**STRUCTURE OF THE INTELLIGENT SYSTEM FOR SUPPORTING EVOLUTIONARY ALGORITHMS**

**M.A. Belykh, V.F. Barabanov, S.L. Podvalny, A.K. Donskikh**

**Abstract:** we give a brief review of evolutionary algorithms as search and optimization methods for modeling various processes and managing complex objects. The main criterion for considering algorithms is practical efficiency in solving optimization problems, in particular, the problem of finding the optimal route. We considered the genetic algorithm, the ant colony algorithm and the bee colony algorithm as algorithms that are promisingly suitable for introducing into the structure of an intelligent system for supporting evolutionary algorithms, we noted their advantages and disadvantages. We carried out a brief overview of software tools based on evolutionary algorithms, with an indication of their strengths and weaknesses, in particular, their focus on a specific algorithm. We developed a structural diagram of an intelligent system for supporting evolutionary algorithms, which is universal and not tied to a specific algorithm. The intelligent system consists of a set of modules: an interface module, a module for working with documents, a module for the mathematical core of EA support, a settings module, a module for generating an objective function, a help system module, a graphic module. We give a description of the functioning of each of them. The system allows one to select the optimal solution by varying the parameters and using tools provided by the system or specified by the user

**Key words:** intelligent system, search for the optimal route, evolutionary algorithms, genetic algorithm, ant algorithm, bee algorithm

**CONVERGENCE OF THE COMPUTATIONAL PROCESS WHEN IMPLEMENTING  
A VARIATIONAL METHOD FOR SOLVING A BOUNDARY VALUE   
PROBLEM OF HYDRODYNAMICS**

**D.K. Proskurin, D.V. Sysoev, S.A. Sazonova**

**Abstract:** we analyze the results of the application of the variational method for solving the boundary value problem of hydrodynamics. From the point of view of the numerical study of problems in mathematical physics, these variational statements are considered as the basis of projection methods (the Ritz method). The problem under consideration is reduced to the study of wave oscillations of the free surface of an ideal incompressible fluid located inside an axisymmetric cavity and subject to the action of a uniform field of mass forces. We present the main techniques that allow one to reduce the consumption of computer time and accelerate the convergence of the computational process when calculating the hydrodynamic characteristics of cavities of various configurations. The use of the Treftz method makes it possible to reduce the time for calculating the boundary value problem. The transformation allows one to reduce a three-dimensional integral to a one-dimensional one. This creates a universal method for determining the hydrodynamic coefficients for cavities of revolution with an arbitrary contour of the meridian section. However, for most resonator configurations, the convergence rate is satisfactory and provides numerical values with a high degree of accuracy. Taking into account that the Bessel functions give fast convergence but are not complete, and the Legendre polynomials are complete, we implemented the construction of a variational series on the basis of a "mixed" system of functions. This technique allowed us to significantly speed up and improve the convergence process for unfavorable cases when the use of each coordinate function system separately did not lead to success

**Key words:** hydrodynamics, variational method, wave oscillations, fluid, Treftz method, Ritz method, cylindrical functions, boundary conditions, Laplace's equation

**CREATION OF ASSOCIATIVE COPIES OF ELEMENTS OF 3D MODELS WITH IMPORTED GEOMETRY**

**A.N. Yurov, D.E. Pachevskiy, V.V. Sokolnikov**

**Abstract:** the article discusses approaches to creating new elements by programmatic copying, formed from existing 3D models and presented in export data formats. We made a block diagram for designing programs for creating copies of elements relative to base models with imported geometry. To create associative copies of imported models, we developed an autonomous software module. We performed the software solution in the implementation of building copies on the classes and methods of the open geometric core Open CASCADE, where, through dialogues, as well as with the help of auxiliary elements, similar elements are constructed from existing models. Modes of operation are available when copies can be obtained in directions, along a circle relative to a point, scaling, mirroring and other approaches to modeling bodies. The project has the ability to expand the functionality to obtain associative copies of elements using data arrays and importing parameters presented in a tabular form. In addition, the software module implements tools for viewing and presenting models, as well as their copies in a separate scalable window, there is functionality for changing the color of models, deleting a selective copy of an object, saving results in open export formats of CAD systems. The development was carried out using the 64-bit architecture of Windows operating systems

**Key words:** CAD modules, imported 3D models, geometric core of Open Cascade

**DEVELOPMENT OF AN ELECTRONIC PLATFORM FOR ORGANIZING ONLINE EDUCATION WITH A COMPETENCE-BASED APPROACH**

**S.A. Kovalenko, N.I. Grebennikova, V.A. Malinovkin, P.S. Skochko**

**Abstract**: the use of the latest technical developments based on the created electronic platforms allows one to organize high-quality online education. In this article, we formulated the requirements for the developed training platform such as: the ability to create and edit courses, the ability to attach methodological materials of various extensions and media files to the course, the ability to create and edit lectures/tests within the course, the ability to conduct video conferences within the course, the ability to view full statistics of test results for the course for teachers and download it, the ability of bidirectional communication between the teacher and students via chat. The created application implements a competence-based approach. The article includes a review of the structural scheme of the course. The "Course" entity can consist of sections, which in turn can consist of subsections (lectures, tests, video conferences). The course includes all the information of the sections for training within certain competencies. The teacher's rights management scheme is also presented. We considered the life cycle of the course, the interface for its creation and the algorithm for passing the course, which gives a complete picture of the functionality and features of the software on the created electronic platform

**Key words:** electronic platform, lecture, test, video conference, competence, course, proctoring

**APPLICATION OF NON-BINARY NUMERAL SYSTEMS FOR ORGANIZING HIGH-PRCISION COMPUTATIONS**

**M.D. Novichkov, D.A. Orlov**

**Abstract:** the purpose of this article is to find a way to increase the efficiency of calculating elementary functions, when the criteria for evaluating efficiency is speed (which depends on the complexity of algorithms, processor clock frequency and degree of parallelization) and the amount equipment required for organization the computations. Many calculations in science and industry require the use of high-precision calculations. However, when using methods oriented to the positional binary numeral system, the computation time is rather long. Within the framework of this study, we give an overview of the most well-known traditional methods of calculation with increased accuracy, we studied existing solutions using non-binary numeral systems. In particular, we described such numeral systems as bit-logarithmic, sign-bit numeral system and multi-modular system of residual classes with advantages and disadvantages. Special attention was paid to the system of residual classes, a non-positional numeral system, which is inherent by internal natural parallelism. After considering the methods for the numerical solution of elementary functions, we developed an algorithm for the accelerated extraction of the square root in the system of residual classes. We formulated this algorithm on the basis of one of the methods that were analyzed in the course of the study, and it can be implemented as a software module, however, it will be most effective if it is implemented as an electronic circuit on a chip. We give the descriptions of the conditions that must be taken into account during the hardware implementation of the algorithm. These notes contain recommendations for the synthesis of the structure of the device, taking into account the physical characteristics of the propagation of information signals in electronic combinational logic circuits

**Key words:** non-binary numeral systems, high-precision computing, modular arithmetic, residue numeral system, elementary functions, square root

**MODIFIED GENETIC ALGORITHM FOR SOLVING THE PROBLEM OF SELECTING SERVER RESOURCES IN BUILDING THE INFRASTRUCTURE OF VIRTUAL DESKTOPS**

**D.K. Proskurin, K.A. Makoviy**

**Abstract:** the transition to cloud technologies is accompanied by significant material costs for the formation of IT infrastructure. Using models that optimize hardware resources reduces hardware costs and increases the success of IT-infrastructure projects. Client workspace virtualization is dramatically changing the way of interaction with end users and expanding the opportunities for digital transformation of the organization. The article presents a genetic algorithm for solving the problem of choosing hardware for the formation of virtualized desktops infrastructure. The mathematical model for the selection of server platforms and the amount of memory to place a given number of virtual machines with given requirements for RAM is a nonlinear integer programming problem that has no exact solution, therefore, for each such problem, various heuristic methods are selected that allow obtaining not exact, but a good enough solution in a reasonable amount of time. The proposed genetic algorithm uses a solution coding method that differs from the classical method and a directed mutation operator being developed. The use of an elitist strategy in conjunction with ranking selection, placing the "best" solution in the genetic bank allows one to solve the problem of getting into local optima and increases the convergence of the genetic algorithm

**Key words:** Virtual Desktop Infrastructure, genetic algorithm, elitist strategy, ranking selection

**LETTER AND LINE DETECTION ALGORITHM IN TEXT IMAGES TYPED BY PRINTED BRAILLE FONT**

**S.F. Yakusheva**

**Abstract:**the article gives a simple algorithm for detecting letters and highlighting lines on scans and photographs of texts typed in braille using window convolutions. The algorithm was originally developed for automatic and semi-automatic marking of datasets for training recognizing neural networks with complex architectures to significantly speed up the data preparation process. It is based on the specificity of this font, in which each letter is encoded by a combination of uplifted points located at the nodes of a rectangular lattice. For letter recognition, a window filter is used, matched to detect pairs of letters in a line, with a threshold cutoff. Then the centers of pairs of adjacent letters are allocated by a greedy algorithm. Next, using the weighted distances for each point, the two nearest are searched and connected by edges in an auxiliary graph. Points included in one connected component in this graph are combined into a line and aligned to improve the quality of the final recognition. The detected letters can then be decoded, for example, using classifying neural networks or other analyzing algorithms, and translated into text according to the positions in the recognized strings. The algorithm does not impose strict restrictions on the input image and allows the parameters to be refined in accordance with the font format; however, it is unstable to perspective distortions and strong deformations and requires additional adjustments when recognizing areas of text with a small number of uplifted points. The method is well suited for scanned images and, with the help of high-quality preprocessing, can be generalized to work with photographs

**Key words:** Braille, detection algorithm, convolutions, recognition

**SOLUTION OF A NAVIGATION PROBLEM WITH THE USE OF AN AIRCRAFT LANDING CONTROL SYSTEM USING A GLIDE PATH LASER BEACON**

**D.A. Smirnov, V.G. Bondarev, А.V. Teplovodskiy, A.V. Nikolenko, K.V. Nikolenko**

**Abstract:** this article describes the problem of existing methods for determining coordinates at the stage of landing an aircraft, which have either low accuracy or require complex equipment. Therefore, we present the features of using the system for ensuring the landing of an aircraft with the use of a glide path laser beacon. To land on a laser glide path, it is necessary to equip the aircraft with a vision system with the help of which control automation is possible. In this case, the technical vision system in flight receives navigation information about the movement of the aircraft in real time. We present the implementation of a laser beacon landing by mathematical modeling of the landing process according to the proposed control law. The simulation results show that at the end point (touchdown point of the runway), the flight altitude changes smoothly, which ensures a “soft” landing. The movement is carried out not in a straight line but along a line close to an exponential. In view of the fact that working with laser navigation systems has an effect on the human body, we propose a safe way of using this system and calculated the reliability of functioning. The proposed system can be applied at airfields of any class and various types of aircraft, on which a photodetector can be installed and there is an automatic flight control system in the landing mode

**Key words:** aircraft, landing, vision system, glide path laser beacon, system reliability, safety assurance, mathematical modeling, laser radiation, runway

**INVESTIGATION OF MULTIBEAM LENS ANTENNAS BASED ON PARALLEL PRINTED**

**CIRCUIT BOARDS**

**M.P. Belyaev, Yu.G. Pasternak, V.A. Pendyurin*,* R.E. Rogozin**

**Abstract:** here we give an analysis of modern designs of lens multipath antennas based on parallel printed circuit boards. The use of printed circuit boards allows you to create lens antennas of various shapes and structures with a small mass, technologically easy to manufacture. Currently, metamaterials are widely used to create various radio devices. One of the typical applications of metamaterials relates to the creation of lenses, as well as lens antennas based on them. The article considers various types of metamaterial lens antennas implemented on the basis of parallel printed circuit boards: with a negative effective refractive index, spherical, cylindrical, flat lenses of various types. We made conclusions about the advantages and disadvantages of using parallel printed circuit boards to create metamaterial lens antennas. We described the possibility of using parallel printed circuit boards to create perspective designs of lens antennas implemented using transformational optics. We give a description of modern designs of high-directional lens antennas based on multilayer printed circuit boards. We carried out the transformation of the wave front in such lenses by changing the electrical lengths of the delay lines connecting the antennas of the shadow and irradiated side

**Key words:** multibeam antennas, metamaterials, metamaterial lenses, Luneberg lens, transformational optics, printed lenses

**LOW-COMPLEXITY NON-BINARY LDPC DECODER MODEL BASED ON THE**

**EXTENDED MIN-SUM ALGORITHM**

**O.Yu. Makarov, N.V. Astakhov, A.V. Bashkirov**, **M.V. Khoroshaylova, A.S. Demikhova**

**Abstract**: the information presented in this article is aimed at reducing the computational complexity of modeling a noise-tolerant decoder using the MIN-SUM algorithm. The main attention is paid to the modifications of the test matrix, in which the decoding performance is improved with reduced computational complexity. The weak point of the generally accepted model is the increased memory requirement and computational complexity. Modifications to the algorithm can improve its performance when developing the hardware architecture of a NB-LDPC decoder. In this paper, we analyze the performance of modified parity control matrices in terms of the bit error rate (BER) for the code length of the IEEE 802.11 n and 504 standards. We describe a computational analysis of modified parity-based control matrices. We give an analysis of the effectiveness of the lower diagonal parity matrix (NDM), and based on the double diagonal parity matrix (DDM), we analyzed the BER of graphs and estimated computational complexity. The number of calculations is significantly less in the NDM compared to other matrices. NDM is suitable for moderate decoding performance with less computational complexity and based on DDM structures. The proposed modifications are applicable to improve the performance of de-coding with a compromise on computational complexity

**Key words:** parity check matrix, min-sum decoding algorithm, binary diagonal parity check matrix, lower diagonal parity check matrix

**SYNTHESIS OF PHASED ARRAY ANTENNA WITH FLAT-TOPPED DIRECTIONAL PATTERN**

**A.V. Ostankov, A.S. Nechaev, S.Yu. Dachian**

**Abstract:** it is difficult to provide the specified indicators of the directivity quality of the flat-topped radiation pattern when synthesizing a phased array antenna using methods based on the expansion of the diagram into a generalized Fourier series. The reasons for the deterioration of the flat-topped radiation pattern indicators are the finite number of basic functions used in the synthesis and the space limitation of the amplitude-phase distribution at the array aperture. The purpose of the work is to show, using the example of a linear equidistant array antenna, that the use of an optimized template of the original form in the synthesis makes it possible to achieve improved indicators of the flat-topped radiation pattern. To ensure the predistortion of the radiation pattern, we proposed a template, one parameter of which determines the width, and the second, the degree of smoothness of the pattern vertex. A small number of template parameters make it possible, when optimizing it, to abandon the methods of evolutionary search and to simplify the synthesis procedure. Using specific examples, we show that the use of an optimized template allows you to achieve improved indicators of a flat-topped radiation pattern. As a result, it is possible to significantly reduce the amplitude of oscillations of the top of the radiation pattern at the maximum possible steepness of its fronts, as well as to achieve an exact match of the width of the pattern to the initially specified sector. The application of the presented synthesis technique allows designing linear phased arrays antenna for the formation of flat-topped radiation patterns with improved quality indicators

**Key words:** phased array antenna, flat-topped radiation pattern, synthesis, Kotelnikov series, template, optimization

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

**TIME-FREQUENCY SIGNAL ANALYSIS ALGORITHM USING CONTINUOUS WAVELET TRANSFORM AND WELCH’S PERIODOGRAM METHOD WITH ITS IMPLEMENTATION**

**ON GRAPHICAL PROCESSING UNIT**

**D.V. Kozlov, A.B. Stepanov**

**Abstract:** in the work we describe the algorithm for performing time-frequency analysis of the signals using continuous wavelet transform together with the use of the Welch’s periodogram method. At the same time, we present two methods for calculating the continuous wavelet transform based on the cross-correlation function and on the basis of the fast Fourier transform. We give the results of the implementation of this algorithm on various graphics processors (on single-board computers with a graphics accelerator and discrete video cards). We performed the estimation of the computation speed of the continuous wavelet transform from the sampling frequency of the input signal, the evaluation of the computation speed of the continuous wavelet transform and the Welch periodogram method from the number of physical channels, the evaluation of the computation speed of the Welch periodogram method from the number of frequency cells. We compared the execution speed of the two methods for calculating the continuous wavelet transform. As the studies have shown, among the considered graphics processors, the best results were demonstrated by the discrete Nvidia GTX1660 SUPER graphics card, which made it possible to execute the proposed algorithm in 32.5 ms. We show that this algorithm can be used in the analysis of an electroencephalogram in order to determine its frequency composition and localization in time of its main types of features (corresponding to pathology and artifacts)

**Key words:** continuous wavelet transform, implementation, graphical processing unit, periodogram, Welch’s method

**MATHEMATICAL APPARATUS FOR DETERMINING THE RELIABILITY OF PROJECTED SATELLITE COMMUNICATION STATIONS ON MOBILE OBJECTS**

**D.G. Pantenkov, V.P. Litvinenko**

**Abstract:** currently, satellite communication systems are widely used, allowing information and command exchange between different remote subscribers, both fixed and mobile. Some satellite communication system necessarily consists of a terrestrial satellite communication station and a plurality of user terminals of various origins (aviation, marine, etc.) and versions (wearable, carried, installed on mobile facilities, etc.). At the same time, the quality of the developed technical systems and devices often plays a particularly important role, which directly affects the effectiveness of solving the assigned target tasks of the facilities that include this equipment. In this article, the quality of equipment is understood as its reliability during operation, which is quantifiable, depending on a number of factors. We present the main approaches to solving the problem, we give the main requirements for the reliability of the SCS, and we present the methodological apparatus for determining reliability, taking into account the specifics of the problem being solved. The purpose of the article is to develop a scientific and methodological apparatus for assessing the reliability indicators of the designed satellite communication stations. The methodological apparatus takes into account the main functionally related reliability indicators - mean time between failures, average recovery time, and article readiness factor. The methodological provisions of the calculations for the formation of the reliability assurance program are based on the sequential determination of the composition and structural reliability scheme of the product, the mathematical model for each element and the product as a whole, which determines the main calculation relationships for determining the reliability assurance program, take into account the main technical limitations. Evaluation of reliability indicators of components (elements, devices) of the product is carried out according to the hierarchy of the structural reliability scheme "bottom-up," therefore, the values of reliability indicators of components of the lower level are initial data for calculating the values of reliability indicators of components of the higher level. The developed technique is universal, invariant to input parameters and can be applied to other systems (stations) from the radio link of satellite radio communication. The practical significance of the article is the possibility of obtaining quantitative estimates of reliability indicators of satellite stations even at the stage of conducting an advance project when justifying the design parameters of the equipment or forming tactical and technical tasks for development work

**Key words:** station satellite communication, reliability, quality, time between failures, average recovery time, spare parts, tools and accessories, mathematical modeling, dynamic process model, calculations

**APPLYING CONFORMAL MIMO ANTENNA ARRAYS FOR FIFTH GENERATION   
NETWORKS**

**I.A. Barannikov, K.A. Berdnikov, S.I. Derevyankin, E.A. Ishchenko, A.I. Sukachev,   
S.M. Fyedorov**

**Abstract:** the article discusses a flexible MIMO antenna array for fifth generation networks, which is capable of providing operation in the millimeter wave (mmWave). The developed MIMO antenna array is capable of providing reception and transmission of signals in the n258 (24.25-27.5 GHz) and n261 (27.5-28.35 GHz) ranges. In the study, we determined the influence of the bending of the antenna element on the characteristics of the scattering matrix (S-parameters), the directivity diagram, and the efficiency. When using a curved MIMO antenna array, we found that at a small bend radius, an improvement in the envelope correlation coefficient occurs, while the addition efficiency in a MIMO system does not change during bending formation. The study considered bends with a radius of 100 mm, 250 mm, 500 mm. The use of curved antenna arrays allows the installation of a larger number of base stations with antennas of the millimeter wavelength range, which allows one to provide the best 5G mmWave coverage, since it is in this wavelength range that the main characteristics of fifth generation networks are achieved: low signal transmission delay (1 ms), high data transfer rate (1 Gbps). The development of fifth generation networks opens new opportunities for each user, not only in the field of information consumption but also in the technologies of the Internet of Things

**Key words:** MIMO, 5G mmWave, conformal antenna

**QUESTIONS OF IMPROVING THE DRAIN EFFICIENCY OF A CLASS D POWER AMPLIFIER WITH CURRENT SWITCHING**

**A.V. Shuvaev**

**Abstract:** this article discusses the main characteristics of a Class D current-switched power amplifier (CSCD). I give a proof that the theoretical maximum drain efficiency that can be achieved by switching the current of a class D power amplifier is 100%, under some idealized assumptions, namely: instantaneous switching of transistors, zero knee voltage, and an ideal shunt resonator with infinite Q-factor and zero loss. In this paper, when analyzing a real power amplifier, I demonstrate that the drain efficiency decreases as the value increases 𝑉𝑑𝑠,/𝑉𝑚𝑎𝑥. As a result of changes in the knee voltage, the CSCD power amplifier has better performance than the voltage-switched power amplifier. I conclude that the main advantage of the CSCD the power amplifier is that the output capacitance of the semiconductor transistor can be grounded by the output resonator, which leads to switching at zero voltage. However, as the frequency increases, zero-voltage switching becomes more difficult to achieve with an increase in the parasitic inductance introduced by the wires. And I also conclude that the output resonator that grounds the signal provides an open circuit and a short circuit on all adjacent harmonics. The choke inductor provides an open circuit for all harmonics

**Key words:** amplifier theory, drain efficiency, solid-state (semiconductor) element amplifiers, class D power amplifier

**NEW METHOD FOR ESTIMATING THE FATIGUE LIFE OF A PRINTED CIRCUIT BOARD**

**USING THE PRINCIPLE OF LINEAR ACCUMULATED DAMAGE UNDER VARIOUS**

**BOUNDARY CONDITIONS**

**Z.H.M. Al-Araji**

**Abstract:** modern electronic components are subjected to various types of stress during operation, such as vibration and shock. Vibration loading, as one of the conditions for loading electronic components, has become a key factor in assessing the reliability of modern electronic systems. The challenge here is how to quickly and accurately perform a vibration fatigue analysis. Vibration damages the PCB and compromises the integrity of the solder joints due to overvoltage. Here I considered the technique, which differs from traditional ones, using the relationship between the methods of loading and fixing the board. The techniques previously proposed did not take into account the type of component mounting on the board and its effect on surface stress distribution. I show the relationship between mechanical stress and board fixation methods. An assessment of the fatigue strength of a printed circuit board to help the analyst make a relatively accurate prediction of induced fatigue life. The PTC Creo Parametric modeling process includes four boundary conditions (clamping) for the board to determine the best clamping method with the least stress. In addition, the definition of fatigue life using mathematical equations before the start of fixing reduces costs and time

**Key words:** printed circuit board (PCB), vibration, radio electronics, design, modeling, CREO Elements / Pro 7.0, fatigue damage, Three-interval method

**SYSTEM OF COMPREHENSIVE EXPRESS EVALUATION OF HUMAN FUNCTIONAL**

**READINESS**

**D.V. Zhuravlev, A.A. Provodnikov**

**Abstract:** due to the general availability and use of various computing devices, it has become possible to integrate them with telemedicine systems for various purposes. It is especially important to create highly efficient radio-technical means for remote control systems and functions of a human's functional state. In the article, we developed a microsensor-recorder based on the BMD101 microcircuit, which makes it possible to transmit information over a radio channel organized on a microcircuit, BK3231 and to conduct a comprehensive express assessment of a human's functional readiness using non-invasive diagnostic methods. Real-time heart rate detection is possible through digital signal processing, which can also filter out industrial power and motion noise. We give a list of the calculated statistical indicators and spectral characteristics allocated to the systems adopted as the European standard for the study of cardiac activity. We show the examples of the physiological interpretation of the results obtained using this software. We carried out a cycle of tests and the subsequent analysis of the results obtained for the indicators of the functional state in 25 people of different ages and sports training. In the course of the experiments, we established the main regularities of the results. The results of the express assessment can be used by athletes, amateurs, personal trainers and teams in their sports practice

**Key words:** BMD101 microcircuit, functional state indicators, non-invasive diagnostics

**IMPLEMENTATION OF A NEURAL NETWORK ON FPGA USING HARDWARE RESOURCES**

**M.V. Khoroshaylova**

**Abstract:** this article provides a study aimed at analyzing various solutions for implementing a neural network architecture on programmable logic integrated circuits (FPGAs) using floating point accelerators. In particular, two different implementations are being investigated: a high-level architecture for creating a neural network based on a software processor with different strategies to improve process performance, and a low-level architecture built using a cascade of floating point arithmetic elements, synchronized and coordinated by a state machine described in a high VHDL layer that implements full precision floating point computation in a fraction of the run time. This can benefit the model by allowing standard interfaces (such as JTAG or I2C) to be incorporated into the system that are useful for many applications, while maintaining RTL control over the data flow. I tabulated the performance analyzes for each architecture. The results obtained can go into a new form of implementation of a neural network on FPGA. I give comparisons of the achieved performance in terms of time and FPGA resources used for architectures. Using hardware acceleration of the software processor for floating point operations, I implemented and tested for performance an alternative polynomial approximation for activation functionse

**Key words:** FPGA, floating point, neural networks, VHDL, high-level architecture, performance

**APPLICATION OF MODERN INFORMATION TECHNOLOGIES IN AUTOMATION**

**OF MACHINERY PRODUCTION**

**A.P. Suvorov, A.E. Alyeshina, T.P. Safonova**

**Abstract**: the relevance of the study is justified by the expansion of the functionality of modern automated design systems, which include not only automation tools for most of the product life cycle but also the use of cloud technologies, which significantly expands the possibilities of their application. In this regard, the article is aimed at disclosing the features of the use of modern means of automated design and additive technologies for the manufacture of complex parts or structural elements in a single and pilot production, when it is necessary to conduct theoretical and experimental research based on the design and development of a complex-profile electrode-tool for electrical processing techniques. The article presents a method for designing and producing a tool-electrode for electrical processing methods, followed by the application of a conductive coating, using modern computer-aided design systems in experimental design and unit production. The materials of the article are of practical value for enterprises of the machine-building complex since they allow making changes in the design technology and manufacturing of complex parts or structural elements. Through the use of modern computer-aided design systems and additive technologies the cost reduces and the variability of its application increases

**Key words**: computer-aided design systems, additive technologies, electrode-tool, electrochemical processing

**FORMATION OF AXISYMMETRIC SHELLS FOR THE HOT PART OF A TURBOJET ENGINE**

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

**Abstract:** the article considers the information on the shaping of panels on stretch-bending presses, allowing to obtain parts of the required quality. We analyzed the issues of the formation of axisymmetric shells in UHH furnaces, which are used for noise damping casings of turbojet engines. We present the technology of production of metal sound-absorbing structures (SAD) of the hot part of the engine. We give the materials used for the manufacture of SAD. We show the frame for the calibration of axisymmetric shells. The performed calculation of the increase in the diameter of the shell when heated in the UHH furnace showed that this value is determined by the coefficient of linear expansion of the frame material. We determined deformations and pressure arising in the process of shaping. We give comparison of the arising pressures on the honeycomb filler with mechanical tests of samples and determined the limiting compressive stresses. A feature of this method is a small increase in the diameter of the shell during heating. To expand the technological capabilities of the calibration process, we developed a device that makes it possible to increase the degree of deformation during the shaping of the shell. We present the design of the device, which allows the process of forming shells at the expense of rings made of steel and titanium. At the same time, due to various coefficients of linear expansion, the movement of the disks is transferred to the levers and expanding sectors in contact with the shell. This design makes it possible to obtain a given degree of deformation for the shell by changing the geometric dimensions of the device elements. We developed a methodology for designing a device. We give an example of calculating the displacement of the device levers

**Key words:**shell, strain, coefficient of linear expansion, device

**RESEARCH OF CHANGE IN INTERNAL STRESSES IN THE PROCESS OF DRILLING BLOCKS FROM NON-FERROUS ALLOYS IN A PRELIMINARY ELASTIC-DEFORMED STATE**

**V.V. Kuts, A.S. Byshkin, M.S. Razumov**

**Abstract**: drilling holes is one of the most common operations in the manufacture of parts. As a result, increasing the efficiency of this process is an urgent task. To improve the efficiency of the drilling process, we developed a method for drilling in a pre-stress-strain material of the workpiece, which is subjected to elastic deformation by a load not exceeding the proportionality limit of the workpiece material. After removing the load, the dimensions of the workpiece remain the same. We show that with this method of drilling, a decrease in the axial component of the cutting force from 20 to 30% is observed. The reason for this is that the workpiece material will enter the cutting zone, namely the primary deformation zone, being in a pre-deformed state, which contributes to the saturation of the crystal lattice of the metal being processed with energy. Within the framework of the presented work, we carried out the modeling of the process of drilling workpieces from non-ferrous alloys in a pre-elastically deformed state. Of particular interest in the disclosure of the mechanism of this phenomenon is the study and description of changes in the zone of the preliminary elastic-deformed state of the processed material at different drilling depths. This study was carried out in the DEFORM-3D finite element analysis environment. Thus, it can be argued that the elastically deformed state of the processed material will be provided in the cutting zone throughout the entire processing time

**Key words**: drilling, elastic limit, device, deformation, workpiece, fracture, proportionality limit, physical and mechanical properties

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**METHOD FOR DETERMINING THE PLASTICITY OF LOW-PLASTIC MATERIALS UNDER HIGH HYDROSTATIC PRESSURE**

**Yu.A. Tsekhanov, M.N. Podoprikhin, I.V. Shepelenko, Ya.B. Nemirovskiy**

**Abstract:** the article proposes a method for determining the plasticity of low-plastic materials. It consists in axial compression of a cylindrical specimen, consisting of several mating sleeves made of different materials: from the investigated low-plastic and high-plastic ones. During deformation, a high hydrostatic pressure is created in the bushing under study, which increases its plasticity and deformability. We developed a theoretical model of the compression of such a composite sample, which makes it possible to experimentally achieve plastic fracture of a brittle material at high hydrostatic pressure. This is achieved both by the choice of plastic material and by the position of the sleeve made of low plastic material in relation to the bushes made of high plastic materials. The accuracy of the proposed method is confirmed by comparing the calculation results both by the model and by the finite element method. Calculations performed according to the developed model make it possible to determine the parameters of the stress-strain state of a specimen from the investigated low-plastic material, as well as its accumulated deformation before failure at various negative values of the stiffness coefficient. We used the developed method to determine the ductility of cast iron SCH20, from which the liners of engines are made, processed using deforming broaching, when large hydrostatic pressures and plastic deformations arise in the contact zone from the tools. In this case, to assess the quality of processing, it is necessary to calculate the resource of the used plasticity using the plasticity diagram of cast iron. In the experiments, significant deformations of brittle cast iron have been achieved. The results obtained made it possible to construct a diagram of the ductility of cast iron in the area of high hydrostatic compression

**Key words:** theoretical model; stress-deformed state; cast iron; plasticity; deformation