

## MECHANICAL AND THEORETICAL ENGINEERING

**D. I. Chernyavsky, D. D. Chernyavsky**

Study of dynamic characteristics of impact of two solid deformable bodies at impact speed of up to 100 m/s

The paper analyzes the dynamic dependencies between the impact force and the depth of the indenter penetration into the obstacle. The indenter is a hardened steel ball. The target is made in the form of a rod from various types of steel, duralumin, aluminum and lead. As a result of digitizing the graphs of dependencies, interpolation formulas are obtained for different phases of the impact (the first phase of the impact is compression; the second phase of the impact is unloading). In the course of the analysis of interpolation formulas, absolute and relative data on the transformation of the initial kinetic energy of the indenter into the distribution of energies after impact are obtained: the value of the kinetic energy of the indenter after the impact, the values of the energy of elastic and plastic deformations, and the energy of shock waves. The results obtained can be used to design impact machines with an indenter impact speed against an obstacle up to 100 m/s.

**Keywords:** mechanical shock, solid deformable body, elastic and plastic deformations, shock wave energy, indenter penetration depth, strength.

**O. G. Feoktistova, D. Yu. Potapova**

Using correlation matrices in predicting airline performance

The article considers the issue of making forecasts of the main indicators of the activities of airlines for their effective functioning in the air transportation market. It describes the life cycle of airlines and provides a classification of the forecasts that are currently being made. The interrelation of correlations of the key parameters of the airline's functioning is considered, the use of correlations in forecasting is shown, actual calculations are presented, and a significant increase in forecast accuracy when using this forecasting method is demonstrated.

**Keywords:** life cycle of an airline, forecasting the main indicators of airline activities, correlation coefficient, correlation matrices, correlation radius, forecast error.

**A. I. Shinkevich, S. S. Kudryavtseva, Yu. N. Khakimullin, M. I. Farakhov**

Environmental innovations as factor of development of petrochemical industry in Russia

Problem statement (Relevance): the article reflects the current directions of improving the environmental safety of petrochemical production through the development and implementation of environmental innovations that meet the requirements of new technological methods of production. Objective: development of methodological tools for assessing resource efficiency and analysis of the processes of introducing environmental innovations in the petrochemical complex. Methods applied: general scientific methods are used — system analysis, cause- and-effect relationships, description and generalization; as well as special methods — graphical analysis, component analysis, factor analysis, descriptive statistics. Informational and analytical materials of the Ministry of Economic Development of the Russian Federation, the Ministry of Industry and Trade of the Russian Federation, Rosstat, the Oslo Guide, government programs are used as an information base for the study. Originality: the factors of environmental innovations in the petrochemical industry are systematized, the coefficients of elasticity between the costs and the resulting indicators of eco-innovations in the petrochemical industry are calculated. Result: the article shows that among the main types of environmental innovations introduced in the petrochemical industry are the reduction of material and energy costs, the reduction of carbon dioxide emissions, the reduction of the negative impact on the environment, the replacement of petrochemical materials with safer ones, recycling of petrochemical waste; it is revealed that the primary factor influencing the intensification of the introduction of environmental innovations in the petrochemical industry is the result of the

introduction of eco-innovations at industrial petrochemical enterprises, which is reduced from the intensity of costs for environmental innovations in this industry. Practical relevance: the conclusions and results presented in the article can be applied in the development of strategies and programs to improve environmental safety in the production of petrochemical products along the entire value chain in this industry. In addition, the toolkit proposed in the article may be a prospect for further development and improvement of the methodology for studying the impact of eco-innovation on increasing the efficiency of the petrochemical complex.

**Keywords:** petrochemical industry, environmental innovation, organization of production, energy saving, certification, standardization, recycling.

#### **V. A. Ilyinykh**

Experimental studies of profile joints of machine parts under cyclic loading conditions

The increasing demands on the quality of machines, in particular multipurpose CNC machines, determine the tasks aimed at improving the designs of their critical components. The aim of the work is to ensure the accuracy, contact rigidity and durability of torque-transmitting connections of spindle assemblies during reusable replacements of auxiliary tools based on the use of conical profile connections with an equiaxed contour. The paper presents the results of experimental studies of these compounds on models that are made of optically active materials, which allows us to visually study the processes of contact interaction of profile parts under cyclic loading conditions. The method of static photoelasticity in the study of flat profile joints with an equiaxed contour made it possible to establish based on the analysis of isochrome patterns, that the change in the values of maximum tangential stresses per revolution of the profile joint is subject to a pulsation cycle.

**Keywords:** auxiliary tool, profile connections with equiaxial contour, static photoelasticity method, stress fields, small amplitude displacement.

#### **A. A. Lubnina, A. A. Farrakhova**

Modeling technological development of petrochemical enterprises in context of «Industry 4.0»

With the transition of technological systems to the path of Industry 4.0, an urgent task is to assess the current level of industrial development of petrochemical enterprises. The purpose of the article is to identify trends in the technological development of petrochemical enterprises within the framework of the Industry 4.0 concept. The obtained results of the study are of great importance for petrochemical enterprises and can also be useful for relevant ministries and departments to assess the level of development of various industries.

**Keywords:** technological development, Industry 4.0, petrochemical enterprises, energy efficiency, modeling, correlation-regression analysis.

#### **T. A. Polyakova, Yu. P. Makushev, L. Yu. Volkova, V. V. Ryndin**

Kinematic calculation of convex cam profile using MATHCAD program

The article shows the features of the construction of cams with a convex profile, the method of kinematic calculation of the pusher when it moves along a convex and rounded surface is given. A technique is proposed to determine the coordinate center of the radius of the convex surface of the cam. Calculations of the stroke, speed and acceleration of the pusher depending on the angle of rotation of the cam shaft are performed using the Mathcad system. Using the Mathcad program for cams with a convex profile, graphs of the pusher lift, changes in its speed and acceleration are constructed. The proposed method of calculating the cams of a convex profile of various sizes with the determination of the lifting height, speed, acceleration of the pusher and the construction of their graphs in the Mathcad system will allow designing cams and copiers necessary for processing cam shafts.

**Keywords:** engine mechanisms, convex cam, derivation of formulas, calculation of pusher kinematics, Mathcad program, graphs.

#### **D. B. Grits**

The dependence of performance characteristics of roller bearing on material used

The main materials for the manufacture of rolling stock bearing assemblies are steel ShKh15, ShKh15SG, ShKh4. The article discusses the possibility of using steels 20Kh2N4A, 95Kh18-Sh, 12Kh18N9T as alternative materials, an assessment of the arising contact stresses on the surfaces of the raceways of the bearing rings and rolling elements is given. When using 12Kh18N9T steel, the maximum contact stresses are reduced by 4 % in comparison with standard materials, which can provide an increase in the resource of the bearing assembly.

**Keywords:** bearing assembly, steel, contact stresses, service life, fatigue spalling.

#### **D. Yu. Potapova**

The task of prognostication main indicators of air company

The issue of improving the efficiency of the functioning of airlines in the air transportation market is considered. A statistical and mathematical model has been developed and allows us to make a prognosis of the main indicators of the airline's activity. This model is a distribution of a random variable, which distribution density is described by the Gauss' Law. The influence of the correlation coefficient value on the accuracy of the prognosis, the average quadratic values on the mathematical expectation of the predicted value is shown. The given model allows to increase the accuracy of the prognosis of the indicators of the airline work.

**Keywords:** the prognosis of indicators, the functioning of air companies, statistical characteristics, Gauss' Law, standard deviation, random variable, the correlation length, the accuracy of prognosis.

### **ELECTRICAL ENGINEERING**

#### **A. A. Kuznetsov, A. V. Ponomarev, A. G. Zverev, G. V. Volchanin**

Electro-corrosive state diagnostics of internal surfaces of reinforced concrete supports of contact network

The article discusses a device for diagnosing the electro-corrosive state of hollow reinforced concrete supports of the contact network and power lines. The operation of the device is based on the use of a visual method for monitoring electro-corrosive defects. A design of a video endoscope is proposed that provides an improvement in image quality by eliminating fluctuations in the position of a flexible optical probe during its vertical movement, an increase in the level of automation of the diagnostic process with registration of the coordinates of defects and documentary evidence in the form of a replenished database of images of the diagnostic object — the inner surface of hollow reinforced concrete supports from the surface soil to their base.

**Keywords:** hollow reinforced concrete supports, electrocorrosion state, diagnostics, video endoscope, automated electric drive, panoramic image.

#### **A. E. Bychkov, T. A. Funk, A. V. Aleksandrov**

Methods of synchronization of electric drives not mechanically connected

The article provides a comparative analysis of the structures of synchronization of the motion of electric drives of medium and high power. A comparison of synchronization structures is made in terms of the impact on the final operation of the system and hardware synchronization methods in terms of applicability and maximum performance. The mathematical apparatus is based on the principle of separation of the movements of each of the electric drives and the representation of its transfer function in matrix form. The control ranges and speed of different types of systems are compared experimentally by evaluating the speed of data transmission and evaluating the speed ripple at low revs.

**Keywords:** synchronization, AC drive, slave-master system, cross-coupled system, coordination, closed loop.

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

**S. V. Biryukov, L. V. Tyukina, A. V. Tyukin**

Dual spherical intensity sensors for new generation low- frequency electric fields

These electric fields adversely affect the environment, technical and biological objects. In this regard, it is necessary to control the levels of electric fields, an important characteristic of which is the strength of the electric field. Sensors of the electric field strength are required to sense the electric field. The existing sensors are inconvenient in operation and have a high error in the perception of the electric field strength, reaching  $\pm 20\%$ . In the work under consideration, the idea of creating a universal sensor of a new type, related to the type of dual sensors, is put forward. Its versatility lies in the fact that it embodies all types of known sensors – single, double, and now twin. The error in the perception of the intensity of the inhomogeneous electric field of the dual sensors does not exceed  $+5\%$  in the entire spatial measurement range  $0 \leq a \leq 1$ . In this case, the distance  $d$  to the field source is limited only by the radius of the spherical base of the sensor, i.e.  $d \approx R$ . At the same time, for sensors that are part of a dual sensor in the same spatial measurement range, the error is  $\pm 35\%$ . Using a dual sensor, it is possible to achieve a significant increase in the accuracy of measuring the strength of inhomogeneous electric fields in a wide spatial measurement range in comparison with known sensors.

**Keywords:** electric field strength sensor, single sensor, double sensor, dual sensor, electric field strength, error from field in homogeneity.

**I. A. Kirovskaya, N. V. Chernous, E. V. Mironova, A. O. Ekkert**

Solid solutions of InSb-ZnS heterosystem — primary converters of semiconductor sensors

Using the specifically developed method, solid solutions of the AIII BV (InSb), AII BVI (ZnS) type semiconductor compounds of various composition  $(\text{InSb})_x(\text{ZnS})_{1-x}$  have been obtained. According to the results of the performed X-ray, micro-, electron-microscopic studies, the obtained solid solutions are certified as substitutional solid solutions with a cubic sphalerite structure, data on multicomponent diamond-like semiconductors has been enlarged. The chemical composition of the solid solutions surfaces and binary components of the InSb-ZnS system exposed in air and in high-vacuum, high-temperature conditions have been determined. According to the results of the acid-base properties studies, the surfaces of the InSb-ZnS system components exposed in the air are assigned to the weakly acidic region ( $\text{pH}_{\text{iso}} < 7$ ). The views on the predominant relative contribution of Lewis acid sites and the increased activity of surfaces toward the main gases have been stated and proved. The interrelated consistent patterns of changes in the composition of bulk and surface properties have been established. The practicability of their use for a less labour consuming search for the advanced materials intended for the sensor technology has been shown. The obtained solid solutions, specifically those with the lowest  $\text{pH}_{\text{iso}}$ , are recommended for the manufacture of the sensors for the main gases, particularly  $\text{NH}_3$ , trace contamination.

**Keywords:** advanced materials, solid solutions, bulk and surface properties, consistent patterns of changes in properties, correlations, sensors.

**V. A. Maystrenko, O. A. Bezrodnykh, R. A. Dorokhin**

Methodology for determining actual threats to information security in medical information system

In this article based on the processing of statistical data from various electronic resources the most frequent types of threats to information security (UBI) for medical information systems (MIS) are identified and their classification is carried out. The issues of determining the actual UBI when creating MIS that process personal data using a specific technology of expert assessment are considered. The proposed methodology for determining actual threats to information security for MIS, in comparison with those used, eliminates subjective assessments that are a characteristic feature of traditional expert assessments. Its use also makes it possible to assess the relevance of information security threats for MIS that do not have qualified specialists in the field of information security in the staff of a medical

institution, which is relevant for a large number of medical institutions. The authors investigate the practical possibilities of using the theory of fuzzy sets and fuzzy logic in determining the actual UBI for MIS for various purposes.

**Keywords:** medical information system, types of medical information systems, personal data protection, fuzzy logic, fuzzy assessment.

**T. G. Galieva, D. A. Ivanov, M. F. Sadykov, A. V. Golenishchev-Kutuzov**

Laboratory stand for development of method and system for continuous non-contact non-destructive testing of technical condition of insulation equipment

Measurement of partial discharges (PD) is a generally accepted method of diagnosing the insulation of electrical equipment worldwide. Today, the trend is to move from conventional offline testing to online monitoring to predict the service life of insulation. For testing and calibration of the developed new methods with the contact method, a laboratory stand has been developed in accordance with GOST R 55191-2012 (IEC 60270:2000). The article suggests the use of acoustic and electromagnetic methods for a system of continuous non-contact non-destructive testing of the technical condition of insulation equipment, which will allow monitoring insulation equipment online and predicting its residual life. On their basis, a system of «on-line» diagnostics of high-voltage insulators has been developed.

**Keywords:** partial discharge, diagnostics of insulation equipment, laboratory stand, electromagnetic method, contact method, ultrasonic method.