ABSTRACT AND REFERENCES

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STUDY INTO THE RESONATOR STRUCTURES WITH MICROPROBE SENSING ELEMENTS (p. 6-13)

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By using methods of mathematical modeling and in the course of an experimental study we have investigated various types of microwave resonator measuring transducers with microprobe sensing elements of coaxial type. Such a study was necessitated by their widespread application for local non-destructive testing and for diagnostics electrophysical characteristics of micro- and nanoscale objects and structures.

In order to analyze the resonator measuring transducers with microprobe elements, we have chosen, as the basic criterion, attaining the maximal quality factor, which determines the sensitivity of measurements. We have investigated the structures of measuring transducers based on a coaxial resonator with gradually changing geometrical dimensions, resonators based on the segments of regular waveguides, a cylindrical resonator. In addition, the microwave measuring transducers based on hybrid irregular volumetric and planar structures have been examined. We have considered the distribution character of an electromagnetic field in the structures of transducers, the amplitude-frequency characteristics, as well as changes in them during interaction with external objects. The result of this study is the identified possibilities to improve quality factor for different types of the resonator measuring transducers with microprobe elements to the magnitudes the order of 104. We have proposed, designed, and examined practical structures of measuring transducers, which could be used both in scanning microwave microscopy and in other measuring systems and complexes. We have developed and investigated a measuring transducer based on a coaxial structure that has resonances in a wide range of working frequencies. We have designed and explored the technologically simple structures of high-quality resonator transducers of the pass-through type in the centimeter and millimeter wavelength range based on segments of regular waveguides. A possibility to construct a high-quality measuring transducer based on the hybrid irregular structures, which are excited at the highest types of oscillations, has been experimentally proven. We have revealed a strong influence of characteristics of the coupling elements on the parameters of resonator measuring transducers, which must be taken into consideration when they are applied in practice. The results of our study would make it possible to expand the range and scope of application of methods for the local non-destructive microwave diagnostics of small-dimensional objects and structures.

Keywords: microwave diagnostics, resonator measuring transducer, microprobe structure, scanning microwave microscopy.

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A COMPARATIVE ANALYSIS OF AC/DC TRANSFER STANDARDS FOR COMPARISON OF NATIONAL STANDARDS (p. 14-24)

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The development of standards based on quantum effects, in particular, alternating voltage synthesizers, has not yet allowed defining the metrological characteristics of measuring instruments for alternating voltage up to 1,000 V at a frequency up to 1 MHz. Therefore, a comparative analysis of international comparisons of national standards has summarized the possibilities of metrological support with the use of AC/DC voltage transfer standards.

The conducted analytical and experimental studies give grounds to state the decisive contribution of national metrological institutes in the formation of the modern equivalence level of AC/DC voltage transfer standards. A comparative analysis of the uncertainty of measurements achieved by the leading national metrology institutes has made it possible to distinguish the most accurate type of thermal voltage converters based on the thermocouples connected in series. Such a measuring instrument allows measuring AC/DC transfer difference with an uncertainty of less than 1 μV/V at certain points of the measuring range.

Consideration of the capabilities of the travelling standards to ensure a stable storage of a value of AC/DC voltage transfer difference has indicated the advantage of the thermal converter of an indicated above type, relative to the other types used in the comparisons of AC/DC transfer standards. The calculation of stability coefficients for different types of standards has shown an approximately twofold advantage of thermal converters based on the thermocouple comparing with multi-range thermal comparators on the basis of the root-mean-square voltage sensor. The results of the considered comparisons have shown that there were no advantages of any of the measurement schemes used by the laboratories since no relation has been found between the reported measurement uncertainty and the scheme.

The results of the estimation of the frequency influence of the input voltage on the transformation coefficient of the AC/DC voltage transfer standards of the two types have given the grounds to neglect correcting the contribution of this source of uncertainty. The proposed approach to measuring the AC/DC transfer difference with providing the connection with a direct definition allows us to estimate more appropriately this metrological characteristic in two ways.

Keywords: comparison, thermal converter, voltage transfer, travelling standard, uncertainty of measurement.

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DESIGN OF LINEAR CAPILLARY MEASURING TRANSDUCERS FOR LOW GAS FLOW RATES (p. 25-32)

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The performed analysis of known capillary flowmeters for low gas flows reveals the prospect of constructing the primary measuring transducers of flowmeters with a linear output signal. Owing to the stability of dimensions of the pass-through channels in glass capillaries channels such flowmeters can demonstrate high metrological characteristics. In this regard, we have investigated the capillary as a sensing element in the primary transducers of flowmeters for low gas flows.

Different circuits of capillary primary transducers for the measuring instruments of low gas flow rate have been examined. Our study makes it possible to select the optimal circuit of a primary measuring transducer based on the measurement range, as well as the number and size of the pass-through channels in capillaries. For example, the flow meter based on a package of capillaries demonstrates a wider measurement range compared to other schemes.

We have derived analytical dependences that enable the design of single- capillary, package, and bridge transducers. Comparative characteristics of the specified primary measuring transducers are provided. We have constructed algorithms for calculating dimensions of channels in the capillaries of transducers with a linear output signal.

The influence of temperature and barometric pressure on a deviation in the static characteristic of the transducer has been estimated. It was established that the bridge circuit, unlike others, ensures partial compensation for the influence of external factors.

We have designed and investigated a capillary oxygen flowmeter, constructed using the bridge measurement circuit with a linear conversion function, intended for an automated system of the manufacturing process of workpieces for fiber light guides. The upper limit of measurement by the flowmeter is at the level of 54 l/h, its basic relative error is 0.8 %.

Keywords: capillary package, bridge capillary circuit, linearity of conversion function, low gas flow rate.

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EXPERIMENTAL STUDY OF THE EFFECT OF NANOPARTICLES OF TiO_2 ON THE THERMOPHYSICAL PROPERTIES OF THE REFRIGERANT R141b (p. 33-42)

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The results of the experimental study of the thermophysical properties of the R141b refrigerant, R141b/Span-80 surfactant solution and R141b/Span-80 surfactant/TiO_2 nanoparticles nanofluid are presented. The content of both the surfactants and TiO_2 nanoparticles in the objects of the study was 0.1 wt. %.

The measurements have been performed along the liquid-saturation line in the temperature ranges of (273...293) K for the density, (293...343) K for the surface tension, (300...335) K for the kinematic viscosity, (293...348) K for the thermal conductivity and (261...334) K for the specific isobaric heat capacity.

It was shown that the effect of surfactants and TiO_2 nanoparticles on the density of the R141b refrigerant was insignificant and within the uncertainty of the experimental data (up to 0.08 %). Additions of both the surfactants and TiO_2 nanoparticles contributed to a decrease in the surface tension of R141b by up to 0.3 % in comparison with pure R141b. Additives of both the surfactants and TiO_2 nanoparticles in R141b contributed to an increase in viscosity of (0.8...1.0) %, and additives of surfactants led to a significant decrease in viscosity – by (3.5...5.0) % compared to the viscosity of pure R141b. It was shown that surfactant additives in R141b did not significantly influence the thermal conductivity (the effect did not exceed 0.25 %), and additions of both the surfactants and TiO_2 nanoparticles lead to an increase in the thermal conductivity of the refrigerant by (0.3...1) %. A decrease of the specific isobaric heat capacity by (1.5...2.0) % was observed by adding the surfactants and TiO_2 nanoparticles to R141b. The slight increase in the specific isobaric heat capacity by adding the surfactants to R141b was observed (up to 1.0 %).

It was concluded that the influence of the addition of nanoparticles and surfactants on the thermophysical properties of the R141b refrigerant is ambiguous and unpredictable. The results of experimental studies on the effect of nanoparticles on the thermophysical properties of a refrigerant confirm the importance of developing methods for predicting these properties. This method can be based on taking into account the presence of a structured phase of the base fluid or surfactant molecules on the surface of nanoparticles.

Keywords: R141b refrigerant, R141b/TiO_2 nanoparticles nanofluid, density, surface tension, specific isobaric heat capacity, thermal conductivity, kinematic viscosity

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METHOD FOR DETERMINING THE THICKNESS OF A BINDER LAYER AT ITS NON-UNIFORM MASS TRANSFER INSIDE THE CHANNEL OF A HONEYCOMB FILLER MADE FROM POLYMERIC PAPER (p.42-48)

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Sandwich panels with honeycomb filler based on polymer paper "Nomex" is widely used in crucial structures for various purposes. In the process of manufacturing such panels, some factors of the technological process, such as the application of the binder on a honeycomb

filler, the temperature modes of drying and polymerization of the applied layer, most significantly affect physical-mechanical characteristics of finished products. A specific factor of production of a honeycomb filler from polymer paper is its multi-stage impregnation with the dressing composition, and then by the binder during the final operations with subsequent drying and heat treatment of the honeycomb units. These operations result into non-uniform heat and mass transfer (migration) of the binder from the central part of the panel to its peripheral end areas. The regularities of this non-uniform heat and mass transfer of the binder along the length of a honeycomb channel were explored. It was shown that these phenomena are conditioned by hydrodynamic motion of the binder, caused by temperature gradient, its density and surface tension coefficient. Based on this, we designed the method for determining the thickness of the binder layer along honeycomb channels at the known (assigned) law of the change in density and surface tension along the length of the cell of a honeycomb filler. The method makes it possible to reduce the non-uniformity of mass transfer by technological means, ensuring the necessary tolerance for physical-mechanical characteristics of honeycomb fillers from polymer paper. The problem of mass transfer enabled deeper revealing the mechanisms of the formation of the non-uniform impregnation layer at the stages of the drying process during the production of a honeycomb filler from polymer paper. Using the obtained mechanisms and technological possibilities of the regulation of characteristics of binders, it is possible to improve the non-uniformity of the layer thickness along the honeycomb channels to the values that ensure the necessary tolerance for physical-mechanical characteristics of a honeycomb filler.

Keywords: honeycomb filler, physical-mechanical characteristics, polymeric paper, non-uniform heat and mass transfer, binder, hydrodynamic motion, uniformity of impregnation.

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NUMERICAL STUDY OF THE PROCESS OF COMPRESSING A TURBULIZED TWO-TEMPERATURE AIR CHARGE IN THE DIESEL ENGINE (p. 49-53)

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We have investigated the issue on improving energy efficiency of systems that facilitate the start of diesel engines by heating the air charge. The enhanced energy efficiency is based on the heating of part of the charge only. The result is the formed air charge in the engine cylinder, which consists of two layers of air with different temperatures.

To substantiate the new method for facilitating the cold start of the multi-liter diesel engine, a numerical study into the compression of a different-temperature air charge in the engine was conducted. Using an engine of the type 6TD as an example, we have numerically studied a change in the temperature field of the charge at compression, taking into consideration the vortex flows that arise when a charge forms in the engine's cylinder. Based on an analysis of the temperature field in the charge, we have identified the existence of conditions for a reliable self-ignition of fuel in the charge at its compression. In order to form two layers of air with a different temperature, we first assigned, under conditions of modeling, the injecting of cold air into the engine's cylinder at a temperature of 253 K. Next, the heated air was injected at a temperature of 773 K. A volumetric fraction of the heated air in the charge was 10 %.

Based on the simulation results, it was established that the existence of charge layers with different temperatures is retained at compression. We have confirmed that the temperature of the fuel auto-ignition in the pre-heated layer of air could be achieved at the intake air temperature of −20 °C.

The results obtained could be applied to substantiate the requirements for the energy-efficient systems that facilitate a cold start of the diesel engines.

Keywords: cold start, diesel engine, numerical study, compression process, engine start facilitation.

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DEVELOPMENT AND INVESTIGATION OF PROTECTIVE PROPERTIES OF THE ELECTROMAGNETIC AND SOUNDPROOFING SCREEN (p. 54-61)

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We have developed a technology for manufacturing an universal electromagnetic and soundproofing screen based on foam-latex and foam-polystyrene. The dispersity and physical characteristics of components in a material for shielding electromagnetic field and noise have been investigated. The designed material consists of latex and iron ore dust with dominating dispersion of 12 μm. In order to improve the soundproofing properties, latex was supplemented during fabrication with a foam-forming agent – synthetic oleic acid. To reduce the weight, we added granulated foam-polystyrene with the size of granules 1–3 mm to the material. We examined screens with a thickness of 5 mm and 10 mm with a different content of the metallic substance. It was determined that the shielding coefficients of the material 5 mm think containing 5–20 % of iron ore content are as follows: for electromagnetic field of frequency 2.4–2.6 GHz – 1.8–44; for the magnetic field of industrial frequency – 1.2–15.0. For the material with a thickness of 10 mm they are 2.9–52.0 and 2.3–38.4, respectively. The noise reduction index of 41–44 dB is achieved at noise frequencies of 6–8 kHz, which is the most critical for humans. The structural study of the materials' surface was performed. It has been established that at the content of the metallic substance above 15 %, its distribution in the bulk of the material becomes non-homogenous. In order to improve the efficiency of electromagnetic protection, it is expedient to produce a magnetic or rheological fluid from iron dust in advance, to apply it in the technological process for foam-latex fabrication.

It has been proven that the combined electromagnetic and soundproofing (acoustic) screens, that are small in thickness and low in weight, could provide reduction of the levels of electromagnetic fields and noise to match the norms, which is especially important when they are applied in the transportat industry.

Keywords: electromagnetic screen, soundproofing screen, iron ore dust, shielding coefficient, foam-latex, foam-polystyrene.

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A STUDY OF THE EFFECT OF CYCLING MODES ON THE ELECTROCHROMIC PROPERTIES OF $Ni(OH)_2$ FILMS (p. 62-69)

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As a result of conducted studies, a series of electrochromic $Ni(OH)_2$ films were prepared using the cathodic template method under the same conditions. Prepared films have been used for comparison of regimes for coloration-bleaching cycling. Main qualitative characteristics were also evaluated – averaged absolute coloration degree, averaged irreversibility on bleaching and visual comparison in the colored state after cycling.

To compare the influence of different regimes, potentiodynamic, galvanostatic and complex regimes were proposed. For potentiodynamic regimes, different upper and lower potential limits were chosen. Initial current density for galvanostatic and complex regimes was chosen based on the results of the cyclic voltamperometry curve. Chosen current density was equal to the cathodic peak value on the fifth cycle of the cyclic voltamperometry curve recorded in the following regime: potential window [201–751 mV], scan rate 1 mV/s.

Coloration-bleaching cycling in different regimes revealed high effectiveness of potentiodynamic regimes which showed the highest coloration degree of the films. On the other hand, it was found that narrowing and widening of potential windows relative to optimal

resulted in worse characteristics of electrochromic films. Galvanostatic regimes showed the most optimal results in terms of absolute coloration degree and time required for coloration/bleaching. Complex regimes demonstrated the worst results. Theses regimes resulted in significant irreversibility and average rate of coloration and bleaching.

Galvanostatic and complex regimes revealed the presence of two plateaus on the current density curves, which indicates the presence of both α-$Ni(OH)_2$ and β-$Ni(OH)_2$ in electrochromic material.

Keywords: electrochromism, cycling, cyclic voltamperometry, galvanostatic, potentiostatic, electrodeposition, $Ni(OH)_2$, nickel hydroxide.

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