ABSTRACT AND REFERENCES

APPLIED PHYSICS

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COMPARATOR EFFECT ON EQUIVALENCE OF RESULTS OF CALIBRATING CURRENT TRANSFORMERS (p. 6-15)

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Many different high-precision systems for determining the ratio error and phase displacement of current transformers have been developed by leading specialists in the world. The latest research solutions with the use of the latest measurement tools, instantaneous sampling techniques, and analysis of sources of uncertainty have been applied in these developments. The objective difficulty is that only a limited number of specialized institutes implement such projects with the involvement of leading experts in the field of measurement and significant funds. First of all, these are the national metrological institutes of countries with high economic opportunities. At the level of conventional calibration laboratories equipped with modern facilities and highly qualified personnel, the uncertainty of measurements increases 10 times or more when calibrating precision instrument transformers. Thus, it has not been investigated to what extent the readouts of commercial comparators of different manufacturers in the calibration of instrument transformers of class 0.2S and more precise are equivalent. Determination of the equivalence level of AC comparators of different types in the day-to-day calibration of current transformers is the main objective of this research. More than 50 comparators of different types (with inductive or resistive current transducers) were investigated relative to 2 well-characterized reference current transformers. Comparison of the results obtained by two instruments with radically different principles of measurement gave a difference of 23 μA/A in ratio error and 52 μrad in phase displacement. The results of estimating the readout stability of modern comparators of serial production are also highlighted. The results of the analysis of the data obtained allow us to assume that measurement results of ratio error of about 50 μA/A have equivalence level within ±20 μA/A. The measurement results of phase displacement of about 50 μrad have equivalence level within ±15 μrad. Concerning the determination of metrological characteristics of current transformers with accuracy class 0.2S, their equivalence must be considered taking into account all exploited comparators. The results cause the question about the adequacy of the accuracy margin of the current transformer in the production to overlap the difference in the readouts of 260 μA/A and 500 μrad.

Keywords: equivalence, measurement, comparator, current transformer, standard, ratio error, phase displacement, uncertainty.

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DESIGN OF THE CONCEPTUAL IMPLEMENTATION OF AN APPARATUS WITH THE INDUCED HEAT AND MASS TRANSFER FOR VAPORIZATION AND RECTIFICATION (p. 16-21)

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The need to find solutions to problems on the efficient use of energy resources has been substantiated, under conditions for meeting the requirements to the environmental sustainability of production in the process of executing such technological operations as vaporization and rectification. We have identified the prospects of searching for and applying the induced processes, which are characterized by high energy efficiency and are environmentally friendly.

The kinetics of temperature have been investigated under the effect from the induced heat transfer of the components of the internal thermostat volume, under condition of using different liquids in its internal environment.

Our study has established the impossibility for the liquid in the inner volume thermostat to achieve the boiling temperature under condition of the effect of the induced heat and mass transfer, proven by the visual observations and by the value of its temperature. In the experiment under atmospheric pressure, the thermostat temperature was equal to 115...116 °C, while the temperature of the volumetric water did not exceed 97 °C. It was established that at the thermostat temperature of 105...106 °C and under atmospheric pressure, the ethyl alcohol temperature did not exceed 72...73 °C, and for water – 83...85 °C, under the condition of the effect of the induced heat-and-mass transfer.

It was found that ethyl alcohol and water are transferred to the gas state under the effect of the induced heat-and-mass transfer separately. It is possible to register the removal of the liquid phase of the mixture components based on the jump-like transition in the kinetics of the fluid temperature. It was established that the liquid phase did not boil for a mixture of ethyl alcohol with water under the effect of the induced heat-and-mass transfer at the thermostat temperature of 105 °C and under atmospheric pressure.

We have proposed a conceptual solution to the technical implementation of the universal device that employs the effect of the induced heat-and-mass transfer in order to execute technological operations of vaporization and rectification excluding the boiling phase. Based on a given conceptual solution, we have built a laboratory prototype of the installation, in which vaporization is carried out under atmospheric pressure at the liquid phase temperature of 83...85 °C. The economic effect from the installation is achieved through the simplified equipment and reduction in energy consumption per product unit by larger than 1.3 times compared to the vacuum-evaporator apparatus.

Keywords: effect of induced heat-and-mass transfer, vaporization operation, rectification, temperature kinetics, thermostat obturator.

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DETERMINING THE FORCE FUNCTION DISTRIBUTION IN THE WORKING ZONE OF A DISK MAGNETIC SEPARATOR (p. 22-29)

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The paper reports a research into the distribution of magnetic force function in the working zone of a newly-designed disk separator, intended to clean the finely-dispersed bulk substances, transported by a belt conveyor, from unwanted ferromagnetic impurities. It has been shown that it is expedient, in order to create the required magnetic field topology in the working volume of the separator and to improve its energy efficiency, to use permanent magnets. It has been substantiated that the main advantage of the proposed device on permanent magnets is a possibility to self-clean the surface of a non-magnetic rotating discharge disk. Solving the main tasks of this research has employed a finite-element method implemented in the programming environment COMSOL Multiphysics. We have investigated a magnetic force function that acts on multi-domain ferromagnetic particles. Given the complexity of the spatial geometry of power field distribution in the working zone of a disk magnetic separator, we have constructed a three-dimensional model of the magnetic system. The effect of the magnitude of an air gap and, accordingly, the effective length of sector-like permanent magnets on the distribution of power magnetic function in the working zone has been determined. It has been shown that changing the air gap alters both the force function distribution for the height of the working zone and the magnitude of the power action. Recommendations have been given on the use of magnetic systems with different gaps. It has been established that for the extraction of ferromagnetic inclusions the uniformity of the force function distribution in the direction of deploying a spiral of magnets is important. It has been proven that magnetic systems with small gaps should be used in separators without an unloading disk. In this case, the magnetic system can be installed in close proximity to the separated material while the surface of permanent magnets should be carried out manually in proportion to the accumulation of the extracted ferromagnetic inclusions on them. The result of our study is the established rational size for an air interpolar gap, which ensures the maximum magnitude of power action and, consequently, a more efficient operation of the magnetic separator.

Keywords: permanent magnet, force function, magnetic system, magnetic separator, unloading disc.

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DEVELOPMENT OF THE AEROMAGNETIC SPACE DEBRIS DEORBITING SYSTEM (p. 30-37)

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The study has considered the possibility of creating an aeromagnetic system for removing space debris from low Earth orbits. The peculiarity of the design of the aeromagnetic deorbiting system is the use of magnetic controls for the relative position of the aerodynamic element with permanent rotary magnets that are shielded with the help of special screen capsules with shutters. It should be noted that this system is offered for aerodynamically unstable spacecraft. Besides, to analyse the performance and benefits of using permanent magnet aeromagnetic input systems, a corresponding discrete law is proposed to control the magnetic parts. The control of the relative position of the aerodynamic element in the orbital coordinate system is carried out in order to orient and stabilize it perpendicular to the dynamic incident atmospheric flow. A mathematical simulation has been performed for the orbital motion of a spacecraft during its removal with the help of a permanent magnet aeromagnetic system from different orbits. It has been determined that when stabilizing the aerodynamic element perpendicular to the vector of the incident dynamic atmospheric flow, the withdrawal time is reduced by 25 % compared with the non-oriented passive deorbiting. However, this advantage during the removal time is peculiar only to aerodynamic elements whose midsection area is much larger than a quarter of the total surface area. It is noteworthy that the design of aeromagnetic evacuation systems is only appropriate using aerodynamically deployable sail elements and is not effective at all for large inflatable elements.

Thus, the development of an aeromagnetic space debris removal system with permanent magnet controls extends the boundaries of effective use of aerodynamic sailing systems. The use of permanent magnet units provides a new direction for further research on the orientation of large-scale space systems with minimal fuel and onboard energy consumption.

Keywords: aeromagnetic deorbiting system, permanent magnets, spacecraft, discrete control law.

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IMPOVING ENERGY CHARACTERISTICS OF THE WELDING POWER SOURCES FOR TIG-AC WELDING (p.38-43)

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This paper proposes a circuit solution and a control algorithm for a welding power source for TIG-AC welding with improved energy characteristics. The source is made using a welding transformer and a low-voltage series active power filter on power field effect transistors with a low channel resistance. The transformer used can be with normal or increased leakage. The proposed source is characterized by improved technical parameters due to the possibility to form V-I characteristic with the required stiffness without switching the welding transformer taps. Control scheme ensures the elimination of a DC component of welding current during a TIG-AC process; it is also possible to control the waveshape of a welding current. Also, a "soft"

arc ignition based on the Lift-Arc principle is provided, which positively affects the service life of a non-fusible electrode. The developed source is distinguished by a possibility to work in a reactive power compensation mode. This reduces the consumption of reactive power by electrical complexes with welding power sources and reduces a current loading on the distribution network. Application of the proposed principle to construct a source for arc welding with an alternating current makes it possible to modernize existing transformer sources by installing an active power filter unit in them. That would improve consumer properties of the sources by improving the stability of a welding arc, by smooth regulation of welding current, reducing the effects of a network voltage fluctuations on quality of the welding process. It eliminates the need to apply ballast resistors for adjusting a welding current, as well as the block of capacitors to eliminate the magnetization of a transformer during the TIG-AC process. The proposed source could be used not only to implement TIG-AC, but the MMA, MIG, MAG alternating current welding processes.

Keywords: non-fusible electrode welding, welding power source, reactive power, active filter.

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PROCEDURE FOR MODELING DYNAMIC PROCESSES OF THE ELECTROMECHANICAL SHOCK ABSORBER IN A SUBWAY CAR (p. 44-52)

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A procedure has been devised for modeling the dynamic processes in the proposed structure of an electromechanical shock absorber. Such shock absorbers can recuperate a part of the energy of oscillations into electrical energy allowing the subsequent possibility to use it by rolling stock. The procedure is based on solving the Lagrange equation for the electromechanical system. The model's features are as follows. The model takes the form of a Cauchy problem, thereby making it possible to use it when simulating the processes of shock absorber operation. Two generalized coordinates have been selected (the charge and displacement of the armature). The components of the Lagrange equation have been identified. Based on the results from magnetic field calculation and subsequent regression analysis, we have derived polynomial dependences of flux linkage derivatives for the current and linear displacement of an armature, which make it possible to identify a generalized mathematical model of the electromechanical shock absorber. The magnetic field calculations, performed by using a finite-element method, have allowed us to derive a digital model of the magnetic field of an electromechanical shock absorber. To obtain its continuous model, a regression analysis of discrete field models has been conducted. When choosing a structure for the approximating model, a possibility to analytically differentiate partial derivatives for all coordinates has been retained. Based on the results from modeling free oscillations, it was established that the maximum module value of current is 0.234 A, voltage – 52.9 V. The process of full damping of oscillations takes about 3 seconds over 4 cycles. Compared to the basic design, the amplitude of armature oscillations and its velocity dropped from 13 to 85 % over the first three cycles, indicating a greater efficiency of electromechanical shock absorber operation in comparison with a hydraulic one. The recuperated energy amounted to 3.3 J, and the scattered energy – 11.5 J.

Keywords: electromechanical shock absorber, subway car, Chebyshev polynomials, finite-element method, Lagrange equation.

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