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# SUMMARY. KEYWORDS

## MECHANICAL AND THEORETICAL ENGINEERING

**P. D. Balakin, V. N. Belkov, A. V. Borodin**  
**Kinematics of auto variator drive machines**

**Omsk State Technical University, Omsk, Russia**

On the basis of theoretical provisions of the principle of design of mechanical systems by endowment of systems with properties of adaptation to real parameters and the operating mode it is offered to use for the control movement of energy of the main power flow and separate modeling of partial movement in a multi-mobile nonholonomic communication that allows to solve a problem of movement of mechanical system as a whole. For example, a frontal auto variator the decision communicated to the engineering calculation of the elements of the control circuit transfer function of auto variator under variable external loading.

Keywords: nonholonomic, multimotional link, generalized coordinates, modeling of movements, a built-in control circuit, auto variator, transfer function.

**E. N. Eremin<sup>1</sup>, V. M. Yurov<sup>2</sup>, V. C. Laurynas<sup>2</sup>, A. Sh. Syzdykova<sup>3</sup>**  
**The influence of technological parameters of deposition of multi-element ion-plasma coatings on its quality**

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The technological parameters of deposition of high-entropy ion-plasma coatings based on Kh18N10T alloyed steel by zirconium, copper and aluminum are studied. It has been established that with increasing evaporator arc current, the surface energy of the coating decreases, which is explained by a rapid increase in its thickness, leading to an increase in the dislocation density in the coating being formed. The optimal value of the arc current is 90–110 A. Coatings obtained at a nitrogen pressure of  $P=10-3$  mm Hg. and the substrate temperature of 400 °C, have the most evenly distributed fine dense structure, the minimum content of the droplet phase, pores, influx, detachments, the highest values of surface energy and an increase in microhardness by 30 %.

Keywords: ion-plasma spraying, multi-element coatings, microhardness, surface energy, deposition parameters.

**A. P. Morgunov, V. V. Derkach, I. V. Kirgizova**  
**Development of control unit for parameters of material processing modes**

**Omsk State Technical University, Omsk, Russia**

The use of modern energy and resource-saving technologies in multifactor technological processes is a promising direction for development of the manufacturing sector in most developed countries.

The purpose of the work is to develop a control system for the Arduino UNO program with the parameters of material processing mode.

The article describes the results of the development and creation of a control system for the parameters of the material processing mode in an electrochemical installation.

As a result of the experiments, a control unit system was developed with automatic programming with predetermined cycles focused on changes in the macro deviations of the shape of the processing blank.

Keywords: electrochemical processing, processing modes, control unit, aeroponic installation, agro-industrial sector.

**A. V. Shtib<sup>1</sup>, V. R. Vedruchenko<sup>1</sup>,**

**I. I. Malahov<sup>2</sup>**

**About modeling of working process of ship diesel at use as fuel of gas condensate from Urengoy fields**

<sup>1</sup>Omsk State Transport University, Omsk, Russia

<sup>2</sup>Omsk Institute of Water Transport (the branch) of Siberian State University of Water Transport, Omsk, Russia

The article provides a brief overview of the basic physical and chemical properties of different fuels including mixtures of diesel fuel and gas condensate. The analysis of indicators of working process of the diesel engine on liquid fuel of different structure is considered. Graphical and analytical interpretation of the operating cycle, fuel combustion and pressure changes are presented. The influence of the properties of liquid standard and alternative fuels on the parameters of the working process is analyzed. The results of numerical simulation of the diesel indicator process on a mixture of gas condensate and standard diesel fuel are analyzed.

Keywords: marine engine operation, engine cylinder, marine diesel engines, diesel fuel, gas condensate, indicator process, cetane number.

## ELECTRICAL ENGINEERING

**V. V. Kharlamov, S. N. Nayden,**

**P. K. Shkodun,**

**P. G. Petrov, A. S. Khloptsov**

**Method for estimating condition of commutation of traction electric DC motors of carrier dumping during operation**

**Omsk State Transport University, Omsk, Russia**

The article describes a method for assessing the state of commutation of traction DC electric motors of BELAZ dump trucks based on processing data obtained using an automated video measuring commutation complex. The developed algorithm for the formation of the spark intensity value from the video image is given, the criteria for evaluating the switching are determined, the analysis of the modes and quality of operation of the traction electric motors is performed depending on the operating mode of the mining truck. The input and output data processing is carried out in the MATLAB 2017 program.

Keywords: the dump truck, DC motor, switching the intensity of the sparking, the algorithm of video processing, the pixel matrix of the image, graphic filters, cycle, data synchronization, ripple factor, ratio of field weakening.

**V. V. Kharlamov, D. I. Popov**

**Development of algorithms for effective control of process of testing induction motors by mutual load**

**Omsk State Transport University, Omsk, Russia**

The urgency of the development of energy-efficient electrical systems designed for testing induction machines is formulated. The necessity of automation of test stands in order to increase their reliability is noted. As research object selected scheme for testing of induction motors by mutual loads. For these schemes, efficient control algorithms have been developed, eliminating the possible overload during the starting and subsequent loading of electric machines to the nominal mode. The results obtained in the study can be applied in the production and operation of induction machines.

Keywords: test complex, induction motor, frequency converter, load tests, control algorithm, mutual load.

**K. S. Markelova, O. A. Sidorov, V. M. Philippov**  
**Increase in environmental safety of system of current collecting of electric elevated transport**

**Omsk State Transport University, Omsk, Russia**

The article presents the advantages of the available types of elevated electric transport. The conditions have been indicated for ensuring reliable, economical and environmentally current of collection by electric transport. The results of experimental studies are published of negative factors of current collecting in real conditions of operation of elevated electric transport. The methods are considered that increase the environmental safety of current-collecting. The description is given of the best designs current of collectors with excellent environmental specifications.

Keywords: electric transport, system of current collecting, current wire, current collector, environmental safety, negative factors in transfer the current, quality of current collection, protective screen.

**I. V. Prisukhina, D. V. Borisenko**  
**Machine classification of code signals in electric train warning systems**

**Omsk State Transport University, Omsk, Russia**

Automatic train warning systems being currently in service on Russian railways use electric track circuits as signal communication media.

Electric signals transmitted through a track circuit often get corrupted by the noise produced by electric locomotives and other sources. This, in most cases, causes errors in automatic train warning systems and temporarily disrupts the operation of a railway.

To improve the stability of such systems while receiving signals from a track circuit, we propose a machine classification algorithm based on a neural network.

In this article, we describe all the stages of this algorithm and discuss the architecture of a neural network for classification of an electric signal received from a track circuit. We also demonstrate the successful application of the algorithm for receiving a noisy electric signal which currently used automatic train warning systems fail to decode.

Keywords: train warning systems, code modulated signal, machine learning, neural network, railway signaling, finite state machine.

**A. A. Tatevosyan**  
**Solution of optimal control problem for magnetoelectric drive with oscillatory motion**

**Omsk State Technical University, Omsk, Russia**

The mathematical formulation and solution of optimal control problem for magnetoelectric drive of machines with oscillatory motion of the working body are given. On the basis of the obtained solution, the algorithm for optimizing design of magnetoelectric motors for a given law of rotor motion is constructed under condition of providing the maximum electromagnetic force produced by the engine and the minimum mass of the active materials used.

Keywords: optimal control, functional minimization, rotor motion law, maximum electromagnetic force, minimum mass of active materials used.

**INSTRUMENT ENGINEERING, METROLOGY  
 AND INFORMATION MEASURING  
 EQUIPMENT AND SYSTEMS**

**K. K. Kim<sup>1</sup>, A. A. Tkachuk<sup>1</sup>, A. A. Kuznetsov<sup>2</sup>**  
**Two-channel electric liquid helium level meter**

**<sup>1</sup>Emperor Alexander I St. Petersburg State Transport University, Saint Petersburg Russia**

**<sup>2</sup>Omsk State Technical University, Omsk, Russia**

The liquid helium level meter for the transport cryomodules of high-speed ground vehicles with the magnetic suspension is presented in the article. The need to develop such a meter is dictated by the specifics of the functioning of cryomodules that

are part of transport systems, namely, functioning in the strong magnetic fields. We consider the operation principle of the measuring system of this meter. We draw conclusions about the accuracy of its measurements. The possibility of using the multi-channel sensor system with the sensors and the switching device in the secondary device circuit has been determined.

Keywords: transmitter, liquid helium, superconductivity, cryomodules, measurement error, sensors.

**A. I. Blesman<sup>1</sup>, R. B. Burlakov<sup>2</sup>**  
**Electrical and photoelectric properties of photocell on base of Schottky barrier contact Au-n-GaAs**

**<sup>1</sup>Omsk State Technical University, Omsk, Russia**

**<sup>2</sup>Dostoevsky Omsk State University, Omsk, Russia**

Structure and strategy of the fabrication of the photocell on the base of the Schottky barrier contact Au-*n*-GaAs are considered. There are measured I(V)-features of photocells, their C-V-features, spectrums photovoltage and current of the short circuit, and determined height of the Schottky barrier contacts Au-*n-n*<sup>+</sup>-GaAs by photoelectric method. It is shown that air annealing of structures *n-n*<sup>+</sup>-GaAs-AuGe under (200–220) °C within 30 minutes before precipitating a film Au on *n*-GaAs brings to the reduction on two- three orders direct  $I_{dir}$  and inverse  $I_{inv}$  currents (under 0,5 V) to reduction on three orders of density of the current of the saturation  $J_0$ , to reduction of capacities of photocells before values (204–191) pF under inverse tensions (0,22–0,96) V, reduction of the current of the short circuit of photocells and to increase their photovoltage that connected with formation fine oxide layer on *n*-GaAs under air annealing of structures *n-n*<sup>+</sup>-GaAs-AuGe.

Keywords: method of fabricating the photocell, *n*-type gallium arsenide, Schottky barrier contacts.

**A. I. Blesman<sup>1</sup>, R. B. Burlakov<sup>2</sup>, D. A. Polonyankin<sup>1</sup>**  
**Electrical and photoelectric properties of photocell based on two Schottky barrier contacts Al-p-Si and Ti-p-Si**

**<sup>1</sup>Omsk State Technical University, Omsk, Russia**

**<sup>2</sup>Dostoevsky Omsk State University, Omsk, Russia**

Task of studies is a development of the structure and way of the fabrication of the photocell capable to take a radiation or in near infrared region of the spectrum (1–1,4) microns, or in the field of (0,5–1,4) microns. Way of fabrication and results of studies of photoelectric features of two spectrum photocell based on two Schottky barrier contacts Al-*p*-Si and Ti-*p*-Si, situated on opposite parties Si plate are considered.

Keywords: method of fabricating the photocell, *p*-type silicon, Schottky barrier contacts.

**S. S. Kolmogorova<sup>1</sup>, D. S. Baranov<sup>2</sup>,  
 A. S. Kolmogorov<sup>3</sup>, S. V. Biryukov<sup>1</sup>**  
**Automation of signal processing of electric field intensity sensors included in information-measuring system**

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The adverse effect of electromagnetic fields on a person makes it necessary to exclude his presence in the measurement process. Therefore, the tasks associated with the automation of measurement parameters of electromagnetic fields are relevant. In this regard, the article deals with the automation of the processing of measuring signals from sensitive elements of sensors in the measurement process. Sensors of electric field, having from one to six sensitive electrodes (depending on the modification) are involved in the examination. Signal processing and algorithmic operations are carried out on the Siemens S7-300 platform with Siwerex weighing modules. A distinctive feature is the algorithm for processing the readings of sensors in the process of obtaining data. Integration of the lower level into a third-party SCADA system is possible. The results of the study made it possible to conclude that with direct measurements it is necessary to take into account the overlap area of the sensor sensitive electrodes and the rate of change of its readings; the implementation of correction algorithms for the specified parameters allows the system to quickly adapt to changes in process conditions and

achieve high measurement accuracy; Siemens WinCC Flexible software should be used as a man-machine interface.

Keywords: automation of the measurement process, electric field strength sensor, sensitive electrode, measuring signal, sensor signal processing, processing program, electrometric measurements.

**E. V. Leun**

**Improvement of methods and means of control of deviations from straightness by using acousto-optic heterodyne laser measuring systems**

**Lavochkin Association, Moscow region, Khimki, Russia**

The article deals with the construction of high-precision acousto-optic (AO) heterodyne laser measurement systems for monitoring deviations from straightness when working in continuous mode with phase-digital  $\Delta\varphi(\Delta l_y) - \Delta N_{out}$  and frequency-digital  $\Delta f(\Delta l_y) - \Delta N_{out}$  transformations, as well as in pulse mode. It discusses the use of solid-state AO modulators, phase-locked loop systems phase and frequency together with the fiber phasemodulators and precision ADC. The variants of linearization of the transformation function, increasing the resolution are proposed. It discusses the possibility of implementing laser measurement systems with support channels and admittance control.

Keywords: the deviation from straightness, laser measurement system, acousto-optic modulator, heterodyning, phase lock, phase shift, space-sensitive coordinate, the phase-to-digital conversion, the frequency-to-digital conversion.

**I. V. Platov<sup>1</sup>, E. V. Leun<sup>1</sup>, A. I. Cheredov<sup>2</sup>, Yu. N. Mishin<sup>1</sup>**  
**Features of pressure control in pipelines of spacecraft propulsion systems**

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<sup>2</sup>Omsk State Technical University, Omsk, Russia

The article examines the construction of strain-gauge systems for pressure control of gas pipelines and fuel lines to the propulsion of the spacecraft. We discuss the possibility and details of installation of sensing elements in the pipeline does not violate their integrity. The method of calculating minimum and maximum values of the internal pressure in a stainless steel pipeline by using semiconductor sensing elements based on samarium monosulfide (SmS) is presented.

The scheme of the generator sensor based on semiconductor sensing elements with built-in phase-locked loop frequency with the possibility of frequency-digital conversion is proposed.

Keywords: spacecraft, propulsion system, gas and fuel lines, tensometric system, samarium monosulfide, phase-locked loop system, frequency-digital conversion.

**A. M. Demin, A. P. Naumenko**

**Diagnostics of heat exchange equipment on basis of operating parameters of diesel fuel hydrotreating unit**

**Omsk State Technical University, Omsk, Russia**

The research focuses on problems related to fouling of heat exchange equipment of DHT (diesel hydrotreatment) processes

and heat exchanger condition diagnostics. The purpose of the work is to determine the critical parameters of operation of heat exchangers. According to the results of calculations on a mathematical model of a typical hydrotreating unit using a real-time diagnostic program based on monitoring operational parameters, the criterion for assessing the state of the reactor unit heat exchanger increases from 1 to 1.37 with an increase in the annulus pollution coefficient. When this occurs, the temperature of the raw material at the exit of the apparatus decreases and the cost of additional fuel consumed by furnaces in the amount of more than 1 million rubles / month. Diagnosis of heat exchangers in real time allows you to optimize operating costs, including choosing the optimal time for cleaning tube bundles in terms of comparability of costs for additional fuel consumed and cleaning.

Keywords: condition monitoring, diagnostics, heat exchange equipment, diesel fuel hydrotreating, real-time monitoring, sign.

**V. A. Komarov<sup>1</sup>, A. A. Fedotov<sup>1</sup>, L. A. Denisova<sup>2</sup>**

**Defects detection of main pipelines by vibroacoustic control systems**

<sup>1</sup>Omsk State Transport University, Omsk, Russia

<sup>2</sup>Omsk State Technical University, Omsk, Russia

The article deals with defects detection in main pipelines through use of active vibroacoustic control systems of their condition. Descriptions and principles functioning of systems based on using probabilistic recognition methods of technical condition are presented. The results of numerical experiments are presented and dependences of defect detection error estimates on the acoustic noise intensity are obtained. It is shown that the use of active vibroacoustic control systems can effectively detect the defect in pipeline (incut, pit) even at small values of the signal/noise ratio.

Keywords: vibroacoustic signal, acoustic noise, pipeline defect, incut, distribution moment, identification tester, correlation coefficient, detection error.

**I. S. Kudryavtseva, A. P. Naumenko, A. M. Demin**

**Evaluation criteria of objects vibration state by parameters of signal characteristic function**

**Omsk State Technical University, Omsk, Russia**

In operation, research results are presented in the field of technical diagnostics and are related to detection and examination of new faults diagnostic signs on the basis of vibroacoustic signal characteristic function parameters. The obtained signs are integral estimates of the vibroacoustic signals statistical characteristics for piston compressors. The paper presents the boundary values of diagnostic signs based on the parameters of the area under the curve of the vibroacoustic signals characteristic function modulus. The decision-making risk curves were constructed, the probabilities of missing a malfunction and a false alarm were calculated for the selected values of diagnostic signs. The use of suggested signs makes it possible to increase reliability of technical devices condition monitoring and their diagnosis.

Keywords: vibroacoustic signal, characteristic function, diagnostic sign, vibroacoustic diagnostics, piston compressor.