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**OPTIMIZATION OF THE STRUCTURE OF WIND POWER STATION WITH THE USE OF THE BRANCH AND BOUND METHOD (p. 4-9)****Taras Teslyuk**

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The model of an optimization problem, which allows us to determine the optimal structure of a wind power system, was stated. The constructed optimization problem includes the objective function, describing the dependence of efficiency of a wind power system on its structure, and constraints that imply integer design parameters and demand for providing the assigned capacity of the WPS. In the process of solving the stated problem of integer programming, we determined the rule of division of a set of solutions into subsets and the computational criterion of assessment of the upper bound of each subsets, which made it possible to apply the branch and bound method, which allows us to find the optimal solution at minimum computational costs. The software system for solving problems of integer programming with the use of the branch and bound method was designed and implemented. The structure of a software system, based on a modular principle, which provides quick modification and improvement of the application in the process of its development, was built.

In the process of implementing a software system, the software was developed, based on the doubly connected list data structures and allowing us to process efficiently large arrays of information. For effective organization of data exchange with existing software systems, the XML format was used. The results of application of the developed software system with the use of the branch and bound method to determine the optimal structure for a wind power system were presented.

**Keywords:** wind power station, problem of integer programming, branch and bound method.

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#### ANALYSIS OF DYNAMIC CHARACTERISTICS OF THE ACTIVE FILTER-STABILIZER (p. 10-15)

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At the railway sections with intensive and high-speed train traffic, it is advisable to use active stabilizer-filters to increase efficiency of DC traction power supply systems. They are introduced into converter units of traction substations to ensure active filtration and stabilization of the output voltage. The active filter stabilizer consists of a voltage converter based on a capacitive energy storage unit and is connected in series with the main rectifying unit of the traction substation. The voltage converter with a two-way pulse-width modulation simultaneously forms a voltage for compensating harmonics and deviations of the mean value of the rectified voltage with respect to the specified voltage.

It was established that the voltage converter of the active filter-stabilizer with two-way pulse width modulation for small values of the control signal increment is an amplitude-pulse second-order modulator. In this converter, information is transferred by two channels having static and dynamic transfer coefficients. Dynamic connection between the increments of the input and output signals of the active filter-stabilizer converter is of a variable character at each interval of discreteness of the pulse-width modulation. This property of the voltage converter is called forth by the changes in the static and dynamic transfer coefficients which must be taken into account when describing dynamic processes in closed-loop automatic control systems.

**Keywords:** active filter-stabilizer, converter unit, traction substation, pulse-width modulation, pulse model.

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#### RESEARCH ON GASIFICATION OF LOW-GRADE FUELS IN A CONTINUOUS LAYER (p. 16-23)

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The technology of thermal processing of low-grade fuel into gaseous fuel is an essential problem whose solution will create clean energy as an alternative to natural gas and coal gasification. It also can solve the problems of the

ecological utilization of industrial and household waste as well as of obtaining cheap energy and improving industrial effects for the environment.

The analysis of the theoretical provisions and experimental tests has proved the possibility of processing wood during its gasification in a gas generator with a continuous layer; it is processed into gaseous fuel with the lower calorific value being 1.5 times higher in comparison with the calorific value of the gaseous fuel that is produced by other known gas generators of this type.

The experimental results have specified the regression dependence of heat that is produced by burning the synthesis gas during the gasification of low-grade fuel on the fractional composition of the fuel, the amount of air, and the fuel layer height. The resulting regression equations can be the basis for implementing the studied process and its rational management. The equations of the input factors' dependence on the original setting make it possible to determine every possible parameter of assessing the process under study at any value of the factors between the upper and lower levels. The tests have revealed the rational values of the input parameters for operating a gas generator with a continuous layer at which the lower heating value of burning the syngas reaches its maximum.

**Keywords:** LHV (LCV or NCV), synthesis gas (syngas), gasification of low-grade fuels, regression dependence.

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## DEVELOPMENT OF XENON COLLISIONAL RADIATIVE MODEL FOR PLASMA DIAGNOSTICS OF HALL EFFECT THRUSTERS (p. 24-29)

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Hall Effect thrusters (HET) have demonstrated its applicability on satellites for the Low earth orbit (LEO), Geo-stationary earth orbit (GEO) and long duration missions. High thrust density and long lifetimes are attractive parameters of the HET. In order to improve the thruster performance and lifetimes, decades of efforts are made to understand the plasma physics.

Several intrusive and non-intrusive diagnostics techniques are employed for HET investigation. Simple and precise diagnostics technique is attractive to delineate the characteristics of the thruster. Optical emission spectroscopy provides several advantages over the other methods which are used for the HET diagnostics. Using this diagnostics tool in correlation with the collisional radiative model, the information of electron kinetics is extracted instantaneously.

Collisional radiative model is developed by using the xenon near-infrared emission lines. This kinetic model can be used to determine the local electron temperature with error less than 15 % for investigating the HET physics.

**Keywords:** collisional radiative model, Hall effect thruster, optical emission spectroscopy, plasma, electron temperature.

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### EXAMINING A DEVICE FOR AIR DISTRIBUTION BY THE INTERACTION OF COUNTER NON-COAXIAL JETS UNDER ALTERNATING MODE (p. 30-38)

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The research deals with the solution of the relevant problem of increasing efficiency of air distribution by the interaction of counter non-coaxial jets for providing the standard parameters of the air in industrial premises. The mathematical model of air supply by the interaction of counter non-coaxial jets in these premises was improved. It was shown that to achieve maximum efficiency of air distribution, it is necessary to supply the air by jets that attenuate rapidly even before entering the working area. We developed and explored the structure of the air distributor with the interaction of the counter non-coaxial jets, which provides intensive attenuation of velocity and excess temperature of the resulting airflow. The specific feature of this structure is the possibility to supply two non-coaxial inflowing jets.

In this way, intensive mixing of inflowing jets with the surrounding air is provided and alternating mode is maintained. The graphic dependences were plotted and the theoretical dependences based on the conducted experimental studies were derived, which may be used in further engineering calculations. The authors developed

and protected by the patent of Ukraine [12] the design of air distributor for the air supply by the interaction of the counter non-coaxial jets, as well as for supplying inflowing jets in the alternating mode. The cost-effectiveness of using the air distributor with the interaction of counter non-coaxial jets was shown, compared with alternative options, and specific indicators of the air distribution efficiency were given.

**Keywords:** air distribution, counter non-coaxial flat jets, velocity, excess temperature, alternating mode.

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## IMPROVEMENT OF ENERGY EFFICIENCY IN THE OPERATION OF A THERMAL REACTOR WITH SUBMERGED COMBUSTION APPARATUS THROUGH THE CYCLIC INPUT OF ENERGY (p. 39-44)

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We examined the formation of oscillations of contacting phases (gas-fluid) in the thermal reactors, equipped with submerged combustion apparatuses, with the help of the cyclic input of energy for the intensification of heat-mass-exchange processes and improvement in the energy efficiency of their operation. It is established that the cyclic input of external energy increases the mass transfer by 2–2.5 times, as well as energy effectiveness of the process as a whole. A distinctive feature of the thermal reactor with the cyclic input of energy is in the fact that the air, preheated in the thermal installation with SCA that works on the principle of a “vapor pump”, enters the upper and lower collectors of SAD. In this case, the air is dispersed depending on the angle of blade rotation, which contributes to the turbulization of phase boundary, which improves energy efficiency of the reactor operation.

Based on the conducted studies, we designed a thermal reactor with the built-in submerged combustion apparatuses and the cyclic input of external energy for creating the turbulent pulsations that works on the principle of a “vapor pump”. The performance characteristics of the device with the cyclic input of external energy were determined based on the obtained results. The developed thermal reactor makes it possible to control the process of heating and can be easily modified, depending on the technological requirements. The energy-technological indicators of the designed thermal reactor meet the world requirements: the content of nitrogen oxides does not exceed 56.8 mg/m<sup>3</sup> at high-temperature water heating – to 70–80 °C. The thermodynamic efficiency of the thermal reactor operation reaches 98.6 % (by direct balance).

**Keywords:** submerged combustion apparatus, cyclic input of energy, screw agitating device, energy efficiency.

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## DEVELOPMENT OF EFFICIENT SOLAR CELLS WITH THE USE OF MULTIFUNCTIONAL MULTITEXTURES (p. 45-51)

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Here we demonstrate the prospects of creating a solar cells using the hybrid technologies of obtaining multifunctional multitextures of porous silicon (PS) to the frontal surface. We conducted analysis of the existing models of PS and selected the models, most suitable for the creation of microtexture. We theoretically examined the relationship between the diameter of pore  $dP$ , porosity  $P$  and the region of specific surface  $S$ . On the samples with high specific resistance, we explored the interaction between porosity  $P(t)$  and the region of specific surface  $S(t)$  of the PS grown by the electrochemical etching of silicon substrates. Depending on the technological parameters, it is possible to form the layers of macro-, micro- or nanopores. Multifunctional multitextures were fabricated on the frontal surface of photoelectric converters (SC). VAC were measured by the spectral conditions AM 1,5G, experiments for both samples of SC were carried out on the silicon substrates with the same parameters and area. SC parameters were confirmed by the volt-ampere characteristics of SC and resulting measurements of efficiency in the obtained SC and spectral characteristics.

Spectral characteristic for the multitexture in the range of 400–1150 nm has a significant feature; it practically has no high values in the infrared range. This significantly reduces the integral coefficient of reflectivity for the frontal surface multitexture of SC ~7 %, different from other integral coefficients of reflectivity. For the chemical texture ~17.5 %, random pyramids ~11.2 %, for the polished surface of Si – larger than 35 %.

**Keywords:** solar cell, porous silicon, photoelectric converter, conversion efficiency, multifunctional microtexture.

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**DEVELOPMENT OF A MODEL FOR PREDICTING THE RELIABILITY INDICATORS IN THE DESIGN OF CASCADE THERMOELECTRIC COOLERS (p. 52-60)**

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Here we report a development of the reliability-oriented model, which makes it possible to evaluate the efficiency of functioning and to predict indicators of reliability of a two-cascade thermoelectric cooler.

The model is proposed for the interrelation between indicators of reliability of two-cascade thermoelectric coolers at sequential electrical connection of cascades and basic parameters under the mode of maximum refrigeration coefficient. The relations obtained allow us to estimate both the basic parameters and the indicators of reliability, in particular: the failure rate and the probability of failure-free operation of the chosen variant of design of a two-cascade thermoelectric cooler at the specified ratio of the number of thermoelements in the cascades and the assigned temperature differential.

It is demonstrated that by manipulating the operating current and the ratio of the number of thermoelements in the cascades of a cooler in the range of functioning temperatures, it is possible to determine the conditions, which correspond to the maximum of refrigeration coefficient. We obtained an analytical dependence of the relation between relative failure rate and the number of thermoelements in the cascades, thermal load, operating currents and the values of temperatures.

We examined the model for a fixed geometry of thermoelements, working range of temperature differential at the variation in the relation of the number of thermoelements in the cascades of a thermoelectric cooler. An analysis of the calculated data revealed that there is an optimum relation of the number of elements in the cascades, which corresponds to the maximum of refrigeration coefficient at the assigned temperature differential. In the point of the maximum of refrigeration coefficient there is the equality between values of relative drop in temperature and the refrigeration coefficients in cascades.

The given data make it possible to estimate the efficiency of functioning and to predict reliability indicators of a two-cascade TED of the chosen design under the mode Emax under different operating conditions.

**Keywords:** thermoelectric coolers, reliability indicators, temperature differential, energy efficiency.

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## IMPROVEMENT OF THE ENERGY PROCESSES ANALYSIS METHOD OF ELECTROMECHANICAL SYSTEMS WITH SEMICONDUCTOR CONVERTERS (p. 61-68)

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The paper presents the improvement of the method for the analysis of energy processes in electric circuits with semiconductor converters by means of a commutation function. The improvement has been achieved due to the realization of the frequency domain with the use of the discrete convolution algorithm. The proposed method has been verified taking an electric circuit with a sinusoidal-power controlled key voltage regulator with active-inductive load as an example. The correction of the analytical expressions of the commutation function, voltage, current and power, determined in the frequency domain, has been verified by comparison of the curves plotted on the basis of the obtained analytical expressions and the curves plotted by means of the inverse Fourier transform of the results of electric signals operations in the



frequency domain. It has been demonstrated that this method makes it possible to simplify the analytical calculation and achieve its automation and obtain the predicted result.

**Keywords:** energy process, semiconductor converter, commutation function, analytical analysis, frequency domain, Fourier transform.

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