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EXPERIMENTAL RESEARCHING OF BIOLOGICAL OBJECTS NONINVASIVE PASSIVE ACOUSTOTHERMOMETRY FEATURES (p. 6–12)

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Experimental confirmation of the possibility of real-time measurement of the internal (deep) temperature of a biological object by thermal acoustic radiation with an accuracy of at least 0.2 °C using an acoustic thermometer implementing the modified zero modulation method is obtained. The model of a single-channel passive noninvasive focussed acoustic thermometer based on a plate piezoceramic electro-acoustic transducer, acoustic elliptical lens and blocks of two serial voltmeters is developed. Electronic switching of the output signals of the noise simulator and the equivalent circuit of the focused piezoelectric transducer is proposed, when resistance generates thermal noise with an intensity equal to the sum of intensities of acoustic radiation of the biological object and natural noise of the piezoelectric transducer. This circuitry solution made it possible to exclude the mechanical modulator (shutter) unit used in analogs from the acoustic thermometer circuit. When developing the original switching and detection unit, it was proposed to use the key mode of n-channel field-effect transistors to perform modulation of the input noise signal. Calculation of equivalent circuits of the piezoelectric electroacoustic transducer and noise simulator, which are connected circuits with a bandwidth in which the average noise voltage level is determined by the noise voltage at the electric resonance frequency of the piezoelectric element, is performed. The possibility of using the model of the single-channel passive noninvasive focussed acoustic thermometer, constructed according to the circuit implementing the modified zero modulation method, for measuring noise voltages in the range from 5 to 30 μV is proved. Since the process of manufacturing or operating a piezoceramic electroacoustic transducer may lead to a deviation of its parameters from theoretically calculated, a method is developed to measure the frequency response of the active and reactive components of electrical impedance. Using the proposed method, the assembly quality of the focused piezoelectric electro-acoustic transducer is monitored and the temperature dependence of electric noise voltage at the electrodes of the focused piezoelectric receiver is obtained.

Keywords: ultrasound, acoustothermometry, internal temperature, piezoelectric transducer, acoustic thermometer, thermal acoustic radiation.

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THE CHOICE OF THE METHOD AND TECHNICAL MEANS FOR THE AUTOMATIC CONTROL OF THE INSULATION THICKNESS OF THE FRAMES IN THE WINDING PROCESS (p. 13–18)

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The existing problems in the field of controlling the insulation thickness of cylindrical frames in the process of automatic winding are shown. Methods of controlling the insulation thickness of steel and plastic frames used in the electrical industry are also analyzed.

Control of the insulation thickness after winding increases the amount of waste thermal insulation from expensive materials (for example, glass insulation), eliminating the identified violations is rather time-consuming and can make products unusable. Therefore, automation of the insulation thickness control process during winding has always been a difficult but urgent task. The solution to this problem can eliminate manual labor, reduce waste and improve the quality of industrial products used in the electrical and radio engineering industries. Operation principles, physical models and applications of various types of electromagnetic transducers of non-electrical quantities to electrical ones are considered. Features and characteristics of the main types of electromagnetic transducers of the insulation thickness of frames are analyzed. The characteristics of the main types of electromagnetic transducers of the thickness of glass insulation of frames are compared, their relative advantages and disadvantages are shown. Based on the analysis of the appropriate methods for controlling the thickness of various elements, problems are identified in the automation of insulation thickness control of plastic and steel frames in the winding process. Comparative analysis of the designs and characteristics of existing transducers shows that it is necessary to improve the design of linear induction levitation-screen suspensions and create effective methods of transmitting displacements to the levitation screen. Then the obtained unconventional designs can be successfully used for automatic control of the insulation thickness during winding it on rotating frames. For this purpose, differential inductive and transformer transducers with levitation screens and moving measuring windings are recommended. These transducers provide the required measurement accuracy, unambiguous continuous conversion of the insulation thickness into an electric signal in the winding process.

Keywords: electromagnetic transducer, magnetic conductivity, magnetic resistance, magnetic field, transducer sensitivity.

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DETERMINATION OF COMPOSITION BASED ON THERMAL CONDUCTIVITY BY THERMISTOR DIRECT HEATING METHOD (p. 19–29)

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Thermophysical properties of various substances and mixtures were studied by the non-destructive method. It is proposed to determine the thermal conductivity of substances and mixtures by the thermistor direct heating method.

The device was created for measuring the thermal conductivity of various substances and mixtures, the operation of which is based on measuring the temperature of thermistor heating in the test substance. The nonlinear nature of the obtained thermistor heating dependence is taken into account.

Based on the studies, the possibility of determining the composition of the mixture by its thermal conductivity coefficient is shown. The results of experimental studies with reference liquids, solutions of sugar, glycerin and alcohol in water are presented. The results of the studies to determine the thermophysical properties (TPP) of biological substances (human blood and blood plasma, egg white and yolk and others), some vegetables using the method of thermistor direct heating in the temperature range from +25 °C to +40 °C are given. It is substantiated that when studying the TPP of substances by thermistor direct heating, it is possible to determine the composition of mixtures by their thermal conductivity, but it is necessary to take into account individual properties of the studied liquids. Recommendations are given for studying the TPP of substances and determining the composition of mixtures by their thermal conductivity, taking into account individual properties of the studied substances.

Using the proposed method of thermistor direct heating to determine a mixture of solutions, biological materials and food products allows analyzing the composition of nanosubstances, obtaining reliable data on the degree of allergic reaction, and in determining the composition of food products – taking into account the data obtained when developing refrigeration equipment and extending the shelf life of products while maintaining their useful qualities.

Keywords: measurement, thermal conductivity, thermistor, thermophysical properties of substances, mixture composition.

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MATHEMATHICAL MODELING OF A SYNCHRONOUS GENERATOR WITH COMBINED EXCITATION (p. 30–36)

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The generators of classical design – with a cylindrical stator and rotor – are of interest. This is predetermined by that a given structure is the most common, simple, and technological. The result of the development of such electric machines is a possibility to build a combined series of induction motors and magnetoelectric synchronous machines. In these machines, replacing a short-circuited rotor by a rotor with permanent magnets and controlled working magnetic flux turns the induction machine into a magnetoelectric synchronous one. All existing generators with permanent magnets have a major drawback: there is almost no possibility to control output voltage and, in some cases, power. This is especially true for autonomous power systems. Known methods of output voltage control lead to higher cost, compromised reliability, deterioration of mass-size indicators.

This paper reports the construction of a three-dimensional field mathematical model of a magnetoelectric synchronous generator with permanent magnets. The model has been implemented using a finite element method in the software package COMSOL Multiphysics. We show the distribution of the electromagnetic field in the active volume of the generator under control and without it. The impact of a control current in the magnetized winding on the external characteristics of the generator at a different coefficient of load power has been calculated. Applying the devised model has enabled the synthesis of a current control law in the magnetizing winding at a change in the load over a wide range.

The results obtained demonstrate that it is possible to control output voltage of the generator with permanent magnets by using an additional magnetizing winding. The winding acts as an electromagnetic bridge for the main magnetic flux, which is created by permanent magnets. Our analysis of results has shown that it is possible to regulate the output voltage of the generator with constant magnets within –35 %, +15 %.

Keywords: generator voltage control, magnetizing winding, magnetoelectric excitation, permanent magnets.

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SYNTHESIZING AN ALGORITHM TO CONTROL THE ANGULAR MOTION OF SPACECRAFT EQUIPPED WITH AN AEROMAGNETIC DEORBITING SYSTEM (p. 37–46)

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It is known that the synthesis of the relevant control law is performed and appropriate control devices are selected for specific tasks of controlling relative spacecraft motion. Flywheels, control moment gyroscopes, electromagnetic devices with permanent magnets and micro-jet engines are used as actuators in controlling the orientation and stabilizing the spacecraft. For example, flywheel motors together with electromagnets are most often used to ensure precise spacecraft stabilization in remote Earth monitoring (REM) problems. At the same time, there is a series of problems pertaining to the control over the relative motion of spacecraft where there is no need for precise spacecraft stabilization and ensuring minimal errors in orientation. These problems may include spacecraft orientation for charging solar batteries or orientation control for research and meteorological spacecraft.

The study's purpose is to synthesize a law for spacecraft orientation control algorithm when using executive devices with permanent magnets (EDPM). EDPMs are the devices controlling spacecraft orientation. They consist of rotary permanent magnets, stepper motors, and capsule-screens with shutter flaps. Opening and closure of the capsule-screen flaps and rotation of permanent magnets in a certain way ensure the generation of a discrete control magnetic moment. It should be noted that EDPMs do not provide accurate spacecraft stabilization and hence they are not suitable for the REM purpose. However, EDPMs consume less on-board energy than other spacecraft orientation control systems and are useful in problems requiring less accurate stabilization.

A control law was synthesized for controlling spacecraft equipped with EDPM using a nonlinear controller and a pulse-width modulator. Areas of effective EDPM application for various space-related problems including orientation and stabilization of aerodynamic elements perpendicular to the dynamic flow of the incoming atmosphere were determined. Advantages of using EDPMs in comparison with electromagnetic executive devices in the problems pertaining aerodynamic element stabilization in aerodynamic systems of deorbiting worked-out spacecraft from low Earth orbits were shown.

Keywords: control law synthesis, permanent magnet devices, spacecraft, non-linear controller.

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EFFECT OF THE PRIMER ON BARCODE QUALITY IN INK-JET PRINTING (p. 47–54)

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It has been proposed to modify the surface of offset and coated paper with a special coating (primer) that ensures the high quality of ink-jet printing, specifically barcodes. The application of digital ink-jet printing using aqueous-based inks makes it difficult to achieve the required print quality on conventional paper. Ink-jet printing is widely used in the production of customized packaging and labeling products. Given that this type of products contains the printed barcode, it is necessary to ensure its functionality (readability) after printing.

The primer ensures a controlled process of ink absorption at ink-jet printing, thereby improving the print quality. To this end, a composition of the primer was used on the basis of a water solution of the interpolymeric complex of polyvinyl alcohol (PVOH) and polyvinylpyrrolidone (PVP).

The influence of the primer that contains different amounts of the interpolymeric complex on a change in the water contact angle of imprinted paper has been investigated.

Prints on paper with and without the primer were obtained using an ink-jet printing method; quality of the line and barcode print was assessed. Such quality indicators for the line were defined as a line width on the imprint, a line blurriness at the line-paper interface, a line raggedness, and the optical density. In addition, the primer's effect on the barcode print quality at ink-jet printing was investigated.

The study results make it possible to ensure the high quality of barcode printing on conventional print papers by using an ink-jet printing method. Applying the primer improves the line and barcode print quality. The barcode quality grade increases from the lowest (unacceptable) score of 0 (F) on paper without a primer to a score of 2 (C) on paper with the primer, which warrants that it is readable on packaging by a scanner.

Keywords: ink-jet printing, primer, polyvinyl alcohol, print quality, barcode, bar line.

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DEVELOPMENT OF AN INTENSIVE MICROWAVE-THERMAL TREATMENT TECHNOLOGY FOR HETEROGENIC ENVIRONMENTS (p. 55–64)

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The study suggests a technology of intensive, energy-efficient microwave-thermal mass transfer during washing and drying of agricultural and industrial products in a non-resonant microwave chamber with a uniform heating field. The chamber is equipped with a vacuum pump and an ultrasonic generator and is functionally connected to the evaporator and condenser of the heat pump. The traveling wave mode in the microwave chamber and intense evaporation are facilitated by the microwave field energy concentrator in the volume of the environment and the absorbing ferrite coating, which converts the ballast energy of the field into thermal energy on a perforated partition for products. This helps to reduce the significant cost of time and energy in the case of washing and drying heterogenic environments.

The article substantiates the direction of developing the physicotechnical foundations of microwave-thermal treatment of environments with the aim of washing products using ultrasonic and microwave generators in a vacuum chamber to intensify the process. The authors show the necessity of developing the theory and practice of manufacturing and using radio-absorbing materials converting field energy to thermal energy. A coordinated integration of the upgraded microwave and additional convection drying technologies is proposed for the purpose to harmonize economical, intensive and environmentally friendly mass transfer of moisture during drying of the processed environment. It was found that the achievement and use of a synergistic effect, namely the energy efficiency of the process of complete drying in the middle of the chamber, contributes to the intensive evaporation of moisture from products in a uniform electromagnetic field in the chamber and the current dehumidification of moist air by the heat pump evaporator. Dry air is supplied into the microwave chamber after it is heated by the heat pump condenser. This contributes to a significantly more effective washing and drying of products. The application of this circuit solution and the optimal parameters of the regime in practice make it possible to solve the contradictory problem of increasing the efficiency and environmental friendliness of the processes in everyday life as well as in agricultural and industrial production.

Keywords: microwave-thermal mass transfer, non-resonant microwave chamber, coating-transformer, heat pump.

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A NUMERICAL STUDY OF PROTON EXCHANGE MEMBRANE FUEL CELL PERFORMANCES AFFECTED BY VARIOUS POROSITIES OF GAS DIFUSSION LAYER MATERIALS (p. 65–75)

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One of the factors that can increase the surface transfer property for gas diffusivity apart from the membrane material in PEMFC is the porosity of the gas diffusion layer material affecting species mass distribution at the electrodes. The present study simulates the performance of PEMFC by investigating the effect of GDL porosities in some commercial ELAT-TEK-1200W (ε=0.31), and SIGRACET 25BA (ε=0.63), also an organic material coconut coir (ε=0.88) numerically. It was carried out using COMSOL Multiphysics 5.3a in the form of species mass concentrations plotted in the surface contour and cut points at the electrodes in the elapsed time transiently. Afterward, the results were used to determine the PEMFC performance by calculating some losses; activation, ohmic, and mass concentration polarization. The results showed that the PEMFC performance was only influenced by the mass polarization. It means that the power density is strongly influenced by the concentration of species in the anode and the cathode. The mass concentration is strongly influenced by the distribution of species; H_2, O_2, and H_2O formed during the reaction. The highest H_2 concentration at the anode occurs in the GDL using ELAT-TEK-1200W having the smallest porosity producing the highest power density compared to other GDL materials. It makes an easier diffusion process between H_2 and O_2 species to work properly. However, coconut coir as an organic material can be a promising GDL in the future because of its performance compared to the others.

Keywords: numerical study, PEMFC, performance, porosity, gas diffusion layer, material, COMSOL Multiphysics.

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