MATHEMATICAL MODELING

FINDING OF THE GENERALIZED EQUATION OF THERMAL CONDUCTIVITY FOR POROUS HEAT-INSULATING MATERIALS

page 4–10

The object of this research is the process of the heat transfer through porous heat insulating materials. The problematic place of research is the absence of a generalized equation of thermal conductivity, which makes unable to predict the effective thermal conductivity of the material at the structure formation stage. The reason of it is lack of complex entrance independent factors of porous structure that influence on the effective thermal conductivity. For determining of this factors the computer simulation was used, it includes three dimensional samples and simulation of thermal process. After it, obtained computer modeling results were confirmed by laboratory experiment with using of the thermal conductivity meter ITP-MH4 of the company «SKB Stroyprybor».

The regression equation of thermal conductivity for porous heat-insulating materials was found by the experimental design method, the analysis of it was showed that the most influence (80 %) on coefficient of effective thermal conductivity have the pore diameter along to the heat flow and the total impact of the pore diameter perpendicular to the heat flow with temperature gradient. The thermal conductivity of initial material without pores λ_{mat} in investigated range of 0,05 to 0,95 W/(m·K) isn't a significant factor. The temperature gradient doesn't linear and not directly proportional impact on the thermal conductivity of the final material.

The generalized equation of thermal conductivity and the main factors, which influence on the coefficient of effective thermal conductivity, allow improving the thermal conductivity of new insulation materials and making it possible to develop a complete theory of thermophysical parameters control of porous heat insulating materials by changing the porous structure.

Keywords: convection, closed spherical pore, regression analysis, effective thermal conductivity.

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DEVELOPMENT OF INFORMATION TECHNOLOGY OF PROFESSIONAL RECRUITMENT FOR OPERATORS OF EXTREME ACTIVITIES

page 11–16

Modern medicine is focused on the implementation of non-invasive diagnostic tools and forecasting dysfunctions of the body for operators of extreme activities. To evaluate a psychophysical condition of operators, special information systems are developed, but they have several disadvantages, the main ones are: lack of computerization of psychological testing; lack of integrated criteria for professional recruitment based on electroencephalograph, cephalograph; usually no graphical interface designed for physician specialist. This paper presents information system consisting of hardware and software for evaluation and forecast of the state of information and energy field of the human body, on the basis of which it can implement professional recruitment of operators of extreme activities. This system is a computerized expert system with database and knowledge base that provides physician specialist to analyze quantitative parameters of electroencephalogram, cephalogram and biological parameters of the person.

Normalized values of cephalography, electroencephalography and biological analysis of operators of extreme activities of a cer-

tain temperament type are obtained as a result of research. Due to the obtained results it can not only assess the current psychophysiological state of the body of operators of extreme activities, but also to predict its changes.

The research results can be used in the medical field of organ transplantation for donor selection or monitoring of the rehabilitation process after transplantation of internal organs.

Keywords: information technology, software, psychophysiology, identification process, professional recruitment, electroencephalography.

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DEVELOPMENT OF SIMULATION ALGORITHM OF BIOLOGICAL PARAMETERS FOR OPERATORS OF EXTREME ACTIVITIES USING MONTE CARLO METHOD

page 17–21

Modern medicine is focused on the implementation of non-invasive diagnostic tools and methods of professional recruitment for operators of extreme activities on the basis of estimation and forecasting dysfunctions of the body. However, the specifics of biological data registration require significant expenditures of time and effort. For this purpose it is need to develop the modern computerized approaches to increase the efficiency of statistics for small time expenditures. Based on the statistics it can calculate normalized values of parameters on which basis professional recruitment of operators is implemented.

New tool cephaloencephalograph that is a combination of cephalograph and electroencephalograph is proposed to the collection of experimental data. Research of blood test parameters is proposed for further identification of cephaloencephalograph operation quality. This tool allows to obtain the parameters that characterize the work of information and energy fields of the human body that sensitive to current and forecasted physiological changes in the human body.

Iterative simulation using Monte Carlo method is applied to improve the calculation efficiency of normalized values of biological parameters used in the professional recruitment of operators. Among the advantages of the proposed approach of iterative modeling is implementation of robust method that can increase the quality of statistical parameters specified in the simulation for normal distribution law.

Normalized values of electroencephalography parameters, blood test for one of the types of operators in extreme activities, Antarctic winterers, are obtained as a result of experimental studies. Completed studies have shown that the proposed iterative simulation using Monte Carlo method allows narrow normalized parameters of biological parameters that increased efficiency of evaluation and prediction of psychophysical state of the operator's body. Effectiveness of professional recruitment of operators increased by 20 % compared with similar approaches.

The research results can be used in the medical field of organ transplantation for donor selection or monitoring of the rehabilitation process after transplantation of internal organs.

Keywords: Monte Carlo method, electroencephalograph, biological parameters, integrated assessment.

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RESEARCH OF ALGORITHM FOR CALCULATING THE VECTOR-PARAMETRIC BISPLINE BASED ON POLYNOMIAL OF THE FOURTH DEGREE

page 22–26

In the course of the audit process of the vector-parametric spline of fourth degree on the basis of a segment of three points and two first derivatives at the end points is easy to see that it cannot be set to the same number of boundary conditions at both ends, as for polynomials of third and fifth degree, because a polynomial of the fourth degree is «unbalanced».

New method is proposed to eliminate these disadvantages in the design of fourth degree splines and bisplines (vector parametric surfaces) based on them.

It is proposed to consider the next variant of polynomial of the fourth degree for bispline design: the endpoints, derivatives in them and another middle point are given.

Based on the proposed functions of the polynomial:

$$y = \alpha_0(u)y_0 + \alpha_1(u)y_1 + \alpha_2(u)y_2 + [\beta_0(u)y_0' + \beta_1(u)y_2']h.$$

Vector parametric spline of fourth degree on the basis of a segment of three points and two first derivatives is noted:

$$r = \alpha_0(u)r_0 + \alpha_1(u)r_1 + \alpha_2(u)r_2 + \beta_0(u)r_0' + \beta_1(u)r_1'.$$

Based on the segment of the fourth degree for the portions of the surface recorded this equation is noted:

$$r = \left[\alpha_0(u)\alpha_1(u)\alpha_2(u)\beta_0(u)\beta_1(u)\right]\begin{bmatrix} r_{00} & r_{01} & r_{02} & r_{00}^v & r_{01}^v \\ r_{10} & r_{11} & r_{12} & r_{10}^v & r_{11}^v \\ r_{20} & r_{21} & r_{22} & r_{20}^v & r_{21}^v \\ r_{00}^u & r_{01}^u & r_{02}^u & r_{00}^{uv} & r_{01}^{uv} \\ r_{10}^u & r_{11}^u & r_{12}^u & r_{10}^{uv} & r_{11}^{uv} \end{bmatrix}\begin{bmatrix} \alpha_0(v) \\ \alpha_1(v) \\ \alpha_2(v) \\ \beta_0(v) \\ \beta_1(v) \end{bmatrix}.$$

To specify a portion it must have not only first derivatives but also the mixed derivatives at the nodal points.

Based on these formulas, it became possible to write a test program for visualization of bispline (vector parametric surface) fourth degree in the language Auto Lisp in AutoCAD, spline of fourth degree showed good «custom» properties, the surface is adequate to the input data, subjectively nice-looking.

The paper shows the ability of the splines of the fourth degree to give biplane. Due to the peculiarities of their structure (the ability to give an additional medial condition) the proposed curve has an additional possibility of a more correct and adequate to the task of specifying the conditions. The achieved effect (a new polynomial) gives a method the right to life for designing smooth curves and surfaces.

Keywords: segment of three points and two first derivatives, vector-parametric spline of fourth degree.

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DEVELOPMENT OF THE OBJECT-ORIENTED MODEL FOR THE HEALTH LOSSES ANALYSIS IN THE NON-PROCESS BUILDING

page 26–34

The object of research in this article is interconnected and interdependent thermal process in any complex architectural and constructive structure of non-process building. Today this process is poorly understood, and its experimental research is limited. At present there are no documented software systems for the theoretical study of the process. However, this process is substantially dependent on the conditions of human presence in the house and saving natural energy. The building structure is developed. The basic elements in this building are defined, and in each of them there are the same defining thermal processes (convection, heat conduction, radiant energy). Functional and object model heat losses analysis in the non-process building are developed within object-oriented methodology OMT (Object Modeling Techniques). The example is given for demonstration of the use of the results to analyze thermal process in the building with heat accumulating underfloor electric heating system. It is established that this heating system is very promising because it provides a more comfortable environment for humans (the temperature at the feet slightly higher than at the head). In addition, 46 % of the heat enters into the room of the building by radiant energy using this system. This means that we can significantly save resources in heating the air.

Keywords: non-process building structure, object-oriented model, heat losses, heat accumulating underfloor electric heating system.

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MECHANICAL ENGINEERING AND MACHINE BUILDING

APPLICATION OF ROD MECHANICS FUNDAMENTALS FOR ANALYSIS OF STRESS-STRAIN STATE OF THE TUBING

page 35–44

A method for analysis of stress-strain state of the tubing column in the spatially curved well section with an arbitrary intensity of changes as the zenith and azimuth angle is developed in the article.

Stresses and strains are calculated using the rod mechanics fundamentals. The system of vector differential equilibrium equations in the projections on the axes of the moving coordinate system is used for the analysis of elastic equilibrium of the tubing axis.

The analysis is carried out by solving the direct problem of the rod bending by means of iterative numerical method implemented in software-oriented mathematical environment.

A method to account for the limiting effect of the well walls to move of the elastic tubing axis is provided based on the processing of its geometrical parameters, as well as data and directional survey and profilometric research of the well bore.

Using the designed calculation schemes, it is found that local bend of the well axis substantially increases the bending stress, which can reach the yield strength of the tubing material. For example that discussed in the article, the bending stress is approximately 300 MPa, while the minimum yield strength of steel, which are made tubing, is equal to 379 MPa.

Moreover, the axial force change caused by the reciprocating motion of a rod suspension may initiate the occurrence of cyclic bending moments and stresses in the tubing. So, for the considered operating conditions, we received the following: the minimum stress of the cycle $\sigma_{min} = 303$ MPa; the maximum stress of the cycle $\sigma_{max} = 346$ MPa; stress amplitude of the cycle $\sigma_a = 43$ MPa; loading cycle asymmetry factor $R_\sigma = 0{,}88$. This load pattern allows to speak about the cyclic fatigue of the tubing.

Keywords: stress-strain state, tubing, local bend of the well axis.

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ELECTRICAL ENGINEERING AND INDUSTRIAL ELECTRONICS

EXPERIMENTAL STUDY OF LUMINOUS FLUX FLICKER COEFFICIENT OF ARTIFICIAL LIGHT SOURCES

page 45–50

A phenomenon of luminous flux flicker of artificial light lamps of general and industrial use is analyzed in the article. The analysis shows that luminous flux flicker adversely affects the human condition. However, most manufacturers of lamps not knowingly induce flicker performance for their products. Difficult professional devices are used to check the availability of flicker and measure its depth in the market of electronic devices. They are virtually inaccessible to the public taking into account the producing countries and pricing. On this basis, relatively simple device for analyzing the luminous flux flicker is proposed. It is based on a converter of optical radiation — photodiode and detector-oscilloscope. With the developed device, studies of the most common artificial light lamps that are present in the domestic market were conducted. The resulting waveforms of changes for luminous flux in time were obtained and flicker coefficients were calculated. Studies were found that certain examples of widely used lamps have unacceptable level of luminous flux flicker. Thus it is shown that it can't trust the manufacturer advertising when designing of high-quality lighting systems, and should, if possible, check for flicker.

Keywords: lamps, luminous flux flicker, device, waveforms, flicker coefficient.

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ANALYSIS OF THE POTENTIAL OCCURRENCE FEATURES IN MULTICOMPONENT CERAMIC COMPOSITES BASED ON THE REFRACTORY ANOXIC COMPOUNDS (PART 1)

page 51–62

Formation of the functional zone of multicomponent ceramic composite based on refractory anoxic compounds is the object of research. The disadvantages of this object in the existing operating conditions include high inertia, which shows that the produced functional devices do not affected by sudden changes in temperature peak.

Research was conducted at the Institute for Problems in Material Science of Ukraine using industrial powders. The investigated samples were produced by plastic forming on the spindle stall in the form of plates 100×7×6 mm. Carboxymethylcellulose (CMC) in combination with a plasticizer (glycerol or rubber) was used as a binder for this method. Investigated samples of silicon-nitride composites based on SIALONs were obtained by hot pressing of prepared ceramic tapes using the induction method of the mold heating.

Research was conducted by the methods: chemical analysis of raw materials and samples, X-ray analysis, electron microscopic analysis, X-ray spectral probe microanalysis and quantitative metallographic analysis of microstructure morphology of the ceramic composites.

It was established that the formation of functional areas nonlinear device affect technological factors such as: binder type, temperature, isothermal soaking temperature and composition of the gas environment. Reduction of the isothermal soaking temperature leads to increased non-uniformity of resistance by volume of the functional element with decreasing or exceeding the optimum soaking temperature. Binder, binder composition and gas temperature of the environment significantly affect the anisotropy and dimension of conducting of formed cluster. It is shown that microstructure morphology is formed differently for various binders. It is found that TCR passes through «0» for 13 % concentration of HfC.

These research results can be used to establish the correlation between process parameters, electrical conductivity and Seebeck coefficient of the solid layered multicomponent ceramic composites based on refractory anoxic compounds. Based on these studies it becomes possible to manufacture highly efficient thermoelectric converters.

Keywords: binder, hafnium carbide, temperature, rubber, carboxymethylcellulose, concentration, morphology, microstructure.

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ENERGY, ENERGY-SAVING TECHNOLOGIES AND EQUIPMENT

CONCEPTUALIZATION OF RESEARCH OF POWER HYBRID ELECTRIC POWER COMPLEXES

page 63–73

The following disadvantages were revealed for hybrid diesel-electric propulsion complex (DEPC) under the influence of non-determined external disturbances: lack of coordination parameters of the medium-speed engines (MSE) with other components, leading to uneven regulation of magnetic flux and voltage amplitude, causing an additional increase of voltage pulsation in the output of converters and an emergence of equalization currents at synchronous operation; elevated levels of harmonics in the current of energy consumers; reduced reliability, efficiency, increased size and weight that occur through the use of high power elements and sets of equipment for them; no possibility of balancing three-phase system of power supply voltage with uneven loading of the phases.

The impact of some disadvantages of hybrid DEPC operation has been reduced due to the determination of the ways of their modernization and use of criteria for improving energy processes through the integration of appropriate criteria of management strategies in the power distribution system.

When using the classic PI control with adjustable level of ESS battery charge, power consumption by the consumers connected to the DC-link is decreased by 5 ÷ 7 % depending on the operating mode, and reactive power compensation is increased in the range of 2 ÷ 3 %. Control of frequency and MSE condition with adjustable degree of ESS battery charge for all other equal conditions allows to reduce the number or power of photovoltaic elements by 7 ÷ 10 % and management for criteria to obtain a maximum of alternative energy and control of the charge degree of ESS battery allows to use batteries of smaller capacity within 6 ÷ 8 %.

The proposed approach ensured optimization of power for PVGS, CPU and ESS diesel and generating units for hybrid DEPC that in the future will lead to minimize investment and operating costs.

Keywords: Hybrid Propulsion Complex, alternative energy source, photovoltaic element, battery, simulation.

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