

THE PRINCIPLE OF SEPARATION OF FUNCTIONS IN MODAL CONTROL PROBLEMS

S.L. Podvalny, V.I. Zakhvatov, E.M. Vasil'ev

Abstract: we identified the methodological reasons for the difficulties arising in the synthesis of complex automatic control systems and substantiated the necessity of building such systems on the basis of the evolutionary principles of multialternative reflecting the mechanisms of functioning of biological communities. We determined the specific goal of the research: the development of practical methods and techniques for the implementation of the multialternative principle of separation of functions in robust control systems. Using the example of the synthesis problem for modal control of a non-stationary oscillatory plant, we showed that the solution of this problem is possible only as a result of dividing the eigenvalues of the characteristic matrix of the system into parts, one of which determines the nature of the transition process in the system, and the other provides robust properties of the modal controller. We formulated recommendations for the choice of the values of the indicated eigenvalues and presented a method for calculating a robust modal controller based on solving an extremal problem of mathematical programming. We discussed the questions of ill-conditioning of the desired characteristic polynomials chosen in the synthesis of a modal controller. We give the analytical foundations of the separate synthesis of the modal controller and the observer of the object state coordinates and a proof of cancellation of the zeros and poles of the observer if the parameters of the observer exactly coincide with the corresponding parameters of the object. We carried out the analysis of the sensitivity of the zeros and poles of the system to the parametric nonstationarity of the object. We demonstrated the possibility and expediency of ensuring the robustness of the system and indicators of its accuracy and performance by separate controllers, the synthesis of which, due to this separation, is significantly simplified. We presented a numerical example of practical synthesis of a robust modal control system, the results of which confirm the effectiveness of the application of the principle of separation of functions in the design of control systems

Key words: automatic control, multialternative principles, modal controllers, state coordinate observers

ANALYSIS OF THE INFLUENCE OF TYPICAL FUNCTIONAL REQUIREMENTS ON THE INFORMATION SYSTEM SETUP PARAMETERS BASED ON CLOUD TECHNOLOGIES USING THE DEMATEL METHOD

A.A. Levchenko, V.V. Taratukhin

Abstract: unlike classic on-Premises information systems, which are installed on their own servers, SaaS (Software as a Service) systems are physically located on remote servers in the cloud. This feature imposes restrictions on access to the system's source code and does not allow its free extension in the form of system development implementations. Thus, since the information system based on cloud technologies is unified and standardized, the set of standard functional requirements for the system's design and the set of parameters of the system are limited and represent finite sets. The work aims to assess the influence of a set of typical functional requirements on a set of system settings parameters and to confirm the influence of the sets on each other. The study analyzes the impact of many typical functional requirements on many settings for configuring cloud-based information systems. The DEMATEL method is used to assess the impact, which belongs to the group of multi-criteria decision-making methods. The article provides an approach to describing the sets of the model of research's objects, the argumentation of the DEMATEL method's application, and the comparison of the method with others. We performed the calculation on a quantitative scale through the dispersion coefficient of concordance to confirm the study's quality. We give an example of a numerical test calculation for the example of six factors and the results of applying the method for ninety-six factors. Confirmation of the influence between the sets allows you to move on to the task of automated configuration of a SaaS-class system according to typical functional requirements without the use of experts who are currently actively involved in the implementation of information systems

Key words: information systems, cloud technologies, DEMATEL, functional requirements, system analysis, dependence of factors

DECISION-MAKING MODEL FOR REGULATING THE TEMPERATURE OF AN OIL PRODUCT UNDER CONDITIONS OF UNCERTAINTY

V.A. Mustafaev, K.A. Allakhverdieva

Abstract: we developed a model for determining the temperature of an oil product in a tank under uncertainty in the form of fuzzy Petri nets. We presented the structural elements of fuzzy Petri nets in matrix form and determined the input, output and incidence matrix of the network. We calculated the elements of the Gram matrix and the rules of triggered network transitions. As a result of a computer experiment, we obtained a sequence of triggering transitions from the initial marking. We propose a decision-making approach for regulating the temperature of petroleum products under uncertainty. We formed a database of rules for regulating the temperature of petroleum products in the tank. We carried out fuzzification of all terms of input variables and calculated the degree of truth of the conditions in the rules of fuzzy production. We performed activation and accumulation procedures and found all the values of the degrees of truth of the conclusions for each rule. We implemented in three-dimensional space, the defuzzification procedure in the Matlab environment using the fuzzy logic Toolbox extension package. We present an interactive window of all input and output linguistic variables by means of triangular membership functions

Key words: oil product temperature, model, fuzzy Petri nets, production rules, fuzzification

APPROXIMATION OF THE DISTRIBUTION DENSITY OF TIME BETWEEN FAILURES OF A COMPUTING SYSTEM BY THE ROSENBLATT-PARZEN NONPARAMETRIC METHOD

V.S. Nikulin, A.I. Pestunov

Abstract: determining the causes of equipment failures is one of the main tasks of organizing an experimental assessment of the reliability of objects. The solution of this problem is best met by statistical estimation of the distribution density of random variables. A random variable in reliability theory considers such time indicators as the moments of equipment failure and recovery, as well as the operating time between failures and the time required to restore it after the failure. In this work, we carried out a study on the approximation of the distribution density of the operation time between failures, according to data from the operation of the composite equipment of a computer system. This equipment is highly reliable and is characterized by a small number of failures, as well as the absence of a priori information about the law of distribution of random variables. For these reasons, the nonparametric Rosenblatt-Parzen method is considered as an approximation method. In the method under study, the kernel function is responsible for smoothness, and the smoothing parameter is responsible for the accuracy of the distribution density approximation. The Gaussian function, previously considered in works on reliability theory, is chosen as the kernel. Based on the Hooke-Jeeves method, we developed an algorithm for finding the optimal smoothing parameter responsible for the approximation accuracy. We carried out the assessment of the effect of the smoothing parameter and the sample size on the accuracy of the approximation on the basis of an analysis of the estimation of errors in the L_1 -space metric and a graphical representation. The conducted study allows us to conclude that the use of the optimal smoothing parameter in the presence of samples of different sizes can reduce the final approximation error

Key words: statistical analysis, experimental reliability, computer system, Rosenblatt-Parzen method

OVERVIEW OF VOICE INTERFACE TOOLS AND SPEECH RECOGNITION TECHNOLOGIES

V.A. Malinovkin, N.V. Valuyskikh, N.N. Shvedov, S.L. Kenin, N.I. Grebennikova

Abstract: speech recognition task is one of the most difficult and demanded tasks at the present time. Voice assistants implemented using voice interfaces greatly simplify the management of various systems in limited conditions. Such interfaces should have an intuitive interface for comfortable use by people with various kinds of limitations. When developing a system, the fulfillment of this criterion is one of the main tasks in creating modern technical systems. Currently, the global speech recognition market is of huge volume and high dynamics of development, while the market for speech recognition systems in Russia is small but has prospects for development. This article reviewed the most advanced voice assistants: Goodle Assistand, Amazon Alexa, Microsoft Cortana, Siri, Yandex Alice. We made a comparison in terms of general indicators. Both positive and negative aspects were identified. The advantages are due to such parameters as: the presence of a high level of "humanity", the ability to self-learn, automatically reproduce operations. Among the drawbacks, the most critical are such moments as: mismatch in quality in terms of compliance with the response time and the provided functionality, the lack of quick integration with other systems and universal accessory

Key words: voice interface tools, speech recognition technologies, providing comfortable conditions for users of modern technical systems

ALGEBRAIC METHODOLOGY FOR MODELING LOOP-FREE ROUTING

H. Khayou, M.A. Orlova, L.I. Abrosimov

Abstract: the routing problem can be formulated as follows: given a network G , it is necessary to find the best path between nodes i and j from the network G . However, the concept of "best" is obscure, and it depends on which parameters in the composite metric network operators are trying to optimize. For separation of concerns, routing algebras were introduced to model what the routing protocol is trying to solve while maintaining a generic routing algorithm. However, all routing protocols must address the problem of loop-freedom. The purpose of this article is to present a theory of loop-free routing with an arbitrary metric. It is shown that the choice of the basic algebra can affect the performance of the algorithm itself, as in the presented example for the routing protocol (EIGRP). In addition, the modification of the routing algebra can help in the introduction of new routing algorithms. An example is the DSN protocol (Distributed Sequence Number), which uses a hybrid link-state and distance vector algorithm. New components are added to the DSN metric, which are the sequence number and a flag bit denoting a request to increase the sequence number. This helped, as shown in this article, to solve the problem of loop-free routing with minor changes in the original distance vector algorithm. In this paper, the following tasks have been solved. The conditions for loop-free routing and the relations between them were presented algebraically and proved. The concept of monotonous routing is introduced. Loop-free routing was investigated in the presence and absence of monotony. Based on the formulated theorems, an algebraic model and validation of a loop-free algorithm used in the DSN protocol have been developed

Key words: semicircles, routing algebra, loop-free routing, Bellman-Ford algorithm, diffusion computation

METHOD OF REUSE AND EXCHANGE OF EXPERIENCE IN THE COLLECTIVE INTERACTION OF INTELLIGENT AGENTS

Yu.V. Dubenko

Abstract: I determined the problems of exchange and reproduction of experience generated by different agents in the problem of multi-agent reinforcement learning. I briefly considered my other works in the field of multi-agent reinforcement learning and multi-agent systems, as well as conclusions from these works. I determined that among the problems of multi-agent reinforcement learning are the problems of exchange and reproduction of experience generated by different agents. Here I considered a centralized multi-agent system based on the principles of reinforcement learning and described the types of agents that this system includes: an agent-manager with powerful hardware that manages a group of agents as part of the implementation of reinforcement learning for centralized multi-agent systems, and a subordinate agent designed to directly solve practical problems. I give a standard algorithm for the exchange of experience between agents and propose solutions to the problem of the priority of applying experience gained in solving problems of various types and the problem of adapting and applying experience formalized in the form of macro-actions. I show that the use of macro-actions can provide a shorter time to reach the state of the task of exiting the labyrinth by agents compared to standard algorithms. I developed a computer model in the Unity environment to test the effectiveness of the proposed method of re-applying the existing experience in solving problems, formalized in the form of macro-actions, and presented the results of applying this model and an approach to the "classification of experience" for intelligent agents, according to which the experience of an intelligent agent can be divided into two groups - "elementary experience" and "situational experience"

Key words: hierarchical reinforcement learning, intelligent agent, multi-agent systems, elementary experience, situational experience

INTEGRATION OF BASIC STATIC STRUCTURES AT THE STAGE OF INFOLOGICAL MODELING

O.V. Novoselova, A.S. Sidorov

Abstract: the article discusses the process of integrating descriptions of static structures in the form of diagrams and specifications at the stage of infological modeling in the design of automated systems. The infological model representation is a project of an automated system that is being developed to solve design computational problems in a computing environment. The stage of infological modeling is the stage of designing automated systems according to the methodology of automation of intellectual work. Infological model representation does not depend on the implementation platform of the automated system. The description of the infological model view includes forms (specifications) and diagrams for each component: static, dynamic, functional and the model as a whole. The article provides the integration of descriptions in the form of diagrams for the static components of infological model views. For this, the features the formation of diagrams and specifications when creating an infological structure were investigated, on the basis of which the method and methodology for integrating descriptions of static components for model-projects of automated systems that perform computational tasks in the design of mechanical engineering objects were determined

Key words: the automation of intellectual labor, design task, infological structure, integration of diagrams

IMPROVEMENT OF DIRECTIVITY CHARACTERISTICS OF DIFFRACTION RADIATION ANTENNA BY VARYING PROFILE OF RADIATING OPENING

D.Yu. Kryukov, A.V. Ostankov, A.Yu. Chernyshev, S.Yu. Dachian

Abstract: ensuring the effective operation of most modern radio engineering systems in the microwave and EHF ranges is impossible without the use of antennas with a high efficiency, capable of forming highly directional beams of the directional pattern in space. The problem of providing the required width of the main lobe of the directional pattern at a low level of side radiation can be solved by realizing the optimal amplitude distribution of the field in the aperture. The article discusses a diffraction-type leaky wave antenna, which is an open radiating transmission line and contains a planar dielectric waveguide, shielded by a metal resonant comb-type grating. Antennas of this type are characterized by a high efficiency, and the required amplitude distribution in the aperture can be formed due to the longitudinal variation of the aiming distance - the gap between the dielectric waveguide and the comb grating. To establish the best regularity of changing the sighting distance, we used an original version of the energy calculation method, adapted to the conditions of the problem under consideration. According to the proposed method, the determination of the degree and direction of variation of the aiming distance is reduced to the problem of calculating the share of the power taken by each groove of the comb grating according to a given amplitude distribution in the aperture. The article presents the basic relationships that form the basis of the methodology. We found that the non-uniform profile of the distribution-radiating system allows improving the initial directivity of the antenna by increasing the degree of radiation concentration within the main lobe of the antenna pattern and reducing the level of the side lobes, as well as increasing the antenna gain. We established that when the sighting distance is changed in accordance with the theoretically found regularity, it is possible to reduce the level of side lobes and simultaneously increase the gain in comparison with the case of a fixed sighting distance

Key words: antenna, air gap, periodic array, diffraction radiation, simulation

Acknowledgments: the study was funded by RFBR and CNRS, project number 20-51-15001

STUDY OF A SMALL-SIZED VHF ANTENNA OF VIBRATOR TYPE WITH SPIRAL ARMS

V.I. Nikolaev, Yu.G. Pasternak, V.A. Pendyurin, S.M. Fyedorov

Abstract: we propose an antenna design based on a two-thread flat Archimedean spiral with arms of variable width, designed for use in underground conditions. The design of the antenna makes it possible to reduce losses in the ground due to the significant capacitance between the spiral arms, good DC isolation of the spiral arms and the solenoid nature of the generated magnetic field. Ground loss is a significant limiting factor for underground radio applications, and many studies have addressed these losses. In the course of numerical simulation, we obtained the main characteristics of the developed antenna: the Volpert-Smith nomogram, the reflection coefficient from the input, the efficiency with a different location of the antenna. We verified the theoretical results with the help of full-scale measurements of the layout, placed in the case and without it. As a result of the research, the following characteristics of the antenna were established: the central operating frequency is 38.1 MHz, the relative bandwidth of the operating frequencies is about 0.26%, the average value of the input impedance is 6 Ohm, the total losses in the antenna under the condition of a perfectly conductive and infinitely extended underlying surface – about 0.9 dB

Key words: electrically small antenna, spiral antennas, Archimedes spiral

PROBLEMS OF IMPLEMENTATION OF THE METHOD OF MICROWAVE RADIOMETRIC MEASUREMENT OF THE INTERNAL BODY TEMPERATURE OF ATHLETES

E.V. Turetskaya, N.V. Astakhov, D.A. Dezhin, A.S. Demikhova

Abstract: this paper provides an overview of the methods of non-invasive measurement of the internal body temperature of athletes (in real time). Despite the fact that there are many options for measuring body temperature for inactive people (for example, oral/ear/temporal/rectal thermometers), there are several options for measuring body temperature for active people. Bio-wireless technology has been proposed as a potential method for monitoring body temperature in active people. The article discusses new modeling methods based on existing works to develop a more comprehensive analytical radiometric model in a closed form, which will accurately determine the absolute temperature of the internal organs of the human body. At the moment, there is no fully universal equation of the radiometer system available that would adequately take into account all potential source temperatures. Also, no study has considered the error resulting from the use of simplified equations of the radiometer system in relation to different levels of system isolation. In connection with the above, the task of analyzing all the factors that influence the development of such an equation and the problem of measuring a person's internal temperature in real time with an accuracy of 0.1 degrees is an important and urgent task

Key words: methods of non-invasive measurement of the internal temperature of the human body, bio-wireless measurement technology, radiometry, problems of constructing a universal equation of the radiometer system with the required accuracy and noise reduction

STUDY AND REVIEW OF SDN-BASED LOAD BALANCING MECHANISMS IN 5G / IMT-2020

B. Daneshmand, L.A. Tu

Abstract: the growing number of mobile devices and the demand for user data by 2030 are expected to put pressure on the current mobile network in an unprecedented way. Future mobile networks must have several requirements regarding data amount, latency, quality of service and experience, mobility, spectrum, and energy efficiency. Therefore, efforts have recently begun for more efficient mobile network solutions. To this end, load balancing has attracted much attention as a promising solution for greater resource utilization, improved system performance, and reduced operating costs. This is an effective way to balance traffic and reduce congestion in heterogeneous networks in future 5G/IMT-2020 networks. Load Balancing is one of the most critical tasks required to maximize network performance, scalability, and robustness. Nowadays, with the emergence of Software-Defined Networking (SDN), Load Balancing for SDN has become a significant issue in future network 5G/IMT-2020. SDN allows for programmable load balancers and provides the flexibility to design and implement load balancing strategies. In this survey, we highlight the methods of load balancing based on SDN networks and prospective load balancing requirements on 5G networks

Key words: load balancing, software defined networking (SDN), 5G/IMT-2020

DUAL-BAND SLOT ANTENNA FOR SMARTPHONE WITH MIMO TECHNOLOGIES

A.M. Zhikharev, E.A. Ishchenko, S.M. Fyedorov, I.A. Chernoiivanenko

Abstract: the article considers a multi-band eight-port MIMO antenna array for the fourth (4G) and fifth (5G) generation networks (sub-6 GHz), which allows one to cover two spectral ranges. To achieve multipath, two-element diamond-shaped emitters with microstrip line technology are integrated into the corners of the mobile phone's printed circuit board. Due to the availability of manufacturing a working prototype of the antenna and the ease of integration of the MIMO array into the printed circuit board of the smartphone, the MIMO 4x4 array being developed is implemented on the basis of slot antenna emitters. For the proposed design, we determined the main characteristics of the antenna element: return losses (S-parameters), distribution of surface currents, radiation patterns. To minimize the degree of influence of unaccounted factors, we measured the actual design, and compared the characteristics of the antenna during modeling and real experiment. For the MIMO antenna array, we determined the envelope correlation coefficient and the specific absorption coefficient, which showed the safety of the design for humans. The final simulation results showed that the impedance bandwidth of each antenna emitter ranges from 2.6 to 2.7 GHz and from 3.45 to 3.8 GHz, which cover the resonant frequencies of 2.6 GHz and 3.6 GHz, respectively

Key words: MIMO technology, mobile communication, mobile phone, 4G, 5G, emitter, slot antenna, radiation pattern, influence on a human, SAR

MODELS OF A SYMMETRIC VIBRATOR IN THE FREQUENCY RANGE

A.S. Razumikhin, Yu.O. Filimonova, K.A. Layko, E.I. Algazin

Abstract: here we consider mathematical models of symmetrical vibrators for given overall dimensions in the frequency range. We propose the transition of input impedances calculated for different relative lengths of vibrators to the frequency range, which is necessary for further research of broadband vibrator antennas. We considered classical expressions for calculating the input impedances of a half-wave vibrator in the frequency range, as well as a vibrator model in the form of a series RLC circuit, a modernized RLC circuit, where R is given as a function of frequency, and a model on long lines. The proposed models accurately describe the classical expressions for the vibrator input impedances. We considered these models for a classical symmetric cylindrical vibrator, in the decimeter wavelength range. We give and describe the equivalent schemes of mathematical models of the vibrator. We made comparisons between the calculated input impedances of the vibrator in the frequency range according to the proposed models with classical expressions. The results of calculating the input impedances of the vibrator according to the proposed models and classical expressions with high accuracy within 7-10% coincide in 67% of the frequency band. These models allow you to make a simple transition to the construction of two-, three-loop models of vibrator antennas

Key words: balanced vibrator, balanced vibrator input impedance, balanced vibrator mathematical model

MODIFIED PISTOHLKORS DIPOLE WITH ARMS BASED ON THREE CYLINDRICAL SPIRALS CLOSED AT THE ENDS

V.I. Nikolaev, Yu.G. Pasternak, V.A. Pendyurin

Abstract: we present a modified Pistohlkors dipole with arms in the form of cylindrical spirals. We studied two versions of the dipole design: with opposite winding directions of the spiral branches in the arms and with the same winding directions. The presented design allows solving the actual problem of reducing the size of antennas for radio engineering systems. We compared the performance characteristics of the proposed structures and presented the results of an experimental study. In the course of the study, we obtained a number of basic parameters of the antenna: the Volpert-Smith nomogram, the reflection coefficient from the input, the efficiency under various conditions. We made a model of the developed antenna, placed in various conditions: the lower half of the dipole was placed inside a metal cylinder; the dipole and cylinder were placed on top of a metal cone; the dipole was housed in a dielectric casing mounted on the underlying surface in the form of a steel mesh. As a result of the research, we found that the Pistohlkors dipole with the same winding directions of the spiral branches is characterized by a much wider band of operating frequencies in agreement with the feeder line, and the value of its input resistance is approximately 2 times greater than with oppositely directed windings of the spiral branches

Key words: electrically small antennas, Pistohlkors dipole, helical antenna

DECOMPOSITION OF SIGNAL RADIO PROFILE IN PASSIVE RADIO-SENSOR TECHNICAL DIAGNOSIS AND AUTHENTICATION OF ELECTRONIC DEVICES

K.A. Boykov

Abstract: the paper presents a new method for decomposition of the signal radio profile obtained by recording the electrical component of the electromagnetic radiation of an electronic device. This radio profile carries information about the technical condition and individual characteristics of the electronic device. For a detailed study, it is necessary to decompose into the simplest damped components and determine their parameters. The number of damped components and each of their parameters carries information about the electronic device and its state. In the proposed decomposition method, an analog of the windowed Fourier transform is used to construct the time-frequency dependences of the amplitude spectrum of the signal under study. Examining the constructed dependences for extrema and carrying out their approximation, I found such parameters as the damping coefficient, the oscillation frequency, the time of the onset of radiation, and the reduced initial amplitude. The time-frequency contradiction of the window transformation, the low energy of rapidly damped oscillations gives rather high errors. To correct, I introduced a window correlation feedback - the construction of a temporal correlation function between the reconstructed and the original signal radio profile. If the correlation coefficient in any time section of the signal radio profile has not reached the threshold set by the user, then the values of the parameters affecting the change are changed. This operation is carried out until the required correlation coefficient is reached. The presented decomposition can be performed on FPGA, improving the quality of radiosensor technical diagnostics and authentication of electronic devices

Key words: signal radio profile, decomposition, correlation analysis, Fourier transform, technical diagnostics, time-frequency dependence

RESEARCH OF POSSIBILITY OF USING GENETIC ALGORITHM FOR DETERMINATION OF ANTENNA ARRAY AMPLITUDE-PHASE DISTRIBUTION

I.A. Barannikov, K.A. Berdnikov, E.A. Ishchenko, K.V. Smuseva, S.M. Fyedorov

Abstract: the article discusses a genetic algorithm as a method for calculating the amplitude-phase distribution in a phased array antenna. Thanks to the proposed algorithm, it is possible to determine the amplitude-phase distribution with high accuracy and efficiency. On the basis of the obtained values, we checked the obtained results by carrying out electrodynamic modeling using two methods: the antenna array multiplier and the complete design of the antenna array with the indicated amplitude-phase distribution. On the basis of the results obtained, it can be concluded that the use of the genetic algorithm makes it possible to achieve the required characteristics of the radiation pattern, as well as to determine the necessary amplitude-phase distribution to provide directional radiation in the required direction. To confirm the correctness of the algorithm, we determined the amplitude-phase distribution for the direction of the main lobe at 0 and 30 degrees. The basic antenna element was a patch antenna as an electrodynamic model. The performed electrodynamic modeling confirmed the high correlation of the results, as well as the correctness of the amplitude-phase distribution obtained by the genetic algorithm. The paper provides a description of the genetic algorithm, as well as provides directional diagrams for all investigated methods of calculating the final characteristics: mathematical, antenna array multiplier, modeling of a complete project

Key words: amplitude-phase distribution, antenna array, genetic algorithm

TECHNICAL COMPLEX FOR THE RESTORATION REPAIR OF SURFACE DAMAGE OF PIPELINES BY THE METHOD OF SURFACE RIVETING

O.V. Urazov, A.D. Danilov

Abstract: we present the results of work on the technical support of the process of restoring damaged surfaces of pipelines of various diameters by the method of surface riveting, which implements the phenomenon of surface plastic deformation, leading to a change in the distribution of stresses over the thickness. As a result of laboratory studies of this process at the Novovoronezh NPP, a specialized technical complex was developed for the restoration repair of surface damage to pipelines of various diameters without stopping technological processes. With the help of a laboratory stand, we investigated the following physical and mechanical characteristics: hardening depth, the value of residual stresses, the depth of distribution of residual stresses, the break-in time, the roller load. We proved the obvious advantage of rollers with a larger profile radius - they allow you to provide the necessary change in the roughness of the machined surface when running in with a larger feed, which leads to a decrease in the time of the technological process. At the same time, in the accepted range of parameters of the running-in modes (load 2500÷3000N, indentation depth 0.04÷0.06mm), the values of the residual stress components turned out to be almost identical for the considered modes for all considered rollers. Further studies of the residual displacement of the surface layer under different running conditions, measurements of microhardness and Vickers hardness with recording of the indentation diagram, analysis of the microstructure of the near-surface layers of 10GN2MFA steel after PPD made it possible to conclude that the restored surfaces correspond to operational requirements. Thus, the technical complex presented in the article was approved for commercial operation

Key words: surface riveting, roller running-in, surface plastic deformation, residual stress