ABSTRACT AND REFERENCES
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THEORETICAL STUDY OF THE DISPERSION EFFECTS OCCURRING AT OPTICAL FIBER CONNECTIONS (p. 6-15)

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Processes of redistribution of optical signal energy between the optical fiber core and shell in connection points were studied. Closed formulas of dependence of the signal length at the receiving side on the number of connections and the probability of energy transition from the optical fiber core to the shell were derived in the analytical operator model. An analysis of energy redistribution caused by geometric mismatch of fibers in the connection points was performed.

Apparatus of the probability theory and the Fourier transform theory was used for synthesis of analytical models. Effective pulse duration was used as a measure of signal duration at the receiving side.

The numerical analysis has made it possible to draw a conclusion that the effects under study practically do not depend on the initial form of the optical signal and the variant of distribution of face-to-face lengths along the regeneration section line.

The obtained estimates have made it possible to assert that dispersion effects caused by energy redistribution in the points of connection of optical fibers are possible. These effects are caused by the difference in group velocities in different media of the optical fiber (in the OF core and shell). By their effect on the signal shape, they can be compared with well-studied effects caused by the material, waveguide and other components of dispersion.

On the basis of the performed studies, a scientific hypothesis on existence of the dispersion effect caused by detachable and permanent connections of optical fibers has been advanced.

A diagram of laboratory installation for carrying out field studies of the supposed effects was substantiated. This installation feature consists in that the fiber connections can be arranged with a practically arbitrary step. This makes it possible to test the hypotheses advanced in laboratory conditions.

Keywords: attenuation in the connection point, optical signal, group velocity, effective pulse duration.

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COMPUTER SIMULATION METHODS OF REDUNDANT MEASUREMENTS WITH THE NONLINEAR TRANSFORMATION FUNCTION (p. 16-22)

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The studies of possibilities of methods of redundant measurements have found the high efficiency of the presented methods for increasing the accuracy of measurements. It is proved that the equation of redundant measurements ensures the independence of the measurement result of the parameters of the transformation function and their deviations from the nominal values. The possibility of obtaining an equation of redundant measurements of the parameters of the transformation function is also proved, which will enable the implementation of metrological self-control. Experimental studies have confirmed that the accuracy of measurement is increased by processing the results of intermediate measurements by the equation of redundant measurements. In the proposed equation, due to the subtraction operation, the additive component of the error is excluded, and the multiplicative component is excluded due to the division operation. This leads to the stability of the result of measurement by the redundant method to changes in the parameters of the transformation function. In particular, it is found that the change of the parameters of the transformation function by (1÷10) % does not affect the result of redundant measurements, that is, the relative error in the given operating range will be δ_1=(0.04÷0.01) %. This allows us to assert that the mathematical model underlying the presented method is consistent with the results of computer simulation. The latter, in particular, relates to the comparative analysis of the methods of redundant and non-redundant measurements for the stability to changes in the parameters of the transformation function. It is shown that the methods of redundant measurements provide the automatic exclusion of the systematic error component due to the change in the parameters of the transformation function. This is ensured by eliminating the influence of the absolute values of the parameters of the nonlinear transformation function of the photodetector and their deviations from the nominal values on the measurement result.

There are grounds to argue about the promising development of methods of redundant measurements with various types of transformation functions of the sensor in accuracy improvement. This result is achieved by processing the results of intermediate measurements in accordance with the equation of redundant measurements. In addition, if necessary, the proposed methods allow the implementation of metrological self-control.

Keywords: redundant methods, measurement equations, function parameters, accuracy improvement, self-control, photodiode.

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INVESTIGATION OF COGGING FORCES USING RELUCTANCE CIRCUITS EQUIVALENT APPROXIMATION IN A LADDER SECONDARY SINGLE-SIDED LINEAR INDUCTION MOTOR (p. 23-35)

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Linear induction motors have recently played an important role in positioning linear motion. However, they suffer a low level of precision for very low speed application. For improving the precision of LIM, especially in very low speed application – high-performance motor – the existence of cogging forces due to the magnetic conductance of air gap variation or interactive magnetic edge and end effect variation in the ladder-secondary single-sided linear induction motor (LSLIM) should be reduced as small as possible. This paper developed two simple magnetic circuits: one-slot and multi-slot model. The cogging forces analysis will be concerned with magnetic energy variation in the air gap. Based on magnetic conductance in parallel and series structures, analysis of RCE will be done by implementation of Kirchoff law number one and number two. It shows that analytical result trends are close to the experimental results and finite element method software. This paper provides the prediction of a close form of the mathematical model of maximum cogging forces for single-side linear induction motors. So, those results can contribute one aspect in related designing a physical single or double-sided linear induction motor. The variation of flux densities in the air gap in the middle region of LSLIM can give some contribution for calculating cogging forces, and different variation of leakage magnetic path fields in the end region can reduce the magnitude of flux densities in the air gap, but cogging forces in the end region can cancel each other.

Keywords: linear induction motor, cogging forces, reluctance network, electromagnetic field.

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OPTIMIZATION OF THE DEPOSITION CONDITIONS FOR $Ni(OH)_2$ FILMS FOR ELECTROCHROMIC ELEMENTS OF "SMART" WINDOWS (p. 35-40)

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The study was conducted in order to determine the influence of two factors on electrodeposition of $Ni(OH)_2$ films: concentration of nickel nitrate in the electrolyte and drying stage between deposition and electrochemical and optical tests. For deposition, pure solutions of nickel nitrate without additives were used, so that the presence of the latter did not complicate the analysis of the data obtained.

As a result, two series of films were prepared from electrolytes with nickel nitrate concentrations of 0.01, 0.1 and 1 M. The difference between the two series is the presence or absence of drying stage after deposition. Drying was conducted under mild conditions at room temperatures.

Electrochemical and optical characteristics were evaluated by means of cyclic voltamperometry with simultaneous recording of changes in film transparency.

As a result of analysis of the obtained data, it was found that uniform films with roughly equal thickness are obtained within the nickel nitrate concentration range from 0.01 to 0.1 M. For solutions with the nickel nitrate concentration of 1 M, deposition occurs with significant non-uniformity. A hypothesis was proposed, in which such behavior is explained by redistribution of current density over the electrode surface due to the high conductivity of the concentrated nickel nitrate solution. In turn, the redistribution of current density results in a significantly high current density on the electrode surface near the electrolyte-air boundary. Such an increase could result in shifting of the reaction front away from the electrode or formation of $Ni(OH)_2$ with high thickness. The latter would lose contact with the electrode and fall off.

It was also found that drying process has a significant effect on the structure and properties of the films. Drying process was also found to impact the appearance of nickel hydroxide films due to film cracking. It was also assumed that electrochemically deposited nickel hydroxide contains a large amount of crystal water.

Keywords: $Ni(OH)_2$, nickel hydroxide, electrochromism, NiOOH, film, electrodeposition, cyclic voltamperometry, concentration, nickel nitrate.

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FORMING THE TOOLSET FOR DEVELOPMENT OF A SYSTEM TO CONTROL QUALITY OF OPERATION OF UNDERGROUND PIPELINES BY OIL AND GAS ENTERPRISES WITH THE USE OF NEURAL NETWORKS (p. 41-48)

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A set of defining parameters for modeling stages of a surface defect propagation in the outer surface of a metal pipeline taking into consideration fatigue strength has been formed.

For a section of a pipeline with a surface defect, it was proposed to use an algorithm of forecasting polarization potentials using means of neural networks. A procedure of functioning of the testing set was elaborated for estimating efficiency of neural networks. The procedure includes appropriate training methods.

According to the results of analysis of interconnected deformation and corrosion processes, elements of a methodology of formation of information support for forecasting service life of a linear part of underground metal pipelines taking into consideration corrosion fatigue have been developed.

Known results of estimation of service life of underground metal pipelines assumed linear nature of corrosion rate. Relevant information was presented in international and national standards. Recent experimental studies have shown that it is advisable to take into consideration nonlinear nature of corrosion rate in the outer surface of underground metal pipelines (BMP).

A BMP section was inspected with the aid of a polarization potential meter together with a contactless current meter and principles of using neural networks for processing experimental results were formulated. An example of actual BMP was considered and analyzed for metal of a pipe of 17G1S grade steel with a corrosion defect in its outer surface. This analysis has resulted in estimation of metal service life and revealed nonlinearity characterized by magnitude of δ=1.136.

A control method and procedures for estimating polarization potentials with the help of neural networks were proposed. They make it possible to describe the process of corrosion defect propagation into the depth of the pipe wall physically sound and mathematically more correct in contrast to the standard procedures.

The information presented is important for improving methods of control of underground metal pipelines operated by oil and gas enterprises, in particular, methods of correct measurement and evaluation of polarization potentials and anode currents in insulation defects taking into consideration nonlinearity of informative parameters.

Keywords: underground pipelines, oil and gas enterprises, surface defect, polarization potential, corrosion fatigue, neural network, metal service life.

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ANALYSIS OF BALLISTIC ASPECTS IN THE COMBINED METHOD FOR REMOVING SPACE OBJECTS FROM THE NEAREARTH ORBITS (p. 49-54)

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We have considered one of the ways to clean the near-Earth orbits from space debris implying the removal of large-size objects, which represent a danger to space navigation and ecology of near-earth space, in the dense atmosphere of the Earth. To implement it, a combined method has been proposed that uses a jet propulsion system and an aerodynamic sail. The propulsion system ensures the formation of an elliptical disposal orbit with a perigee in the upper layers of the atmosphere, while the aerodynamic sail enables a gradual decrease in velocity due to the action of air resistance force. It has been shown that a combination of active and passive methods makes it possible to partially compensate for the disadvantages of both methods and implement a guaranteed removal of a space debris object in the dense layers of the atmosphere at minimal cost over the predefined time. In this case, effectiveness of the proposed method depends largely on the conditions of the upper atmosphere, which is a function of solar activity that changes over a period of 11 years.

To identify effective motion trajectories of space debris objects in the upper atmosphere, we have solved a problem on the motion of a body in the gravitational field of the Earth, taking into consideration the dynamics of the atmosphere, as well as considering the cycles of solar activity. The dependences have been derived of the perigee height of the disposal orbit first revolution, providing for a lifetime not longer than 25 years and the magnitude for a velocity pulse required to form a disposal orbit from low circular orbits. We have determined energy costs for the removal of space debris objects taking into consideration the dynamically changing Earth's atmosphere. An analysis of the effect of solar activity on energy costs of the process of removing space objects has been performed.

The research results are of practical interest for the development of means for the combined removal of large-size space debris from the low near-Earth orbits.

Keywords: space debris, gravitational field, low near-Earth orbit, combined method of removal, energy costs.

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DETERMINING EFFICIENT VALUES FOR THE THERMOPHYSICAL PROPERTIES OF BULK MATERIALS (p. 55-62)

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A procedure has been devised for determining the effective thermophysical properties of bulk materials with different granulometric and material composition, based on the integration of discrete and continuous models of media. The problem on the mechanical-thermal state of a cylindrical layer of bulk material has been stated in order to determine its effective thermophysical properties. Based on the discrete-

continuous perceptions of bulk media, an approach has been suggested and a procedure has been devised for solving the problem set. The algorithm for determining effective values of thermophysical properties of bulk materials has been constructed. Numerical implementation of the developed procedure was performed using free open source software (LIGGGHTS, ParaView). The proposed procedure makes it possible to determine effective values for the thermophysical properties of a bulk material (bulk density, effective thermal conductivity coefficient and the effective value for isobaric mass heat capacity) with arbitrary material and granulometric composition. In this case, there is a need for a minimum volume of complex and costly experimental studies with subsequent numerical simulation of the process of the mechanical-thermal state of the examined bulk material. In this case, the true physical properties can be acquired from reference books. Using an example of model material, its effective thermophysical properties have been defined for different granulometric composition and the verification of the developed procedure has been performed. It was established that data on the effective thermal conductivity calculation based on the devised procedure differ from data obtained based on the theoretical averaged dependences, within 0.8–9.0 %. The reported results are useful for numerical analysis in the continual approximation of thermal modes of the processes and equipment where bulk materials are used.

Keywords: bulk material, discrete and continual model, effective thermophysical properties, material and granulometric composition.

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