Informatics, computer engineering and control

APPLICATION OF ARTIFICIAL NEURAL NETWORKS FOR SOFTWARE TESTING OPTIMIZATION

A.D. Danilov, V.M. Mugatina

Abstract: the process of software testing is important, but also it is one of the most resource-intensive activities in the life cycle of software product development. Making changes to the software causes the need for a new cycle of regression testing, and that is why problem of optimal distribution of efforts during test execution in various units of the system under test is actual. The paper considers the most common approach of building the program interface of modern web applications - the REST API, and describes the features of testing of such systems. The approach based on the use of artificial neural networks was proposed. This approach makes it possible to solve the problem of classifying modules into two groups: prone to error modules and modules without defects. This classification allows to allocate resources to check only those modules, the probability of having errors in which is determined by the result of the work of the neural network. The structure of a neural network is given and the parameters of input and output values of neural network are designated. The objectives of further research of the proposed approach are determined

Key words: software testing, neural networks, REST API testing, regression testing, default prediction

A COMBINED METHOD OF AN ANALYSIS AND SELECTION OF COMPLEX TECHNICAL OR SOCIO-ECONOMIC SYSTEMS

V.L. Burkovskiy, B.A. Shiyanov, A.V. Grivachev, A.S. Sizov, E.A. Titenko

Abstract: well-known methods of decision-making are analyzed in the article. Algorithmic properties are chosen as properties of methods: the type of computational process, the data formats, the forms of measurement scales, qualimetry, preprocessing, the type of decision rule, etc. For the task of analyzing, evaluating and selecting the best alternative under incomplete or inaccurate information, none of the considered methods is suitable. That is why the paper proposes a combination of the best properties from the methods considered: visualization of results, hidden regularities, accounting for the non-linearity of the decision function. A combined method that has pre- and post-processing stages and is based on the hierarchy analysis method was developed. The composition of the combined method was supplemented with the stage of obtaining additional information. This stage is based on the allocation and processing of general and individual indicators for subsystems of objects. Values of general and individual indicators are normalized. Then, on their basis, weights are calculated. These are the weights that are used in the standard steps of the hierarchy analysis method. They are used to correct the matrix of paired criteria comparisons. This method allows to obtain reasonable estimates of alternatives with overlapping indicators. It also chooses the best alternative using additional information from clustering objects and their ordering by the weights of general and individual indicators

Key words: hierarchy analysis method, choice, adaptive solution, qualimetric diagram

SOME NOTES TO THE DETERMINATION OF CAPACITY BY SHENNON

Yu.Ya. Agranovich, S.L. Podvalny, I.Ya. Novikov, S.A. Prutkova

Abstract: in this paper, we give a rigorous justification for the determination of the Shannon bandwidth for a channel without noise based on the Perron-Frobenius theorem. In his first work, Claude Shannon makes a reference to the calculus of finite differences, as the main mathematical apparatus required for the justification of the introduced concepts. However, in fact, this is not enough. This requires deep and non-trivial results from functional analysis and graph theory. It took Shannon about ten years to recognize this fact. In one of his articles written in 1957, he casually mentioned that, but confined himself to a brief reference to Frobenius' article. In addition, we note another significant fact: the quality of the Russian translation. The English text of these works by C. Shannon differs from their translation. The translation, unfortunately, contains vague and logically flawed phrases that ultimately lead a reader astray. It seemed natural to us to correct these shortcomings. In our work, the full flow of satisfaction is given. The presentation is accompanied by the necessary definitions and formulations of the corresponding theorems. Nontrivial unsolved problems of interest both for specialists and postgraduates, as well as senior students associated with this problem are formulated as well

Key words: capacity of channel without noise, the theorem of Perron-Frobenius, accompanying matrix, directed graph, strong connectivity

MODELS AND ALGORITHMS OF FORMING THE COMPOSITION OF DISCIPLINE MODULES

M.Yu. Sergeev, T.I. Sergeeva, N.I. Grebennikova

Abstract: the general characteristics of the modular training technology and its implications for improving the efficiency and adaptability of training are given. Features of modular training are considered. The method of formalizing the requirements of the modular training technology and providing the variability of the content of teaching materials differing in the complexity of the learning content is shown. Mathematical models of optimization of the composition of the training modules of the discipline that provide the optimal values of integral indicators of the quality of training are considered. Evaluation of the choice alternatives is carried out using expert assessments of the importance of the modules studied, as well as taking into account the completeness options for the presentation of the training material. The considered models contain restrictions on the time of an audience study of the material. Probabilistic algorithms for solving the problems of forming the composition of training modules are proposed, realizing a brief search of possible alternatives to the solution and obtaining a result for a finite acceptable number of steps. In the search for the optimal solution, the recalculation of the probabilities of the choice of the solution alternatives is realized taking into account the effect of the chosen alternative on the goal function. The structure of information and software of the complex on formation of the modules of disciplines is given. The software allows to apply the proposed models and algorithms. Information support displays the structure of tables in a distributed database. Information and software complex, built on the basis of the proposed models and algorithms, provide an agreed choice of the composition of the modules of the academic discipline

Key words: modular learning, models of the learning contents formation, indicators of modules structure estimation

ALGORITHM OF SUPRESSION OF SELF-OSCILLATIONS IN SERVO-DRIVES BASED ON DIGITAL MICROCONTROLLER REGULATOR

D.P. Lashchenov, V.L. Burkovskiy

Abstract: a software method is proposed for suppressing self-oscillations in servomotors based on a digital microcontroller regulator. The main criteria and methods for reducing the level of self-oscillations in adaptive servo systems are considered, taking into account the nonlinearities of the characteristics of the transmission and actuating mechanisms. As an example, methods for suppressing self-oscillations in a servomotor drive with a regulator based on a digital microcontroller 1887VE4U were developed. These methods were developed and tested during the commissioning tests in the framework of batch production, as well as preliminary tests of the final product. The main criteria for the stable operation of the servo drive in the positioning mode with small changes in the control action are the minimization of backlashes in the transmission mechanism, the introduction of additional position and speed sensors and the output link of the actuator, and the adjustment of the feedback depth according to the active observer's evaluation. The use of a digital controller based on the microcontroller gives new possibilities for fine tuning of gain factors along the contours of angular position, rotation speed and acceleration with the purpose of forming the optimal control principle of the drive providing suppression of the auto-oscillation mode at constant levels of the driving signal. The software algorithm proposed in this paper is an addition to the digital microcontroller regulator and automatically adjusts the regulator coefficients on-line, taking into account the required dynamic parameters. As the initial data for determining the optimal coefficients, the rate of change of the input signal and the magnitude of the error by the position of the output link are used

Key words: servo drive, digital regulator, adaptive regulator, microcontroller, self-oscillations, automatic control

Energetics

INVESTIGATION OF THE LOAD INFLUENCE IN THE FOLLOW-UP SYSTEM IN MATLAB AND SCILAB

A.P. Kharchenko, Yu.S. Slepokurov, P.A. Aver'yanov, I.Yu. Svirskiy

Abstract: to the follower drive with the modal controller (MC) for moving the transport manipulator, the same requirements are imposed on the quality of regulation as to tracking drives for moving the links of the manipulator. We consider a two-loop system with feedbacks on speed and position and a single-loop servo system with feedback on position. In the practical implementation of such tracking systems with MC, the permissible limits of static load variation for a stable operating mode have not been investigated. The search for ways to eliminate the influence of the load is the goal of the presented and subsequent studies of the tracking system with MC. Simulation of structural circuits of single-loop and two-loop servo systems with MC is implemented in the Matlab and Scilab environments. The results of investigations of two variants of the structural circuits of servomechanisms allow us to conclude that a change in the static load in a single-loop servo system leads to oscillations in the components of the controlled state vector X4 (voltage) and X3 (current or developed torque) with a control input waveform of a meander or a triangular form. The variable component of the controlled state vector X2 (velocity) does not change. Parameters of the quality of control of the servo system, determined for the output signal, the movement (component X1) do not change. A change in the specified limits of the static load in a two-loop servo system does not affect the parameters of the components of the controlled vector X

Key words: single-circuit and two-loop electromechanical servo system, motor block diagram, static load, modal controller, observer, transient response

EXPERIMENTAL STUDY OF THE SILICA GEL DRYING PROCESS IN THE APPARATUS WITH CENTRIFUGAL FLUIDIZED BED

A.A. Nadeev, A.V. Barakov, V.Yu. Dubanin, A.Yu. Andreev

Abstract: among all apparatuses used for the drying of dispersed materials, a special place is occupied by apparatuses with fluidized bed. They have a high intensity of interphase heat and mass transfer, small hydraulic resistance and, as a rule, have small dimensions and simple construction. This allows them to solve one of the most important tasks of any industry - energy saving. This paper presents an experimental batch dryer with a centrifugal fluidized bed, which is designed for drying hard-drying and high-moisture dispersed materials. Its construction and operating principle are considered. The scheme of the experimental stand is given and described. The first (preliminary) series of experiments on the dispersed materials drying were carried out. The object of drying is silica gel, used for drying air and industrial gases. Experimental data in the form of time dependences of initial and final parameters of heat carrier (air) and silica gel are presented. Comparison of the process of its drying at heat carrier temperature from 40 to 60 °C is made. On the base of the performed analysis of the experimental data, the operability of the dryer was confirmed and the conclusion was drawn about the high intensity of the heat and mass transfer process

Key words: dryer, fluidized bed, dispersed material, silica gel, heat carrier, experimental study

GENERALIZED STRUCTURE OF THE DECISION-MAKING SYSTEM IN CONDITIONS OF POTENTIALLY HAZARDOUS NUCLEAR POWER OBJECTS

V.P. Povarov

Abstract: the article considers the intellectual decision-making system under in conditions of potentially dangerous nuclear power facilities. The proposed system belongs to the class of consultants and does not take final decisions in case of deviation of the analyzed parameters, but forms a number of alternative solutions for the personnel of the production enterprise. The article uses a fuzzy logic apparatus and an adaptive fuzzy-neural network as a mathematical apparatus. The accumulated experience in the operation of nuclear power facilities shows that there are critical elements (nodes, zones, welded joints) that are prone to increased damage in conditions of high operational loads, including non-projected loads, and negative environmental impact. Usually in such a situation there is a danger of damage to the integrity of the equipment when the power unit is operating at a power level at the appearance of a serious defect, for example, a coolant leak and the prospect of developing an initial through-fault to critical dimensions; all these result in the fact that the final observable result is always the same - the formation and development of an operational crack that constitutes a threat to the structural integrity of the element in question and, as a consequence, there is a serious threat to the safety of the nuclear unit's operation. The proposed situational model is associated with an explicit knowledge base in which the formed situations are stored

Key words: decision-making system, multiple regression, nuclear power

APPLIED METHODS OF SYSTEM ANALYSIS IN PROBLEMS OF POWER PRODUCTION CONTROL AT NOVOVORONEZH NOVOVORONEZH NUCLEAR POWER PLANT

I.A. Kolyagina, A.D. Danilov

Abstract: the article is devoted to the analysis of management tasks and the tools used to solve these tasks at the Novovoronezh NPP for strategic planning and management of the achievement of the strategic goals and objectives set by focusing the enterprise management system on continuous improvement of operations at the points of greatest influence on strategic and production and economic indicators. The key instrument for the decomposition of the goals of the Novovoronezh NPP is the Target Tree, through which it was possible to determine the interrelations between the objectives at all levels of enterprise management, the indicators measuring achievement of these goals, and the responsibility for achieving them. Economic and functional purposes were used. The submission of goals starts from the top level, then they are sequentially disaggregated. The main rule of disaggregation of goals is completeness: each goal of the top level is represented in the form of sub-goals of the next level in an exhaustive manner, that is, so that the unification of the notions of subgoals completely determines the concept of the initial goal, the indicators that determine the possible state of the system, i.e. the degree to which the target standards are met, given the available time, resource or other constraints. Typical examples are: planned generation of electricity and its actual value; planned and actual time of repairs, etc. The level of goal realization determines the ratio of the target to the target standard. The presented logic of decomposition in the form of a target tree can serve a primary information base that can be used to calculate integrated indicators for the whole enterprise and for structural subdivisions with the purpose of making effective decisions. Implementation of this approach in practice allows to get the structure of the organization, oriented entirely to the implementation of the strategy and the system of indicators, allowing the most adequate assessment of the effectiveness of its functioning. At the same time, the enterprise is perceived as a system of interrelated elements with a common goal - to ensure maximum productivity in terms of generating electricity and improving the management system of nuclear power plants

Key words: system analysis, strategy, decomposition, tree of goals, indices

MATHEMATICAL MODEL OF THE PROCESS OF MUTUAL HEAT EXCHANGE IN ELECTROMECHANOTRONIC MECHANISMS

A.I. Borisova, V.L. Burkovskiy

Abstract: the paper proposes an approach to the analysis of the functional tension of a high-resource microcontroller electromechanotronic complex of an integrated design used in spacecrafts of unseald construction with increased thermal tension. Specific features of heat transfer are analyzed for pulse width modulation on the carrier frequency in the circuit "controller electronic converter-executive electromechanism", energy dependencies in the circuits of the digital mechatronic system and their influence on thermal physical processes, taking into account the absence of convection heat exchange and local operational effects according to the matrix of critical reactions of structural-functional components to factors of vitality, durability, longevity; interactive algorithms for the subsequent topological and constructive-modular design of the unit based on mathematical modeling of thermal processes of the integrated design with limited volumes of configuration in the object environment with optimization of mass distribution and heat flows. Convective component of thermal conductivity with the advantage of "conductive radiation" cooling of integrated mechanotronic structures is shown to be negligibly small

Key words: power dependences, convection heat exchange, integrated construct, heat conductivity

EVALUATION OF THE HYDROTHERMAL CHARACTERISTICS OF POROUS COMPACT HEAT EXCHANGER

V.I. Ryazhskikh, D.A. Konovalov, A.Y. Troshin

Abstract: the work is devoted to the determination of hydrothermal characteristics in the forced single-phase flow of a coolant through a porous compact heat exchange element in a 3D-setting. A new mathematical model based on the Darcy-Brinkman-Forchheimer hydrodynamic model in the Xu-Cheng modification and the thermal model based on the Shumman model was synthesized. The linearization of the equations of the mathematical model made it possible to consistently obtain the exact analytical solution first of the hydrodynamic problem, and then the thermal one. On the basis of the exact analytical solution of the hydrodynamic and thermal problems obtained, the hydrodynamic resistance coefficient of the channel filled with a porous medium, the length of the hydrodynamic initial section, the temperature of the porous framework and the cooler are determined, and the Nusselt numbers were calculated. Using the example of calculating the actual design of a porous compact heat exchanger, the influence of initial parameters on hydrothermal characteristics was visually illustrated and key regularities were revealed. A significant influence of the diameter of porous carcass particles on the hydraulic resistance, the ratio of the height and width of the porous rib on the thermal picture was established. The obtained analytical solution qualitatively and quantitatively agrees with the experimental data obtained by other authors. The proposed toolkit can be used to develop modern designs of compact porous heat exchangers for various subject areas

Key words: intensification, porous heat exchanger, single-phase convective heat transfer

INTEGRATION OF TYRISTOR COMPENSATORS OF REACTIVE POWER INTO AUTOMATED PROCESS CONTROL SYSTEM OF INDUSTRIAL ENTERPRISES

V.N. Krysanov, K.V. Ivanov

Abstract: the possibility of automated compensation of reactive power in electric drives of pumps, including asynchronous motors, is considered. As an example, gas boilers for the preparation of steam and hot water, which are on the balance of ALC Electrosignal, are considered. The description of the boiler house, the electromechanical and automation structure of the equipment used are given. The description is given of the electromechanical part, including all parameters of pump motors, and automation parts, where the following things are described: the mnemonic diagram, the pump control automation scheme, digital information processing and control signals issuing devices, control devices and automation of the process control system for steam generation. The technical possibility of integrating condensing installations into the existing process control system is considered. In order to reduce the cost of installing additional equipment, an analysis is made of the dependence of the reactive power consumed on the monitored process parameters (pressure after the pump). The analysis of two variants of connection of capacitor batteries: adjustable (multistage) and unregulated (single-stage), the algorithms of their operation, the disadvantages and advantages of each option are described. The theoretical calculation of the economic efficiency of integration of the compensating devices considered in the existing standard process control systems of industrial enterprises is given

Key words: reactive power compensation, thyristor condensing installations, industrial control

PRINCIPLES OF DEVELOPMENT OF DECISION-MAKING SYSTEMS IN NUCLEAR BLOCK CONTROL PROBLEMS

V.P. Povarov

Abstract: the modern principles of development of decision-making systems in real-time conditions using SPRINT-technology, based on methods implemented within the framework of the problematic of expert systems, are considered. The architecture of a typical decision-making system in the tasks of managing power units of a nuclear power plant (NPP) is considered. The key point of the study is that it applies the method of decomposition of the power unit into diagnostic components - technological systems, i.e. the object is divided into several functionally completed subsystems. Further on, each separate subsystem has its own knowledge base (KB) and database (DB). As a result of these actions, it becomes possible to work with each subsystem separately. This partitioning allows to parallelize the processing of knowledge, which is especially important in real-time systems. In the case when several subsystems are involved at once, the KB and the DB of the upper block level are used for combining and processing such distributed information. The algorithm for monitoring the condition of the power unit, equipment, parameters of the working environment is provided, which ensures the reception and processing of information from the in-house information systems of the in-reactor control (SIRC) and URAN, currently operating on the power units of the Kalinin and Novovoronezh NPPs

Key words: decision-making system, database, knowledge base, SPRINT-technology, control algorithm

INFLUENCE OF THE TEMPERATURE REGIME OF THE COMPRESSOR STATION ON THE ENERGY EFFICIENCY OF WORK OF THE GAS TRANSPORT SYSTEM SITE

L.V. Bulygina, V.I. Ryazhskikh

Abstract: the problem of increasing the energy efficiency of compressor stations (CS) is considered. The influence of the temperature regime at the outlet of the compressor station on the energy efficiency of the gas transmission system (GTS) section was investigated. The analysis of the change in the thermal regime at the section of the GTS consisting of consecutive linear sections of the main gas pipeline (MG) and compressor stations is performed. An experiment was conducted to assess the effect of temperature on the output of the compressor station on the local and system energy efficiency of the compressor station. The GTS site with three linear compressor stations and gas-turbine gas-pumping units GPU-16 (with the scheme of operation 3x1 + 1) was chosen as an object of research. Thermohydraulic calculation, modeling and analysis of the operation modes of the gas transportation system with three linear compressor stations were carried out according to energy efficiency criteria. As criteria for energy efficiency, the annual consumption of fuel gas (FG) for the section of the GTS and the power consumption of the compressor stations were adopted. The technical aspects of the use and the possibility of controlling the temperature at the outlet of the compressor station due to the use of air coolers (AC) of gas are considered. The application of the results of the study of the temperature regime at the outlet of the compressor station will allow increasing the energy efficiency of the GTS section, reducing the power consumption of compressor stations and reducing the cost of fuel gas

Key words: compressor station, energy efficiency, gas compressor unit, air-cooling apparatus for gas

Radio engineering and communication

ARCHITECTURE OF FPGA BASED CHANNEL CODING FOR 5G WIRELESS NETWORK USING HIGH-LEVEL SYNTHESIS

M.V. Horoshaylova

Abstract: this article proposes strategies for achieving a high-performance architecture of FPGA for quasi-circular low-density parity codes (QC-LDPC) based on the construction of an identical circulant-1 matrix. By analyzing the operation of processing nodes in the minimum sum (min-sum) approximation algorithm, we achieve pipelining in a multilevel decoding sequence without using additional hardware resources. Compilation of a high level of synthesis is used to design and develop an architecture on a hardware FPGA platform. To test this architecture on the Xilinx Kintex-7 FPGA, a 608 Mbit/s decoder compatible with IEEE 802.11n is implemented, using the LabVIEW FPGA compiler in the LabVIEW Communication System Design Suite. Scalability of the architecture was used to create a 2.48Gbps decoder on a single Xilinx Kintex-7 FPGA. In addition, a quick prototyped experimentation of a hybrid automatic repeat request system, compatible with IEEE 802.16 is presented based on the developed effective decoder architecture. Despite the mixed nature of data processing - digital signal processing and end-state machines - the LabVIEWFPGA compiler significantly reduced the time to examine the space of system parameters and optimize in terms of error performance and resource utilization. A 4-fold increase in system throughput has been achieved compared to a CPU-based implementation to measure the efficiency of system errors over large, realistic data sets using accelerated simulation for Eb / N0 = 5.5 dB. In addition, a significant reduction in hardware is achieved

Key words: quasi-cyclic LDPC decoder, bandwidth, min-sum algorithm, decoder architecture, FPGA

HIGH-QUALITY TWO-WAY HORN ACOUSTIC SYSTEMS

A.S. Badaev, A.S. Kovshar'

Abstract: the method of calculating horn acoustic design is presented. It is shown that an exponential horn is the most effective from the point of view of the level of characteristic sensitivity and efficiency. To match the input resistance of the low-frequency (LF) horn with the mechanical resistance of the loudspeaker head (LH), a kind of lowering acoustic transformer is used, which represents some amount of air between the neck of the horn and the diffuser of LH (pre-horn chamber). The transformation ratio of such a chamber n is equal to the ratio of the effective area of the diffuser of LH and the area of horn's neck, while the input resistance of the horn, reduced to the diffuser and, accordingly, the radiated acoustic power increases by a factor of n^2. Based on the proposed methodology, high-quality horn speaker systems (SS) are developed, their parameters and characteristics are presented. The design represents two separate blocks of LF and medium-high-frequency (MF-HF). The low-frequency block is a narrow-necked exponential folded horn with a pre-horn chamber, which assumes that the mouth is set back at a certain distance from the wall or the corner of the room. In this case, the walls, the angle and the body of the speaker are a continuation of the horn. The MF-HF section represents a wide-angle exponential symmetric horn of a cylindrical wave. The front and back sides of the LH are loaded on the horn and emit "forward-backward", forming an eight shape, which is very favorable for multi-channel playback. The midrange-high-frequency unit is freely installed on the low-frequency block, its position is chosen experimentally regardless of the setting of the low-frequency block. The analysis of the measurement results shows the high stability of the impedance module and the acceptable unevenness of the amplitude-frequency characteristic over the entire range of reproduced frequencies. The developed SS has a high level of sound pressure and good sound quality

Key words: acoustic systems, horn speaker systems, loudspeaker heads, efficiency, sound pressure level

LOCALIZATION AND NEUTRALIZATION OF RANDOM DEFECTS DURING IMPROVING THE WORKING CAPACITY OF ADC AND DAC

V.S. Kononov, S.I. Rembeza

Abstract: in this paper two methods for estimate of time between failures of analog-to-digital (ADC) and digital-to-analog (DAC) converters are analyzed: analytical method and method of test structures. It is noted, that the first method was developed for estimation of chips with small and medium scale integration, and its adaptation to current nano-sized elements and technologies does not provide acceptable reliability. It is shown, that the second method, based on usage of marginal characteristics of active elements and technological layers, allows to forecast time between failures of ADC and DAC without random defects. Techniques for localization and neutralization of random defects are offered, based on usage of construction methods during ADC and DAC design and special technological control during chip production. It is shown, that usage of this techniques increases reliability of trials for chips with maximum-allowed working temperature

Key words: ADC, DAC, tests, time to failure, failure

VERILOG-DESCRIPTION AND IMPLEMENTATION ON THE FPGA LDPC-DECODER FOR HIGH-SPEED DATA TRANSMISSION

M.V. Horoshaylova

Abstract: this paper presents the FPGA project and the implementation of a parallel low-complexity LDPC architecture for high data transfer rate applications. This article describes the creation of a regular low density code and the study of its characteristics in terms of complexity, data transfer rate, delay, and BER as compared to the signal to noise ratio (SNR) for various iterations and quantitative estimates. The selected code is the usual (3, 4) LDPC code. Verilog model and synthesis of such architecture uses decoding by the belief propagation algorithm, simplified "Min-Sum". The complexity of the proposed architecture has been studied, it is 6335 LE with a data transfer rate of 2.12 Gbit/s for quantizing 8 bits at the second iteration. Also the article presents a platform implementation based on Simulink's joint simulation to verify the performance in the BER (Bit Error Rate) of the architecture described. The performed simulation results show that the developed decoder model has a high data transfer rate, low latency and very low complexity. BER and SNR can be further improved by increasing the code size and maintaining the same concurrency principle

Key words: error correction codes, low-density codes, belief propagation algorithm, Verilog language, FPGA

INCREASING THE GRINDING EFFICIENCY VIA IMPREGNATED ABRASIVE TOOLS RELEASING ACTIVE GAS MEDIA

V.A. Nosenko, A.A. Krutikova

Abstract: studies of materials of the gassing agent class, capable of releasing halogens and chalcogens under thermal action, were carried out. The possibility of decomposition was analyzed basing on the results of derivational studies in the temperature range from room temperature to 1000 °C. The changes in mass and enthalpy of substances were determined. Based on the results of derivatography, the following compounds were chosen: hexachloroparaxylene, tetramethylthiuram disulfide and dithiodimorpholine. The gas analysis of the medium in the grinding zone confirmed the release of gaseous products relating to the of halogens and chalcogenes groups. The concentrations of chlorine and sulfur dioxide in the cutting zone were monitored during operation without cooling during grinding of the titanium alloy VT6 and the steel ShH15. It was established that the amount of chlorine and sulfur dioxide increases with the depth of grinding. Experimental studies were carried out. The compositions for the impregnation of abrasive tools were developed, the novelty of which was confirmed by the patents. The use of recommended compositions for grinding the steel ShH15 and the titanium alloy VT6 with grinding wheels of electrocorundum and silicon carbide provides a reduction in the components of cutting force, wear of the abrasive tool and roughness of the treated surface

Key words: grinding, impregnator, derivatografic analysis, gas analysis, surface roughness, grinding coefficient

DETERMING SIZES OF DEFECTS AT ULTRASONIC INSPECTION OF THE CASTING DETAILS

M.N. Davydov, K.O. Belyaeva, Y.S. Tkachenko

Abstract: in this paper, a method for determining the front and real dimensions of the defect images during ultrasonic inspection of the main oil pump casings from 20GL steel with the use of a defectoscope with digital-focused antenna arrays is considered. The factors are described that complicate and, in some cases, make impossible to use classical ultrasonic testing by a single-element converter of parts of the type in question. The applied equipment, the structure of the antenna array, the principle of operation and its adjustment according to the standard model of the enterprise are presented. The maximum allowable frontal dimensions of the defect images are found. The dependence of the frontal dimensions of the defect images on the depth of their occurrence in the article is considered. According to the obtained data, a graph of the dependence of the frontal size of the image on the depth of occurrence is constructed. With the help of this graph it is possible to determine the maximum permissible sizes of defect images for intermediate depth, excluding calculations. Approbation of the studies was carried out, the most common defect in the product under consideration is "looseness", its visual image with ultrasound control using digital-focused antenna arrays. A formula was derived for determining the dimensions of defects, for the inspection of cast shells of main oil pumps made of steel grade 20GL

Key words: castings, basic parts, non-destructive testing, ultrasonic inspection, antenna array

PROCESSING OF METAL ENGINEERING PRODUCTS WITH POWERFUL ION BEAMS

M.Yu. Turishchev, Yu.A. Tishaninov, O.V. Gorozhankina

Abstract: this article is devoted to the practical use of high-power ion beams in modern industry. One of the modern trends in the development of solid state physics is considered: the effect of high-power ion beams on solid materials. The results of investigation of beam-erosion treatment and hardening of products using high-power ion beams are presented. The results obtained in various research centers and fixed by the patents of the Russian Federation demonstrate the wide possibilities of processing materials and improving the performance characteristics of products made from them. Increasing the strength of products (increasing the service life) under the influence of powerful ion beams is based on structural changes in the surface layer. The possibility of effective use of powerful ion beams for cleaning the surface of products is shown, including as an intermediate technological treatment of the surface of parts before application of coatings. The article demonstrates a real improvement in such performance characteristics as fatigue strength, wear resistance, increase in microhardness, smoothing of the surface, a decrease in the level of adhesion between the cutting tool and the material to be treated, and after the preliminary treatment of products with powerful ion beams, the improvement of adhesion of wear-resistant coating for a wide class of metals, alloys and products

Key words: high-power ion beams, surface layer, hardening

Physics

THE EFFECT OF ANNEALING ON THE STRUCTURE OF Ni-Zr(Y)O_2 NANOCOMPOSITES, OBTAINED BY THE REACTIVE HF-MAGNETRON SPUTTERING

M.S. Filatov, O.V. Stogney

Abstract: two groups of nanostructured Ni_x - YSZ_{100-x} composites were obtained with the help of magnetron high-frequency (HF) reactive sputtering. During the spraying process, the pressure of the reactive gas (oxygen) in the first group was 0.01 Pa. This mode of sputtering made it possible to obtain two-phase composites including a metallic phase (Ni) and stabilized ceramic phase (Zr(Y)O_2). In the second case, the pressure of the reactive gas O_2 during the sputtering process was 0.04 Pa. In this case, during the spraying of metal targets (Ni and $Zr_{92}Y_8$), both metals were oxidized, which resulted in the formation of a two-phase composite consisting of nickel oxide and stabilized zirconium dioxide. With the help of X-ray diffraction analysis, the structure of the resulting composites was studied depending on the content of the nickel metal phase and on the pressure of oxygen during the sputtering process. An investigation of the thermal stability of nanostructured composites led to annealing in an air atmosphere at 700 °C. After annealing at a temperature of 700 °C, in composites obtained in the regime with an increased oxygen pressure (0.04 Pa), phase transitions are completely absent, which indicates a good thermal stability of the structure NiO_x-$(Zr(Y)O_2)_{100-x}$

Key words: nanostructure composite, heat resistance, X-ray diffraction analysis, thermal annealing, magnetron sputtering, reactive gas, structural stability, stoichiometry

MATHEMATICAL DESCRIPTION OF THE HEAT STATE OF THE ELEMENTARY CELL OF POLYMER CHANNEL FLAME BARRIER IN THE MEDIUM OF COMBUSTION PRODUCTS OF AVIATION FUEL

V.I. Rubinov, **V.G. Samarkin, S.A. Gordienko, A.A. Popov**

Abstract: for explosion protection systems of fuel tanks - compartments using polymer channel flame barriers as a filler, one of the basic technical requirements for maintaining the cellular structure of a porous filler is the form-stability of its cell elements. The form-stability of cell elements comes to ensuring their fire resistance. The fire resistance of the cell elements in turn can be ensured by maintaining a predetermined temperature along the cross-section of the cell edge during a certain time interval, i.e. in the direction of ensuring the heat resistance of the material of the edge of the cell of the polymer channel flame barrier. The mathematical description of the thermal state of the edge of a cell of a polymer channel flame barrier is based on the physical model of the rod material and makes it possible to establish a relationship between its thermophysical characteristics and the temperature of the surrounding medium, the density of the thermal flux of the phase transformation of the rod material and its thermal resistance. The proposed mathematical model of the rod fire resistance with appropriate refinement of the components can be used to select the values of structural and thermophysical parameters of the cell and to assess the fire resistance of both polymer and metal (foil) channel flame barriers

Key words: polymer channel flame barrier, fire resistance, heat resistance, rod

DETERMINATION OF THE ULTIMATE STRENGTH OF POLYMER COMPOSITE MATERIAL FOR COMPRESSION AFTER IMPACT, IN ACCORDANCE WITH STANDARD ASTM D 7137

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Abstract: physical and mechanical tests were carried out to determine the compressive strength after impact in accordance with ASTM D 7137. The tests were carried out on specially prepared elementary samples made of unidirectional prepreg, adapted for automated tape laying systems, as part of a comprehensive material study. The test standard describes the low-speed impact on the PCM, simulating possible material damage that occurs during manufacture and/or repair. Tests are carried out in three stages: impact drop, determination of the type of damage by the method of nondestructive testing (NDT), compression before complete destruction. Each elementary sample was subjected to a local lateral impact with a force of 33.5 J. The destruction of the surface layer of PCM was determined visually, the type of destruction in the volume of the material was determined by ultrasonic testing. The compressive tests carried out in accordance with the standard made it possible to determine the main character of the destruction of elementary samples of PCM, the value of the compressive strength after impact (residual strength) and the relative deformation of the material. Cracking of the matrix of the binder caused delamination in the thickness of the sample in the region of impact by compressive stress, which led to a complete destruction of the material over the entire width of the samples

Key words: polymer composite material, PCM, impact drop, compression after impact, residual strength