Informatics, computer engineering and control

HIGH-PERFORMANCE NUMERICAL CONTROL SYSTEM BASED ON PROGRAMMABLE LOGIC DEVICES

A.A. Zelenskiy, M.A. Khar'kov, S.P. Ivanovskiy, T.Kh. Abdullin

Abstract: the paper presents a developed complete system for numerical control of machines with complex kinematics, industrial robots and automated complexes. The control system has a modular structure. Calculations in the control system are distributed over composite modules. The software core of the system is implemented on a multiprocessor architecture integrated into the topology of the programmable logic integrated circuit. This approach has some significant advantages. Researches have shown that the implementation of a software core run by the operating system significantly increases the response time of the system to external events and reduces fault tolerance. For this reason, the core works without the use of an operating system (bare metal) in the control system. The use of specialized hardware instructions and the distribution of calculations for the architecture cores made it possible to significantly reduce the calculation time. The programmable logic controller implemented in the core of the system, as well as the developed high-performance interface and the communication protocol between the modules of the system make it possible to effectively control the complex electroautomation of machine equipment and automated lines. The system was successfully tested on the machines of the leading machine-building enterprises of the Russian Federation and is a contribution to ensuring the technological independence of the state

Key words: numeric control, distributed computations, high-performance interface and communication protocol

STRUCTURE OF THE CONTROL SYSTEM OF COMPLEX RTC BASING ON HARDWARE-CONTROLLED ARTIFICIAL INTELLIGENCE

V.Zh. Bocharov, V.L. Burkovskiy

Abstract: the article considers a multipurpose control system, represented by a complicated robotic complex. For the control system of an object such as the RTC, it is important to solve the control problem in the difficult conditions of various external disturbances, including rapid changes in control actions. As part of solving these problems, a control system will require not only flexibility and reliability, but also the ability to self-learn as it operates. The solution in this case will be the previously considered application of the hybrid parallel neurocontrol system, which involves the use of two controllers at once: normal and neural. The article presents a classic diagram illustrating hybrid parallel neurocontrol, and an already revised scheme applicable for controlling the RTC. Neural networks of the spatial layers of the neurocontroller are illustrated. The approach to the development of control systems for such objects as the RTC within the framework of complex systems described in the article can significantly increase the overall efficiency of the control object and reduce the number of problems arising during operation of such systems

Key words: neural control, robotic complex, PLC, neural networks, optimization

DEVELOPING PROCESS FORMALIZATION OF A USER CROSS-PLATFORM MOBILE APPLICATION

V.N. Chernikov, S.L. Podvalny, V.F. Barabanov, A.M. Nuzhnyy

Abstract: the article describes the methodology for designing cross-platform mobile applications based on the user interface. The analysis of the software development procedure was performed and a list of the problems most frequently encountered by the development team and determined by the specifics of mobile business applications was determined. Based on the identified list of problems, the software development process was reviewed to identify the key steps that have the greatest impact on the speed and quality of coding and testing. An approach based on the visualization of a sequence of user transitions between application pages is described and the process of preliminary preparation of technical documentation that should be performed by the encoders and testers themselves is designed to unify the process of developing and using common terms and notations in technical documentation and program code. Methodical recommendations for creating a structure of cross-platform mobile applications based on the described technical documentation are given. The technique described in the article allows to carry out technical designing by the developers and testers, having received the information necessary for coding and testing in a convenient and visual format. The proposed approach allows to achieve a significant reduction in labor costs for the development and support of software products

Key words: cross-platform development, mobile applications, development methodology

IMPROVING THE EFFICIENCY OF OPERATIONAL MANAGEMENT AND TECHNOLOGICAL PROCESSES OF COORDINATION BASED ON THE ASSESSMENT OF THE PRODUCTION SCHEDULE

M.A. Tsukanov, O.A. Bozhkova

Abstract: the question of the relevance of the task of construction and adjusting the production schedule on the example of steelmaking enterprise is considered. A decomposition of the production plan was carried out and the possibilities of applying various types of adjustments in practice were considered. The analysis of the compiled schedules, taking into account the satisfaction of all restrictions in the current production situation in the realities of the production process, made it possible to determine the difference in the duration of the inter-operation intervals. To select a specific schedule, the dispatcher is offered to make a selection according to optimal criteria. The presented adaptive principle, which allows the formation and adjustment of the schedule on the example of steelmaking using the Cantor fractal, allows one to take into account the specifics of production and significantly improve the quality of the schedule. The developed algorithm for the interaction of production equipment with the use of elements of the theory of deterministic chaos in solving the problem of scheduling is supplemented by criteria for evaluating the effectiveness of the completed schedule. Lowering power consumption, increasing serial production, reducing specific production losses, reducing the changeover time of the units and reducing production costs for heating steel are considered as indicators of production efficiency. The analysis of the effect during the implementation of the production scheduling system was carried out and the economy was revealed by means of mathematical indirect calculations when using the value of time and energy resources. Reducing the time to adjust the schedule directly contributes to improving the performance of enterprises in various industries

Key words: operational management, technological coordination, production schedule, efficiency of processes

SOFTWARE IMPLEMENTATION OF PATHFINDING FOR MULTIPLE OBJECTS WITH AREAS OF DIFFERENT PERMEABILITY

V.F. Barabanov, N.I. Grebennikova, A.K. Donskikh, S.A. Kovalenko

Abstract: a description is given of the solution of the shortest-path search problem for a set of objects with obstacles and difficult-to-reach areas. The functional requirements for the pathfinder module being developed are formed. An overview of the path optimization algorithms is given, and a modular application structural diagram was developed for the selected algorithm. The developed application provides the ability to track the states of objects, which allows one to adjust the results of the search path. For the correct operation of the path finding module, its own data structure was developed. To work with a variety of objects, a special method was proposed that finds the object closest to the target, then builds a path for it using the basic optimization algorithm. For ease of use of the developed software solution, the calculation of the route was proposed to be transferred to a parallel stream. Recommendations were given for the selection of the operating parameters of the software module and the optimization algorithm for obtaining accurate results. These recommendations allow one to make the most of the program module's capabilities to find the shortest path between objects separated by difficult areas

Key words: optimization algorithms, search for the shortest path, software implementation

USING THE PLANT SIMULATION API FOR OPTIMIZING THE TRANSPORT SYSTEM OF THE PRODUCTION DEPARTMENT

P.Yu. Gusev, Yu.S. Skripchenko, A.A. Pak, K.Yu. Gusev

Abstract: the issue of optimizing the transportation system of the production unit using the Plant Simulation software complex is considered. The site of mechanical processing is used as the system under study. DMU machining centers are located in the studied machining area. The complexity of modeling the study area is due to the processing of parts made of several types of materials, as well as the presence of several sizes. The transport system of the machining section is represented by a transport trolley. The site has one transport cart that delivers blanks for processing, and also takes the machined parts to the assembly hall. The production system under study is modeled and analyzed in the Plant Simulation software package. The analysis of the simulation model showed the main directions of optimization of the system under study: the schedule of movements of the transport carriage and the queue of receipt of blanks in production. Due to the difficulty of multi-criteria optimization using standard software tools, it was decided to use the built-in API Plant Simulation. The article describes and provides a diagram of the work of the dynamic optimization library. The basic problems of developing a dynamic library in C++ are described. As a result of the work, an optimized schedule of movement of the transport trolley and the queue of receipt of blanks in production were obtained

Key words: simulation, optimization, interface, dynamic library

COMPARATIVE ANALYSIS OF ARCHITECTURES OF CROSS-PLATFORM SOFTWARE

V.N. Chernikov, S.L. Podvalny, V.F. Barabanov, V.V. Safronov

Abstract: the article describes the architecture, that is the most common in the practice of toolkits and libraries for cross-platform development. An overview of the mechanisms of operating systems that use selected tools is given. Comparison of cross-platform tools in terms of architecture is done. The mechanisms of integration of cross-platform and platform-independent parts of the software product are considered, and the "bottlenecks" of these mechanisms are indicated. The recommendations are given, which allow to determine the choice of cross-platform tools in different teams of engineers. This class of software is considered as mobile applications. Smartphones and pads are gaining popularity, displacing treeware and stationary computers, giving business units the opportunity to use new channels and ways to exchange information with customers and employees. The article compares the most popular tools: PhoneGap, ReactNative, Xamarin and Qt. The target platforms are iOS, Android and Windows UWP operating systems. A detailed analysis of cross-platform software architectures in part: a substantiation of the use of cross-platform development tools; architecture and interfaces for the integration of operating systems (iOS, Android, Windows UWP); architecture of cross-platform applications (PhoneGap, ReactNative, Qt, Xamarin). General recommendations on the choice of the tool for developing cross-platform applications have been formed

Key words: cross-platform development, mobile applications, architecture of computer systems

OPTIMAL TRAJECTORY GENERATION FOR A QUADROTOR USING CONVEX PROGRAMMING

S.I. Savin, L.Yu. Vorochaeva, A.I. Savin

Abstract: in this paper the problem of controlling a quadrotor is considered. A method for generating trajectories for a quadrotor is described; the method is based on the use of numerical optimization methods and algebraic approaches for determining the sequence of robot orientations. It is shown that the problem of generating trajectories can be represented as a convex programming problem. The solution of the problem of convex programming in this case is used to form a sequence of positions of the center of mass of the device and to find the force vectors that must be applied to the quadrotor to move it from the current position to the next, taking into account the dynamics of the aircraft. The information on the orientations of the force vectors applied to the quadrotor can be used to determine the sequence of the robot's orientations. A method for calculating these orientations is proposed, the necessary assumptions are described. To obtain the control inputs for the feedback control system, interpolation of the data obtained by solving the optimization problem for a discrete set of robot positions is used. The tracking control system is implemented using an iterative linear quadratic regulator. The results of mathematical modeling indicate that the quadrotor is able to execute the trajectories obtained by the described method and is stable in relation to the errors of its initial position

Key words: quadrotor, trajectory generation method, convex programming, stability, center of mass trajectory

Energetics

OBTAINING THE FULL PROBABILISTIC CHARACTERISTICS OF THE PARAMETERS OF ELECTRIC ENERGY TASKS

Yu.D. Bay, A.V. Shmoylov, M.V. Andreev, A.A. Suvorov, A.V. Kievets, I.A. Razzhivin

Abstract: in the tasks considered in the power industry, the parameters of stationary modes, electrical values for damage, indicators of functional reliability, power reserves of power stations, wire sections of network lines, transformer and converter stations, etc., are functional dependencies of the initial data, such as active and reactive powers, values and voltage angles of nodes of electrical networks or random arguments. Finding the complete probability characteristics — probability distribution densities (PDDs) and probability distribution functions (PDFs) of these functional dependencies — allows one to get a complete picture of all possible values that the parameters of interest can take. The main problem is that obtaining PDD and PDF of the parameter of interest by standard statistical methods currently has no practical solution. In this regard, we propose a developed method for the selection of the boundaries of input and output data (SBID), which is not critically dependent on the dimension of functional dependence (FD), considered in the article. The actual methods of statistical modeling of random arguments are presented, the method of selection of input and output data boundaries from an analytical point of view is considered, an improved algorithm for obtaining the full probability characteristics of functional dependencies is also presented, the results of low-dimensional examples are demonstrated

Key words: electric power system, numerical methods, probability distribution law, random variable, quantile, functional dependency

STRUCTURAL ANALYSIS OF ENERGY-TECHNOLOGY COMPLEXES OF SMALL DISTRIBUTED GENERATION

O.V. Afanas'eva, G.R. Mingaleeva

Abstract: objects of small distributed generation are sources of reliable power supply to consumers unaffected by a centralized power system. The choice of local energy sources, in particular solid fuel, as a fuel, provides the conditions of autonomy for these objects, allows reducing the cost of fuel delivery and, consequently, reducing the cost of energy and by-products produced. In the article, schemes of low-capacity power plant with production of energy and valuable by-products are presented. This paper discusses the production of activated carbon, which can be used as sorbent, granulated ash-slag materials for the construction industry and commercial sulfur, demanded in chemical plants. Within the framework of the proposed work, a structural analysis of the schemes in question was carried out, information flowcharts were constructed, external and internal relationships and torn flows were identified. In the scheme with the production of activated carbon, four circuits are revealed, in the scheme with the production of ash and slag materials - one circuit, in the scheme with the production of commodity sulfur - ten contours. The analysis of the structure of the connections will allow one to calculate the energy efficiency and optimize the work of the station in order to increase the efficiency of fuel use taking into account the needs of consumers for the output of energy and products

Key words: solid fuel, small energy, technological schemes, structural analysis, by-products

SELECTING WINDINGS OF DISK SYNCHRONOUS GENERATOR WITH EXCITATION FROM PERMANENT MAGNETS

T.E. Chernykh, S.A. Belozorov, A.V. Tikunov

Abstract: modernization of the already existing, as well as the development of new electrical equipment has always been an urgent task. In the last decade, this issue has become even more important due to the need to develop energy-saving technologies in the power industry and introduce new technologies for producing electrical energy, which include alternative renewable energy sources, in particular wind power. There are quite a lot of problems in the Russian wind power industry related to the fact that this direction in our country did not develop for a long time, and therefore there are almost no modern design solutions for both wind power plants and its individual nodes that meet today's needs. In particular, in Russian installations, developers most often use foreign-made electric generators or a general-purpose electrical machine. However, to obtain high energy performance of a wind power installation, it is advisable to use a specialized generator that meets a number of requirements. In this connection, the design of a specialized synchronous generator with excitation from permanent magnets is proposed for a vertical-axial wind power installation that meets these requirements, and also offers various options for winding execution

Key words: synchronous generator, permanent magnets, winding scheme, coil form

Radio engineering and communication

DEVELOPMENT OF THE METHODOLOGY FOR THE REDS BLOCK COMPOUNDING TAKING INTO ACCOUNT ELECTROMAGNETIC AND THERMAL CHARACTERISTICS

M.A. Romashchenko, A.P. Strel'tsov

Abstract: an integrated approach to the process of assembling blocks and cells of radio electronic equipment is considered, taking into account electromagnetic and thermal characteristics. The urgency of the task of creating and further

improving the methods of optimal layout of various hierarchical levels of radio-electronic facilities designs is justified, taking into account electromagnetic and thermal characteristics. The constant increase in complexity and density of the layout leads to an increase in requirements for the qualifications of developers, an increase in the cost of designing and testing radioelectronic devices, slowing down the process of creating promising devices, developing special means of thermal protection and creating techniques to ensure electromagnetic compatibility and noise immunity of radioelectronic units.The technique of optimal layout design of radio-electronic means, based on the use of 3D-models, adapted for application. A feature of the technique is the use of software that allows for repeated iterative analysis in a reasonable time. The methodology includes procedures for the initial layout and optimization of the design of the device unit, the creation of a 3D model and its adaptation for further analysis. The practical application of the technique for solving the production problem is presented, which showed qualitative improvements in the technical and operational parameters of the product - the temperature of the most heat-loaded element, the maximum temperature inside the case, the strength of the electromagnetic and electric fields, and the noise immunity of the structure

Key words: block layout, electromagnetic analysis, thermal simulation, device design optimization

HIGH-QUALITY SMALL ACOUSTIC SYSTEMS FOR WIRELESS INFORMATION TRANSMISSION NETWORKS

A.S. Badaev, A.I. Sukachev, V.O. Alekseev, P.A. Kondratov

Abstract: in the work the design of high-quality, high-performance small-sized acoustic systems (AS) for wireless information transmission systems - a personal Bluetooth network is calculated and developed. It is shown that in order to achieve the highest possible energy characteristics with small dimensions, the optimal type of acoustic design is a "phase-inverter with a passive radiator (PR)". On the basis of the method of electromechanical analogies an equivalent acoustic scheme of the developed AS is constructed. The transfer function of the low-loss phase-input system obtained from the analysis of the equivalent circuit in the low-frequency region (LF) is similar to the transfer function of the fourth-order polynomial type high-pass filter (HF) with a slope of the amplitude-frequency characteristic decreasing toward the LF 24 dB / oct. Taking into account the parameters used by the low-frequency loudspeaker heads (LH), it is established that the frequency response of the developed AS can be approximated by fractional rational functions based on fourth order Butterworth polynomials or by quasi- order polynomials. Based on the proposed methodology, the main design characteristics of the AS are calculated: the volume of the casing, the frequency of adjustment of the PR, its mass and suspension flexibility, a design is developed and presented, and the parameters of the AS are listed. The higher characteristics of the developed systems are compared with the analogues

Key words: wireless information transmission networks, Bluetooth, acoustic systems (AS), power, level of characteristic sensitivity, range of reproduced frequencies

PRODUCTIVITY ANALYSIS OF THE MULTI-PROCESSOR SYSTEM OF DIGITAL PROCESSING OF SIGNALS IN THE CASE 1867VA016T

G.V. Fetisov, D.V. Shekhovtsov, E.D. Alperin

Abstract: the article studies a high-performance multiprocessor digital signal processing system in the 1867BA016T case developed by the JSC "Scientific Research Institute of Electronic Technology", evaluats the efficiency of using a different number of cores to solve digital signal processing (DSP) problems in order to justify the use of multiprocessor systems for DSP tasks. The procedure for communication of processor cores through switching ports that provide data transmission/reception at speeds up to 480 MB/s, as well as methods for combining cores using hypercube technology with various dimensions for the purpose of increasing processing power are considered. A universal program for calculating Fast Fourier Transform (FFT) in C and Assembler languages for each of 1867VTS3F cores and a different number of initial readings were compiled. The performance of the multi-core DSP system in the 1867BA016T case containing four digital signal-processing processors (DSPs) is estimated, with different number of active processor cores, by determining the execution time of the 64-point and 512-point FFT with or without the checksum calculation. The result of the study is the time diagrams and graphs showing the time of FFT execution for 64 and 512 initial samples and the number of active nuclei 1867BA016T. An optimal number of processor cores was proposed, which should be used to solve DSP tasks when working with a common memory area for multiprocessor systems in a chassis or on a chip with the architecture similar to the 1867BA016T

Key words: COM port, FFT, multi-core system, hypercube, DSP, performance, Assembler, C

DEVELOPMENT AND APPLICATION OF METHODS FOR DEFINITION OF PROTECTIVE RELATIONS IN DEVICES USING DIFFERENT PRINCIPLES OF SIGNAL MODULATION

D.V. Vasil'chenko, A.A. Pirogov, I.V. Ostroumov, A.B. Antilikatorov

Abstract: currently, wireless electronics is booming. In particular, wearable gadgets that have recently used wired systems to communicate with various devices have introduced wireless communication channels as connecting elements of information transmission. These include a variety of peripherals, such as headphones, smart clocks, etc. All these channels operate at certain frequencies, which can be damped by the effects of various types of electromagnetic interference. These interferences adversely affect not only the reception of the signal, but also the receiving and transmitting devices themselves, as well as all electronic devices located in the interference zone. The article shows the technique of determining the signal-to-noise ratio and calculating the protective ratio by means of which it is possible to determine the protective ratio by the high-frequency path and at the intermediate frequency without carrying out tests that require large time and material costs. This technique is suitable for use in radioelectronic facilities using signals with phase, as well as frequency modulation, with respect to radio interference of various types. Such disturbances include impulse and continuous radio interference based on phase-manipulated signals, frequency-modulated signals and signals modulated in frequency by harmonic or saw-tooth voltage

Key words: radio electronic means, signal manipulation, wireless communication systems, signal-to-noise ratio, protective ratio

HIGHLY EFFICIENT HORNY AUTOMOBILE SUBWOOFER

A.S. Badaev, D.K. Fomin

Abstract: the paper proposes a calculation technique and develops a horn car subwoofer design with high power, efficiency and maximum sound pressure level (SPL). The analysis of the frequency dependences of the active components of the input impedance R_{in} of the horns of different shapes obtained as a result of the solution of the Webster wave equation shows that the horn with a hyperbolic profile is the most effective for reproducing low frequencies (LF). In the low-frequency region near the critical frequency f_{cr}, which determines the lower limiting reproduction frequency, the hypervalent horn possesses the maximum value R_{in}. This provides the optimal load, in case of matching the acoustic impedances, for the loudspeaker heads (LH) installed at the input of the speaker. When the condition on the comparability of the perimeter dimensions of the horn output opening - "mouth" to a wavelength corresponding to f_{cr} is satisfied, the hyperbolic horn will effectively emit acoustic energy at the low frequency. Using a phase inverter with a passive radiator (PR) as a load for the rear sides of the diffusers of the GG, operating in a phase with the emission of the horn, allows to increase the SPL. Based on the proposed methodology, the design of a horned automotive subwoofer was designed and developed. The work shows higher technical characteristics of the developed subwoofer compared to analogues

Key words: acoustic systems (AS), subwoofer, speaker, bass reflex with passive radiator (PR), power, efficiency, SPL

Mechanical engineering and science of machines

TOPOGRAPHY, CHEMICAL AND PHASE COMPOSITION OF FRACTURE SURFACES OF DIFFUSION-WELDED COMPOUNDS

V.V. Peshkov, A.B. Bulkov, S.B. Kushchev, B.L. Agapov, A.I. Dontsov, S.V. Kannykin

Abstract: experimental studies were carried out on tubular samples with the wall thickness δз = 0.5 mm from OT4 alloy (imitating one cell of a honeycomb of a laminated composite) to the end of which plates with the thickness δ0 from 0.5 to 2 mm from the sheet alloy OT4-1 (simulating the load-bearing layers of the composite) were welded. Diffusion welding was carried out at the temperature of 900 °C, the compressive pressure of 2.8 MPa in the vacuum of 2·10-2 Pa for a time of up to 60 minutes. The welded joints were tested for tearing, then the fracture surfaces were examined. The analysis of the topography of the fracture surfaces showed that when δ0 was less than 1.5 mm, the destruction of the joint occurred along the plane of contact between the welded surfaces and the formation of poorly developed seizure areas, and fractions of film inclusions were present on the fractograms. The results of X-ray spectral microanalysis, X-ray

diffractometry, and Auger spectroscopy of the fracture surfaces revealed sufficiently high oxygen content in the surface layers and it can be suggested that the suboxide films presenting in the contact of the welded preforms were a sufficient barrier to the implementation of the welding process. It was established that the formation of the welded joint occured during deformation of the contact surfaces necessary for the destruction of suboxides and the activation of welded surfaces

Key words: diffusion welding, contact zone, deformation, seizure areas, fractography

COMPARATIVE CHARACTERISTICS OF KITS FOR CAPILLARY DEFECTOSCOPY

I.O. Bogachev, M.N. Davydov, Yu.S. Tkachenko

Abstract: in this article, the method of capillary control is considered and a comparison of a pair of common kits for its implementation is made. The advantages of capillary control are compared with other methods of nondestructive testing. The main problems of the correspondence of the claimed sensitivity class and the optimality criteria are formulated. The applied kits, auxiliary equipment and object of control are described. A method for testing the sensitivity classes of the penetrants used on the control sample was carried out. The stages of conducting the capillary control are considered, the features and disadvantages of the applied sets are highlighted. The advantages of a cleaner, developer and penetrant of one manufacturer before its competitor are shown. Based on the results obtained, an analysis of defects on the controlled product was carried out. Type defects are considered: "single pores", "pore accumulations", "pores of chains", "friable" and "false indications". The sizes of indications, their orientation on the surface are found and the resulting values are compared. For each set, the width of the exposure of these defects is calculated. The inspection was carried out in accordance with the normative and technical documentation. Practically, the dependence of consumption on the monitored area was singled out and a table was compiled for each component of the selected sets. According to the data received, the risk of the product being crocheted and the reasons for the difference in the prices of the test kits for the capillary control method are considered

Key words: non-destructive testing, capillary control, sensitivity class, surface roughness, HELLING, SHERWIN

THE WAY TO INCREASE QUALITY OF AN AIRCRAFT SKIN

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

Abstract: the method of increasing the uniformity of deformation in the longitudinal and transverse directions of the deformable workpiece is considered. The purpose and objectives of the study are formulated. The analysis of the process of shaping the skins on the equipment with CNC is done. The character of stresses and strains at their minimum value along the cross-sections of the workpiece is shown. The non-uniformity of deformations and stresses in the formation of double curvature casings was revealed. A method was developed for leveling the deformation by obtaining a concave surface obtained by a computational method on a technological allowance of a punch. The dependence is obtained, which allows one to design a concave surface taking into account the geometrical parameters of the punch. The technique of punch design is given. An example of calculating the geometric parameters of the punch is made. Experimental studies on CNC equipment were carried out, confirming the effectiveness of the developed method of straightening deformations in the longitudinal and transverse directions, ensuring an improvement in the quality of the obtained skin

Key words: punch, technological surface, concave surface, shaping, deformations, counter forming, deformations alignment, allowance

INFLUENCE OF KINEMATICS OF THE TOOL MOVEMENT ON THE WEAR-RESISTANT COATING FORMATION

S.Yu. Zhachkin, M.N. Krasnova, G.I. Trifonov, N.A. Pen'kov

Abstract: it is known from literary sources that the most used methods for the restoration of machine parts are the technologies with the use of highly concentrated energy flows, for example, gas-thermal surface treatment. In the field of gas-thermal surface treatment of parts, systems of equations are actively used to estimate the physical, mechanical and chemical features (parameters) of the coating the surface of parts. In this regard, the issues of developing improved systems of equations for estimating and predicting key parameters of the plasma spraying process come first in simulating the process of gas-thermal technology. In this paper, we consider the influence of kinematic regimes on the formation of a plasma coating on a complex-shaped surface of a part. In particular, the kinematics of applying a wear-resistant coating on the screw surface of the part was analyzed, and the effect of the coating speed on the thickness of the sprayed layer and the temperature of heating the part was considered. Compiled advanced calculation equations for predicting the thickness of the sprayed layer and the heating of the screw (complex-shaped) surface. The developed mathematical dependencies are planned to be used in the development of technological maps and subsequent correlations of the technology of applying plasma spraying on automated and robotic complexes when processing parts with complex geometrical generatrix

Key words: plasma spraying, speed, coating thickness, surface temperature, modeling, kinematics

Physics

EFFECT OF IRON REPLACEMENT BY NICKEL IONS ON DIELECTRIC PROPERTIES OF FERROELECTRIC CERAMICS $Bi_6Ti_3Fe_{2-x}Ni_xO_{18}$ WITH THE AURIVILLIUS PHASE STRUCTURE

N.A. Tolstykh, A.I. Bocharov, I.Yu. Kobyakov, S.A. Gridnev

Abstract: a solid solution of $Bi_6Ti_3Fe_{2-x}Ni_xO_{18}$, where x = 0; 0.1; 0.2; 0.3; 0.4, was prepared by standard ceramic technology. Temperature dependences of the dielectric constant ε and the loss tangent tgδ were studied at a frequency of 1 kHz in the temperature interval from 25 to 600 ºC. The observed ε and tgδ anomalies are associated with the presence of a structural phase transition in these samples. A verification of the Curie-Weiss law showed the smearing of the phase transition. For the description of the diffused phase transition, the Smolenskiy-Isupov model of the composition fluctuations was chosen. Within the framework of the model, an estimation of the phase transition smearing degree as a function of the nickel concentration was made, the smearing degree becomes larger with nickel content. The dependence of the temperature coefficient of the dielectric constant in the temperature range from 25 to 100 ^oC was studied for all compositions. The revealed ceramic material with the lowest values of the temperature coefficient of dielectric constant can be used for the development and production of highly stable capacitors for radio and electronics devices

Key words: ferroelectric ceramics, layered perovskite, phase transition, Kanzig volume, temperature coefficient of permittivity, Aurivillius phase

MOLECULAR-DYNAMICS SIMULATION OF ATOMIC STRUCTURE OF AMORPHOUS ALLOYS OF A Re-Gd SYSTEM

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

Abstract: using the molecular dynamics method, we carried out a computer simulation of atomic structure of Re-Gd amorphous alloys in a wide compositional region. The interatomic interaction was described by an empirical polynomial potential. The parameters of topological short-range order obtained in the result of the simulation are in good agreement with the experimental results. The local atomic arrangement was studied with the help of the Voronoi polyhedra. The distributions of the topologycal indices of the Voronoi polyhedra were obtained. Among the polyhedra, the centres of which are the rhenium atoms, the significant part are polyhedra with the topological index 0–0–12–0 typical for the local icosahedral surrounding. We studied the dependence of the fraction of the Voronoi polyhedra with the topological index 0–0–12–0 on the concentration of gadolinium atoms. This dependence has the smooth maximum in the middle of the concentration interval. The statistics of the face number and of the side number of the Voronoi polyhedra were studied. The dependencies of these distributions on the composition of the alloy were studied. The average values of the number of faces and the average number of sides of the Voronoi polyhedra were calculated. With the increase of concentration of the Gd atoms for the Voronoi polyhedra constructed around the Re atoms as well as the Gd atoms, the average number of faces and the average number of sides of the faces decrease linearly

Key words: molecular dynamics, amorphous alloys, Voronoi polyhedra, icosahedra

INFLUENCE OF PRESSURE AND TEMPERATURE ON THE KINETICS OF ETCHING OF LITHIUM TANTALATE IN FLUORINATED PLASMA

I.V. Konyaev, L.N. Vladimirova, E.N. Bormontov

Abstract: the data stared in the article show the influence of pressure and temperature on the kinetic features of the etching process of polished single-crystal $LiTaO_3$ samples in a fluorine-containing plasma based on SF_6 gas. The experiments were performed on a Corial D250 with a diode-type reaction chamber. It was established that decrease in etching rates with increasing pressure was observed in the investigated range. The growth in particle concentration occurs with increasing pressure that leads to energy loss of electrons because of decrease in the mean free path (increase in collision frequency). As a result, the rate of dissociation decreased. This has a significant impact on concentration of fluorine radicals involved in the process of plasma chemical etching. Dependencies V_{et}=f(P) have qualitatively similar type of down warding curve at different power values. The etching process is threshold and starts at range of temperature 450÷500 K apparently related to volatility of reaction products. Temperature changes in range from 500 to 570 K lead to exponential growth of the etching rates. The effective activation energy for the range of working temperatures was calculated. Its value was about 100 kJ/mol. Further increase in temperature seems to change the area of passing process from kinetic to diffusion, that can be depicted by decrease of effective activation energy to 8 kJ/mol

Key words: plasma chemistry, lithium tantalite, fluorine radicals, temperature stimulation, activation energy

INFLUENCE OF CHEMICAL AND PHASE COMPOSITION ON SHOCK VISCOSITY ON WEAR-RESISTANT WHITE CAST IRON

L.S. Pechenkina

Abstract: the object of the study is complex-alloyed solid alloys, including white cast iron, used for wear-resistant parts, which already in casting should have the required strength and toughness. The task of the study is to identify the chemical composition, the parameters of the structure formation, which affect the toughness. In the process of investigation, we got the alloys containing such percent of the elements: from 1.18 to 2.49 C, from 0.7 to 5.5 Mn, from 3.1 to 9.6 Cr, from 1.8 to 8.3 V, up to 1.3 Si. The investigated alloys were divided into three groups according to the percentage of austenite contained in their structure. The first group was characterized by an increase in hardness with a simultaneous increase in the percentage of austenite in the structure up to 13. The second contained up to 25 percent of austenite without increasing the hardness, and the third showed a decrease in hardness with larger quantity of austenite (more than 30%). A separate group consisted of alloys containing up to 2.14% of copper, up to 1.73% of molybdenum. An assessment of the change in impact strength is based on the influence of chemical factors (carbon, manganese, chromium and vanadium) and phase composition by multivariate regression analysis. It was determined that the carbide phases (MC, M_7C_3) in the investigated alloys reduce the toughness. This is especially noticeable in the alloys of groups 1 and 3, their influence in the alloys of group 2 is much less pronounced. It was found that the decrease in the toughness occurs at the maximum degree of martensitic transformation in the structure (at 2-2.2% Mn or 20-25% A). It increases with a higher degree of austenitization of the structure (more than 40% A). For an individual group of complex-alloyed alloys this effect is not manifested in connection with the distinctive features of their structure. The best combination of mechanical properties for alloys of this group is provided at 20-40% of austenite in their structure

Key words: impact strength, white cast iron, structure, alloying element

EFFECTIVE ELASTIC NONLINEARITY OF THE PURE PROPER FERROELASTIC $KH_3(SeO_3)_2$

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Abstract: the object of the study was a single crystal of pure proper ferroelastic $KH_3(SeO_3)_2$, grown by spontaneous crystallization from a supersaturated aqueous solution by the controlled temperature decreasing. It is shown that solving the problem of the torsion of an elastic anisotropic rod of rectangular cross-section using the measured values of shear moduli, it is possible to calculate the shear elasticity coefficients of the crystal. As a result, *Z*-orientation samples of the single crystal $KH_3(SeO_3)_2$ were chosen for carrying out the experiments, since for such orientation of the sample one of the shearing components σ_{55} of the torsional mechanical stress is coupled with the shear component of the spontaneous deformation x_{55}. Using a torsional pendulum, mechanical hysteresis loops $x(\sigma)$ were plotted, evidencing the nonlinear mechanical behavior of the material associated with the transition of the sample from the polydomain to the monodomain state. At different temperatures, the dependences of the elastic compliance on the shear mechanical stress are measured. It was found that below the Curie temperature the shear component of the elastic compliance of s_{55} with a change in the torsional mechanical stress passes through a maximum due to the dynamics of the ferroelectric domain walls. The increase in the coefficient of the effective elastic nonlinearity with increasing temperature is explained by the temperature dependence of the mobility of the domain walls

Key words: ferroelastic, elastic compliance, mechanical nonlinearity, single crystal $KH_3(SeO_3)_2$