MECHANICAL AND THEORETICAL ENGINEERING

Yu. P. Makushev, T. A. Polyakova, L. Yu. Volkova, V. V. Ryndin
Kinematic calculation and plotting of lifting height and speed of the tangential cam pusher using MATHCAD program

The article shows the design features of tangential cams with a rounded top, provides a method for determining the lifting height and speed of the pusher when the roller is rolling in a straight line and in contact with the actual profile of the cam. The formulas for the kinematic calculation of the tangential cam are refined taking into account the radius of the initial circumference of the shaft, the radius of the rounding of the cam tip and the value of the radius of the pusher roller. Calculations are given to determine the stroke and speed of the pusher when the roller is rolling on the sections of the straight and arc-shaped surface of tangential cams with a radius of rounding of 6 and 10 mm. Formulas are proposed for determining the lift of the pusher in the rolling section of the roller along the radius of the cam tip at a constant coefficient $\lambda = 1$ and $\lambda = 1,5$. Using the Mathcad program calculations are performed and combined graphs of the pusher lift and the change in its speed are constructed for two types of tangential cams.

Keywords: tangential cam, output of formulas, calculation of lift and pusher speed, Mathcad program, graphs.

D. V. Sitnikov, A. A. Burian
The active dynamic vibration damper in non-stationary operation of a vibroactive unit

The paper considers a vibration isolation system, in which a force is applied to the moving mass of the active dynamic vibration damper by an actuator in proportion to the measured value of the base response. The amplitude-frequency and impulse characteristics are plotted depending on the parameters of the system, assuming the actuator without distortion generates the force proportional to the base response. It is shown that the considered vibration isolation system is quite effective in the low-frequency region, including in the resonance region of the passive system, both in stationary and non-stationary modes of vibroactive forces.

Keywords: vibration isolation, non-stationary mode, active vibration damper, vibration support, electrodynamic actuator.

A. A. Fedorov, Yu. E. Zhdanova, A. V. Linovsky, N. V. Bobkov, Iu. O.
Bredgauer The influence of titanium alloys phase composition on the surface roughness parameters obtained in the process of wire EDM

The paper investigates a roughness of titanium α, $\alpha+\beta$ and β alloys, obtained by wire electrical discharge machining (EDM) with a brass electrode-tool in distilled water. The purpose of the article is to establish the relationship between the electrical parameters of wire EDM with the surface roughness α, $\alpha+\beta$ and β of titanium alloys, in particular with the group of parameters Rk. It was established by the method of contact profilometry that the phase composition of titanium alloys significantly affects the height parameters of the roughness of the treated surfaces. It was shown experimentally that the phase composition has a significant effect on the roughness parameters of the Rk group obtained in the process of EDM.

Keywords: electrical discharge machining, titanium alloy, roughness, oil retention.

V. G. Churankin, A. V. Lyamtsev, V. V. Derkach
Design and technological provision of wear resistance of elastomer surface of rubber-cord casings of damping devices

Two main factors are considered that determining the friction between non-lubricated surfaces of an elastomer and a solid base during their relative motion. The first one is adhesion in the areas of real (actual) catalysis and the second factor is the deformation component, which is due to the delay of recovery of the elastomer after the irregularity is introduced and it is called the hysteresis component of friction. One of the main problems of increasing the resource of pneumatic dampers is minimizing the wear of the covering layer of the rubber-cord casing (RCC). The wear of the RCC is due to the fact that sliding friction occurs in the process of contact between the metal surface and the surface of the RCC, as a result of which the cover layer of the RCC (in some cases with the first cord layer) wears out, depending on the chemical composition of the rubber and the features of the operation of the pneumatic shock absorber. In order to minimize the wear of rubber, it is proposed to change the design of the pneumatic damper so that rolling friction dominates in the contact between the surfaces of rubber and metal.

A. F. Battalov, R. T. Saetova, Ya. V. Denisova
Improvement of organizational and methodological issues of analytical control of natural gas quality in Testing laboratory

The increased requirements for the quality of natural gas transported and used in industrial and domestic purposes have significantly increased the role of the analytical laboratory in the production process, since if the results of analyzes that determine the quality of products depend on the entire work of the gas transportation company as a whole, then the quality and reliability of the analysis results themselves are determined by the work of the testing laboratory. The basis of consumer confidence in the purchased products is ensured by the reliability of confirmation of the conformity of products established in the requirements of technical regulations and standards. Confirmation of the quality of products constantly requires the analytical laboratory to implement methods and techniques for monitoring the quality of analyzes. The research base is Gazprom Transgaz Kazan LLC, one of the gas transmission subsidiaries of Gazprom PJSC serving the Uzhgorod and Novopskov gas trunkline corridors, the Nizhnyaya Tura–Perm–Gorky 1,2 gas pipelines, Orenburg–Zainsk, Kazan–Nizhny Novgorod, etc. The object of the study is the analytical control of the quality of natural gas, the subject is organizational and methodological issues for its implementation. This article proposes a method for calculating the frequency of gas sampling using automated algorithms taking into account data on changes in the composition and properties of gas streams for the reporting period. The description of the method is presented on the example of calculating the frequency of determining the calorific value of the lowest (actual calorific value) and density of natural gas. The central chemical-analytical laboratory of the Gazprom Transgaz Kazan's engineering and technical center and the points of gas sampling at the gas distribution stations of the main gas pipelines in the service area of the company are used as objects of the method implementation.

R. T. Saetova, I. A. Battalov, Ya. V. Denisova
Corporate accreditation system of PJSC Gazprom as a tool for ensuring uniformity of measurements of organization

The relevance of the research is predetermined by factors as the strengthening of the role of chemical analytical (testing) laboratories of gas transmission companies in the implementation of Gazprom's PJSC strategy in the field of reliable and trouble-free transportation of natural gas and the need of testing laboratories to constantly confirm their impartiality and ability to carry out production tasks at a competent level. Protection of the interests of the consumer and the rights of the supplier is ensured by the accuracy of determining the quantity and quality indicators of the supplied products established in technical regulations, standards and by minimizing risks to life, human health and the environment on the basis of reliable measurements. The issue of the quality of measurement results is acute today. Depending on the direction of measurement processes and applications of the measurement results the shape of laboratories attestation has different requirements. All types of measurements carried out in an

organization should be subject to mandatory or voluntary accreditation. Ensuring the competence of chemical analytical laboratories at Gazprom PJSC subsidiaries and companies of in the field of product conformity assessment is facilitated by the corporate accreditation system operating in accordance with Company Standard STO Gazprom 5.8-2020. Uniform requirements adapted to the industry specifics of activities and sufficient for reliable measurement results, encourage subsidiaries to become participants in the updated accreditation system. Gazprom Transgaz Kazan LLC acts as the research base. The object of the study is to ensure the uniformity of measurements through compliance with the accreditation criteria, the subject is the accreditation of a testing laboratory in the corporate system. The article considers the procedure and activities carried out by the testing laboratory during accreditation.

Keywords: gas transportation enterprise, product quality, testing laboratory, natural combustible gas, measurement reliability, corporate accreditation system, ensuring the uniformity of measurements.

A. K. Vasiliev, V. A. Dyachenko
Analysis of conditions and criteria for shock pulse reproducibility on mechatronic test stands

Repeated impact testing is an important part of any product development. The tests are carried out on stands of repeated blows. In order to expand the range of functional parameters of mechatronic stands of multiple blows, the following are proposed: criteria for choosing the parameters of an air suspension, a method for predicting changes in the stiffness of a shaper during stand operation, and a method for assessing the effect of the reproducibility of controlled parameters on the stability of a shock pulse. In contrast to the known works, the proposed criteria and methods take into account the requirements for the reproducibility of the shock impulse.

Keywords: stand of multiple shocks, tests, pneumatic drive, stability of reproduction, parameters of shock impulse.

ELECTRICAL ENGINEERING

A. F. Burkov, V. V. Mikhanoshin, V. K. Nguyen
Improving energy efficiency of power electric power plants of low-tonnage passenger ships

The article is devoted to solving the problem of improving the energy efficiency of power plants of high-speed low- tonnage (planing) vessels used for passenger transportation between coastal settlements on the example of the port of Vladivostok located on the Muravyov-Amursky Peninsula, which has mainly land communication with settlements located on the coast. The oversaturation of motor transport, due to the need for communication between localities, which are usually characterized by dense buildings, is one of the main causes of many hours of traffic congestion, which worsen the environmental situation and increase social tension in society. At the same time, the tourist attractiveness of Primorye is also decreasing. One of the promising areas for solving this transport problem is the use of low-tonnage passenger vessels, in particular planing vessels, with hybrid electrified power propulsion systems. According to the available data, such vessels have reduced consumption of fuel and lubricants necessary for the operation of power plants and reduction in harmful emissions into the surrounding atmosphere by more than two times compared to similar traditional diesel vessels. In addition, the prospects of the proposed scientific and technical solution are due to the reduction in the time of passenger transportation while reducing the cost of travel.

Keywords: battery pack, hybrid electrified power plant, main motor, semiconductor converter, synchronous reversible machine.

B. V. Lukutin, D. I. Muravyev
Matlab/Simulink simulation model of photo-diesel power supply system with intelligent control

In this article, a simulation model of an autonomous PV- diesel power supply (PDPS) system with direct current is considered. The autonomous PDPS is implemented in the Simulink programming environment of the Matlab software package. The system includes: a photovoltaic power station (PPS), a diesel

generator (DG), an energy storage system (ESS), a remote consumer as well as auxiliary converters. The PDPS model makes it possible to analyze the energy balance between generation, consumption, and the energy exchange available from the ESS connected via a DC bus (DCB). With the help of the proposed model, it is possible to analyze and optimize the technical and economic indicators of DC power plants with the priority of the PPS contribution: reducing the consumption of diesel fuel and carbonation of the air reducing the cost of 1 kWh for the remote consumer and controlling the switching in the power plants as per logical conditions. The obtained technical and economic indicators of the PDPS using direct current are superior to similar systems based on alternating current due to an increase in the contribution of the PPS to the energy balance. As a result of experiments with changing input conditions, i.e. annual changes in insolation and temperature at different latitudes, the authors justify technical, economic, and environmental criteria for the effectiveness of decision-making and recommendations for the design and operation of PDPS power plants. Intelligent algorithms for effective control of PV-diesel power systems based on DC are developed and suggested.

Keywords: photo-diesel power supply systems, DC systems, photovoltaic power plants, energy storage systems, renewable energy sources, intelligent control.

A. L. Kashtanov, Yu. V. Plotnikov
Methodology for selecting installation sites for automatic power redundancy systems of DC traction substations

The paper presents a method for selecting the installation locations of power reservation systems of traction substations to reduce electricity losses in the system of traction power supply of DC railways. The analysis of the main criteria affecting the efficiency and reliability of the DC traction power supply system is carried out. The algorithm for selecting the installation locations of power reservation systems has been developed, which allows selecting traction substations that provide the greatest energy effect during the installation of systems.

Keywords: traction power supply system, DC traction substation, converter unit, power losses, energy efficiency.

INSTRUMENT ENGINEERING, METROLOGY AND INFORMATION MEASURING EQUIPMENT AND SYSTEMS

S. V. Biryukov, L. V. Tyukina, A. V. Tyukin
Method for measuring intensity of inhomogeneous electrical fields by average value

Measurement and control of the intensity levels of inhomogeneous electric fields with high accuracy is quite a difficult task. The solution to this problem is connected both with the development of new sensors and methods for measuring the electric field strength. The creation of new high-precision electrical induction sensors has exhausted its capabilities at the current level of technology and technology. Therefore, new ideas are needed for solving the problems of high-precision measurement of the electric field strength. One of these ways is the development of new measurement methods. Existing measurement methods characterized by the complexity of the measurement processes, suitability in some cases, and unsuitability in others, do not provide the desired metrological characteristics. Therefore, the work related to the development of methods for measuring the intensity of inhomogeneous electric fields does not stand still, and is relevant. The aim of the study is to create a new method for measuring the strength of electric fields using known sensors, which makes it possible to significantly reduce the error in measuring inhomogeneous electric fields. The idea of constructing a new measurement method is formed. The idea of the method is that in the presence of two physical quantities measured with different sign values of the error, the average value of the physical quantity will always be closer to the true value. Based on this, a new method for measuring the intensity of inhomogeneous electric fields is proposed, associated only with the original measurement process. The measurement method id named «Average value method» (MSZ). The estimation of the error of this method shows a decrease in the measurement error to +5 % with the full spatial measurement range $0 \le a \le 1$. Using the «Average value method» it is possible to

achieve a significant increase in the accuracy of measuring the strength of inhomogeneous electric fields in a wide spatial range of measurements in comparison with known methods.

Keywords: electric field strength sensor, single sensor, double sensor, measurement method, electric field strength, error from field inhomogeneity.

R. A. Akhmedzhanov, A. I. Cheredov, A. V. Shchelkanov
Magnetic field strength gradiometer

Measurements of magnetic field parameters are the basis of all magnetic measurements. Most methods of measuring magnetic field parameters are based on force (energy) interaction of magnetic field with macro- or microscopic currents and electromagnetic induction. The paper considers the possibility of constructing a magnetic field strength gradient meter based on the absolute helical instability of electron-hole plasma of a semiconductor sample. The functional scheme of the gradiometer and the results of experimental and theoretical studies of the sensitive element of the gradiometer are presented.

Keywords: strength gradient, sample, field, sensing element, range, sensitivity.

B. D. Zhenatov
Expansion of dynamic range of sampling and storage device by weight integration of narrow-band oscillation

The most bottleneck of high-frequency digital radio receivers in terms of dynamic characteristics is the process of analog-to-digital conversion. Most often, to meet the requirements for the speed and dynamic range of the analog-to-digital conversion, a sampling and storage device (UHF) is included in front of the analog-to-digital converter (ADC), which is significantly simpler in structure than the ADC structure, but reduces the requirements for its speed and dynamic range [1, 2]. A method for expanding the dynamic range of the integrating sampling and storage device for digital radio receivers using the weight integration of the input narrow-band oscillation is proposed.

Keywords: integrating sampling and storage device, weight integration, narrow-band oscillation, nonlinear model.

E. V. Leun
The basics of construction of jet-drop optical systems for measuring the electric field strength. Part 1

The article discusses the principles and possibilities of using jet-drop optical measuring systems for monitoring the electric field strength (EFS). Two applied techniques are considered. First, the deflection of flying charged droplets (balls, hollow granules) used as micro-objects sensitive to EFS and deviating from a given rectilinear trajectory of motion, like an electron in a kinescope. Secondly, stroboscopic determination of the position and/or displacement of drops by pulsed illumination of the side of the deflected drop by the optical flow and measurement of the reflection angle for it. The possibilities of implementing the differential method of EFS measurements are discussed. The features of the use of liquids with the addition of metal nanopowders or based on liquid metals, as well as hollow droplets in the form of microspheres or hollow granules are considered.

Keywords: jet-droplet technologies, forced capillary jet decay, drop stream, drop, microsphere, granule, reflectometric measurement method, electrostatic charge, electric field strength.

E. A. Kotov, A. D. Druk, D. N. Klypin
Development of human lower limbs exoskeleton robot for medical rehabilitation

The article deals with the solution of the problem of optimizing the characteristics of controlled motion of human lower limb exoskeleton robot for improving medical rehabilitation. The aim of the work is to develop a rehabilitation device capable of providing controlled motion in two planes,

as well as maintaining balance without loss of mobility. The design and control system of a rehabilitation trainer designed for performing mechanotherapy of the lower limbs of patients with locomotive disorders are proposed and characterized. The developed system has a number of significant differences from analogues and can be recommended for experimental research on patients with impaired locomotive functions.