

Informatics, computer engineering and control

SYNERGIC SYSTEM OF FUZZY CONTROL FOR SUSPENDED LOAD

S.L. Podval'ny, A.A. Kaltyrina, E.M. Vasil'ev

Abstract: the article considers the problem of moving a suspended load without swinging. On the basis of the Lagrange equations for generalized coordinates, we obtained a mathematical model of the carriage-load system, demonstrated the significant nonlinearity of the model and the nonstationarity of its parameters. We made the conclusion about the expediency of solving the problem on the basis of a synergistic approach, which will allow the formation of control with the maximum use of the object's own movement. For this purpose, we carried out an analysis of the physical content of the process of moving the load and found that in order to implement the plane-parallel movement of the system, the start of movement must be carried out in several stages: apply an initial force effect on the carriage to move it from its place, then remove the effect and ensure the free movement of the load, and again give the carriage an acceleration in order to equalize its speed with the speed of the load, followed by a transition to motion without swaying. To stop the load without swinging, it is enough to create a symmetrical sequence of commands with the opposite sign. We proposed to build the specified control on the basis of fuzzy decision-making procedures that have proven themselves well in the conditions of non-stationary parameters of the object. We formed a set of input and output linguistic variables of the regulator and determined a list of fuzzy values necessary for the implementation of synergistic control. We proposed to divide the functions of feedback channels according to the angular position of the load and its angular velocity, defining for the first of them the main function of oscillation compensation, and for the second - the function of switching acceleration and deceleration modes. The resulting fuzzy control algorithm in its simplicity and physical content turned out to be close to informal methods of acceleration and deceleration of loads under the control of a human operator. We noted the similarity of this algorithm with the optimal control synthesized on the basis of the maximum principle with respect to the performance criterion. We checked the operability of the proposed system on a simulation model, and confirmed its effectiveness

Key words: movement of a suspended load, synergetic control, fuzzy controller

DEVELOPMENT OF SOFTWARE FOR AUTOMATED PHOTORESIST APPLICATION UNIT

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Abstract: the level of photolithography technologies and equipment for their implementation is a determining criterion for achieving the required design standards in microelectronics, radioelectronics, optics and microelectromechanical systems. The work is related to the development of the hardware composition of the control system of the automated technological installation for applying photoresist, made in a cluster design with a controlled gas medium, as well as the creation of a package of its software. In accordance with the developed control algorithms, command and sensor signal processing bit grids, as well as operation cyclograms for each module and installation as a whole, a software package was created to control the units and modules of the automated installation of application of the UNF photoresist - 200A, logic to the database of technical characteristics of units and modules, as well as process indicators for monitoring these values on the screen. The program consists of several main modules, namely: transport, heat treatment, thermal stabilization, loader, receiver, application, as well as auxiliary modules: database operation, indicator output, logic, interaction with industrial logic controllers and error processing. The developed software works out a number of interlocks introduced to avoid non-scheduled processing of substrates, as well as to fail the installation modules or harm the health of maintenance personnel. The software interface has means of displaying a message about the interlock actuation, as well as methods of unlocking

Key words: automatic installation of photoresist application, cluster design, controlled gas medium, control system, functional process modules, software.

MATHEMATICAL MODEL FOR PREDICTING HEAT EXCHANGE OF A SINGLE BLAST OF FURNACE SLAG DROPLET IN UNSTEADY MOTION IN A COUNTER GAS FLOW

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Abstract: dry granulation of blast furnace slag, unlike wet granulation, makes it possible to utilize the physical heat of liquid blast furnace slag, the yield of which is 0.3 ... 0.35 t per t of iron, as well as to exclude the formation of harmful gaseous sulfur compounds. When designing pilot plants for dry granulation of blast-furnace slag, engineering methods are needed to calculate the characteristic dimensions of the granulation chamber, namely the diameter and height to exclude the adhesion of liquid blast-furnace slag droplets to the chamber walls. Before colliding with the wall, the blast furnace slag droplets must solidify. In this paper, we developed a mathematical model for cooling a single drop of liquid blast furnace slag in unsteady motion in a counter gas flow with consideration of the phase transition of blast furnace slag. The differential equation of heat conduction is solved by the finite difference method, according to the explicit derivative

approximation scheme. The phase transition is taken into account by means of effective heat capacity. In this case, the phase transition temperature is smeared out in some temperature interval. The slag transition boundary from liquid to solid state is determined by the blast furnace slag phase transition temperature. When testing the algorithm, we determined the model settings: the number of calculation grid nodes and the blast furnace slag phase transition temperature interval. The velocity of blast-furnace slag droplet in the counter gas flow is described by the system of ordinary differential equations, solved by numerical Runge-Kutta method, followed by determination of the droplet relative velocity and heat transfer coefficient at each moment of time. We presented the trajectories of blast furnace slag droplet motion up to the moment of complete stop in the horizontal direction and temperature fields along the droplet cross section at the moment of stop. We developed an algorithm for calculating the heat exchange of the droplet as it moves in the counter gas flow. Mathematical model of heat exchange of blast furnace slag droplet during its movement in the counter cooling gas flow makes it possible to predict the droplet behavior in the pelletizing chamber and to predict its characteristic sizes

Key words: dry granulation, blast furnace slag, temperature field, phase transition, unsteady motion, motion trajectories

IT-ARCHITECTURE OF AN INTELLIGENT STAND

A.V. Bredikhin, V.V. Sokol'nikov, D.A. Zinovkina

Abstract: the article describes the IT-architecture of the software and hardware complex of an intelligent stand in the concept of lean manufacturing. The system is designed for enterprises with manual control of a valuable tool. This task is performed by the head of the tool warehouse and other responsible persons. This development will speed up and facilitate the process of obtaining and issuing the necessary equipment, reducing the time for routine filling in the accounting log. The intelligent stand is a large-scale system that automates the previously long process of issuing a tool. A rack with a stored tool, which gives out what is needed by a pass. In parallel, information from the camera, recognized by artificial intelligence, goes to the mobile application. According to the resulting image, an intelligent definition of the taken tool is carried out. The mobile client is intended for enterprise workers. The application makes it possible to personally receive a shift assignment and conveniently track statistics regarding the condition, availability of the tool, as well as the history of use. The reading microcontroller determines by the unique ID of a specific user of the system. The web application is focused on application by those responsible for the tool. Privileged opportunities to add new users and tools to the database are available only to competent employees. Preliminary estimates of modern production facilities show high prospects for implementation.

Key words: smart stand, artificial intelligence, automation, neural network

USING RECURRENT NETWORKS TO PREDICT ELECTRICITY CONSUMPTION

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Abstract: the paper demonstrates the possibility of predicting hourly electricity consumption according to the independent system operator of the PJM Interconnection LLC region using recurrent neural networks. We present a brief description of the coefficient of determination, which is a version of the root mean square error. We demonstrated the structure of the initial data, eliminated the erroneous order of the records and carried out normalization for the subsequent training of the models, and divided the entire set of available data into test and training samples. We briefly described the used architectures of recurrent neural networks: recurrent neural network (RNN) and long short-term memory (LSTM). We present the main parameters of architectures for neural networks, the values of one part of which are taken by default, as they were selected experimentally during the study, and the rest were selected to obtain the optimal model. We carried out a comparative analysis of the performance quality of the models depending on various learning optimizers and activation functions in neural layers, and presented the result of this analysis. We obtained optimal parameters for a recurrent neural network and long short-term memory of models, which gave the maximum values of the coefficient of determination

Key words: recurrent neural network, long short-term memory, prediction, time series, coefficient of determination

Radio engineering and communication

FREQUENCY CHARACTERISTICS OF MODIFIED MICROSTRIP SUB LINES EQUIVALENT TO QUARTER-WAVE SEGMENTS

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Abstract: classical quarter-wave segments of UHF microstrip transmission lines are characterized by considerable overall dimensions. To reduce them, the segments are replaced with modified sub lines implemented on the basis of

standard topologies. The aim of the work is to compare the frequency characteristics of a range of topologies used in modified sub lines with the same wave impedances and substrates, provided that they operate at the same frequency. Using electrodynamic modeling, we optimized and studied the frequency properties of modified microstrip stub lines based on T- and Π -shaped sections. The optimization was to provide a 50-Ohm impedance and a minimum reflection coefficient at the operating frequency. We pointed out the features of the formation of T- and Π -shaped sections of sub lines with integral and interdigital realizations of vertical parts. We give the dimensions of the optimized modified sub lines. We present and compare the amplitude and phase-frequency characteristics of the formed sub lines. We confirmed that the requirements of broadband and the greatest minimization of dimensions are contradictory. We established that optimized sub lines can have a length that is 23-42 % less than a quarter-wave segment. In this case, the relative bandwidth of the sub line narrows to 30-90 %. The results obtained indicate the possibility of using these sub lines to minimize the dimensions of a number of microwave devices and allows making a reasonable choice of a specific topology

Key words: microstrip sub line, topology, modification, T-section, Π -section, minimization, bandwidth

ACTIVE RECTANGULAR WAVEGUIDE BANDPASS FILTER BASED ON THE METAMATERIAL

E.A. Ishchenko, Yu.G. Pasternak, V.A. Pandyurin, S.M. Fyedorov, I.A. Chernovivanenko

Abstract: the paper considers the design of a waveguide of the WR75 type, in which an active metamaterial is integrated, which acts as a device that forms a waveguide bandpass filter with tunable characteristics. Due to the possibility of switching in the layers of the active metamaterial, it becomes possible to form a transparent mode of operation, which allows one to transmit electromagnetic waves while maintaining the main indicators for a rectangular waveguide, while switching in the salts of the metamaterial using pin diodes, a structure arises those forms one of two bandpass waveguide filters - with an operating frequency range of 10 to 11 GHz or 11 to 12 GHz. Moreover, due to the high-quality characteristics of the active metamaterial, it is possible to achieve low losses in the operating ranges of the filter, high isolation and suppression outside the operating range of electromagnetic waves. Due to the scalability of the metamaterial, it is possible to form a similar design for other operating frequency ranges. The proposed design of an active waveguide bandpass filter makes it possible to deplete several microwave devices in one design, which has a positive effect on optimizing the space occupied by microwave devices, as well as reducing losses for flowing electromagnetic waves

Key words: waveguide filter, metamaterial, reconfigurable waveguide

COMPARATIVE ANALYSIS OF SOFTWARE PACKAGES FOR DETERMINING THERMAL CHARACTERISTICS OF RADIO-ELECTRONIC DEVICES

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Abstract: for the design of radio electronic devices (RED), one of the main tasks in the process of their design is to determine the critical thermal load. Based on the data obtained from the analysis of thermal effects, the selection of the most relevant and cost-effective material for the future device and its design will take place. Also, at the design stage of the device, vulnerabilities can be identified, which saves both financial and time resources. To achieve the above goals, various specialized software systems are used. Such software products include Creo, SolidWorks, T-FLEX, ASONIKA and Nastran. This article will focus on the listed software, namely, their main parameters and functionality, their advantages and disadvantages. We compared the presented software systems according to the method of conducting thermal analysis on the design of the RED. For these purposes, we carried out a comparative experiment, a thermal analysis of the printed circuit board, thanks to which we revealed the features of each of the listed software and their design differences. All results of the experiment are listed in the table for comparison

Key words: Creo, SolidWorks, ASONIKA, T-FLEX, Nastran, finite element mesh, strength analysis

USING NEURAL NETWORKS FOR MIMO DETECTION AND CHANNEL DECODING

A.V. Bashkirov, I.V. Sviridova, M.V. Khoroshaylova

Abstract: the article proposes a deep learning approach for the joint problem of MIMO detection and channel decoding. Conventional MIMO receivers use an existing model approach to detect MIMO and decode the channel in a linear or iterative manner. However, due to the complex model of the MIMO signal, an optimal solution to the problem of joint MIMO detection and channel decoding (i.e., maximum probability decoding of the transmitted codewords from the received MIMO signals) is computationally impossible. As a practical measure, all current standard model based MIMO receivers use sub-optimal MIMO decoding techniques with affordable computational complexity. This work applies the latest advances in deep learning to the design of MIMO receivers. In particular, we use deep neural networks (DNN) with

supervised learning to solve the problem of joint MIMO detection and channel decoding. DNNs can be trained to provide much better decoding performance than conventional MIMO receivers. Simulations show that a DNN implementation consisting of seven hidden layers can outperform traditional linear or iterative receivers based on the models used. This performance improvement points to a new direction for future MIMO receiver design

Key words: deep learning, neural networks, MIMO receivers, channel decoding

USING NEURAL NETWORK ALGORITHMS FOR VISUAL CONTROL OF THE TOPOLOGY OF PRINTED CIRCUIT BOARDS

M.A. Romashchenko, D.V. Vasil'chenko, D.A. Pukhov

Abstract: in the production process of any electronic device, a large number of both software and hardware are currently involved. In the manufacture of electronic products, elements are automatically installed on the board using robotic devices. Along with the installation of components, the quality of the printed circuit board design is also of great importance. Quality control at any stage of production is assigned to a person, which significantly reduces not only productivity, but also the quality of rejection. This article discusses ways to determine defective sections of the printed circuit board topology that occur during its production, as well as the possibility of adjusting the production line control algorithms. The proposed solution is aimed primarily at improving the quality and increasing the speed of modern production of printed circuit boards, the main indicator that it is able to provide is a reduction in the percentage of scrap. A distinctive feature of the developed principle is the increased, relative to analogues, accuracy of determining defective areas, as well as the possibility of automatic control of the conveyor line. The line is monitored in real time and allows you to adjust the indicators "online" by entering into the database the possible causes of occurrence, subsequent analysis and elimination

Key words: artificial intelligence, convolutional neural networks, machine vision, deep learning, quality improvement

FLAT ANTENNA ARRAYS WITH VARIOUS WAYS OF EMITTER ARRANGEMENT

A.D. Bazanova, K.A. Layko, Yu.O. Filimonova

Abstract: the article discusses various types of structures for locating emitting elements in a flat antenna array. We give the description of various structures of flat antenna arrays. We considered three most common variants of the emitter arrangement in the nodes of a flat antenna array with rectangular, radial and hexagonal grids, for different shapes of the opening geometry (rectangular round and triangular). We described the parameters of these structures, namely: the step d_x , d_y for a rectangular grid, d - for a hexagonal grid, d_r and d_φ - the step along the radial and angular coordinates, respectively, between the emitters, and N_n - the number of emitters for a radial grid on a circle n . We presented the influence of the opening geometry for rectangular, triangular and round apertures of the antenna array with different grids of emitters in the nodes of the flat antenna array. For all the considered cases, we calculated directional diagrams in three-dimensional space, which are represented on the drawing plane by various sections along the angular coordinate φ with a step of 15° . We carried out a comparative analysis of the obtained radiation characteristics of antenna arrays with different emitter placement structures, as well as with different opening geometries. We note that an antenna array with a circular opening and a radial structure, unlike other structures, has the same radiation patterns in different planes φ . This indicates the optimal shape of the opening and the structure of the placement of emitters according to the criterion of optimizing the utilization factor of the opening surface for a given level of side lobes

Key words: antenna array, antenna array aperture, radiation pattern, antenna array pitch, side lobe level

APPLICATION OF VIRTUAL ARRAY TECHNOLOGY TO INCREASE THE ACCURACY OF AIR-BASED DIRECTION FINDER

E.A. Ishchenko, Yu.G. Pasternak, V.A. Pendyurin, S.M. Fyedorov, I.A. Chernov

Abstract: the article considers an airborne passive radio direction finder, which is installed on an unmanned aerial vehicle using stealth technologies. Thanks to the use of virtual antenna array technology, as simulation results show, it is possible to improve the direction-finding accuracy, so the error and the standard deviation of the bearing decreased by more than 2 times. Based on all the studies conducted, it can be concluded that the use of virtual antenna array technology has made it possible to reduce the distortions introduced by the housing, which seriously distorts the characteristics of the electromagnetic field. Thanks to the use of the Hankel function in the process of formation (it can be used as a fundamental solution of the Helmholtz equations) of a virtual antenna array, it is possible to increase the speed of calculations, as well as solve the problem of the lack of a reference signal in the process of forming a virtual antenna array. Field approximation, which is based on the use of the Hankel function, has high accuracy, and also reduces the influence of surrounding surfaces that distort the characteristics of electromagnetic waves. Thus, it can be said that the use of the apparatus of virtual antenna arrays based on the field characteristics measured by a real radio direction finder makes it

possible to improve the direction-finding characteristics, which is an important and urgent task in passive radio direction finding

Key words: virtual antenna array (VAA), direction finding, unmanned aerial vehicle (UAV)

THE METHOD OF AUTOMATED ASSESSMENT OF THE STABILITY OF ELECTRONIC MEANS TO ELECTROMAGNETIC INTERFERENCE

M.A. Romashchenko, D.V. Vasil'chenko, D.A. Pukhov

Abstract: the paper describes a method for processing signals coming from the device under test during its testing for electromagnetic interference (EMI). The practical solution to the problem of determining the potentially vulnerable places of the structure, as a rule, is reduced to an analytical assessment of the experimental data and the issuance of a conclusion on the suitability of the studied electronic means for further use. The analytical assessment itself, which makes it possible to determine failures in the operation of an electronic tool, at the moment can only be made through a subjective expert assessment. This causes an additional error associated with the influence of the human factor on the results. The proposed solution is to develop an automated method for detecting critical places in the structure. This approach is based on the assessment of the impact of interference on electronic devices during testing using a hardware and software complex. The algorithm of operation is based on the search for deviations in the output data of the tested product and further detailed processing and automatic identification of the causes of their occurrence. Detection of occurrence is based on linear classification algorithms and neural networks

Key words: electromagnetic compatibility, electromagnetic radiation, electromagnetic interference, testing, testing, results processing, quality improvement, neural networks

IMPROVING THE DESIGN AND ENERGY PARAMETERS OF SWITCHING POWER SUPPLIES BY OPTIMIZING HIGH-FREQUENCY LOSSES IN THE WINDINGS OF MAGNETIC COMPONENTS

N.Yu. Veretennikov, O.Yu. Denisov, A.V. Bashkirov, O.Yu. Makarov

Abstract: the main way to improve the weight and size parameters of switching power supplies is to reduce the dimensions of the magnetic component. The simplest way to reduce the volume of the magnetic core is to increase its operating frequency. However, with an increase in the frequency of conversion of the magnetic component, its efficiency can significantly decrease, due to the occurrence of high-frequency losses in the core and copper conductors. In this paper, we considered the main mechanisms of occurrence of high-frequency losses in the windings of the magnetic component. Most engineers take into account only ohmic losses and skin effect losses when calculating pulse transformers. We show that with increasing frequency and number of winding layers, the effect of shortness tends to become dominant in the formation of losses in copper. We show the dependence of losses in each layer of the winding on the thickness of the conductor and frequency on the example of the calculation of a straight-line transformer. Based on the results of mathematical modeling, we propose a method for optimizing losses in winding products without alternating windings using the Dowell formula

Key words: eddy currents, proximity effect, skin effect, optimization of magnetic components, high-frequency magnetic components, pulse transformers, calculation of losses in magnetic components, Dowell method

IDENTIFICATION OF SPEECH PAUSES IN CONDITIONS

DIFFICULT ACOUSTIC INTERFERING SITUATION

R.S. Vlasov, I.A. Kozlov, A.A. Afanas'ev, A.V. Pitolin

Abstract: we present materials on the study of the possibilities of determining pauses in a speech signal under the condition of acoustic noise at the microphone input. The need for such studies is due to the incorrect operation of the voice activity detector when encoding speech using the G.729 algorithm. This circumstance does not allow efficient use of the SS redundancy associated with the presence of pauses in the tasks of improving the quality indicators of speech transmission systems. The reasons for the incorrect operation of the existing voice activity detectors are taking a pause in the speech signal for a stationary random process. In the absence of intense interference, the distribution of counts of inactive sections of the speech signal is indeed quasi-stationary. However, under conditions of intense acoustic noise, the time intervals at which the probabilistic characteristics do not undergo significant changes are significantly less than the average length of speech pauses. This does not allow us to consider such segments of the speech signal as quasi-stationary. Nevertheless, the probabilistic distributions of counts that make up pauses under IAI conditions and active parts of the SS differ. We proposed to use these differences in the identification of pauses in acoustic noise conditions

Key words: speech signal, acoustic noise, consecutive statistics, Wald's criterion, speech pause

MULTI-BAND PATCH ANTENNA BASED ON ACTIVE METAMATERIAL

E.A. Ishchenko, Yu.G. Pasternak, V.A. Pendyurin, S.M. Fyedorov

Abstract: the article discusses the design of a planar patch antenna with an active metamaterial, which allows you to control the operating range of the antenna by connecting additional layers. Thanks to the design of such an antenna, it was possible to achieve that a rectangular patch antenna has four modes of operation, which provide four operating frequency bands of the antenna. At the same time, in all modes of operation of the antenna, stable characteristics are maintained, so the efficiency did not decrease below 72%, the directional coefficient of the antenna was not lower than 7.2 dB. Thanks to these characteristics, we can say that the use of active metamaterial in planar antennas can improve the characteristics of the antenna by increasing the number of antenna ranges while maintaining the main characteristics of the antenna. Also, due to the fact that in the process of switching modes, only one antenna resonance is preserved, it is possible to increase the noise immunity of the antenna since there is no reception on side channels. The pin diodes used for switching the metamaterial make it possible to ensure fast switching of layers, provide low resistance in the on mode, and thereby ensure the obtained high-quality characteristics that would correspond to equivalent full-metallization patch antennas

Key words: patch antenna, metamaterial, multiband antenna

CONVERGENCE ALGORITHM FOR LDPC CODEC OF LOW COMPLEXITY BASED ON NEURAL NETWORK

M.V. Khoroshaylova

Abstract: the paper describes a modified soft-computing technique for a less computationally complex LDPC encoder/decoder. This learning technique is computationally less complex than the conventional gradient learning method and is highly accurate. I used two forms of approximate lower triangle calculation to change the H-matrix, namely systematic Gaussian elimination coding and coding with complexity that grows linearly with block size. The performance of the developed technique is compared with traditional methods in terms of maximum error, minimum error and computational complexity. I developed an LDPC encoder/decoder based on an artificial neural network to emulate the codec. A neural network has three layers, namely an input layer, one hidden layer and an output layer. The number of neurons in the input and output layers depends on the size of the parity check matrix of the LDPC encoder. I compared the performance of the proposed LDPC codec with the performance of conventional codecs in terms of the learning algorithm. The proposed learning algorithm has X-L multiplication as opposed to X2 and X multiplication of conventional methods. I also propose an efficient architecture for the neural network to act as a generic LDPC codec by choosing either 0/1 for a set bit

Key words: backpropagation algorithm, LDPC codec, computational complexity, perceptron

Mechanical engineering and science of machines

STUDY OF THE PHYSICAL AND MECHANICAL CHARACTERISTICS OF THE COMPOSITE WELDED JOINTS OF NPP INSTALLATIONS RESTORED BY THE METHOD OF SURFACE PLASTIC DEFORMATION

O.V. Urazov, V.G. Egorov, A.D. Danilov, I.G. Drozdov

Abstract: at the Novovoronezh nuclear power plant, a unique technique was developed and equipment was designed for the restoration of damaged composite welded joints of pipelines of various diameters by the method of surface plastic deformation (SPD) without shutting down the nuclear unit. The article presents the results of a study of the physical and mechanical characteristics of the restored joints to confirm their compliance with operational requirements. For this, we made a full-scale test sample of the welded joint of the NPP breathing pipeline with the VVER-1000 power unit. We measured the residual displacement of the surface layer on a Keyence VHX-600 3D digital microscope. An analysis of the deformation of the surface layer showed a high convergence of the calculated and experimental data. In order to compare the hardness values for the original and processed surface by the SPD method, we carried out Vickers hardness measurements using a Zwick ZHU2.5 hardness tester. Based on the results of hardness measurements, we concluded that the hardness values for single-pass and double-pass modes differ insignificantly. We measured the microhardness of the cut metal in accordance with GOST 9450-76 on a Zwick ZHV10 semi-automatic hardness tester, which makes it possible to measure the Vickers hardness at loads from 10 g to 10 kg. To determine the surface hardness values, we used the instrumental indentation method (regulated by GOST R 8.748) using the TEST-5U instrument. We carried out the study of

residual stresses along the depth of the material by the Sowett and Vancrombrugge method. Comparison of the results of testing for cyclic strength of the samples that have been processed by the PPD method at $\sigma_a = (194-208)$ MPa showed their advantage in durability by more than 10 times

Key words: surface plastic deformation, residual stress, microhardness, kinetic indentation

INVESTIGATION OF CHANGES IN THE KINEMATIC ANGLES OF THE MILLING CUTTER DURING THE PROCESSING OF ECCENTRIC SHAFTS

V.V. Kutz, Yu.A. Mal'neva, A. Beye

Abstract: to increase the efficiency of processing eccentric shaft necks, we propose a method, the essence of which is to use milling cutters when basing it along the shaft axis. We assumed that the direction of rotation and the rotation frequency of the shaft and the broach cutter coincide, and the shaping of the eccentric shaft neck will be performed in one turn of the tool. When implementing this processing method, the key task is to create a tool, for which it is necessary to perform a set of theoretical and experimental studies aimed at developing methods for assigning its geometric characteristics and processing modes. We obtained formulas of the initial tool surface, cutting edges, front and back surfaces of the cutter teeth. We show the result of modeling the installation of the plane of the front surface for one tooth and for all the cutting teeth of the cutter. Using the developed software, we carried out a study of the changes in the rear angle during milling at different values of the transverse feed, the rear angle from the longitudinal feed at different values of the rotational speeds of the shaft and the milling cutter. The conducted research allowed us to establish that the teeth of the milling cutter work in various conditions. The application of the developed software will allow one to determine the values of the static rear angles on the milling cutter ensuring their change within the contact with the allowance in the specified ordinates of the range.

Key words: broach cutter, kinematic angles, shaping, eccentric shaft, modeling

METHOD FOR DETERMINING THE THICKNESS OF NARROW COLLECTOR WELDED JOINTS USING IONIZING RADIATION

V.V. Shurupov, D.I. Bokarev, V.P. Chumarny, S.V. Safonov, M.N. Davydov

Abstract: here we propose a method that allows you to determine the thickness of the material in products of complex structural shape, excluding the possibility of using conventional controls, providing high sensitivity and accuracy of measurements and not requiring high qualification of a specialist. The method relates to non-destructive testing methods and can be used to control the thickness of metal materials, as well as to determine the amount of penetration and (or) thinning of welds made mainly in places that are difficult to reach for mechanical controls of products that have, for example, narrow collector welded joint. When ionizing radiation passes through a solid, part of the radiation energy is lost. The amount of radiation energy transmitted through the material varies in proportion to its thickness. Thus, the study of the dependence of the change in the intensity of X-ray radiation on the presence and size of the discontinuity was a very urgent task, the solution of which allowed us to simultaneously control the quality of the welded joint for internal defects and measure the thickness of the joint. As the conducted studies showed, a necessary and sufficient condition for estimating the size of the desired value (the thickness of the joint) is to determine the ratio of radiation intensities before and after the object of control

Keywords: thickness, welded joint, ionizing radiation, intensity, photometry, film blackening density, radiography, collector