

# Summaries

UDC 621.039.53

**Shamanin I.V., Gavrilov P.M.**  
**HIGH-TEMPERATURE NUCLEAR ENERGY TECHNOLOGIES**

The author's vision of the perspective of development and inclusion of nuclear energy technologies on the basis of high-temperature gas-cooled nuclear reactors into the current energy scheme has been stated; the brief review of the results of investigations carried out in Tomsk polytechnic university has been introduced.

UDC 621.039.543.6

**Shamanin I.V., Gavrilov P.M., Martynov V.V.,  
Bedenko S.V., Nefedov S.A., Gnetkov F.V.**  
**NEUTRON RADIATION FIELD AND RADIATION  
ENVIRONMENT NEAR THE IRRADIATED CERAMIC  
URANIUM FUELS  $UO_2$ , UC AND UN**

The comparative analysis of neutron field dose characteristics of irradiated ceramic uranium compounds has been carried out. The procedure of calculating the neutron constituent of radiation characteristics of irradiated ceramic nuclear fuel was proposed. The reasons of considerable differences in contributions of ( $\alpha$ ,n)-reaction into neutron radiation intensity of the irradiated  $UO_2$ , UC and UN were determined. The results of simulating parameters of irradiation field near the complete transport container TC-13 was compared with the results of radiometric experiments.

UDC 621.039.516.4

**Golovatskiy A.V., Nesterov V.N., Shamain V.N.**  
**THE INFLUENCE OF NUCLEAR FUEL COMPOSITION  
AND BURN-UP ON THE VIRTUAL VALUE OF DAMAGING  
NEUTRON FUEL DENSITY IN THE REACTOR GT-MGR**

The technique of determining the virtual value of damaging neutron fuel density in the reactor GT-MGR has been stated. Several variants of nuclear fuel starting load at implementation: uranium-plutonium and thorium-uranium nuclear fuels of fuel cycles were considered. The dependences of damaging neutron flux density on fuel block operating time are introduced. The ratio connecting the burn-up average value and fuel block operating time is given. The dependences of multiplying characteristics on the fuel block operating time are obtained. The influence of fissionable nuclide concentrations on the value of damaging neutron fuel density was analyzed.

UDC 621.039.517.5

**Chertkov Yu.B., Ivanov A.A., Naimushin A.G.**  
**TEMPERATURE CONDITIONS OF FUEL ELEMENT  
OPERATION IN THE REACTOR IRT-T**

The results of thermo physical calculations of active zone of the reactor IRT-T have been introduced. It is shown that at the reactor nominal capacitance the fuel element temperature conditions are fallen on the limiting values and correspond to the requirements of security technical evaluation.

UDC 621.039.51:541.126

**Demynyuk D.G., Dolmatov O.Yu.,  
Isachenko D.S., Semenov A.O.**

**CONTROLLING THE PROCESS OF SELF-PROPAGATING HIGH-  
TEMPERATURE SYNTHESIS OF TWO-COMPONENT BORON-  
CONTAINING MATERIALS OF NUCLEAR POWER PLANTS**

The model of controlling the process of self-propagating high-temperature synthesis has been developed on the basis of rated-theoretical studies of the temperature field dynamics at combustion wave propagation. The applicability of this model for synthesizing boron-containing materials of nuclear power plants was proved.

UDC 536.468

**Vysokomornaya O.V., Kuznetsov G.V., Strizhak P.A.**  
**HEAT AND MASS TRANSFER AT LOCAL HEATING AND  
IGNITION OF LIQUID FUEL BY FOCUSED RADIATION FLUX**

The numerical simulation of a complex of related processes of heat and mass transfer with phase transfers and chemical reactions at heating and further ignition of typical liquid fuel by focused radiation flux has been carried out. The scales of influence of energy absorption process by vapor and gas mixture and liquid on the ignition characteristics were determined.

UDC 536.2

**Grigorieva M.M., Kuznetsov G.V.**  
**HEAT AND MASS TRANSFER IN CONDITIONS  
OF CABLE LINE ELECTRICAL OVERLOAD**

The two-dimensional problem of heat conductivity for three-layer cable in the region with limited heat removal has been solved. The fire danger of cable line overload mode in conditions of the limited heat exchange was evaluated.

UDC 519.6

**Kuznetsov G.V., Ivanova E.V.**  
**MATHEMATICAL MODELING OF TEMPERATURE FIELDS  
AT VULCANIZATION OF TYPICAL CABLE PRODUCT**

The mathematical modeling of cable product temperature fields at their vulcanization has been carried out. The results of analyzing the cable temperature fields considering their real configuration, heat exchange with the environment due to radiation and convection as well as polymerization effect were introduced.

UDC 621.384.3;681.3.01

**Torgunakov V.G., Sukhanov M.S., Yamanaev M.S.**  
**APPLYING THE FOURIER TRANSFORMATION FOR IDENTIFY-  
ING LOCAL ANOMALIES IN A ROTATING KILN BODY**

The results of investigations on applying the Fourier transformation for identifying local anomalies in a rotating kiln body have been introduced. It was shown that the method possesses simplicity of mathematical apparatus, efficiency of determining the formed anomalies. The example when in 1,5 hours after covering chip, its location is discovered by the method of Fourier transformation is given.

UDC 662.612.321

**Lebedev B.V.**  
**ASH DEPOSITIONS IN CONVECTIVE SURFACES OF BOILER  
HEATING AT UNGROUND COAL COMBUSTION**

The results of the experimental investigations of brown coal mineral part transformation processes in the boiler and occurrence of pipe ash adjournments at anmilled burning technology have been introduced. Quantitative and qualitative features of forming chemical composition of adjournments on convective heating surfaces are shown.

UDC 662.87:662.65

**Drobchik V.V., Shilyaev A.M., Volokitin G.G.**  
**STUDYING THE CONDITIONS OF IGNITION OF LOW-GRADE  
FUEL DUST AIR MIXTURE**

The conditions of combusting fuel mixture consisting of dusty black coal of Kuzbass basin and grinding wood dust have been studied. It was proved that stable self-ignition of dust air mixture flux is achieved in 5...7 min after plasma module warming. The distance from module nozzle section, where the peak temperature in the mixture 700...900 °C is achieved, was ascertained; fuel particles are burning intensively at this temperature.

UDC 621.17

**Bespalov V.V., Bespalov V.I.**  
**THE TECHNOLOGY OF TPS COMBUSTION PRODUCT DRAINAGE USING MOISTURE CONDENSATION HEAT**

The technology and diagram of the unit for combustion product drainage using condensation warm for heating air and obtaining condensate has been introduced. The heated air is used for warming rooms and delivering to the boiler that allows saving fuel. The efficiency of using the industrial unit was evaluated. The results of calculating the combustion product and air parameters produced by mathematical model of the industrial unit are introduced in the article.

UDC 621.11

**Belyaev L.A., Yurgin B.I., Romashova O.Yu., Shevelev S.A.**  
**THE SELECTION OF RATED PRESSURE IN HEATING SAMPLING AT DESIGNING TPP EXTRACTION TURBINES**

The opportunities of improving the technology of the combined heating at operation of the extraction turbines with two-stage delivery water warming have been analyzed. It was shown that at joint heating in system water heaters of various coolants the optimal heat stage distribution differs from equal one. The formula for determining the rated vapor pressure in lower heating sampling for designing extraction turbines was obtained.

UDC 621.311.22:697.34

**Galashov N.N.**  
**THE MODEL OF AUTOMATED FORECASTING OF TPP OPTIMAL INDICES**

The task of automated forecasting of TPP indices has been considered. The algorithm of the forecasting model of TPP indices at load optimization by the equipment group is introduced. Developing the model the balanced approach is applied. The model is implemented in calculation program of Tomsk GRES-2 predictive indices.

UDC 004.65+621.928.93

**Aslamova V.S., Zhabey A.A.**  
**THE AUTOMATED SYSTEM OF STUDYING CYCLONES AND VOLUMES**

The structure and functionalities of the automated system of studying cyclones and volumes intended for determining density of dust and its grain composition by the method of liquid sedimentation in gravitational field, statistical processing of the results of the experimental research of separate process in straight-flow cyclone at intermediate dust selection, calculation of the efficiency of dust collection and cyclone and volume flow resistance by the known authors' techniques, selection of optimal dust collector for its set operation condition have been introduced.

UDC 621.373.5:534.838.7

**Khmelev V.N., Barsukov R.V., Shalunov A.V., Abramenko D.S., Genne D.V., Abramov A.D.**  
**THE FEATURES OF DESIGNING ELECTRONIC GENERATORS FOR IRRADIATORS INTENDED FOR INFLUENCING GAS MEDIA**

The questions of designing and maintaining electronic generators for ultrasonic intensification of processes in gas media have been considered. On the basis of the analyzing the features of modern piezoelectric oscillating systems with disk irradiators performing high-amplitude bending oscillations (high Q-factor, multi-frequency, multi-packaged piezoelectric elements) the general requirements to electronic generators are stated and new approaches and circuit designs of continuous control of the system parameters and setting the optimal operation conditions of electronic generators are proposed.

UDC 621.375.126

**Avgustinovich V.A., Artemenko S.N., Novikov S.A.**  
**RESONANT MISROWAVE COMPRESSOR WITH ENERGY OUTPUT THROUGH THE WAVEGUIDE BRIDGE FROM CIRCULAR WAVEGUIDE**

The microwave compressor for obtaining nano-second microwave signals with amplification factor  $\sim 22$  dB, power  $\sim 500\text{--}600$  MW and amplitude stability  $\sim 15\%$  has been proposed. The results of the

experimental research of the resonant microwave compressor of 10 cm wavelength range with energy output through the waveguide bridge made on the basis of two N-junctions of circular waveguides are introduced. The signals from peak capacitance  $\sim 270$  MW, duration  $\sim 3$  ns and amplitude stability  $\sim 10\%$  were experimentally obtained.

UDC 533.9

**Ryabchikov A.I., Stepanov I.B.**  
**APPLICATION OF HIGH-FREQUENCY SHORT-PULSE DISPLACEMENT POTENTIAL FOR ION-BEAM AND PLASMA TREATMENT OF CONDUCTING AND DIELECTRIC MATERIALS**

The results of studying the applicability of the method of high-frequency short-pulse plasma-immersion ion implantation and/or plating with gas-arc and ablation plasma to the conducting and insulating substrates have been introduced. It was shown that ion implantation with ion sputtering compensation by plating from plasma and ion-assisting plating may be implemented for metal and dielectric samples changing negative displacement potential in the range 0...4 kV at pulse-repetition frequency  $(2\text{--}4) \cdot 10^5$  pulse/s, pulse duration 0.5...2  $\mu\text{s}$  and pulse duty factor 0,1...0,9. It is experimentally determined that at plating from ablation plasma obtained by effecting by the high-intensive ion beam with the duration 90  $\mu\text{s}$ , with current density  $3 \cdot 10^{-2}$  A/m<sup>2</sup> and ion energy 350 keV to the target, the micro-arc phenomena on the substrate surface are observed at constant displacement potential more than 60 V. The transition to the pulses with duration of 0,5  $\mu\text{s}$  allowed increasing the displacement potential to 4 kV. The opportunity of applying high-frequency, short-pulse displacement potentials for forming coatings from vacuum-arc and ablation plasma with high adhesive strength and advanced operational conditions is discussed.

UDC 533.9.07

**Ryabchikov A.I., Stepanov I.B., Eremin S.E.**  
**STUDYING THE CHARGED STATE OF GASEOUS AND METAL PLASMA USING PLASMA-IMMERSION TIME-OF-FLIGHT SPECTROMETER**

The regularities of changing mass composition and charged state of gaseous and metal plasma ions in the range of pressure 0,1...2,7 Pa have been studied using the plasma-immersion time-of-flight spectrometer. It was shown that application of the plasma-immersion time-of-flight spectrometer with the path length of 35...100 cm allows determining the charged state of vacuum-arc one- (Ti, Zr, W, Ar, Ni) and multi-component (Ti-N, Ti-Zr) plasma at duration of displacement potential pulse of 300...650  $\mu\text{s}$ . The fields of electrophysical equipment practical application were determined.

UDC 621.384.6

**Ryabchikov A.I., Stepanov I.B., Sivin D.O.**  
**THE SOURCE OF PSEUDO-RIBBON BEAMS OF METAL IONS**

The construction of the extended source of conductive material ion has been considered on the basis of continuous vacuum-arc discharge «Raduga-6». The opportunity of forming pseudo-ribbon metal ion beams with the extension to 0,6 m with current to 2 A and energy to 160 keV applying the extended vacuum-arc evaporator with a close movement path of a cathode spot is shown. The results of studying the regularities of changing ion-emission properties of vacuum-arc evaporator for various systems of forming magnetic field are given. The conditions of forming ion beam depending on generation modes of accelerating voltage were examined.

UDC 629.78.01

**Boyazitov S.Yu., Vastryukov V.F., Deev V.E., Katasonov N.M., Mikhailov M.V., Podoplelov I.A.**  
**THE POWER SUPPLY SYSTEM OF CORRECTING PROPULSION DEVICES IN MINOR SPACE VEHICLE**

The features of designing the power supply systems of electro-jet plasma propulsion devices used for correction of the minor space vehicle orbits have been considered. The opportunity of increasing specific capacitance of these systems combining the functions of several power transformers operating in parallel, in one, is shown. The flow chart of the device constructed on the basis of the combined transformer, its principle parameters are introduced, the appearance is shown.

UDC 62-533.7

**Shifanov D.D., Pavlov V.M.  
IMPLEMENTATION OF CONTROL CIRCUIT OF TOROIDAL  
FIELD COIL CURRENT OF TOKAMAK KTM**

Implementation of control circuit of toroidal field coil current of Tokamak KTM has been described. The automatic control system of coil current was developed, the transfer functions of links included into its composition were calculated, the obtained system was implemented in the Simulink medium of Matlab package and the parameters of regulator adjustment were designed. The experiment with the developed model was carried out.

UDC 621.314

**Shkorkin V.V., Kazantsev Yu.M.  
DECREASING EMISSION OF DISTURBANCE OF TOROIDAL  
CONSTRUCTION POWER THROTTLES**

In order to calculate the extraneous field of toroidal construction power throttles used in pulse sources of secondary power supply the model in the form of the equivalent coil with current has been proposed. It was shown that in order to decrease the throttle emission of disturbance it is appropriate to divide it into two ones of less size. At their opposite connection and arrangement at supporting base so that terminal seats are in parallel planes, the total value of magnetic field intensity decreases more than 20 dB.

UDC 541.64:547.759.32

**Krivososenko A.V., Krivososenko D.A.  
THE CONVERTER OF CONSTANT VOLTAGE TO ALTERNATING ONE WITH SYMMETRICAL CONDITIONS OF MAGNIFICATION OF THE OUTPUT TRANSFORMER MAGNETIC CORE**

The converter of constant voltage to alternating one, single-step and two-step by the output with symmetrical conditions of magnification of the output transformer magnetic core has been described. The converter capacity is 500 W, the output voltage is 5 kV, the conversion frequency is controlled in the range from 3 to 30 kHz, supply net is 230 V, 50 Hz, volume is 3 dm<sup>3</sup>.

UDC 621.314.5

**Tatur V.V.  
VOLTAGE REGULATOR FOR SUPPLYING LASERS  
AT METALLIC VAPORS**

Voltage regulator at storage capacitor is intended for transforming constant unregulated voltage into pulse, amplitude fixed one in laser electric supply circuits. The device principle of operation is based on opportunity of storage capacitor preliminary charge to the voltage allowing compensating the input voltage alternating component.

UDC 535.37:621.373.8

**Khasenov M.U.  
EMISSION OF MIXTURES He-Ne-H<sub>2</sub> (Ar, Kr)  
AT WEAK PUMPING BY HARD IONIZING AGENT**

The influence of extinguishing admixtures on luminescent properties of helium and neon mixtures at pumping with  $\alpha$ -particles <sup>210</sup>Po has been studied. The conclusion was drawn that population of 3p[1/2]<sub>o</sub>-level with NeI at excitation by a hard charges particle does not occur at dissociative recombination of molecular ions. The excitation transfer to the neon atoms from metastable helium atoms He (2<sup>3</sup>S<sub>1</sub>) and direct neon excitation by nuclear particles and secondary electrons are supposed to be the most probable channels of Ne(3p) population.

UDC 621.031.585

**Pikulev A.A.  
ANALYTICAL STUDY OF THE CIRCUIT OF TWO LASER  
CHANNELS PARALLEL COMPOSITION. THE EFFECTS  
OF LONGITUDINAL MODES SELECTION**

The results of the rated-analytical study of the circuit of two laser channels parallel composition at approximation of an average «effective reflection ratio» have been introduced. The effect of longitudinal

modes selection was studied by the example of a single laser channel with a cross-sectional radiation coupling. Generation capacity at approximation of equal distribution of radiation longitudinal modes spectral composition was calculated by a wave number and the analysis was compared with the experimental results.

UDC 621.031.585

**Pikulev A.A., Tsvetkov V.M., Sosnin P.V.  
THE ENHANCEMENT OF NPL EMISSION DIVERGENCE  
IN A FAR-FIELD BY INTRACAVITY ANGULAR FILTER**

The results of the experimental and analytical studying of improving the nuclear-pumped laser radiation parameters by the intracavity angular filter have been introduced. For diaphragm diameter 2 mm the emission divergence decreased in three times in horizontal and twice in vertical position. The peak value of emission radiance 9 kJ/avg was obtained for diaphragm diameter 5 mm that is 20 % higher than the radiance without diaphragm.

UDC 535-3;53.083

**Tsvetkov V.M., Pikulev A.A.  
THE EFFECT OF DYNAMIC PRESSURE JUMP  
IN KrCl- EXCILAMP OF BARRIER DISCHARGE**

The results of investigations of thermodynamic processes in barrier discharge lamps measuring the pressure jump have been introduced. The researches were carried out at KrCl- excilamp (222 nm) of the barrier discharge in the pressure range 4...50 kPa and the ratio of the mixture components Kr:Cl<sub>2</sub> from 50:1 to 400:1. The experiments show that at tuning on (turning off) the lamp the dependence of the pressure jump on time consists in rapid (typical time 30...160 ms) and slow (100 s) parts. The rapid part is connected with acoustic wave generation (10...30 ms) and the direct gas heating (30...160 ms) at discharge. The slow part of the pressure jump is conditioned by heating the excilamp bulb.

UDC 621.373.1

**Rybin Yu.K.  
THE CONDITIONS OF REPRODUCING THE PRESCRIBED  
SHAPE PERIODIC OSCILLATIONS IN GENERATORS**

It has been theoretically substantiated that the balance of amplitudes and phases should be performed on frequencies of all harmonics of output oscillations for forming the prescribed shape periodic oscillations in generator oscillation system consisting of linear frequency dependent circuit and active nonlinear element.

UDC 621.311.018

**Nosov G.V.  
FREQUENCY METHOD APPLICATION  
FOR CALCULATING TRANSIENTS IN HOMOGENEOUS  
CIRCUIT WITH DISTRIBUTED PARAMETERS**

Frequency method application for calculating transients in homogeneous circuit with distributed parameters has been considered by the example of one phase of transmission line at connecting and disconnecting of source and load. The source and load containing the sine wave electric moving force and passive elements with constant parameters are connected to the transmission line. The reduction of the design diagram to the zero initial condition is used. The determined voltages and currents depend on two variables: distance measured from the beginning of the line and time. The method takes into account multiple line passing by voltage and current waves and these waves reflection from load and source.

UDC 621.311

**Vainshtein R.A., Lozinskiy K.S., Kolomiets N.V.  
THE DESIGN OF ASYMMETRICAL MODES IN ELECTRIC SYSTEM  
ON THE BASIS OF COORDINATE SYSTEM COMBINATION**

The technique of designing the electric system modes at multiple asymmetry subject to electromechanical transients has been proposed and demonstrated. The design is based on the fact that only that part

of electric network where short circuits and phase loss occur is introduced in the form of three-phase equivalent circuit. The rest part is introduced in the system of symmetrical components of direct, inverse and zero sequences. The interaction between the parts of the diagram given in symmetrical components and three-phase coordinates is carried out at step-by-step calculation by the proper direct and inverse coordinate transformations.

UDC 621.311.016.361

**Gotman V.I., Glazachev A.V.**  
**MAKING EQUIVALENT POWER SYSTEMS  
 FOR ESTIMATING STATIC STABILITY**

The calculation of transmission capacity of power system backbone relation by the conditions of static aperiodic stability has been considered. The power system is proposed to be introduced in the form of three-node circuit for solving the problem. The technique of making equivalent power system on the basis of its operating conditions is given.

UDC 681.51:681.3

**Khizhnyakov Yu.N., Yuzhakov A.A.**  
**RELAY-LOGICAL METHOD OF CONTROLLING  
 BRUSHLESS SYNCHRONOUS GENERATORS**

The relay-logical method of controlling parallel operation of brushless synchronous generators in parallel operation conditions with the network in polar coordinate system has been considered. The variants of structural diagrams and scheduling algorithms were developed. The technique advantage is application of «strong» adjustment which supports equal distribution of the reactive and active power among the brushless synchronous generators with quazi-static external characteristics.

UDC 621.06:62-83

**Egorov V.F., Egorov S.V.**  
**CONTROLLING THE DISTRIBUTION OF LOADINGS  
 OF ELECTRICALLY OPERATED CYCLIC MECHANISMS**

The methods of controlling the distributions of cyclic mechanisms engineering loadings at their transmission to the engine shaft at low working mass inertia have been determined. It was shown that a certain quantitative ratio between their root-mean-square value and the average one corresponds to each form of loading distribution. This index does not depend on physical properties of the studied function, supports estimates uniformity and may be applied as a control parameter at forming loadings.

UDC 621.06:62-83

**Egorov V.F.**  
**TRANSIENTS OF ELECTRICALLY OPERATED MECHANISMS  
 IN TWO-PERIOD MODE OF OPERATION**

The transients optimal modes of without constraining to the motor overload capacity have been determined. It is shown that the main factors influencing the choice of motor torque maximum value in transients are the duty factor, the character of changing the dynamic torques, the form of high-speed graph.

UDC 621.3.07

**Langraph S.V., Sapozhnikov A.I., Glazyrin A.S., Kozlova L.E.,  
 Glazyrina T.A., Timoshkin V.V., Afanasiev K.S.**  
**THE DYNAMICS OF DRIVE WITH FUZZY CONTROLLER**

The comparative analysis of the dynamics of a drive with classical and fuzzy controller has been carried out; the advantages of applying fuzzy logic in automatic drive control have been shown.

UDC 621.318.38

**Glazyrin A.S., Timoshkin V.V., Tsurpal S.V., Glazyrina T.A.**  
**IDENTIFICATION OF THE MECHANICAL SYSTEM  
 PARAMETERS BY THE EXAMPLE OF VIBRATION  
 ELECTROMECHANICAL ENERGY CONVERTER**

The methods of identifying the mechanical system parameters on the basis of frequency responses of shift, rate, acceleration have been stated. The estimator of the mechanical system parameters applying the mathematical model and the experimental frequency responses of working element acceleration is introduced by the example of vibration electromechanical energy converter.

UDC 621.313.33

**Gusev V.V.**  
**THE INDICES OF ELECTRICAL MACHINE RELIABILITY  
 AT MAINTENANCE OF DIAMOND-MINING COMPLEX**

Quantitative characteristics of reliability characterizing the safety of electric machines of mining dust-ignition-proof construction at the stage of maintenance in the diamond-mining complex have been determined. The relation of reliability criteria towards the electric machine sizes was determined. The given data on maintainability allow estimating the influence of operation conditions on them and may be used in comparative technical and economic assessments as well as when designing and producing electrical machines.

UDC 621.313.333

**Tyuteva P.V., Muravleva O.O.**  
**EVALUATING THE COST OF INDUCTION MOTOR  
 MODERNIZATION AT CHANGE  
 OF CROSS-SECTION GEOMETRY**

The way of induction motor modernization at change of machine geometry allowing designing energy efficient induction motor with the highest performance factor IE3 according to the CEMEP specification has been proposed. The increase of the induction motor cost is compensated by the decrease of costs for service life as well as increasing working time and reliability.

UDC 001.6

**Boiko V.I., Koshelev F.P., Dyadik V.F., Selivanikova O.V.**  
**CONTRIBUTIONS OF TOMSK PHYSICAL ENGINEERS INTO  
 DEVELOPMENT OF RUSSIAN NUCLEAR INDUSTRY**

The article is devoted to the 60<sup>th</sup> anniversary of physico-technical department of the Tomsk polytechnic university. The questions of formation and development of physico-technical education in Siberia are considered in the article.