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SUMMARY. KEYWORDS

MECHANICAL

K. V. Syzrantseva, K. V. Kuskov, M. A. Pazyak
Justification of choice of corrosion-resistant material of blowout preventer body based on modeling of its elastic-plastic deformation

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The paper considers a method for justifying the choice of a corrosion-resistant material for the manufacture of a blowout preventer body based on computer simulation of an elastic-plastic task in the ANSYS Mechanical APDL software. To describe the material properties, a multilinear deformation model is used, the reference points of which are calculated as a result of working out the macro developed by the authors based on two models: Ramberg-Osgood and the "method of sequential corrections" proposed by TSAGI specialists. The paper presents the results of computer simulation on the loading of the PShKM-ASMT-114x21 preventer body by working and double starting pressure for four variants of body materials. The calculations confirmed the high safety factor of the body for the currently used 40X steel showed sufficient working capacity of corrosion-resistant steels 20X13 and 30XMA. However, a computer experiment detected very extensive zones and the level of plastic strains as a result of loading the body made of 12X18H10T steel with double starting pressure. The obtained results indicate that the investigated preventer can be manufactured in corrosion-resistant versions K1 and K2, but for the execution of K3 it is necessary to develop a fundamentally different geometry of the body.

Keywords: blowout preventer, durability, corrosion-resistant steel, computer simulation, ANSYS, elastic-plastic deformation, stress-strain diagram of material.

L. Yu. Volkova
Determination of technical condition of high-pressure pump and injectors of MAN B&W 6S50MC-C marine diesel engine by changing the pressure and temperature in pipeline

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The purpose of the work is to propose methods and means for determining the technical condition of fuel equipment. A method is proposed for determining the technical condition of the high-pressure pump and injectors of the marine diesel MAN B&W 6S50MC-C by changing the maximum fuel pressure and temperature of the outer surface of the pipeline. For fuel equipment with a maximum pressure in the pipeline from 50 to 150 MPa, the permissible pressure change zone is determined. A formula is proposed that additionally takes into account the cyclic fuel supply and its mass when estimating the temperature from its compression by the pump plunger. The fuel temperature during compression is determined depending on the pressure value. The calculation of the heat transfer process through the pipeline wall and from the heated wall surface to the air is performed. A portable RGK PL12 pyrometer is proposed to measure the temperature on the pipeline surface and determine the technical condition of the fuel equipment. The permissible temperature change zone of the pipeline surface is given, according to which the serviceable condition of the pump and the nozzle is evaluated.

Keywords: pump, pipeline and nozzle, technical condition, pressure and temperature, diagnostic signal, permissible zone, pyrometer.

A. P. Zhigadlo[1], Yu. P. Makushev[1], T. A. Polyakova[1], V. V. Ryndin[2]
Selection of cam mechanisms for driving the plunger of high-pressure pump of diesel engines using Mathcad program

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The purpose of the article is to select the cam profile (with equal design parameters) for driving the plunger of a high-pressure pump that provides the maximum speed and permissible acceleration of the pusher. A method of selecting a cam profile by analyzing combined graphs of changes in the path, speed, and acceleration of a cam pusher of various profiles using the Mathcad program is proposed. Calculations have been performed and combined graphs of changes in the path, speed, and acceleration of the cam pusher with tangential, convex, and concave profiles have been constructed. A comparative analysis of the combined graphs showed that the maximum speed of the cam pusher with a concave profile is 1,5 times greater than for cams with a tangential or convex profile. A cam with a concave profile is recommended for driving pump plungers of low-speed marine diesel engines (up to 250 min^{-1}). To create ultra−high pressures (more than 120 MPa), the fuel supply system must be battery-type with a drive of small diameter plungers (4−6 mm) from an eccentric shaft with a special-shaped washer and electronically controlled injectors.

Keywords: cam mechanisms, cam profile, calculation, Mathcad program, graphs of path, speed, acceleration, cam profile selection.

O. P. Evdokimova, D. S. Makashin
Analysis of the effect of cutting mode and coolant on the formation of burrs when drilling aluminum alloy AK5Mch

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Aluminum alloy Ak5m is widely used in the aerospace and automotive industries to replace heavier alloys. This is due to its excellent properties of high specific strength, high corrosion resistance, good formability and low manufacturing cost. Ductility and heat generation during drilling AK5MCH often leads to the formation of burrs at the inlet and outlet from the surface of the workpiece. This study shows the effect of cutting speed and drilling conditions on the formation of burrs in the AK5MCH alloy. Drilling is carried out using coolant and without coolant using drills made of high-speed steel with a diameter of 6,0 mm with cutting speeds of 20, 42 and 60 m/min at a constant feed of 0,15 mm/rev. This study showes that drilling AK5MCH with a cutting speed of 42 m/min using a coolant is advantageous, as it leads to the least tool wear and minimal burr formation.

Keywords: drilling, aluminum, processing, burr, hole, performance, accuracy.

I. Yu. Lesnyak,
Z. N. Sokolovsky, S. V. Gavrilenko
Investigation of endurance of AMg6 alloy under cyclic volumetric thermal deformation

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Theoretical studies of the endurance of an aviation alloy of AMg6 type during its long-term cyclic volumetric temperature deformation beyond the limits of Hooke's law have been carried out. A technique has been developed for assessing the endurance of aviation alloys in cyclic volumetric temperature deformation taking into account the presence of cavities (cracks) based on bringing the cyclic volumetric temperature deformation conditions to the conditions of standard mechanical testing of samples. According to the developed method, a preliminary assessment of the endurance of the aviation alloy of AMg6 type with a work-hardened and annealed surface is carried out using the available limited base of empirical data obtained on the basis of standard mechanical tests of experimental samples. The effect of the initial length of a crack in experimental samples on the endurance of the experimental samples, at which its uncontrolled growth is possible during cyclic volumetric temperature deformation, is assessed. A comparative analysis of the calculated endurance of the experimental samples with the actual endurance of the structural material (hard worked alloy AMg6) of a real orbital object such as the «Zarya» module of the international space station shows a discrepancy of no more than 12,5 %.

Keywords: endurance assessment, temperature cycle, deformation, cracks, loading.

D. S. Makashin, D. A. Blokhin
Comparison of drilling and helical milling process for holes in titanium alloy

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Drilling holes in titanium alloy VT-3 is a difficult task due to its poor machinability. The evaluation of the helical milling process is carried out by comparing the axial force, surface roughness and diametrical accuracy of the hole with the conventional drilling process. Holes created with helical milling have a high surface quality at lower axial feed, while the drilling process is accompanied by a higher axial feed, which leads to vibration of the cutting tool. When manufacturing high-precision holes in the elements of fuel control equipment, it is recommended to use helical milling.

Keywords: drilling, titanium alloys, helical milling, roughness, productivity.

V. I. Kirishchieva, M. A. Mukutadze
Investigation of wear resistance of polymer-coated radial bearing running on micropolar lubricant

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The article is devoted to one of the important problems of increasing the wear resistance of tribosystems by applying an antifriction polymer composite coating containing a groove that operates in a hydrodynamic mode to the tribocontact surface. Based on the equation of the flow of truly viscous liquid for a «thin layer» and the continuity equation, a self-similar solution is found taking into account the groove and without taking into account the groove, as a result, the velocity and pressure fields in the groove and on the surface of the polymer antifriction composite coating are determined, as well as the load capacity and friction force allowing to determine the increase in wear resistance; an increase in duration of the hydrodynamic regime. The results of numerical analysis of the obtained theoretical calculation models and experimental evaluation of the proposed design are also presented in order to verify and confirm the effectiveness of the obtained theoretical models.

Keywords: radial bearing, increased wear resistance, antifriction polymer composite coating, groove, hydrodynamic mode, verification.

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Simulation of finished and thermal stocks of two-stroke engine piston modified with catalytic material

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The calculations of the thermal and stress-strain state of the two-stroke gasoline engine (CS5200) pistons are completed. The model of an original piston and a piston modified with catalytic materials is used in the calculations. The technique used in modeling static and thermal loads using the SolidWorks Simulation program is described. A comparative analysis of the results of modeling the original and modified pistons is given. The efficiency of the piston is estimated when the surface is modified with catalytic materials.
The technique for estimating the boundary conditions is used to solve thermal and mechanical problems. It allows you to take into account the features of loading, as well as the available calculated and experimental data.

Keywords: catalytic materials, piston, internal combustion engine, thermal stress, heat tension.

ELECTRONICS, PHOTONICS, INSTRUMENT ENGINEERING AND COMMUNICATION

K. A. Ankudinov, K. S. Khalikova
The analysis of methodological foundations for optimal design of gas transmission information systems

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An analysis is carried out on the problem of creating methodological foundations for the optimal construction of information technologies that provide integrated logistics support for the life cycle of gas transmission system samples with uncertainty of the initial data. The analysis of the state of research of the problems of analysis, synthesis and forecasting of the development of complex.

Keywords: gas pipeline, gas transmission system, pipeline, complex technical system, stray currents, corrosion.

S. V. Biryukov[1], S. S. Kolmogorova[2]
Dual spherical electric field strength sensors with separate sensitive elements and their research

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A new type of electric induction spherical electric field strength sensors is being investigated, which is classified

according to the newly introduced classification feature - to dual sensors. The paper focuses on the study of dual sensors with separate sensitive elements. As a result of the study, a relationship is obtained between the angular dimensions of the sensing elements of a dual sensor and its error due to field inhomogeneity maintained in the maximum possible spatial measurement range. This relationship formed the basis for constructing a mathematical model of the dual sensor, which made it possible to identify the ranges of angular sizes of the sensitive elements of the sensor and its errors due to the inhomogeneity of the electric field. The range of set angular dimensions of the sensing elements of the first double sensor is $35,53° \geq \theta_1 \geq 33,53°$ and the second double sensor is $35,53° \leq \theta_2 \leq 85°$ at $\theta_3 = 90°$ and the corresponding error range is $\pm 0,78\,\% \leq \delta \leq \pm 9,12\,\%$ and spatial measurement range $0 < a < 1$. The results of the conducted studies show the promise of using dual sensors with composite sensitive elements.

Keywords: electric field strength, measurement, single sensors, double sensors, dual sensors, composite sensing elements, field inhomogeneity error, mathematical model, optimization.

K. K. Kim[1], A. A. Tkachuk[1], A. A. Kuznetsov[2]
Design of small capacity meter with linear characteristic

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We consider the small-capacity meter with its technical and metrological characteristics in this paper. The diagram of the functional generator and the voltage timing diagrams are given to study operation of the functional generator. The issues of using a capacity meter during the measurement of the parameters of the railway transport devices are considered.

Keywords: capacitive sensor, dielectric constant, capacitance meter, linear measuring characteristic.

V. V. Danshina
Characteristics of electrical properties of nanocrystalline systems of zinc and cadmium selenides

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The physical properties of nanocrystalline systems of cadmium and zinc selenides have been studied experimentally and theoretically. The effect of temperature and various gaseous media on the specific conductivity of films of cadmium and zinc selenides has been experimentally studied. The values of the Fermi energy, the concentration of donor charge carriers in the conduction band, the activation energy of donors, and the temperature coefficient of resistance are theoretically calculated.
It is shown that the calculated values correlate with the experimental ones, which will make it possible to predict the stability of the operation of semiconductor devices.

Keywords: CdSe, ZnSe, activation energy, Fermi energy, donor concentration, temperature coefficient of resistance.

A. S. Semenov[1], Yu. V. Bebikhov[1], I. A. Yakushev[1], O. V. Fedorov[2]
Implementation of PI-speed controller of DC motor by mathematical modeling

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The work is devoted to mathematical modeling of a DC motor rotation speed control system based on the use of a PI controller. DC motors are widely used in industry for driving cyclical mechanisms where high speed response, high starting torque, linear control are required. The main methods for controlling the required characteristics of the speed of rotation of a DC motor with independent excitation are to control the parameters of the armature and excitation windings fed from different sources. The PI controller is widely used in programmable logic controllers due to the simplicity and clarity of the mathematical apparatus. The proposed mathematical model of the PI controller is based on the choice of optimal parameters that ensure that the actual speed is kept close to the set one. The optimum PI controller coefficients KP and KI have been determined to give the best result for a constant speed. The results of computer simulation in MatLab are compared with the results of simulation on a laboratory setup. The data are obtained when using the PI controller for the steady-state error and transient time look preferable to the simulation model with voltage regulation. The developed mathematical model shows the following main results: acceleration time < 0,3 s; transient process time < 0,5 s; overshoot does not exceed 0,5 %; the steady-state error does not exceed 0,1 %. As a result of the study, a mathematical model is developed and the operation of a DC motor with a PI controller is analyzed, which makes it possible to almost completely eliminate forced oscillations and a steady-state error. The advantage of the proposed method of using the PI controller is noted as a more familiar and easy-to-use control element when implemented in existing control systems without any special changes.

Keywords: DC motor, PI controller, mathematical modeling, MatLab, rotation speed, error.

V. V. Fedyanin
Research of the microwave generator and antenna emitters for hyperthermia of oncological diseases

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Purpose. Currently (2022), the existing hyperthermia installations are large. As a result, hyperthermia treatment is carried out only where this equipment is located. In this paper, a study is conducted aimed at creating a compact hyperthermia device. Flat antennas in the form of a spiral for heating the local area have been developed and investigated. Calculations and simulation modeling for the developed antennas have been carried out.
Materials and Methods. The materials and methods of computational mathematics, ultrahigh frequency technology and the theory of automatic regulation are used in the study. Software is used to develop high-frequency systems.
Results. The directional patterns of the electric field of the developed antennas are obtained. With the help of simulation modeling, magnetic field strength distributions for the developed antennas are constructed. It is established that the maximum radiated power occurs when the oscillation frequency is equal to the natural frequency of the antennas. The nonlinear dependence of the supply voltage on the radiation power is established. During the experiments, local heating of the back area of the left forearm is carried out using the developed antennas and a generator. The maximum heating temperature is 41,5 °C.
Conclusion. The heating technology using a spiral antenna and a generator makes it possible to heat local areas to temperatures of the therapeutic range. The developed generator circuit is turned out to be very easy to operate. The maximum power of the generator is 3,2436 watts. The supply voltage is 6,36 volts. Creating antennas on a biodegradable film using an inkjet printer will allow you to create both contact and non-contact heating.

Keywords: hyperthermia, high-frequency oscillator, fractal modulation, planar antennas, spiral antennas.

I. V. Khomenko, A. V. Kosykh, E. Yu. Kompanets
Optimization of parameters of the reference frequency source with a composite resonator-thermostat

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A promising design of a thermostated quartz oscillator with a resonator-thermostat is considered. In order to study the effect of replacing the material of the microplate in the resonator-thermostat on the operation of the generator, the processes of establishing a stationary temperature regime after switching on are investigated. The material of the new microplate corresponds to the technology of low-temperature co-fired ceramics. An unacceptable change in the nature of the establishment of a stationary regime has been detected. To solve the problem found, the design change is proposed.

Keywords: oven controlled crystal oscillator, low-temperature co-fired ceramics, quartz resonator-thermostat, thermoregulatory, thermal model of the design, temperature setting process.

A. I. Cheredov, A. V. Shchelkanov
Magnetometer transducer based on oscillistor effect

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Magnetic testing is one of the most widespread types of the NDT. When carrying out magnetic testing various analog magnetic measuring sensors are used: ferroprobe, based on Gauss and Hall effects, etc.
A perspective direction of research in the field of non-destructive testing and technical diagnostics is the development of measuring transducers with a digital output signal, or a signal easily convertible into a code.
The paper considers magnetic transducer based on the oscillistor effect, which has a threshold nature and involves the appearance of electric current oscillations, flowing through a semiconductor sample, placed in the longitudinal electric and magnetic fields. The results of experimental studies of the dependence of the threshold electric field strength on the magnetic field strength are presented.
The scheme of the converter of magnetic field induction into the impulses of electric voltage, and diagrams of its work are given.
The sensitivity of the converter depends on the frequency of the sample frequency generator and the conversion coefficient of the ramp generator.

Keywords: control, converter, magnetic field, intensity, induction, oscillistor.

N. N. Chigrik
A quantitative estimate of uncertainty of the random scattering of the average clearance and interference in mating

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Actual dimensions of suitable parts made according to the same drawings can fluctuate between the given limit dimensions, and the clearances and interferences in the conjugations — depending on the random scattering of the actual dimensions with the deviation of the shape of the real surface or profile. The error of the shape of the real surface affects the probabilistic estimate of the results of sorting parts, leads to uncertainty in the size of the maximum of the material, a random scattering of the average clearance and interference in the mating and, as a consequence — the uncertainty to use all that come in for assembly of parts. The main result of the study is related with ensuring the receipt for the assembly of an equal number of parts, to the conclusion possessing novelty of the analytical dependences of finding a quantitative estimate of the uncertainty of the random scattering of the average clearance and interference in the mating, the random scattering of the average size relative to the upper and lower acceptance boundaries. Using the assembly method proposed with the initial reduction of real clearances and interferences in the mating by means of narrowing the tolerances of the actual dimensions to the tolerance of the shape of real surfaces in diametric terms within the random dispersion of the average size relative to the upper and lower acceptance boundaries allows to ensure the receipt on the assembly of an equal number of parts is achieved, including in the tested batches of parts with a breakdown of the tolerances of the actual dimensions into an equal number of dimensional groups.

Keywords: selection of parts, assembly, uncertainty of the average size, uncertainty of the average clearance, uncertainty of the average interference, size of the maximum of the material, error of the shape.

P. Sh. Madi [1,2], A. D. Alkina[2], A. V. Yurchenko[1], A. D. Mekhtiyev[3], R. Zh. Aimagambetova[4]
Fiber-optic system for monitoring stability of quarry slopes

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This paper presents issues related to the development of a system for monitoring the displacement of the mountain range leading to the collapse of the sides of the quarry. The control system uses chiseled fiber-optic sensors. Fiber-optic sensors are based on Single Mode optical fibers. A laboratory sample of a point fiber-optic sensor based on a two-shoulder Mach-Zehnder interferometer using a Single Mode optical fiber for displacement control has been developed. The simulation stand of a laboratory sample of a fiber-optic sensor showed high measurement accuracy, linearity and can be used to control the stability of the sides of the quarry after the design has been improved. The experimental data obtained are processed using the Wolfram Alpha computer program. A hardware-software control complex has also been developed with a wide range of elements that allows you to adjust sensitivity and has machine learning elements.

Keywords: optical fiber, sensor, control, quarry, safety, slopes.