Informatics, computer engineering and control

DESCRIPTION AND ESTIMATION OF THE EFFICIENCY OF THE SUBSYSTEM OF SUPPORTING MAKING MANAGERIAL DECISIONS UNDER CONDITIONS OF UNCERTAINTY WITH THE APPLICATION OF THE MATHEMATICAL MODEL BASED ON RISK ASSESSMENT ON THE EXAMPLE OF WORK OF AN AMBULANCE CENTER

I.M. Pashueva, S.M. Pasmurnov, A.V. Bondarev

The article proposes a subsystem supporting the adoption of operational management decisions in conditions of uncertainty, based on an assessment of the risks in a critical state of emergency. On the example of an ambulance center, this critical condition is characterized by the transition of the service from normal to emergency operation. The mathematical model allows us to analyze quickly the workload of the district centers, predict the workload in the near future and propose the optimal solution. In the process of solving this problem, a model and principles of risk assessment and analysis were proposed for optimizing the schemes of resource redistribution between district centers. To determine the quantitative characteristics of a risk assessment, it is possible to apply a method based on the construction of generalized estimates of decision options. To compare the solution options, several aggregation functions are used. As an optimal option, the one on which the aggregation function is maximum is selected.

The description of the subsystem supporting the adoption of operational management decisions in the city ambulance center using Petri nets is given. The positions of the system are selected from the moment of receiving a call until the ambulance crew returns to the station. The mechanisms of functioning of the subsystem of ambulance in so-called emergency mode of operation, which is characterized by a significant increase in the number of calls in one of the areas of the ambulance center, are described as separate items.

The article presents the results of simulation modeling of the subsystem of support for making operational management decisions based on the example of the functioning of the city ambulance center in Voronezh in different modes of operation

Key words: subsystem of support of making management decisions, Petri nets, modeling, risk assessment

MATHEMATICAL MODELING OF VENTILATION SYSTEMS FOR PRODUCTION FACILITIES

A.M. Shmyrin, C.L. Podval'ny, O.A. Meshcheryakova, V.V. Syemina

In the production of building materials such as cement, the operation of dust-free ventilation systems is not effective enough. Dustiness of air in working areas at various stages of production can exceed the maximum permissible concentrations by many times. Optimization of the room ventilation system with the help of neighborhood modeling is considered in this paper. It allows to clean the incoming air, remove excess heat, moisture, dust, harmful gases and vapors entering the air of work premises during the technological process, maintain the air humidity in the room required by technological parameters, and also to clean the polluted and dusty air before it is released into the atmosphere. The model is built for the workshop, in which there are three rotary cement kilns, a clinker warehouse. The proposed model has a hierarchical structure, the output values of higher-level models are used as parameters of lower-level models. The task is to identify the models of a complex system under conditions of parametric coupling of models that describe the incompleteness of the initial data

Key words: mathematical modeling, neighborhood systems, ventilation systems

SPECIALIZED SIMULATION SYSTEM FOR IMITATION OF FUNCTIONING OF MULTISTAGE SERVICE COMPLEXES

S.A. Oleynikova

One of the key tasks in analyzing the functioning of multi-stage service complexes is evaluation of the execution time of an application. The mutual dependence between operations, as well as the stochastic nature of their duration, does not allow to guarantee the necessary accuracy in obtaining the corresponding estimates of the desired random variable. Simulation of the service process will allow not only to estimate the numerical characteristics of such a value, but also to gather detailed information about its distribution law, to calculate the risks of service delays and to solve a number of other necessary tasks. The study of the specifics of the problem solved made it possible to put forward a number of requirements for a system designed for modeling multi-stage maintenance. Analysis of existing simulation systems, Anylogic in particular, necessitated development of our own such system. Taking into account the specifics of the functioning of the complexes under investigation, and also on the basis of the requirements for the system, the system's structure was developed and the assignments of the main subsystems were determined.

Thus, a simulation system designed to simulate the process of functioning of multi-stage service complexes, providing the ability to collect and analyze statistical data on a random variable describing the duration of the project

Key words: simulation system, multi-stage service complex, distribution law, numeric characteristics

PROGRAM IMPLEMENTATION OF THE NEURAL NETWORK DESIGNER

E.A. Gantseva, V.F. Barabanov, N.I. Grebennikova, D.S. Boldyrev

At present, artificial neural networks are an important extension of the concept of computation. Neural networks are either manufactured as part of specialized devices, or rather expensive, and often both. They demand a considerable amount of time to develop, while the software implementations on the latest computers are only an order of magnitude less productive, which makes the use of neuroprocessors unprofitable. The functionality of various software products have similar capabilities to varying degrees, some of them have a large number of tools that are not suitable for initial acquaintance with neural networks, and also have a high cost.

The article suggests a model of the class library for constructing neural networks. The library contains classes that allow to create, configure, train, and test neural networks. The modular structure of the library allows the developer to make changes in order to expand the functionality, without fear of disrupting the work of other modules. Considerable attention is paid to the description of software development for the construction of neural networks based on this library; the overview of existing software products with similar functionality is given

Key words: linear neuron, perceptron, multilayer neural network, back propagation error algorithm

DEVELOPMENT AND IMPLEMENTATION OF THE ALGORITHM DESIGN COMPILING SCHEDULE OF STEELMAKING BASED ON ADAPTATION OF THE FRACTAL CANTOR

M.A. Tsukanov, O.A. Bozhkova

The article deals with the issues of technological coordination and operational management of complex production systems. Within the operational management of production, sub-tasks of dispatching production, monitoring of plan violations were identified taking into account the occurrence of nondeterministic events (downtime, breakdowns) requiring corrective actions to be taken with respect to the planned state of the technological process. Examples of such productions are given, the system of interrelations and its main characteristics are described, decomposition of

the production plan execution is shown on the example of metallurgical production. Steelmaking is characterized by a complex system of connections, which makes it difficult to plan the technological process. The article describes the decomposition of monitoring the production plan; the stage of assessing the production costs of the completed schedule is shown separately. The authors identify a number of limitations that make it difficult to compile a timetable for complex production systems and suggest to use fractalization in the process of constructing and adjusting the production schedule. As a mechanism for constructing the schedule, an adaptation of the Cantor dust algorithm is proposed. The proposed algorithm for the formation and adjustment of production schedules makes it possible to compensate for the influence of nondeterministic events on the course of the production process in dispatch mode. The implementation of the algorithm will reduce the non-production costs of energy consumption during the realization of products, as well as simplify the dispatcher's work in the decision-making process in various situations

Key words: operational control, manufacture schedule, technological coordination, Cantor fractal

EXPERIMENT RESULTS ANALYSIS USING THE NEURAL NETWORKS DESIGNER

E.A. Gantseva, V.F. Barabanov, N.I. Grebennikova, D.S. Boldyrev

In the work "Software implementation of the neural network designer", a developed modern software product for neural network design is described, which is easy to learn, has a clear and intuitive interface, is freely distributed, open source. The created software application allows the user to master the technologies for building neural networks and solve a wide range of practical problems, which include, in particular, the problems of regression and classification of images. The article presents the results of experimental studies using the created software application for neural networks design, as well as recommendations on the choice of network design parameters for improving the quality and speed of training neural networks. Due to the fact that training neural networks is a very long process and requires a large amount of test data, a test set of data for a sine function module with a volume of 30,000 readings was created, and this example demonstrates the effect of various configurable parameters of the network design on the speed of its training. The conducted researches made it possible to develop recommendations on the choice of architecture and adjustment of the values of the neural network design parameters, which should be used when working with the "Neural Networks Designer" software application

Key words: linear neuron, perceptron, multilayer networks, training, testing

BAYESIAN NETWORK STRUCTURE FORMATION OF INFORMATION SYSTEMS RELIABILITY TESTING PROCESS

T.V. Azarnova, N.G. Asnina, D.K. Proskurin, P.V. Polukhin

The article describes the results of a study aimed to develop an adaptive model for managing the process of testing the reliability and fault tolerance of information systems, the main components of which are web applications. The testing process control model is built on the basis of the application of fuzzing methods and the apparatus of dynamic Bayesian networks. All stages of the web applications testing process by fuzzing are made in the form of learning tasks for the structure, parameters, and implementation of the probability output for dynamic Bayesian networks. This article focuses on the training the structure of dynamic Bayesian networks. The structure of the Bayesian network can be determined on the basis of the causal model of the investigated problem area, which is constructed in accordance with the conception of experts with extensive experience in testing the application vulnerabilities in question. But more effective results can be achieved through the use of special algorithms for learning the structure of the network based on statistical data. This method is able to flexibly adjust to structural changes in the external environment of the simulated

process. The learning algorithm used in the work is based on the assumption of the Markov cover and the search methodology based on the principle of ascent

Key words: Bayesian network, testing, information system reliability, structure training, Markov cover, ascent method

Energetics

OPTIMIZATION APPROACHES DETERMINATION IN THE DESIGN OF AN AUTONOMOUS CURRENT SOURCE BURNER DEVICE ON THE BASIS OF THE THERMOELECTRIC GENERATOR MODULE OF RING GEOMETRY

T.S. Timoshinova, **I.E. Sviridov**, **D.P. Shmatov**

The development of modern equipment and technology, the expansion of the sphere of application of electricity is inextricably linked primarily with the search for new energy sources. At present, a very topical solution is the use of thermoelectric generator modules, which are part of autonomous current sources. Existing options for the use of thermoelectric generator modules are considered. Also, the article presents data on modern developments of nanostructured thermoelectric materials of a new generation that can increase the power and specific weight characteristics of thermoelectric generator modules. Based on the results of the review and analysis of modern approaches to the development and creation of autonomous thermoelectric current sources, a circuitry of the thermoelectric generator module of circular geometry was proposed. The main systems included in the autonomous current source are listed. A methodology for calculating a natural gas-fired device that can be used to design a thermoelectric generator module as a part of an autonomous current source was developed and topological optimization of the design was carried out using computer simulation in the ANSYS Fluent software complex using Adjoint Solver, during which the probability of flame separation from the gas-burning device's crater was minimized by observing the permissible speed regime of the gas-air mixture

Key words: thermobattery, thermoelectric generator, Seebeck effect, autonomous current sources, gas burner, topology optimization

PROGRAM-TECHNICAL COMPLEX OF CONTINUOUS MONITORING OF OPERATING DAMAGE TO EQUIPMENT OF NUCLEAR ENERGY INSTALLATIONS

V.P. Povarov, M.B. Bakirov, A.D. Danilov

The article deals with the system of multi-parameter continuous monitoring of operational damageability of critical elements of nuclear installations, which relates to software and hardware technical systems for ensuring the reliability and safety of high-risk facilities. The practical result of the application of the system is the possibility of realizing the current diagnostics of the technical condition of the control object with regard to the evaluation of the integrity of the metal. The evaluation of the stressed-deformed state of the collapsing element is based on a three-dimensional finite element model, the calculated core of which is calibrated according to the field measurements obtained from additional control sensors installed in critical areas. The program for calculation and experimental analysis of the loading and survivability of the controlled critical zone is the central core of the continuous monitoring system. Accumulated for a certain period of time, the knowledge base on the behavior of the monitored equipment in various operating modes and the corresponding complex analysis of the stress-strain state and the behavior of defectiveness make it possible to develop effective compensating measures

Key words: monitoring, critical elements, diagnostics, stress-strain state, loading parameters, finite element model, knowledge base

Radio engineering and communication

AUTO-CALIBRATION OF AMPLIFIERS IN ADC

V.S. Kononov, S.I. Rembeza

The calibration technique of amplifiers of various types used in creating analog-to-digital converters (ADCs) is described in the article. The technique is designed to calibrate amplifiers in the remote access mode during long-term operation of the ADC under "hard" conditions, when due to the effects of natural aging of the semiconductor material and its degradation under the influence of the external environment, the characteristics of the amplifiers can undergo significant changes. The proposed calibration technique is based on the use of hardware that provides automatic calibration of bias voltage at the inputs of amplifiers and common-mode voltage at their outputs. It is noted that the application of this technique, unlike the most common laser fitting and electrical programming of fusible links, does not lead to a decrease in the service life of an ADC, and therefore it is in demand first of all for the creation of conveyor ADCs, which predominate in the production of modern converters. The proposed technical solutions for building hardware are based on the use of a set of D- and SR-type latches, single pulse generators, decoders, programmable current mirrors and voltage dividers, which allow to emulate the calibration process via automatically changing the 4-digit code generated inside the ADC crystal, and then, after selecting the necessary values of the compensation bias current or commutating voltage, fix this code. It is noted that the use of the discussed hardware does not lead to a significant increase in the area of the ADC crystal

Key words: calibration, amplifier, bias, voltage

IDENTIFICATION SIGNALS FORMING DEVICE BASED ON A MICROCONTROLLER

N.N. Kosheleva, A.B. Buslaev, S.I. Rembeza

The paper describes a device based on a microcontroller, which provides the formation of text, encoded in the Morse code. The proposed device is capable of forming a one-, two-, three-letter identification signal. The sequence cycle of the identification signals is 15, 30 or 60 seconds. The use of the device makes it possible to realize the formation of an identification signal on a new element base, with minimal mass and size and energy indices. The device contains a microprocessor system, a control panel, output stages of the FIS (formation of an identification signal) and a control scheme for the FIS. The identification signal is formed in the microprocessor system (MPS) in accordance with the program written in its memory. MPS can be implemented on the basis of a microcontroller, the characteristic feature of the structure is the placement on one chip with a central processor of internal memory and a large set of peripheral devices (data I / O ports, programmable interval timers, ADCs, DACs). The use of the proposed FIS device makes it possible to reduce the number of functional nodes in the device, and also provides an increase in the probability of failure-free operation of the device. The paper shows the basic scheme of FIS based on the microcontroller, as well as the algorithm of the microcontroller in the FIS board

Key words: the microcontroller, the identification signal, radio drive unit, microprocessor system

THE SINGLE-THRESHOLD SEQUENTIAL ALGORITHM FOR DETECTION OF THE RECTANGULAR RADIO PULSE WITH UNKNOWN DURATION, AMPLITUDE AND INITIAL PHASE

B.V. Matveev, M.M. Shahmoradian, A.A. Makarov

We synthesize the single-threshold sequential algorithm for the detection of the rectangular radio pulse with unknown duration, amplitude and initial phase observed against Gaussian white noise. Unlike common optimal detection algorithms, it allows us to reduce the time needed for taking decision on presence or absence of the useful signal in the observable realization without decrease in detection quality. Unlike the classical sequential detector, the introduced detection algorithm carries out the comparison of the decision statistics formed in real time with a single threshold. The analysis of the observable realization stops either at the time of the threshold crossing, or when the predetermined time comes. As the decision statistics we use the logarithm of the functional of the likelihood ratio. We find the asymptotic expressions for the characteristics of the efficiency of the single-threshold sequential detector whose accuracy increases with the signal-to-noise ratio. The considered single-threshold sequential detection algorithm is the heuristic one, but, however, its detection errors probabilities coincide with the corresponding probabilities of errors allowed by the maximum likelihood algorithm. We also show that, under invariable characteristics of detection efficiency, we can get a gain in the decision time, if we apply the single-threshold sequential detector instead of the common detection algorithms

Key words: radio signal, parametric prior uncertainty, maximum likelihood method, sequential detection, decision time, false alarm probability, missing probability

Mechanical engineering and science of machines

METHOD FOR DETERMINING THE POSITION OF THE TEETH OF THE INTERLOCKING SIDE CUTTER WITH THE CONSTRUCTIVE RADIAL FEED

V.V. Kuts, V.V. Ponomarev

The problem of processing equiaxial contour profiles with an interlocking side cutter equipped with replaceable polyhedral plates with constructive radial feed is considered. Calculation of the height of the deviation from the nominal profile in the radial direction is given for the shaft processing and the dependence of the deviation on the angle of the plate is determined.

The issue of developing a method for calculating the number of replaceable polyhedral cutter plates with constructive feed and determining their position is considered, with due account to the condition of constancy of the values of the maximum deviations of the processed profile. An algorithm for calculating the angles of the location of replaceable polyhedral plates is proposed.

The results of calculations are presented for processing of the equiaxial contour profile shaft of radius R = 40 mm and eccentricity e = 3.4 mm for different cutter radii and accuracy grades.

The application of the presented method of calculating the position of the replaceable polyhedral plates makes it possible to equalize the deviations from the nominal profile in the radial direction when machining the workpiece with the equiaxial contour profile by the interlocking side cutter. Further ways of studying the wear of replaceable polyhedral plates have been determined in order to obtain an efficient design for this cutter

Key words: equiaxial contour profile, interlocking side cutter, mathematical model, shaping, profile deviations, replaceable polyhedral plate

THE WAYS TO INCREASE EFFICIENCY OF ACOUSTIC HONEYCOMB SANDWICH FOR AN AIRCRAFT AIR INTAKE DUCT

V.I. Maksimenkov, M.V. Molod, V.I. Fedoseev

The article discusses an aircraft air intake duct manufacturing. The ways to increase efficiency of an aircraft air intake duct are described using acoustic honeycomb sandwich constructions. Application of sandwich constructions provides noise reduction in the wide frequency spectrum.

The technological processes of the air intake duct manufacturing are described. The analysis of the accuracy of the manufacturing process of the air intake channel is presented. This allows to predict the obtaining of the given geometric dimensions of the outer and inner surfaces

of air intake duct. The provision of specified dimensions of the skin is determined by the process of shaping on CNC equipment with the use of universal punches.

To improve the acoustic efficiency of the air intake duct, proposals have been developed to change the two-layer design of the noise reduction structures, when the intermediate skin is replaced by a grid.

To carry out acoustic studies, samples were prepared for testing with an interferometer on the stand "channel with flow" in the Federal State Unitary Enterprise "Central Airo-Hydrodynamical Institute". The tests showed that the use of grids located in the intermediate layer of the panel provides a noise reduction of ~ 5 dB, which determines the effectiveness of the new solution for the development of a two-layer structure.

The compressive stress limit values are defined for new sandwich constructions by durability tests. The obtained data proved a sufficient margin of safety

Key words: air intake duct, honeycomb sandwich, noise reduction

SYNTHESIS OF GEOMETRIC ACCURACY PARAMETERS TOLERANCES OF METAL-CUTTING EQUIPMENT

O.V. Anikeeva

The article sets and solves the complex problem of creating a fully functional mathematical apparatus for translation of requirements to accuracy parameters of processing and arrangement of surfaces into the requirements to the accuracy of manufacturing and assembly of machine nodes. The aim of this work is to create a method for synthesizing tolerances for the values of geometrical errors of metal-cutting equipment. For the first time, it is justified to exclude the accuracy of forming processes, as well as the specific types of cutting tools used in the processing, from calculating the accuracy. Two developed approaches to the estimation of geometrical errors of processing based on the use of matrices of transformations of homogeneous coordinates and the total variation of the obtained dependences are investigated. The application of these approaches does not fundamentally support the separation of the machine and the equipment, as well as the requirements for the parameters of their accuracy and accuracy of parts machining. The advantages of the created mathematical apparatus are shown when analyzing the geometric accuracy of a multi-axis machine based on the dependences obtained, which were first presented in this paper. On the basis of the created mathematical apparatus the method of synthesis of tolerances on values of geometrical errors of metal-cutting equipment is developed. Key questions are identified on the main stages of the proposed method for the synthesis of tolerances, which require the adoption of key decisions. Examples are given of the identification of dimensional relationships between geometrical errors of the machine and the errors of the machined surfaces in the analysis of the forming system of a five-axis machine. The work is useful for researchers involved in the study of geometrical precision of machining on metal-cutting machines

Key words: metal-cutting equipment, processing errors, geometric accuracy

HIGH TEMPERATURE CREEP OF THE NITRIDED TITAN

V.V. Peshkov, **A.B. Bulkov**, **I.B. Korchagin**

This article presents the results of studying the effect of preliminary nitriding of titanium on the development of its creep under conditions of diffusion welding. The studies were carried out on samples with a diameter of 5 and a height of 10 mm from alloys OT4-1, which were loaded with a compressive pressure from 1.0 to 3.0 MPa at 850-950 ° C (OT4). The preliminary nitriding was carried out at 800 ° C. for 60 minutes in pure nitrogen atmosphere.

In the course of work it was established that the value of the accumulated deformation at identical parameters of the test regimes in all cases was significantly lower for nitrided samples, although with increasing test duration their creep rate increases, approaching the creep rate of unnitrided samples. Creep curves distinguish near-linear areas at the beginning and end of the dependencies and a nonlinear region due to the transition from one creep regime to another. The duration of the existence of linear sections at the initial stage of the dependences is in an exponential dependence on temperature and decreases with temperature rising.

The mechanism of high-temperature deformation of nitrided samples is determined depending on the duration of the test: by multiplication and displacement of dislocations in the initial sections and viscous flow, on the final sections of the dependences.

Based on the studies carried out, the kinetic regularities of the development of high-temperature creep of nitrided samples are explained and expressions are obtained for calculating their creep rate at linear initial and final sections

Key words: titanium alloys, creep, nitriding

Physics

ELECTRICAL RESISTANCE AND THERMAL ELECTROMOTIVE FORCE OF NANOCOMPOSITES $Cu_x(a\text{-}C)_{100-x}$

V.A. Makagonov[1], A.A. Krasnova[2], L.I. Yanchenko[3], I.M. Tregubov[4], M.A. Kashirin[5]

The $Cu_x(a\text{-}C)_{100-x}$ thin films containing 15-85 at. % Cu were obtained by the ion-beam sputtering technique in argon atmosphere. According to the structure investigations the obtained films are nanocomposites, where in a prepercolating regions the copper particles with size from 1 to 20 nm are embedded in an amorphous carbon matrix. The concentration and temperature dependence of electrical conductivity in DC and AC modes and the thermal electromotive force at room temperature were experimentally investigated. The analysis of concentration dependences of electrical resistance shows that the $Cu_x(a\text{-}C)_{100-x}$ is a percolating system with the percolating threshold at 54.3 at. % Cu. The concentration dependence of thermal electromotive force has a maximum in the vicinity of the percolation threshold. It is shown that in the studied temperature range the charge transfer is carried by the hopping conductivity in the samples with the small concentration of the metallic phase 15 to 54.3 at. % Cu, (before the percolation threshold). The usual metal conductivity is dominated at a concentration range from 54,3 to 85 at. % Cu (after the percolation threshold). The heat treatment of the $Cu_x(a\text{-}C)_{100-x}$ composites carried at temperatures of 280 and 400 ° C for 30 min leads to a shift of the percolation threshold to x_c=34 and 46.5 at. % Cu, respectively. It is established that the temperature coefficient of electrical resistance of $Cu_x(a\text{-}C)_{100-x}$ thin films with the copper concentration of 54 at. % remains close to zero in a wide temperature range

Key words: nanocomposite, thin films, copper, carbon, electrical resistance

ADJECTION PROPERTIES INCREASE OF SWITCHING LAYERS ON N-TYPE SEMICONDUCTOR BRANCHES OF THERMOELECTRIC GENERATOR BATTERIES

E.K. Belonogov, V.A. Dybov, A.V. Kostyuchenko, S.B. Kushchev, D.V. Serikov, S.A. Soldatenko, E.N. Fedorova, A.V. Bugakov

The efficiency of thermoelectric generator panels, in addition to the properties of the semiconductor, is determined by the values of the contact resistance, and adhesion at the interface “semiconductor – metal”, which in turn depend on the material, the structure of the commutation and anti-diffusion layers, physic-chemical interaction at the interface “solid solution of bismuth telluride - switching contact”, surface modification of semiconductor legs prior to deposition of metal layers. Therefore, the aim of this work is the implementation of different technological variants of preparation of the surface the leg of the Bi_2Te_3-Bi_2Se_3 n-type and evaluation of their influence on the value of the adhesion metallization of molybdenum and nickel.

X-ray diffractometry, atomic force microscopy, and nanoindentation were used to study the phase composition, morphology, and hardness of the surface of semiconductor legs of n-type conductivity, based on a solid Bi_2Te_3-Bi_2Se_3 solution, which underwent various types of surface preparation (mechanical treatment, pulsed photon treatment PPT, electrochemical polishing , ultrasonic dispergation). The adhesion properties of commutation barrier layers based on Mo and Ni on the modified surfaces of semiconductor legs are investigated by shear testing. It is shown that mechanical polishing of the surface of thermoelectric legs on the basis of a n-type solid solution of

Bi_2Te_3-Bi_2Se_3 leads to hardening of surface layers and an increase in the adhesion properties of switching barriers on the basis of Mo and Ni by more than 4 times. Subsequent pulsed photon treatment with incoherent light does not lead to a significant change in the adhesion properties of the switching barrier layers, while subsequent electrochemical polishing leads to a decrease in the adhesion properties of the coatings. It is established that PPT leads to an increase in the thickness of the hardened layer on the surface of a semiconductor leg that has undergone mechanical polishing, which can contribute to thermal stability in the operation of these legs

Key words: thermoelectricity, bismuth telluride, barrier layer, adhesion

COMPOSITION OPTIMIZATION OF SELF-HARDENING CAST-IRON

L.S. Pechenkina

Details of the excavators are subjected to intensive abrasive wear. For such operating conditions, it is optimal to use complex-alloyed white cast irons. White cast iron with special eutectics, which have become the object of the study, has increased wear resistance and mechanical properties. A composite structure is obtained due to the arrangement of phases. The combination of a soft metal matrix in the structure of the alloys and solid hardening inclusions of the phases gives these alloys the properties of anti-friction and wear resistance. Investigations of the wear resistance of complex-alloyed white cast iron from the structure of the metal substrate have shown how important it is to provide a martensitic or martensitic-austenite structure of the base in the castings of parts of excavators subjected to intensive wear, and in many cases also to large dynamic loads.

The aim of the study is to obtain the required structure in cast iron foundings capable of obtaining a martensitic (or martensitic-austenitic) structure of the metal substrate and a high hardness directly in the cast state without hardening heat treatment (air-hardening white cast irons), by optimizing the chemical composition.

For the selection of the optimal composition of cast iron, a series of melting was carried out. The structure and properties of the air-hardening white cast irons are investigated. It has been scientifically justified and experimentally determined: with martensitic structure of the matrix and high hardness (HRC_e 60-63), the parts are characterized by high wear resistance ($K_i \approx 6$), however the castings are often affected by microcracks. On the experimental production of the bushings of the hydraulic distributor of the excavator, the optimum chemical composition of self-hardening white iron was found, in which these defects in the castings are excluded. It is established that alloys with a structure of 20-35% of austenite have maximum wear resistance. In general, it can be concluded that as the amount of carbon increases, the wear resistance of cast iron increases, but the impact elasticity decreases. Therefore, to ensure sufficient wear resistance of castings with increased impact elasticity, low-carbon complex-alloyed white iron is recommended, containing 2.3% of carbon, 4.2% of manganese, 6.5% of chromium

Key words: air-hardening white cast iron, austenite, impact elasticity, alloying, wear resistance

ELECTRICAL AND MAGNETIC-RESISTANCE PROPERTIES OF $Co_X(MgF_2)_{100-X}$ ANOXIC COMPOSITES

T.V. Tregubova, O.V. Stogney, I.M. Tregubov, V.V. Kirpan, K.G. Korolev

The electrical and magnetoresistive properties of thin films of Co_x $(MgF_2)_{100-x}$ in a wide range of the concentration of the metallic phase ($14 \leq x$, at.% ≤ 62) in the initial state and after thermal annealing in vacuum are studied. It was found that the percolation threshold for a $Co_x(MgF)_{100-x}$ system corresponds to the interval of 30-36 at.% Co. The character of the change in the magnetoresistive effect of composites under thermal action as a function of the concentration of the metallic phase is investigated. The magnetoresistive effect of the samples under study in the initial state reaches 7% in epy field of 10 kOe at cobalt concentration of 25 at. %. The conducted heating changes the magnitude of the magnetoresistive effect. In composites located before the percolation

threshold, the magnetoresistance increases, while in composites located after the threshold it decreases. It is established that the matrix of the system is resistant to the effect of thermal heating to 250 ° C, but further heating to 350 ° C leads to changes in the properties of the system - the magnetoresistive effect is practically lost. Thermal annealing at 350 ° C leads to an increase in the average size of cobalt granules, which affects both the magnetoresistive effect and the magnitude of the electrical resistivity

Key words: thin-film nanocomposite, magneto-resistive effect, thermal annealing

STATISTICAL GEOMETRY ANALYSIS OF ATOMIC STRUCTURE OF Re-Tb SYSTEM AMORPHOUS ALLOYS

A.V. Bondarev, I.L. Bataronov, I.M. Pashueva

Using the molecular dynamics method, the computer models of atomic structure of amorphous alloys of the Re-Tb system in the wide compositional region were constructed. Interatomic interaction was described by the empirical polynomial potential. The radial distribution functions calculated for the models are in good agreement with the results of the X-ray diffraction experiment.

The local atomic arrangement was studied with the help of Voronoi polyhedra. The distributions of the Voronoi polyhedra by the topologycal indices were calculated. Among the polyhedra constructed around the rhenium atoms, the significant part is polyhedra with the topological index 0–0–12–0 typical for the local icosahedral surrounding. We constructed the dependence of the fraction of the Voronoi polyhedra 0–0–12–0 characterizing the local icosahedral short-range order among the polyhedra constructed around the rhenium atoms on the concentration of terbium atoms. This dependence is nonlinearly increasing. The distributions of the Voronoi polyhedra by the number of faces and the distributions of the faces by the number of sides were calculated. The dependencies of these distributions on the composition of the alloys were studied. We calculated the average values of the number of faces determining the geometrical coordination number and the average number of sides of the faces of the Voronoi polyhedra. With the increase of concentration of the Tb atoms for the Voronoi polyhedra constructed around the Re atoms as well as around the Tb atoms, the average number of faces and the average number of sides of the faces of the Voronoi polyhedra decrease linearly

Key words: amorphous alloys, rhenium, terbium, Voronoi polyhedra, icosahedra

APPLICATION OF GRADIENTOMETRIC SCHEMES FOR DETECTING THE CONTRIBUTIONS OF DIFFERENT MAGNETIC FIELDS SOURCES

I.M. Golev, E.A. Nikitina, A.M. Ageev, A.V. Sergeev

Gradient measurements are used to refine the characteristics of the fields of closely located sources against the background of magnetic fields of remote sources with smaller values of the gradient at the measured point. To determine the characteristics of the interference field made by a mobile object, it is necessary to solve the inverse problem - to conduct measurements of the Earth's magnetic field, whose sources are at a great distance from the measuring equipment, against a background of closely located sources of magnetic interference. A method for separating of sources of magnetic fields characterized by the different magnetic induction vector and its components spatial dependences was proposed in the article. The scheme of the gradientometric system which makes it possible to measure the components of the magnetic induction vector and its first and second derivatives in the chosen direction was considered. The structural magnetometric system that realizes the separation of magnetic field useful source from magnetic interference was proposed. The analysis was carried out for the case when the useful signal model is unknown, and the noise magnetic field model is a magnetic dipole with a variable value of the magnetic moment for simplicity. In the considered magnetometric scheme it is possible to use SQUID magnetometers, quantum magnetometers with optical pumping, as well as ferroprobe magnetometers with a high

sensitivity, stability, and with a large dynamic range. The above model can be applied for solving the problems of mobile objects magnetic navigating as well as in solving problems of objects with their own magnetic moment detection

Key words: magnetic field, gradiometer, magnetometer, magnetic interference reduction, navigation by magnetic field, magnetic dipole

AGEING EFFECT ON THE THERMAL STABILITY OF THE POLYMER CHANNEL FLAME BARRIER MATERIAL

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Currently, in order to prevent the explosion of aircraft fuel tanks, a channel fire barrier is used, which consists of elastic, highly porous cellular polymers with open pores. The fire resistance of such a polymer channel fire barrier is determined mainly by the morphological structure of its cells. The analysis of ways to increase the fire resistance of the fire barrier has made it possible to determine two directions: a change in the conditions in which the material of the cells is located, and an increase in the thermal stability of the material itself. The operation of a flame barrier in an aviation fuel medium leads to a change in its morphological structure. In order to determine the behavior of the material of the polymer channel flame barrier in the conditions of a fire in the fuel tank, three samples of polyurethane foam of the PPU-EO-100 grade were tested for heat resistance, the first of which was not installed in the fuel tanks, the second was in aviation kerosene for 3 years, the third sample was in the aviation kerosene medium for more than 9 years. The tests were carried out using derivatography methods, and the material samples were heated to a temperature of 10000 C at a rate of 100 C per minute. The obtained test results confirmed the assumption about the effect of the aging process on the thermal stability of a polymer channel fire barrier during its operation in an aviation fuel medium and allowed to determine the optimal ways of keeping its morphological properties

Key words: derivatography, polymeric channel fire prevention device, fire resistance, polyurethane foam, thermal stability

THERMAL STABILITY OF MULTILAYER Mg/NbO NANOSTRUCTURE

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A multilayer $(Mg/NbO)_{82}$ nanostructure containing 82 bilayers (Mg + NbO) was obtained by ion beam-sputtering of oxide (NbO) and metal (Mg) targets followed by deposition of material through an asymmetric shield onto substrates rotating around the targets. According the results of small-angle X-ray reflectometry the thickness of bilayers in the obtained structures varies from 2.2 nm to 6.2 nm. When the bilayer thickness is less than 4 nm the magnesium layers are not continuous but are a collection of discrete nanoscale magnesium granules. In a case of larger thicknesses of the bilayers the magnesium forms solid layers. It was found that depending on the morphology of the magnesium layers the temperature dependence of the electrical resistivity of the $(Mg/NbO)_{82}$ nanostructure is significantly different. For samples with a low magnesium content the temperature dependence of the resistance is identical to the temperature dependence of the resistance of nanocomposite films which are before the percolation threshold. For samples with a continuous layer of magnesium a different picture is observed: due to the oxidation of metal layers at 430 ° C the resistivity of the multilayer structure sharply increases by 1-2 orders of magnitude. It is shown that the $(Mg/NbO)_{82}$ nanostructure is thermally stable and is not be destroyed when is annealed in vacuum for 4 hours at 450 ° C

Key words: ion beam deposition, small-angle X-ray reflectometry, multilayer nanostructure, thermal stability

NANOSIZED OXIDE FILLER INFLUENCE ON THE PROPERTIES OF P-TYPE CONDUCTIVITY BISMUTH CHALCOGENIDES

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The paper considers the issues of increasing the thermoelectric quality factor of the known thermoelectric materials. A significant breakthrough in achieving high thermoelectric Q (ZT) of the materials was carried out in 1950s, thanks to the introduction of Ioffe concept of semiconductor solid solutions, which was further implemented in practice. In recent years, there has been a new breakthrough in enhancing the ZT of thermoelectric materials based on the concept of creating nanostructured thermoelectric materials.

Taking into account the recent trends in increasing thermoelectric Q, we have studied the effect of nanosized oxide filler on thermal characteristics of composite material based on solid solutions of Bi_2Te_3-Sb_2Te_3 in the temperature range from 20 to 320 ºC. Samples for studies are synthesized by the ceramic technology by hot pressing with the nanosized oxide filler concentration to 0.52 wt. %. It is established that the introduction of oxide nanoscale filler leads to an increase in the thermal electromotive force, electrical conductivity and lower coefficient of thermal conductivity was found to be related to the introduction of oxide nanoscale filler. As it follows from the data obtained, the thermoelectric Q of composites obtained reaches the maximum values ZT = 1.2-1.43 in case of oxide filler concentration 0.1-0.3 wt. %

Key words: nanocomposites, electrical properties, thermal electromotive force, electrical resistivity, thermal conductivity coefficient