IDENTIFICATION OF LINEAR DYNAMIC NEIGHBORHOOD MODELS WITH FUZZY HIERARCHICAL STRUCTURE

I.A. Sedykh

Abstract: neighborhood models and their modifications are used to model various distributed systems and processes. The paper gives a definition of a non-hierarchical dynamic neighborhood model with vector inputs and states, which functions in discrete time. The equations of the functions of the recalculation of states in the cases of a complete and incomplete structure graph are given. A general view of the linear recalculation function of states is shown. An example of a two-node dynamic neighborhood model is considered, for which a graph of the structure, the adjacency matrix, and the equation for recalculating states in the general and linear cases is given. The concept of a two-level fuzzy dynamic neighborhood model with a fuzzy hierarchical structure, each node of the first level of which is fuzzy connected with the nodes of the second level included in it, is given. The algorithm of fuzzy structural and parametric identification of a two-level neighborhood model is considered; its block diagram is shown. An example of the structural and parametric identification of a linear dynamic neighborhood model with a fuzzy hierarchical structure is given. It is shown that for the considered source data, the introduction of a fuzzy hierarchical structure several times reduces the mean square error of identification and significantly improves the adequacy of the neighborhood model

Key words: linear dynamic neighborhood models, hierarchy, fuzzy structure, structural and parametric identification

Acknowledgment: The work was supported by the Russian Fund for Fundumental Research (project no. 19-48-480007 r_a)

DEVELOPMENT OF THE METHOD OF FORMING THE END-TO-END TECHNOLOGICAL PROCESS IN DIGITAL PRODUCTION

A.V. Bredikhin, M.V. Kuznetsov, Yu.M. Shkol'nikova

Abstract: one of the most important factors determining the successful production activity of a company in competitive conditions is the use of industrial information technologies that provide automated interaction between the objects of technological preparation of production and allow controlling the development of technological processes in a single information environment of the enterprise. The introduction of these software tools allows one to organize joint and parallel technological preparation of production, reducing the time for reconciling engineering solutions and increasing the relevance of technical information. This article describes the process of developing a technique for forming an end-to-end mechanical processing using the PLM system Teamcenter. The issues of editing the PLM data model of the system and its adaptation to the domestic standards of management of technological preparation of production are considered. The object model used in the data model allows one to organize a hierarchy of information objects with inheritance of properties and behavior of business objects. The proposed technology platform allows one to fully manage the creation of the route, as well as transfer the elements of the technological process to be developed by technologists from different workshops. Technological redistribution, shop technological processes and operations can be elements of the technological process. All of them are independent objects. The developed solution will allow one to reduce the time of development of technological processes due to the controlling a set of interrelated technological data. The possibility of taking into account industry peculiarities in the process of customization of the information system is shown

Key words: end-to-end technological process, PLM, mechanical engineering

TARGET ARCHITECTURE OF A HYBRID ANALYTICAL DATA WAREHOUSE FOR AN E-COMMERCE ENTERPRISE

S.L. Podval'nyy, V.F. Barabanov, F.G. Loginov, S.A. Kovalenko

Abstract: the article discusses solutions for the collection, storage, real-time processing and analysis of Big Data for one of the leading Russian multi-format food retail companies operating in the field of direct retail sales and e-Commerce. The objects of research are: customer requirements for the system; existing IT-architecture of the customer, including various systems-data sources, data warehouse, business intelligence and data visualization; best practices for building scalable high-load data processing and analysis systems; target architecture of the designed corporate data warehouse. The relevance of the solution development is determined by the fact that currently there is a constant increase in the volume of data, processing and analysis of which through the use of traditional data analysis methods is difficult or not feasible at all. In this connection, the development of a data warehouse of hybrid architecture, which includes components of the classic Business Intelligence, Big Data, as well as data virtualization tools, allowing one to combine these components within a single system, becomes the most popular direction of development. The article describes the collected, analyzed and agreed system requirements and the model of the target storage architecture developed with the help of UML. The result of the work described in the article is that the system meets all the requirements for systems for storing and analyzing large amounts of data, is horizontally scalable, fault tolerant and highly accessible. The resulting solution will reduce labor costs, and the use in the development of open source software can further reduce the cost of developing and using software

Key words: data storage, hybrid architecture of data warehouses, data processing and analysis system

QUALITY EVALUATION OF THE IN-CIRCUIT CONTROL TEST OF DIGITAL CIRCUITS

G.V. Petrukhnova

Abstract: the object of research is control test to analyze the faults which are modeled as «stuck-at faults» and «bridging faults». The test model is a binary matrix. A matrix column is a minimal unit of binary matrix's partitioning into structural elements. The reciprocal permutations of identical matrix columns are selected as transformations. Under such transformations, the matrix structure is preserved. The symmetry properties of a binary matrix are investigated and the symmetry measure of the matrix is calculated. The obtained criteria allow us to rank the tests, represented by the binary matrix, in the order of their preference. The use of the obtained theoretical results in the tasks concerned with test control of digital devices has been shown. The presented criteria allows to analyze the presence of «stuck-at faults» and «bridging faults», and to determine the quality of test represented by a binary matrix. The control points can include the inputs of a digital device, its outputs and accessible internal points. It was assumed that a «bridging faults» could occur between any control points of the digital circuit under test, and «stuck-at faults» in any control points of the digital circuit under test. The tests were devised, checking all possible single faults of specified types at control points. The results of the study of the obtained criterion are presented. The experimental data analysis enables us to make a conclusion about the expediency of using the entropy criteria in the theory and practice of digital device testing

Key words: entropy, symmetry, binary matrix, digital device, test control, a fault of the «bridging faults » type, a fault of the «stuck-at faults» type

STUDY OF CHANGES OF ROTMAN LENS GEOMETRY FOR PLACING ON MOBILE CARRIERS

L.N. Korotkov, Yu.G. Pasternak, S.M. Fyedorov, V.I. Chuguevskiy

Abstract: the paper investigates the influence of the change in the geometry of the Rotman strip lens on its performance. Rotman lens (sometimes called the Rotman-Turner lens) is a type of diagram-forming scheme. This lens allows you to form multiple antenna beams without using switches or phase shifters. Antenna elements are connected to one of the end sides of the lens, while the ports of the rays are on the opposite side. You can imagine a lens as a quasi-microstrip (or quasi-strip) scheme, where the location of the ports of the rays is chosen so as to achieve constant phase shifts on the ports of the antenna elements. When antenna elements are powered by linearly varying phases, the device behaves exactly like a phased array. One of the remarkable properties of this lens is that, despite the presence of multiple ports of 50 Ohms, they remain isolated, and therefore do not affect the loss (or noise) of adjacent rays. A well-designed Rotman lens can have a loss of just 1 dB. Since the structure is more like a plane-parallel waveguide than a transmission line, linear antenna modeling programs are not suitable, and you have to use numerical methods that Rothman himself used, or powerful software systems. As a result of the field experiment, we obtained the matching characteristics for the original and transformed lenses, which are compared with the design parameters of the antenna

Key words: antenna array, Rotman lens

SPEECH SIGNAL PROCESSING ALGORITHMS AT VARIABLE DURATION OF THE ANALYSIS SEGMENT

A.A. Afanas'ev, R.S. Vlasov, V.G. Lisichkin, A.V. Pitolin

Abstract: the materials on the study of such speech signal properties as homogeneity (similarity) of the distribution of instantaneous sample values are presented. This property is used in the method of selecting speech processing segments based on sequential statistical analysis. This approach focuses on linear prediction-based speech coding systems. Prediction parameters are linear spectral frequencies. The consistent statistics methods used in analyzing a segment of speech require the validity of the restrictive constants necessary to make a decision about the expansion of a segment. These constants are calculated on the basis of errors of the first and second kind, taking into account the requirements imposed on speech transmission systems. The linear spectral frequencies calculated at each expansion step undergo minor (within the quantization step) changes with respect to the initial segment. This fact makes it possible to use the results of the analysis of the initial section to restore the section extended by the above method, which can significantly reduce both the computational complexity and the coding rate of the speech signal. At the same time, it is necessary to take into account the requirements of the standards for algorithmic delays in speech processing, which limit the maximum possible segment of the analyzed data along the length

Key words: speech signal, analysis segment, linear spectral frequencies, quantization step, segment expansion

MATHEMATICAL MODEL OF THE WINDOWED RADIO CHANNEL ESTIMATION FOR MULTI-ANTENATE OFDM SYSTEMS

O.N. Chirkov

Abstract: the article discusses the current noise-tolerant methods of estimating the radio channel of communication in high-speed LTE data transmission standards using orthogonal frequency division multiplexing. The analysis of methods for improving the efficiency of radio communication channel estimation algorithms based on pilot signals was carried out. A mathematical model of a windowed estimate of a radio channel for systems with orthogonal frequency multiplexing of channels with multiple receiving and transmitting antennas is proposed. A block diagram of the weighted iterative evaluation of the MIMO radio channel of the OFDM system is given, based on optimized weighting factors for single-carrier frequency division multiple access systems. The LTE communication system was simulated with two transmitting antennas at the base station and two receiving antennas in the ETU standard. The simulation results showed that the proposed model allows us to provide an improvement in the characteristics of the mean-square MSE reception error and the BLER block error compared with the pilot evaluator. It is experimentally shown that in order to achieve almost optimal performance of the proposed weighted iterative evaluation of the radio channel, it is sufficient to use 3 iterations. The main simulation results and conclusions are given in the conclusion. The gain in MSE performance is up to 5 dB, the improvement in BLER errors is 2 dB

Key words: channel estimation, pilot signals, windowed estimate, iteration, weighting factor

DEVELOPMENT OF CONTACTLESS ECG SIGNALS READING SYSTEM

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

Abstract: in this article, we consider the features of the development of a system designed for non-contact reading of biomedical indicators (ECG signals), by calculating and modeling the electrical circuit that allows the non-contact sensor system to register the bioelectric potentials of the human body. The electrical circuit provides maximum gain in the most favorable conditions. If you rely on the worst performance, the amplitude of the QRS-complex will reach the gain limit with the appearance of the best conditions for the removal of biopotentials. Capacitive electrodes will allow one to reach a completely new level of convenience and comfort of using biomedical measuring devices in everyday life, and will significantly reduce costs due to the very long term use of such electrodes. The active filter, among other things, also helps to get rid of common-mode noise induced by the power supply network. The model includes: a direct electrode that provides contactless sensing of the biopotentials of the person through capacitive coupling; buffer stage, necessary for matching the receiving part of the device with the subsequent stages; high-frequency filter with the required cutoff frequency; voltage divider as a DC voltage mixer to the required value; active filter, serving for the final gain and low-frequency filtering of the electric signal

Key words: system of non-contact reading of biomedical parameters, ECG, active filter, capacitive electrode

EFFECT OF LOCATION TSV AND RDL ON THERMAL DISTRIBUTION IN 3D-DRAM

D.A. Kharajidi, K.N. Bagnyukov, N.V. Tsipina, A.V. Muratov

Abstract: the article reviews 3D design features - DRAM (dynamic random-access memory) of integrated circuits (IC) assemblies, with different arrangement of TSV (through silicon through), protrusion (bump - solder ball), the presence/absence of RDL (redistribution layer) on the crystals of the stack and logic. The dependence of the influence of the position of key elements on the heat release of each individual assembly element and the entire system as a whole is investigated. For thermal studies, 4 versions of the 3D-IC design were proposed, depending on the location of TSV and RDL for memory and logic: edge + non-center, center + center, edge + center + RDL and center + RDL + center + RDL. Each key element of the assembly is assigned the properties of their real prototypes, such as density, melting point, thermal conductivity, thermal expansion coefficient, and specific heat of fusion. Thermal research carried out with the help of modern automated design systems. The work determined the most optimal variant of the cost and heat dispassion of assembly

Key words: TSV, 3D-assembly, RDL, modeling, design, thermal analysis

EVOLUTION OF PERCEIVED FREQUENCY OF SPHERICAL WAVE

I.P. Popov

Abstract: it is established that the frequency of the electromagnetic wave perceived by the receiver does not always coincide with the frequency of the radiation. The most common example is the Doppler effect, which, however, is not the only possible cause of this discrepancy. When a wave is superposed, the perceived frequency is equal to the intermediate value of their frequencies, for example, the combination of blue and yellow is perceived as green. The electromagnetic wave emitted by a solitary point source is spherical. This is an amplitude modulated wave. In this regard, it is not monochromatic. The perceived frequency of the electromagnetic spherical wave is less than the radiation frequency. The higher the radiated frequency ω_0 and the distance between the source and the receiver, the greater the difference between the radiated and the perceived frequencies. Three formulas for the frequency of a spherical electromagnetic wave are obtained on the basis of various mathematical models. In this regard, the experiment can play a key role. In addition, each formula can have a better fit in a particular spatial zone. The perceived frequency of a spherical electromagnetic wave is in any case less than the original radiation frequency and decreases with distance from the source, which is caused by the mathematical features of the spectrum of a spherical electromagnetic wave

Key words: source, receiver, radiation, wave, frequency, spectrum

TECHNIQUE OF CONSTRUCTION OF GRADIENT CARDS OF THE NEAR ELECTROMAGNETIC FIELD OF BILATERAL AND MULTILAYERED PCB

M.A. Romashchenko, A.L. Neklyudov, D.V. Vasil'chenko

Abstract: in the modern world, with rapidly developing electronic industry, electromagnetic compatibility of devices plays a crucial role to ensure their trouble-free operation. At the stage of designing and sample prototypes production, a number of tests are performed, including tests for electromagnetic compatibility. However, all existing methods are expensive and ineffective in many ways. The article describes the method of testing electronic equipment (EE) using the scanner's electromagnetic fields, as well as its design. These scanners have high accuracy and low cost compared with other test methods. The main disadvantages of such scanning devices are the impossibility of scanning the test item by changing the height and, consequently, low reliability of measurement results. The proposed design of the scanner in combination with software has the ability to build height maps, which increases the accuracy of the results and speeds up the testing process of the product. As a result, we can see a 3D model of electromagnetic radiation of the test sample on the PC screen. It is possible not only to know what part of the PCB is the point of greatest electric field intensity but also the distance to it

Key words: electromagnetic compatibility of RES, scanner of the near electromagnetic field, near electromagnetic field, distance sensor

RELAXATION ITERATION SEMISTOCHASTIC DECODERS FOR LDPC CODES

M.V. Khoroshaylova, I.V. Sviridova

Abstract: the article presents a semi-stochastic relaxation (SSR) with a low density parity check (LDPC) decoding algorithm that uses some elements of the sum-product algorithm (SPA) in its variable nodes, but it maintains a low complexity interleaver and a check node structure characteristic of stochastic decoders. The algorithm is based on the principle of sequential relaxation to convert binary stochastic flows into a log-likelihood ratio (LLR) representation. Variable nodes use a method similar to sequential relaxation to estimate the current value of incoming stochastic flows. Modeling (2048, 1723) of the RS-LDPC code shows that a relaxation semi-stochastic algorithm can exceed 100-iterative decoding of the sum product floating-point algorithm. The work presented approaches for the implementation of a relaxation semi-stochastic algorithm with low complexity. In addition, it shows how the stochastic nature of the propagation of trust can be used to reduce the level of errors. Random convergence properties are a natural part of all stochastic decoders and play an important role in improving the existing iterative decoding algorithms, making them even more attractive for high-speed applications with low BER. Also the article studies a simplified implementation with a fixed comma, the performance of which is close to the ideal algorithm

Key words: stochastic decoding, low-density decoder, check and variable nodes, sum-product algorithm

ITERATIVE TECHNIQUE OF INTERFERENCE-RESISTANT RECEPTION OF QAM-SIGNALS

O.N. Chirkov, A.O. Kuznetsova

Abstract: the article describes an iterative turbo receiver for time-varying fading channels, whose operation is based on an estimate of the channel offset and frequency, along with signal detection and data decoding. The paper analyzed the Bayesian maximum likelihood and regularized maximum likelihood estimates depending on the availability of various radio link static stats, as well as the simulation results showing the possibilities of further technology development. Different approaches for obtaining the highest performance were considered, the positive and negative sides of each of them were revealed, an improved algorithm of operation based on the turbo QAM modulation system was presented by increasing the number of interleavers. The joint channel estimate and QAM signal detection are based on the representation of the base decay time expansion model. A dichotomous search technique was used to track the frequency shift. The information generated in the turbo coder was used to increase the efficiency of the proposed technique in subsequent iterations. The simulation results showed that the models of noise-tolerant reception of QAM signals offered in this work have extremely high performance, while using less statistical information about the communication channel

Key words: receiver, iterative estimation, resulting estimate, channel, decoder

FORECASTING DEGRADATION PROCESSES OF MODERN TUBE DEVICES AND ANALYSIS OF THEIR EFFECTIVE ADVANTAGES OVER SEMI-CONDUCTORS

A.V. Bashkirov, S.E. Ivannikov, A.M. Kolyadina, A.S. Demikhova

Abstract: the article discusses the development trends of modern tube electronic devices in the concept of their technical, technological and economic advantages over semiconductor electronic devices. The analysis of the actualization of the development of such devices in modern electronics is carried out. The article gives the comparison of critical indicators of tube and semiconductor electronic stations, the review and prediction of degradation phenomena in modern high-tech lamps. This study includes information on the history and circuit design of vacuum tubes, the theory of amplifier design and sound measurement methods that may be useful for further work of audio engineers. The study examines the basic principles of signal amplification in the low-frequency range (sound frequency). The results of the study give amplifiers based on electrovacuum devices, as well as an analysis of the future prospects of the device. On the basis of open domestic and foreign sources, it is concluded that modern electrovacuum devices (radio tubes) have the best characteristics in comparison with semiconductor devices, namely, they have low noise and are resistant to radiation. However, they have a significant drawback, namely, a short service life compared to semiconductor devices

Key words: modern high-tech tube components, tube amplifiers, degradation processes in radio tubes

BASIC PRINCIPLES OF BUILDING, MAINTENANCE SERVICE AND DIAGNOSTICS OF REUSABLE LIQUID ROCKET ENGINE OF SPACE APPLICATION

A.F. Efimochkin, A.A. Ponomarev, M.A. Lyubinetskiy

Abstract: in the course of work for the newly developed reusable LPRE, two main methods of technical operation were identified – technical exploitation of the resource and exploitation of the state. Formation of the scope of work on the control of the technical condition of the engine is determined at the stage of experimental construction work and is gradually reduced to a minimum level by the time the experimental construction work is completed. By the time the engine is put into operation, the list of operations on the control of the technical condition should be optimal and meet the minimum cost criterion. A list of typical work performed at the technical condition control on the engine in the interflight period is made. The structure of the engine diagnostics system and a schematic diagram of inter-trigger diagnostics are also given. In order to reduce the cost and timely determine the technical condition of the LPRE, a method for conducting functional diagnostics of LPRE based on the traditionally performed engineering analysis of telemetric information and based on the use of computer diagnostic programs in an automatic mode was compiled. An algorithm for detecting engine malfunction in the case of using the onboard equipment of the engine was developed. An example of determining the presence of a malfunction in the LPRE using this algorithm is given. The optimal technology for diagnosing LPRE was determined

Key words: liquid-propellant rocket engine, diagnostics, technical condition monitoring, functional diagnostics, computer diagnostics

OPTIMIZATION OF THE CUTTING SPEED AND THE CUTTING TOOL REPLACEMENT PERIOD IN THE STATISTICAL ADAPTATION MODE

A.V. Antsev, N.I. Pas'ko

Abstract: the article considers the task of optimization of the cutting speed and the cutting tool replacement period directly in the process of machining a batch of parts on a specific metal-cutting machine, taking into account the variability of the cutting process. Since the tool life of a cutting tool is a random variable, the tool life equation is defined in the form of a distribution law of the tool life and the dependence of the parameters of the distribution law on the parameters of the cutting mode. In this paper, it was assumed that the tool life of a cutting tool dispersed according to the lognormal distribution. To take into account the uncertainty of the state of the metal-cutting machine during designing the technological process, the parameters of the tool life equation are estimated sequentially as statistical data on the machining and wear of the cutting tool were accumulated, and based on this dependence, the optimal for the current adaptation step cutting speed and cutting tool replacement period were obtained. The parameters of the stability dependence were estimated using the maximum likelihood estimation. An algorithm for optimizing the cutting speed and the cutting tool replacement period directly during the machining of a batch of parts was presented. The proposed solution was illustrated in a numerical example of turning. It showed the convergence of the algorithm to the optimum according to the criterion of unit costs, i.e. the average cost of machining, replacement of the cutting tool and the possible defect per one processed part

Key words: optimization, cutting speed, replacement period, unit costs, tool life equation, wear, log-normal distribution, wear statistics, adaptation, self-learning

DESIGNING TECHNOLOGICAL EQUIPMENT FOR ADDITIVE FORMING WITH A HYBRID COMPONENT

A.N. Grechukhin, V.V. Kuts, A.V. Oleshitsky, Yu.E. Simonova

Abstract: the article is devoted to the study of issues of dynamic control of the process of additive shaping products. The analysis of domestic and foreign works on the topic of research was carried out. It was proposed to apply mechanisms with a hybrid arrangement for ensuring the dynamic control of the process of additive shaping of products, ensuring sufficient angles of rotation of the part relative to the vertical axis. An installation for additive shaping of products based on mechanisms with hybrid layout was designed. A model of a molding system of equipment for additive shaping with a hybrid layout was built. The problem of parametric synthesis of the device for the dynamic control of the process of additive shaping of products was solved, as a result of which the allowable values of the lengths of the booms of the installation for additive shaping with constant dimensions of the base and the movable platform of the installation were determined. The dependences of the lengths of the rods depending on the design parameters of the product being formed were revealed. Thus, with an increase in the radius of the formed surface in the form of a hemisphere, a decrease in the range of rod lengths is observed, which during the shaping process ensure contact of the extruder with all points of the formed part (internal points of the part and points on its surface), setting the normal to the surface of the part at the formed point for all points on the surface of the part along the extruder axis. The proposed method allows one to form the space of the design parameters of the additive unit that implements the dynamic control of the orientation of the formed part in the process of shaping based on the conditions of contact of the extruder with all points of the formed surface; establishing a normal to the surface along the axis of the extruder; placing rods movable platform molded parts in the workspace installation

Key words: additive technologies, layer-by-layer synthesis, shaping, error

Acknowledgements: The study was supported by the Grant of the President of the Russian Federation for young scientists MK-6406.2018.8

USING LIQUID-PROPELLANT ROCKET ENGINE WITH AN ADDITIONAL AFTERBURNER ON THE CARRIER ROCKET WITH THE POSSIBILITY OF REDUNDANCY

V.D. Gorokhov, M.A. Lyubinetskiy, A.A. Ponomarev

Abstract: this article presents the concept of an innovative liquid-propellant rocket engine with an additional afterburner introduced into the design of a turbopump unit. The use of this engine in the first and second stages of a carrier rocket will allow the implementation of a redundancy for a thrust. The relevance of the work is due to the high accident rate of carrier rockets in the world and in Russia in particular. The use of the liquid-propellant rocket engine construction considered in the article will make it possible to reduce this indicator to the lowest possible value and make Russian carrier rockets more competitive in the world market. In this work, the dependence of changes in engine reliability on the operating mode is considered, the results of a comparative analysis of LPRE reliability indicators when operating in conjunction of several engines are given, the parameters are calculated and a comparative analysis of the forced mode of the LPRE is given, performed according to the classical scheme with the forced mode of an innovative afterburner engine, the main advantages of the innovation scheme are shown. An assessment was made of the possibility of using an innovative engine for carrier rocket redundancy. The obtained results confirm the relevance of further development of this circuit design for realizing the possibility of hot redundancy of a CR for a long time

Key words: liquid rocket engine, turbine, reliability, redundancy, afterburner

FORMATION OF PIPES WITH THE APPLICATION OF THE FLEXIBLE FILLER

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

Abstract: the article discusses questions of forming pipes using filling. A filler in the form of a flexible mandrel is proposed, which ensures the creation of internal pressure on the pipe walls, which excludes the appearance of rejection signs. The pressure on the inner wall of the pipe can vary with the change of the bending radius of the pipe and the angle of the wedges of the mandrel. The main materials used for forming pipes are aluminum and titanium alloys, stainless steels. Methods for the manufacture of pipes are formulated. The purpose of the work is to improve the quality of the pipes produced. The process of forming pipes is considered. At the same time, this flexible mandrel is placed inside the pipe. The flexible mandrel contains two rods with wedges strung on them, which provide interaction with split rings in opposite directions relative to the middle part of the pipe. Rings can change their diameter, reinforcing the inner surface of the pipe. When forming a pipe, pressure on its walls increases due to a change in the bend radius and a change in the length of the outer layer. A flexible mandrel provides increased resistance of the pipe to the occurrence of folds and distortion of its geometric shape from the original in its cross section. The parameters of the pipe billet are given. Calculations were made of the pressure of the split ring on the pipe q_{in}, taking into account the mechanical and geometrical parameters of the tubular billet. The main condition of the process of forming tubular billet, providing quality parts, and excluding the appearance of rejection signs, is the condition $q_{out} \leq q_{in}$

Key words: pipe forming, flexible mandrel, rejection sign, split ring, wedges, flexible pulls

CONSTRUCTIVE SOLUTIONS OF THE SHOCK PULSE GENERATOR FOR HARDENING TREATMENT OF SPECIAL PARTS

V.E. Parfenov, A.V. Khandozhko

Abstract: methods of surface hardening using impact, the existing design of devices for the implementation of these methods are analyzed, the possibilities of using such technologies in the manufacture of special parts are considered. The article considers the general design solutions of shock hardening devices as applied to wave strain hardening, as well as the design of shock pulse generators for these devices, using different principles to form a blow: using a pneumatic or hydraulic actuator, using a crank mechanism, and electromagnetic pulsation. The advantages and disadvantages of these structures are analyzed from the point of view of the possibility and convenience of embedding such an instrument into the composition of the process equipment, process controllability, and also the main characteristics of the impact systems: single impact energy, impact frequency, efficiency, overall dimensions, etc. Based on the analysis made, a number of recommendations were formulated on the choice of a type of shock pulse generator for various technological tasks, and the limitations and areas of rational use of such generators were identified, including the type of processing and requirements for process equipment. The obtained histogram of the dependence of the impact energy on the frequency for various types of generators confirms and clearly demonstrates conclusions about the application areas of various shock pulse generators

Key words: pulse generator, General hardening theory, hardening in additive technologies, impact tool, impact machines

FORMING WAVINESS OF THE PROCESSED SURFACE WHEN RUBBING BY AN ABRASIVE WHEEL

S.G. Bishutin, A.A. Kozlenkova

Abstract: the article is devoted to the study of the formation of high-altitude and stepping parameters of the surface waviness at the stage of sparking-out with the grinding wheel periphery. Studies have shown that in most cases the last working stroke of the tool and sparking-out moves of the grinding wheel (if there is no sparking-out process in the grinding operation) has a significant effect on the waviness of the surface. In addition, less waviness is achieved when grinding under more severe technological systems. It is shown that with a slight change in the rotational speeds of the wheel and the workpiece during processing, it is possible to significantly reduce the height of the waviness of the surface. However, a simple and reliable method of technological reduction of the surface waviness is to increase the number of sparking-out moves of the wheel. It was established that with an increase in the number of sparking-out tool moves, the height and step of the surface waviness decrease by 2-3 times, with the strongest change in the waviness parameters occurring in the first 7 ... 9 sparking-out moves of the tool. After 12 ... 15 sparking-out moves of the grinding wheel, the waviness of the surface practically does not change. The dependences for calculating the height and stepping parameters of the surface waviness are obtained, taking into account the main factors of the grinding process, including the conditions of sparking-out with an abrasive tool. The results of experimental verification of the obtained theoretical dependences are presented

Key words: grinding by the periphery of abrasive wheel, waviness of surface

EXPANSION OF TECHNOLOGICAL CAPABILITIES of MOBILE MILLING EQUIPMENT

A.M. Kozlov, E.V. Kiryushchenko, A.A. Kozlov

Abstract: the development of machine production has led to the creation of mobile equipment – machines that can be installed on the treated product. A distinctive feature of these machines is the lack of the frame, which makes the technological system not rigid. This, in some cases, leads to the occurrence of vibrations in the technological system, which limits the productivity of the process, reduces tool life and increases wear of machine components. The emergence and development of vibration are the most characteristic of milling when the design tool detects the intermittence of cutting. The most universal parameter characterizing the components of vibration is velocity. When milling with the use of mobile equipment, we proposed to influence the oscillatory process with introducing additional oscillating mass (damper) into the technological system, the vibration parameters of which can be controlled independently of the cutting data. Analysis of the dynamic system in milling operations showed that the equality of own and driving frequencies, the phase shift can be equal only $-\pi/2$. This value of phase shift corresponds to the conditions of occurrence of resonance. If a sufficient amount of energy spent on the establishment of the equilibrium position, the excitation of vibrations will be less and the resonance will not occur. Effectively compensate for the effect of regenerative oscillation by creating a working environment of the system in which the energy of oscillatory processes will be continuously consumed to such reconfiguration

Key words: milling, vibrations, vibration process, cutting conditions, damping