ABSTRACT AND REFERENCES

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DEVELOPMENT OF A METHOD FOR DETERMINING THE WEAR OF ARTILLERY BARRELS BY ACOUSTIC FIELDS OF SHOTS (p. 6–18)

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A possibility of assessing the level of wear of artillery barrels by acoustic fields of shots was studied. Despite the importance of knowledge on the current barrel state, existing methods of wear assessment are not sufficiently prompt. These methods give rather rough estimates of wear or require expensive equipment. Unlike the known methods, the method proposed in the article is prompt, does not require large expenses, can be combined with a training firing, and is easily automated. Characteristics of the shock and muzzle waves generated by a gunshot were studied and differences in their parameters for barrels without wear and those with a critical wear level were shown. Initial shell velocity serves as a criterion indicator of wear. It was shown that according to the acoustic characteristics, a shot from the barrel having any degree of wear is equivalent to a shot from a gun of a smaller caliber. A computational experiment was conducted on real acoustic signals recorded during the firing of a 155 mm howitzer. Informative attributes of acoustic signals from shots were selected. They make it possible to automatically classify barrels into two classes: barrels suitable for use and barrels with wear exceeding the critical level. It was shown that the application of the support vector method (SVM) makes it possible to confidently classify barrels by the level of their wear based on the temporal and spectral attributes of the shock and muzzle waves. A cumulative analysis of spectral characteristics was used in the analysis of acoustic signals from shots. This has a significantly increased likelihood of correct barrel classification. The results are useful for practical use in artillery units in the field conditions. The study results enable the development of an automated system for assessing the barrel condition with high promptness. This ensures sufficient accuracy in assessing the level of barrel wear in the combat practice.

Keywords: artillery barrel wear, initial shell velocity, shock wave, muzzle wave.

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DEVELOPMENT OF A SYSTEM FOR DETERMINING THE INFORMATIVENESS OF THE DIAGNOSING PARAMETERS FOR A CYLINDERPISTON GROUP IN THE DIESEL ENGINE DURING OPERATION (p. 19–29)

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A possibility has been investigated to diagnose the condition of a cylinder-piston group in the diesel engine KamAZ-740.63-400 for trucks KamAZ-6460 after a 60,000 km run. The following diagnosing parameters have been selected: a crankcase gas pressure, the compression and vacuometric properties of a cylinder-piston group. A special feature of these mated parts is that they maintain the normal combustion process in the diesel engine cylinders, as well as its resource. We have determined the boundary limits for diagnosing a crankcase gas pressure – 2.39–2.41 KPa. Based on data about the crankcase gas pressure, the examined trucks revealed malfunctions on the runs of 36,000 km, 48,000 km, 60,000 km. Given the rules for assessing the characteristics of compression-related faults, the minimum compression value for the diesel engines was 30.05 MPa or its difference among the cylinders did not exceed 10–12 %. The data on compression helped detect faults after 48,000 km run and 60,000 km run. We have determined the boundaries of wear based on the vacuometric parameters: maximum vacuum – 69–86 KPa; residual vacuum – 26–41 KPa. Control of the vacuometric properties of a cylinder-piston group has revealed faults in the diesel engines over their run interval of 36,000–60,000 km.

An entropy approach has been applied to estimate the informativeness of the appropriate diagnosing parameters in bits. The informativeness level of a crankcase gas pressure is 0.329 bits, compression in cylinders – 0.249 bits, vacuometric indicators – 0.582 bits.

This study allows the rational formation of the diesel engine condition diagnosing complexes during technical operation, as well determining the prerequisites for malfunctions. The data acquired are important for transportation and service enterprises and companies that manage freight vehicles.

Keywords: diesel engine, diagnosing, compression, cylinder-piston group, crankcase gas pressure, vacuometric properties of mated parts, entropy, informativeness.

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ANALYTICAL AND PHYSICAL MODELING OF THE MAGNETICALLY ACTIVE PART OF A LINEAR ELECTRIC GENERATOR WITH PERMANENT MAGNETS (p. 30–37)

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Linear electric generators are increasingly used in autonomous systems that require a compact source of electricity and when it is necessary to simplify mechanisms of power systems. To study the characteristics of a linear electric generator, an analytical model of its magnetically active part was proposed. The model is based on the assumption of the periodicity of linear translational motion of the armature relative to the stationary cylindrical winding. Based on the representation of the magnetic field of the generator's armature by cylindrical harmonics of the scalar potential, the magnetic flux generated by the inductor was analyzed. The inductor design contains several pairwise oppositely oriented cylindrical permanent magnets. The use of representations based on cylindrical harmonics for the magnetic flux and EMF induced in a circular circuit has made it possible to substantiate the rational number of cylindrical armature magnets and their geometric parameters. The losses caused by the technological necessity of using annular magnets instead of solid continuous cylindrical ones with the same overall dimensions were estimated. Analysis of losses of the magnetic flux linkage with the current winding resulting from the presence of technologically necessary clearance between the permanent magnets and the winding sections was carried out. An analysis of arrangement and switching of the winding sections was carried out. It has made it possible to justify the choice of rational cross-sectional dimensions. For experimental verification of the analytically obtained results, a physical model of a linear electric generator with an armature containing permanent cylindrical magnets was designed. Its translational periodic movement was provided through an external electric drive. Analysis of the EMF dependences recorded with a digital oscilloscope with a small (5 %) error has confirmed the obtained analytical results and correctness of the theses underlying the model.

Keywords: linear electric generator, magnetic flux, permanent magnet, electromotive force, cylindrical harmonic.

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THE STRESSEDSTRAINED STATE OF A ROD AT CRYSTALLIZATION CONSIDERING THE MUTUAL INFLUENCE OF TEMPERATURE AND MECHANICAL FIELDS (p. 38–49)

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This paper reports a solution to the problem of determining the motion law of the crystallization front and the thermomechanical state of a two-phase rod for the case of mutual influence of the temperature and mechanical fields. An approximate analytical method has been used to solve the problem, combined with the method of successive intervals and a Gibbs variation principle. This method should indicate what is "more beneficial" to nature under the assigned external influences – to change the temperature of the fixed element of a body or to transfer this element from one aggregate state to another. It is this approach that has made it possible, through the defined motion law of an interphase boundary, to take into consideration the effect of temperature on the tense-deformed state in the body, and vice versa. The ratios have been obtained to define the motion law of an interphase boundary, the temperature field, and the tense-deformed state in the rod. The results are shown in the form of charts of temperature and stress dependence on time and a coordinate.

An analysis of the results shows that changes in the conditions of heat exchange with the environment and geometric dimensions exert a decisive influence on the crystallization process, and, consequently, on temperature and mechanical fields. The principal result is the constructed approximate analytical method and an algorithm for solving the problem on thermoviscoelasticity for growing bodies (bodies with a moving boundary) in the presence of a phase transition considering the heat exchange with the environment. Based on the method developed, the motion law of an interphase boundary, a temperature field, and the tense-deformed state are determined while solving the so-called quasi-related problem of thermoviscoelasticity. An approximate analytical solution has been obtained, which could be used by research and design organizations in modeling various technological processes in machine building, metallurgy, rocket and space technology, and construction.

Keywords: thermomechanical state, Gibbs variation principle, crystallization front, approximate analytical method.

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FEATURES OF MATHEMATICAL MODELING OF ELECTROMAGNETIC PROCESSING OF BULK MATERIALS (p. 49–59)

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The article notes the features of applying the general equations of mathematical physics of an elliptic type in problems of modeling specific phenomena of the interaction of electromagnetic fields with elements and particles of an inhomogeneous dispersed medium. Such phenomena take place in installations for the separation of organic and mineral raw materials or the electromagnetic treatment of grain, seeds, etc. This is relevant, because the usual approach to the formulation of mathematical models in these problems, which is mainly based on differential equations of field theory in a simplified form, does not always adequately reflect the physical essence of the mentioned phenomena. Therefore, it limits the possibilities of an in-depth study of the influence of many factors determining the final results of separation and electromagnetic processing (EMP)

processes. In the present work, an alternative approach is proposed based on the use of integral equations of field theory, which is based on the concept of primary and secondary field sources and can significantly reduce the order of the system of equations for the numerical implementation of algorithms for solving EMP problems, and the total amount of necessary computing resources. With this approach, local parameters of the field in interaction with individual particles and their influence on one another become available for calculation. This aspect is essential for determining the technological characteristics of EMP production installations. The presented mathematical model, in contrast to the common simplified approaches to determining the field parameters and ponderomotive forces acting on the particles of matter in the field, adequately reflects the physical laws of the distribution of potentials and electric field strength of real charges and induced sources. Due to this, it clearly reproduces the mechanism of the formation of the main components of mechanical forces acting on the polarized body from the side of the electric field as a whole, through the densities of elementary forces with which the field acts on surface charges induced in dielectric bodies in the field of action of the fields. Such a mathematical model is a universal and compact tool for analysis, design, and optimization of various installations and devices that use an electric field and its electromechanical interaction with the medium and individual bodies.

Keywords: electromagnetic treatment, dispersed materials, mathematical modeling, electric field, particles, substance, force.

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