo is unloaded) is indicated, at which a flash and explosion may occur. It was determined that the main technological operation that prevents spontaneous ignition of cargo vapors in cargo tanks is their inerting using nitrogen. The main advantages and disadvantages of the schemes for inerting cargo tanks are considered and determined: cascade, semi-cascade and parallel. The effective use of these schemes is based on the consumption of nitrogen, the amount of which is necessary for inerting, as well as the duration of the inerting process. The results of determining these indicators for a group of gas carriers with a cargo capacity of 38,646–62,233 m^3 are given. At the same time, it is stated that the lowest consumption of nitrogen is necessary to ensure the process of inerting according to the cascade scheme. It was established that semi-cascade and parallel inerting schemes require an increase in the amount of nitrogen by 1.74–2.42 times and by 1.28–1.83 times, respectively. It was also established that the cascade scheme of inerting requires more time for its implementation. The duration of inerting according to the semi-cascade and parallel scheme is reduced and is 0.43–0.64 and 0.58–0.75 times in comparison with the cascade scheme.

Keywords: cargo tanks, explosiveness of cargo tank atmosphere, inerting of cargo tanks, inerting using nitrogen.

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DOI: 10.15587/2706-5448.2024.310800

CONSIDERATION OF DC/DC CONVERTER FOR PHOTOVOLTAICS WITH SOFT SWITCHING WITH MODIFIED PUSH-PULL CURRENT SOURCE INVERTER CIRCUIT

pages 51–57

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The object of research is the power part of the two-stage converter. The paper evaluates the parameters of the power part of the two-stage converter with transformer isolation, designed for the transfer of solar battery energy to the 400 V constant voltage net-

work with the possibility of maintaining the maximum power point tracker (MPPT). The primary stage of the converter is made as a push-pull current source inverter topology with an additional switch, which is installed between the common point of the transformer's primary half-windings and the common point of the primary stage switches. The primary stage switches are made as a series connection of MOSFET transistors and Schottky diodes. The secondary stage has the traditional topology of a half-bridge voltage source inverter on MOSFET. A special switching algorithm of separated commutation is described, which provides non-dissipative snubber turn-on for of the current source inverter switches and their natural zero current turn-off switching (ZCS). The role of a snubber is performed by the leakage inductance of the transformer. For voltage source inverter switches, natural zero voltage switching (Zero Voltage Switching, ZVS) is provided. The role of non-dissipative capacitive switching snubbers may be performed by the MOSFET own output capacitance. The essence of this algorithm is to create a delay between the moment of forced switching on of the main key of the primary link and the moment of forced switching off of the transistor of the secondary link. There is also a small interval of energy return to the input source. Adjustment of the converter for the implementation of MPRT can be carried out by adjusting the ratio of the durations of the conduction state of the main and additional switches of the primary stage relative to the duration of the half-period of the frequency conversion. The types of switches were selected, static losses were estimated, simulation modeling was carried out in the MATLAB/Simulink environment, which confirmed the theoretical conclusions and the presence of soft switching modes.

Keywords: photo energy systems, DC/DC converter, current source inverter, voltage source inverter, soft switching, MOSFET, Schottky diodes, static losses, MATLAB/Simulink.

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