Informatics, computer engineering and control

DYNAMIC CONTROL OF THREE-COORDINATE MANIPULATOR, OPERATING IN THE ANGULAR COORDINATE SYSTEM

V.A. Medvedev

Abstract: the theoretical problems that need to be solved to control a modern high-speed robot with low power consumption are determined. A calculation scheme of a three-coordinate manipulator with an angular coordinate system is developed. The analysis of methods of formation of dynamic models of manipulation mechanisms of robots is carried out. Expressions for kinetic and potential energy in accordance with the calculated scheme of the three-coordinate manipulator operating in the angular coordinate system are obtained. Based on the Lagrange apparatus, the equations of motion of a three-coordinate manipulator with an angular coordinate system in differential and vector forms of recording are derived. The solution of the direct and inverse kinematics problem for the considered three-coordinate manipulator, which can be used for kinematic control of the manipulator in the Cartesian coordinate system, is obtained. The theoretical approach providing for the formation of a complete dynamic model of the robot's manipulation mechanism in the control process is considered. The scheme of formation of control actions on the actuator under dynamic control of the manipulator is determined. The structure of microprocessor system of dynamic control of three-link manipulator with angular coordinate system is developed

Key words: robot, three-axis manipulator, dynamic model, dynamic control, angular coordinate system

SOFTWARE COMPLEX FOR RESEARCHING ALGORITHMS OF STOCHASTIC OPTIMIZATION OF IMPLICIT FUNCTIONS

A.M. Korneev, A.V. Sukhanov

Abstract: in modern intelligent decision-making systems, it is increasingly necessary to resort to various methods of stochastic optimization in determining the calculated parameters of mathematical models that simulate the work of the object under study or structured, such as cast iron, casting and others. The functions that determine the relationship between the calculated parameters of mathematical models and the quantities that determine the adequacy of the models themselves, as a rule, are implicit. The purpose of this paper is to familiarize the reader with the software package, which allows one to study the accuracy and speed of convergence of stochastic optimization algorithms for implicitly specified functions. The principle of operation of the software system is described in detail; its modular-functional scheme is presented. Algorithms based on random search methods in discrete space and known under the general name of annealing simulation algorithms are considered. The program allows one to optimize the calculated parameters of mathematical models using various modifications of the schemes of the simulated annealing algorithm: the Cauchy and Boltzmann schemes of modifications A, B, and C, superfast annealing, and the algorithm proposed by Xin Yao. The main design parameters of the algorithms that are paid attention to in the article are the dimension of the search area, the parameters of the stopping criterion (temperature change), the algorithm's operation time, and the values characterizing the probability of the search point moving to a new state (parameters of the Gibbs distribution function). We propose our own variants of schema modification. Special attention is paid to the analysis of the accuracy of the results of the algorithms.

Key words: stochastic search, annealing simulation algorithm, accuracy, optimum, random variable, Gibbs distribution

APPLICATION OF GENETIC ALGORITHMS IN OPTIMIZATION OF PLANNING DECISIONS OF INDUSTRIAL DIVISIONS OF MACHINE-BUILDING ENTERPRISES

P.Yu. Gusev, K.Yu. Gusev, S.Yu. Vahmin

Abstract: the work solves the problem of optimizing the planning decisions of the production departments of machine-building enterprises. To solve the problem, the use of a genetic algorithm is proposed. The genetic algorithm, as a method for solving the problem of finding the optimal layout, has been repeatedly described. However, the description of the practical application of the genetic algorithm in the engineering field has not been reflected in the scientific literature. To solve the problem of finding the optimal planning solution, it is possible to use simulation tools that already have built-in optimization mechanisms, including those based on genetic algorithms. But the use of such software is hampered by the complexity of creating a simulation model, as well as a closed program code that implements the work of the genetic algorithm. In this work, the formalization of the problem was done. The selection of a production unit specific to machine-building enterprises was carried out. Based on the formalized presentation of the task, an optimization criterion was chosen and an algorithm was developed for calculating the adaptability function of the genetic algorithm. In the work, traditional approaches to the development of the principles of functioning of the genetic algorithm were applied and a crossing method was proposed that takes into account the repeatability of elements. The implementation of the proposed crossing method in the form of an algorithm made it possible to avoid additional checks on the repeatability of elements after the crossing procedure. Based on the developed genetic algorithm, a software tool in the C# programming language was implemented. The features of the software include the possibility of changing the initial data of both the task itself and the initial settings of the algorithm, among which there are the number of populations, the number of genotypes in the

population, the number of mutated genotypes. The paper reflects some features of software development. As a result of the analysis of the obtained data, the optimal parameters of the algorithm were determined for solving the set optimization problem for the planning solution

Key words: genetic algorithms, optimization, formalization, engineering, genotype, adaptability function

MODELING OF THE DISSOLUTION AND GROWTH OF SUGAR CRYSTALS

D.V. Arapov, S.L. Podvalny, S.G. Tikhomirov

Abstract: nonlinear probabilistic mathematical models of the rate of dissolution and growth of sucrose crystals in multi-component solutions are described. The experimental basis of the developed models was: for the dissolution rate — 255 exper-iments of A. Brigel-Muller, for the growth rate — 421 experiences of the scientists A. Brigel-Muller, G. Vavrinets and others. The error model of the solubility rate was ± 9.6% rel., and the models of crystal growth rate ± 11.3% rel. at the magnitude of the iteration step. The additive model of the dissolution rate consists of four components: diffusional, due to chemical reactions with water and non-sugars, with the formation of hydrated sugar molecules and sugar - non-sugar complexes, and formed as a result of pulling active sucrose molecules from the crystal. The model of the growth rate of a sugar crystal includes the following components: diffusion, surface crystal chemical, direct capture of sucrose molecules by a crystal, disintegration of sugar-nonsugar complexes, incorporation of non-sugars and water into the crystal. To build the models, a genetic algorithm was used, followed by specification of model parameters using the Hook-Jeeves configuration method

Key words: mathematical model, dissolution and growth rates, sugar crystal, genetic algorithm, Hook-Jeeves configuration method

COMPUTATIONAL MODELLING OF HEAT-TRANSFER AGENT CONDENSATION IN HORIZONTAL PIPELINE

A.E. Kishalov, A.A. Zinnatullin

Abstract: currently, decentralized energy production gains a significant relevance due to several essential disadvantages of centralized power supply such as energy loss to the environment while transferred, the need for energy transformation and a probability of de-energizing a large number of consumers in case of an accident. One of the methods of decentralized energy generation is using low-power plants based on Rankin organic cycle. The working body enters the turbine and performs useful work once it has been heated and converted into the vapor. Then it gets into the condenser, is condensed and is fed back to the boiler with the use of the pump. The turbine rotates the electric generator and electricity is generated. In this paper, one of the options of removing working fluid heat to the cold source – ground – using a horizontally oriented pipe of circular cross section is considered. The modelling is conducted using engineering simulation and 3D design software ANSYS CFX based on finite element method (homogeneous model) and finite difference method (separate O-ring flow model). For both multiphase flow modelling approaches, the distribution of steam mass content (steam dryness) and averaged heat-transfer agent temperature along the pipeline length is determined. Results of multiphase flow modelling by finite element and finite difference method are analyzed

Key words: decentralized energy generation, heat transfer, condensation, homogeneous flow model, separate O-ring flow model, thermophysical processes mathematical modeling, ANSYS CFX

ON THE TASK OF CONTROLLING THE TEMPERATURE MODE OF THE DIFFUSION STAGE OF SUGAR PRODUCTION

A.S. Kanyugina

Abstract: to control distributed production processes with several nominal modes, the actual task is to unite local static neighborhood systems describing nominal modes into a general neighborhood system with a general control law imitating the controller's actions both in stabilizing modes and in transferring a process from one nominal mode to another. Methods of such a combination should take into account, in particular, the variations in the dependence of these local modes and switchings on both external conditions (external inputs) and internal states of the system nodes. The paper proposes a solution to the described actual problem in the framework of the theory of quasistatic neighborhood systems. The developed technique is used to solve the problem of controlling the temperature parameters of the stage of diffusion of sugar production in diffusion apparatus of the column type in terms of the dependence of the nominal temperature on the quality of sugar beet. The obtained formulas of static proportional temperature control can be used to correct the actions of the operator, which contributes to the efficiency of the diffusion process. The studies cited in the study were conducted on the basis of a seasonal sample of data produced by JSC APO Avrora JV Borinsky Sugar Refinery, the sample volume of more than 10,000 observations

Key words: quasistatic neighborhood system, bilinear neighborhood system, clustering, nominal mode, control near nominal mode, control of quasistatic system

SOLVING THE INTERVAL INVERSE NEUROMODELING PROBLEM IN THE CAST SLABS QUALITY CONTROL

Yu.E. Polozova

Abstract: the paper is devoted to applying of dual-parametric neural networks for solving the inverse problem of neuromodeling in the cast slabs quality control. The relevance of the study is due to the possibility of hot-rolled products quality improvement by using of interval analysis methods. In addition, the proposed approach allows one to reduce training time of the neural network model and the training set amount due to an initial data intervalization. The article presents a brief theoretical background that represents the results of previous studies, describes the used subclass of interval neural network models – dual-parameter neural networks. The developed algorithm for solving the inverse problem of interval neuron modeling is presented; the necessity of applying a randomized approach is substantiated. The results of numerical experiments for a different number of input parameters of the model and slabs in the training set are given; the sequence of modeling steps is described. According to the experiment results, the probability of defect occurrence for the found interval values of input parameters was calculated and conclusions were drawn about practical application of the proposed approach. Subsequent modification possibilities of the presented algorithm are noted, depending on the input parameters constraints associated with the technological features of the production and processing of cast slabs

Key words: interval neural network modeling, dual-parameter neural network, inverse problem, cast slab quality control, randomized algorithm

IDENTIFICATION OF WEAKLY CONNECTED NEIGHBORHOOD SYSTEMS

V.V. Semina

Abstract: the task of identifying system models is to determine their structure and parameters from the results of observations on the input and output variables of a real system and is solved by optimization methods. With regard to complex systems, the problem of identification becomes more complex: a large number of system components affect the resource-intensive computational procedures and the increased requirements for the amount of RAM for storing data structures. In this connection, the development and analysis on the basis of neighborhood models of new classes of models describing complex connected systems, allowing one to optimize the management of complex systems, increase the efficiency of reliability and quality of technical systems is relevant. The article discusses the problem of neighborhood modeling of parallel and loosely coupled production processes. The concept of weakly coupled neighborhood systems is introduced, an algorithm for separating the neighborhood structure of a binary system is given, and the problems of identification and control of such systems are also considered. For a binary system consisting of two weakly coupled systems, an algorithm is proposed for finding a quasi-optimal mode and, under additional dimensional constraints, an algorithm for stabilization near a given nominal mode. As an example, we consider the local ventilation and air conditioning system in the production area of the clinker burning plant. In the production of cement there is a problem of exceeding the permissible concentration of dust and air temperature in the workshop, as well as the concentration of dust in the environment, associated with the suboptimal operation of the system of dust removal ventilation in the clinker burning shop. The use of weakly coupled neighborhood systems allows one to reduce the number of system model coefficients to be parametric identification, as well as to find the optimal control mode of the ventilation system and air filtration

Key words: neighborhood structure, neighborhood system, weak connections, ventilation systems, cement production, identification of systems

EMC PARAMETERS CONTROL OF MODERNIZED EQUIPMENT OF AUTOCLAVE INSTALLATION

V.N. Krysanov, Yu.V. Nefedov, A.V. Romanov

Abstract: the issues of electromagnetic compatibility control of newly commissioned electrical power equipment during the modernization of a section of an autoclave unit for the production of polymer-composite material are considered. The control station is a set of hardware and software tools that provide the formation of control actions on the actuators of the process equipment of the autoclave unit, as well as the collection of information from process sensors. Electromagnetic compatibility is impaired if the level of interference is too high or the immunity of the equipment is insufficient. In connection with this violation, the number of cases of triggering false commands in automatic control systems is increasing, which can lead to failure of electrical devices, as well as to large production losses. As a result, the control of the parameters of electromagnetic compatibility must be a mandatory stage in the development and implementation of new technical means (TS) in production. To reduce the time of introduction of new equipment, a technique is proposed for carrying out simulation modeling on a developed mathematical model of a frequency-controlled electric drive, full-scale tests of power equipment in basic operating modes, followed by analysis of the results obtained for electromagnetic compatibility control. The results of the analysis allow one to form the necessary recommendations for the equipment of the newly commissioned equipment

Key words: electromagnetic compatibility, higher harmonic components, frequency converter, autoclave installation, simulation modeling, mathematical model

MODELING AND OPTIMIZATION OF THE PROCESS OF OBTAINING VISCOUS LUBRICANTS FOR HEAVY-LOADED MECHANISMS

D.V. Arapov

Abstract: a substantially non-linear additive mathematical dependence of the main characteristics of grease based on calcium soaps on the technological parameters of its production is described. The most important technological parameters of the process are: the oxygen content in the reactor, the heating time of the reaction mixture to the required temperature, the processing temperature of the mixture, the aging time at the treatment temperature, the cooling rate and the mass of the injected seed. The following lubricant properties were modeled: 1) penetration, 2) colloidal stability, 3) tensile strength at 50 °C, 4) viscosity at 0 °C and shear rate 10 s^{-1}, 5) viscosity at 0 °C and shear rate 100 s^{-1}. In view of the insufficient knowledge of the process, regression analysis was used to develop mathematical dependencies. The developed model differs from published regressions by the presence of terms in the form of squares of the values of technological parameters and the term in the form of their product, as well as by a free coefficient. The error of the model is respectively: 1) ±1.15% rel., 2) ±1.18% rel., 3) ±4.32% rel., 4) ±3.0% rel., 5) ±2.46% rel. Models-analogues have errors of 20 - 30% rel. and more, although they satisfy the Fisher criterion. Operational analysis of the quality of the lubricant obtained is implemented through the mathematical dependence of the properties of the lubricant on penetration as the most reliable and accessible quality measurement. The relative error in determining the characteristics of the lubricant depending on the penetration is no more than ± 3.5%. On the basis of the created model, a criterion was developed, limitations were chosen and the task of optimizing the process of manufacturing a lubricant based on calcium soaps was formulated. The problem was solved by means of a genetic algorithm. The result of its solution is information on the optimal values of the technological parameters, which make it possible to obtain a lubricant with the highest values of penetration and strength and the lowest values of colloidal stability and viscosity. Developed in C #, the program can be used to optimize the industrial process for producing a calcium-based grease lubricant

Key words: soap lubrication, mathematical model, optimization of the process of obtaining

COMPUTER MODEL OF LONGITUDINAL MIXING IN A GAS FLOW AT RESTRICTIONS FOR CALCULATION TIMES

S.Yu. Alekseev

Abstract: the paper discusses the method of organizing calculations and building software systems that implement modelling tasks to improve the performance of technical systems. It considers the software system as a set of interacting elements, each of which describes properties and implements the functionality of a separate element of the technical system. The principal difference of the considered method from the existing ones is that the software system does not implement the algorithm for solving a general mathematical problem. The method considered in the work is based on analytical solutions to solving modelling problems. This is due to the smaller amount of calculations, and a shorter calculation time. For modelling problems that are solved at the stages of the operation of technical systems, the time for obtaining the result is one of the defining characteristics. The paper considers an example of using such a method of organizing calculations on the example of calculating the law of change in the composition of a gas mixture over time as it moves through the shell in which the coil is located. The example shows the use of container objects in modelling the cell structure of flow areas of processes. Two options for constructing containers based on linked lists and based on an array are investigated. In the course of the research, the structure of the program element was estimated, representing the cell of the apparatus and the time of calculation. To estimate the calculation time, several series of experiments were carried out, each with a different cell length of the apparatus and, as a result, the number of cells

Key words: computer modeling, container classes, polymorphic objects

Radio engineering and communication

DETECTING THE UNKNOWN STEPWISE CHANGE OF THE GAUSSIAN PROCESS BANDWIDTH

B.V. Matveev, L.A. Golpaiegani, M.M. Shahmoradian

Abstract: the maximum likelihood algorithm is introduced for detecting the abrupt change of the bandwidth of a fast-fluctuating Gaussian random process. This algorithm can be technically implemented much simpler than the ones obtained by means of common approaches. The technique for calculating the characteristics of the synthesized detector is presented and the closed analytical expressions for the type I and II error probabilities are found through the multiplicative and additive local Markov approximation of the decision statistics and its increments. It is established that the presented algorithm for detecting the abrupt change provides a better performance when the bandwidth is stepwise increasing in contrast with when it is stepwise decreasing. By statistical simulation methods, it is confirmed that the considered method of the statistical analysis of the random processes with the abrupt changing characteristics is operable, while the theoretical formulas describing the quality and efficiency of detecting the bandwidth of abrupt change approximate satisfactorily the corresponding experimental data in a wide range of the parameters of the analyzed process. The additional analysis

demonstrates that the detectors synthesized by means of the proposed approach can also be used when receiving low-frequency fast fluctuating non-Gaussian random processes with the unknown piecewise constant frequency parameters, without conspicuous losses in the performance

Key words: abrupt change of random process, unknown bandwidth, maximum likelihood method, discontinuous parameter, local-Markov approximation method, false alarm probability, missing probability, statistical simulation

STUDY OF THE FEATURES OF PHASE-SHIFT KEYED SIGNALS IN TERMS OF SOLVING THE TASKS OF ANALYSIS AND ENSURING ELECTROMAGNETIC COMPATIBILITY OF RADIO ELECTRONIC DEVICES

I.V. Ostroumov, D.V. Zhuravlev, I.S. Anisimov

Abstract: in this article, we consider the features of phase-shift keyed signals that must be taken into account when developing and improving the methodological support for solving EMC problems in a radio electronic system, namely: the effect on the spectral characteristics of a signal of the envelope shape of an elementary parcel; the need to take into account the distortion of the waveform in the various elements of radio transmitters and receiving devices; the use of code sequences and various ways of processing them, including the use of complex signals and matched filtering; the complex nature of the SPMI, which differs from that of the bell-shaped form adopted in solving EMC problems. This topic is particularly relevant, given that phase-shift keyed signals have a very wide scope of application. The total number of RESs using phase-shift keyed signals, for example, IEEE 802.11 standards (including: b, c, f, g, i, k, l, m, n) or GSM (the signal of which can also be represented as a phase-shift keyed signal with a special (Gaussian) form of the elementary parcel envelope), in the territory of the Russian Federation it is estimated in tens of millions

Key words: spectral density, radiation power, elementary signal envelope, EMC

GENERATION OF THE OPTIMAL INITIAL DATA FOR EDUCATIONAL RADIO ENGINEERING TASKS

I.A. Kirpicheva, A.V. Ostankov

Abstract: compiling high-quality training materials on radio engineering disciplines requires the generation of multivariate baseline data for laboratory work, computational exercises, course design. The source data should be tied to the variant number and ensure coverage of the entire range of acceptable result values. Since the number of input data within the framework of the problem is large, their search is reduced to solving an underdetermined system of equations. The paper proposes to reduce the solution of the system to the problem of nonlinear programming. The objective function is defined as the absolute difference between the actual and the desired result, taking into account the limitations on the size of the source data. It is recommended to search for the minimum of a multi-extremal objective function with a large number of arguments using an approved version of the genetic algorithm. On the basis of the described methodological technique, computational algorithms for generating initial data for various radio engineering tasks are implemented. The article presents the formulation, implementation and results of generation for two tasks. In the first case, the choice of the nominal values of the parameters of voltage sources and current, as well as radio elements of a complex electrical circuit, providing a priori voltage parameters at a key element. Within the framework of the second task, a structural synthesis of a combinational circuit with a given logical function (truth table) is implemented. Its peculiarity is the use of numeric identifiers, corresponding to logical functions and elements. The generated multivariate source data received practical use in the educational process

Key words: input data, generation, nonlinear programming, goal function, genetic algorithm

DEVELOPMENT OF THE METHODOLOGY FOR ESTIMATING THE NECESSARY BANDWIDTH OF PHASE-SHIFT KEYED SIGNALS IN A RADIO TRANSMITTING DEVICE

I.V. Sviridova, I.V. Ostroumov, I.S. Anisimov, I.A. Safonov

Abstract: the features of the development of a method for estimating the necessary bandwidth of phase-shift keyed signals in a radio transmitting device are considered, namely: the establishment of model parameters that exclude signal distortion by band-pass filters (reference line); determination of the minimum signal level at the receiver input, ensuring the transmission of information with a given quality for the reference line; reducing the bandwidth of the filters of the transmitter and receiver, for the corresponding necessary excess of the signal level at the receiver input compared to the reference line, providing transmission with the indicated energy loss; energy loss in the algorithm. The developed estimation method makes it possible to determine the probability of a symbol failure in the received information sequence for given signal manipulation parameters (type of manipulation, duration and elementary parcel envelope parameters), signal frequency band, signal level at the receiver input and reference level in the resolver. A flowchart of the procedure for calculating the energy loss coefficient using a software implementation that simulates a phase-shift keyed signal communication system is proposed. This topic is particularly relevant, given that phase-shift keyed signals have a very wide scope of application, and the number of telecommunication systems in use increases, using new technologies for data transmission

Key words: necessary bandwidth (NBW), minimum signal level, reference line, energy loss in an algorithm

MODERN METHODS AND PROBLEMS OF SPECTRAL ANALYSIS OF SIGNALS: BRIEF DISCUSSION AND COMPARISON

O.E. Zhurilova, A.V. Bashkirov, S.Y. Beletskaya, S.N. Panychev, A.S. Kostyukov

Abstract: digital signal processing is one of the most important components of modern coding, transformation and processing of information. Therefore, the development of this area is extremely important for the entire radio communications industry. In turn, the digital signal processing itself is inextricably linked with the spectral analysis of signals, since many solutions and functions in digital processing are built specifically on the use of spectral analysis. The existing methods and tasks of spectral analysis of signals were considered. A detailed classification of spectral analysis methods was presented and the most used of them were considered. The wavelet transform was considered; classical methods of spectral analysis of signals, which are basically based on the Fourier transform and which, in turn, are divided into periodogram and correlogram methods; and autoregressive spectral analysis methods, which are also divided into various transformation methods: the Yule – Ulker method, the covariance method and its modification, and the Berg method. A comparative analysis was carried out, the advantages and disadvantages of all the methods of spectral analysis of signals described above were revealed and the corresponding conclusions were made

Key words: spectral analysis, Fourier transform, wavelet transform

ANTI-INTERFERENCE CODING IN MODERN COMMUNICATION FORMATS

A.S. Kostyukov, A.V. Bashkirov, L.N. Nikitin, I.S. Bobylkin, O.Yu. Makarov

Abstract: noise-resistant coding is one of the most important branches of radio communications, thanks to which it is possible to transfer large amounts of digital information with a minimum number of errors. Therefore, the development of this area is extremely important for the radio engineering industry. This article considers various error-correcting codes that exist at the moment. Starting from the simplest and most common, such as Hamming code, parity codes, Bose-Chaudhuri-Hokvingham code, cyclic redundant code, potential coding, Reed-Solomon code, Manchester coding, etc. and ending with the advanced developments in the field of noise-resistant coding - the steganographic algorithm and the algorithm of Klovkoy-Nikolaev. The article describes their main characteristics, such as the signal clock frequency, the number of code iterations, the signal decoding rate, and the channel capacity. A brief description of each of the codes is presented and it is considered in which communication standard a particular noise-resistant code is used

Key words: anti-interference coding, turbo codes, cascade codes, Reed-Solomon code, LDPC code

USING NEURAL NETWORKS TO OPTIMIZE DECODING LDPC CODES FOR 5G WIRELESS NETWORK

I.V. Sviridova, M.V. Khoroshaylova

Abstract: in this article, we propose a generalized min-sum decoding algorithm using linear approximation (LAMS) for low density parity check codes with quasi-cyclic structures (QC-LDPC). The linear approximation introduces some factors at each decoding iteration that linearly correct the update of the test node and the output of the channel. These factors are iteratively optimized using neural learning, where optimization can be effectively solved using a small and shallow neural network with training data obtained using a LAMS decoder. The neural network is built in accordance with the parity check matrix of the QC-LDPC code with a parity structure that can significantly reduce the size of the neural network. Since we optimize coefficients once per iteration of decoding, optimization is not limited to the number of iterations. Then we set the optimized coefficient results in the LAMS decoder and perform decoding simulation for QC-LDPC codes in fifth-generation mobile networks (5G). In the simulation, the LAMS algorithm shows a noticeable improvement compared to the normalized and minimum amount of bias algorithms and even better performance than the belief propagation algorithm in some areas with a high signal-to-noise ratio

Key words: quasi-cyclic low-density codes, min-sum decoding algorithm, neural networks, decoding optimization

Mechanical engineering and science of machines

ERRORS FOR BALANCING ROTORS OF GAS TURBINE ENGINES

V.M. Ryzhenkov, V.V. Tikhomirov

Abstract: the possible causes of the main balancing errors in the manufacture of rotary systems of gas turbine engines are considered. These include errors from the misalignment of the installation bases when assembling rotors and errors in the "machine + rigging + rotor" technological system. As the calculations show, the errors from the misalignment of the bases (mounting imbalances) can be many times higher than the allowable ones. Measurement of the beats of the rotor seats, the calculation and installation of the corresponding corrective masses in many cases can quite accurately

compensate for mounting imbalances. If the accuracy achieved at the same time does not meet the technical requirements for the rotor, then when balancing, special technological mandrels should be used, and the errors in the "machine + tooling + rotor" system should be determined by experimental and analytical methods. The verification of passport accuracy of the balancing equipment is carried out in accordance with the ISO recommendations of the control rotors of three main types. In serial production, errors are estimated using calibration rotors that are geometrically and physically similar to those produced. In experimental studies, in addition to determining imbalances, the values and angular positions (phases) of the beating of the control surfaces of the rotors should be measured. The recommendations developed as a result of the research will reveal the dominant balancing errors, identify and eliminate their causes, which, without significant costs, can provide a noticeable improvement in the quality of the engines produced

Key words: gas-turbine engine, definition of errors of rotor balancing, reduction of balancing errors

EXPERIMENTAL UNIT FOR VIBRATION CONTROL DURING PROCESSING ON NPC MACHINES

A.V. Antsev, T.H. Dang, E.S. Yanov, M.V. Polev

Abstract: the issues of accounting for the variability of the cutting process by collecting statistics on the wear of the cutting tool were considered. The level of vibration of the technological system was chosen as an indirect parameter characterizing the process of wear of the cutting tool. The level of vibration of the technological system depends on the self-oscillations caused by the deviation of the allowance for processing due to technological heredity, and fluctuations due to the action of the cutting force, which varies with the wear of the cutting tool. Using the example of turning, the structure of an experimental measuring stand for estimating the level of tool wear was demonstrated. The experimental measurement bench consists of a personal computer and three sensor blocks connected to it, located on the main nodes of the technological system. A method for processing the signals received from the sensors was presented, including the removal of the effect of gravitational acceleration on the measurement result, filtering the received signal, integrating the signal and analyzing the spectrum. An example of vibration signals of different parts of the technological system, obtained by processing a new and worn on the back surface to the level of 0.35 mm hard-alloy cutting plate CCMT 060204-14 IC807 of the company Iscar, was given. It was found that there is a strong relationship between the state of the cutting tool and the vibration of the technological system, and the monitoring of the level of vibration can be used to diagnose the state of the cutting tool in specific working conditions

Key words: cutting operation, variability, tool life, wear, vibration, measuring bench, turning

PRODUCTIVITY AND QUALITY OF DIAMOND-ABRASIVE PROCESSING OF PLATES FROM SILICON CARBIDE

S.G. Bishutin, S.S. Alekhin

Abstract: the article is devoted to the study of the productivity and quality of diamond-abrasive machining of silicon carbide plates to substantiate the directions for improving the machining process under consideration. It was established that with a decrease in the grit size of the diamond abrasive paste (from 60/40 to 28/20 μm), the roughness of the treated surface decreases 2.5...3 times. Smaller surface roughness (Ra=0.5...0.6 μm) is achieved using glass lapping. Studies have shown that the productivity of the process is 5...10 μm/h with the use of diamond paste ACM 60/40 and ACM 40/28, and it is 4...7 μm/h - using diamond paste ACM 28/20. The performance of diamond-abrasive machining of silicon carbide plates increases with an increase in the speed of rotation of the tool and the efforts of its pressing to the workpiece. In addition, the rate of removal of material from the workpiece significantly affects the cutting ability of the tool (lapping tool), the size, shape and number of plates processed. The dependence for calculating the rate of removal of material from the workpiece is shown, taking into account the main factors of diamond abrasive machining. It is shown that changing the processing scheme by adding oscillating movements of the faceplate, using steel or cast iron lap, increasing the concentration of super hard cutting materials in the paste are the most effective ways to improve this diamond abrasive machining

Key words: diamond abrasive processing, ceramic materials

INTERACTION OF THE MAGNETIC FIELD WITH THE RHEOLOGICAL FLUID WHEN MARKING

A.A. Kozlov, A.M. Kozlov

Abstract: in diversified production, paper carriers of information are increasingly being abandoned and markings are applied on them to identify products. Various types of markings are used in mechanical engineering: paints, percussion, EDM, lasers, etc. However, most of them damage the surface of a part when applied to signs and can cause stress concentration. To protect the applied information from mechanical damage and negative environmental impact, the markings are protected with various coatings. A scheme of applying markings by a raster method under an insulating coating without its destruction is presented, when rheological fluid is used as the working medium. Physical phenomena

occurring in a rheological fluid under the action of a magnetic field on it are described. It is established that the mechanism for the formation of informational signs from magnetic fluids under a layer of an elastic dielectric coating depends on the electrical conductivity of the rheological fluid used. It is shown that a constant magnetic field plays the role of an axial magnetic lens, whose focal length depends on the impulse and charge of the ions, the magnitude of the current and the radius of the "current cord". By changing the current and the radius of the electrode tool, you can adjust the width of the contour of the mark, providing a beneficial effect on the clarity of the contour

Key words: marking, magnetic field, rheological fluid