

«ХПІ». Серія: Енергетичні та теплотехнічні процеси й устаткування. – Х.: НТУ «ХПІ», 2014. – № 11(1054). – С. 176–180. – Бібліогр.: 4 назв. – ISSN 2078-774X.

В статті представлений комплекс заходів по транспортуванні, вивантаженню та зберіганню рідких, в'язких продуктів на прикладі нафтяного бітума. Виробництво бітума в нафтехімічній галузі промисловості відбувається при порівняно високих температурах (~140–150 °С). При вказаних температурах цей матеріал знаходиться в рідкому стані і має в'язкість порівнянну з в'язкістю води. В зв'язку з цим, транспортування бітума від місця виробництва до місця споживання здійснюється в залізничних цистернах (звичайні цистерни, цистерни-термоси, цистерни з паровою рубашкою). Цей матеріал різко збільшує в'язкість при зниженні температури і частіше його вивантаження з цистерни без додаткового розігріву стає складним завданням. Найбільш складним питанням є визначення параметрів бітума, який охолоджується при транспортуванні. Для цього потрібно правильно визначити коефіцієнт теплопередачі від гарячого бітума через стінку цистерни в оточуюче середовище, також необхідно знати коефіцієнти теплопередачі від бітума до стінки і від стінки до оточуючого середовища при русі цистерни. Були розглянуті дві можливі фізичні моделі теплообміну бітума з оточуючим середовищем. В подальшому необхідно провести натурні спостереження охолодження бітума при русі цистерн на комплексі вивантаження та зберігання бітума, а також лабораторні дослідження.

**Ключові слова:** теплообмін, коефіцієнт теплопередачі, конвекція, коефіцієнт теплопередачі, температура.

## ABSTRACTS

**Condensation-&Heat Extraction Steam Turbine Plant KT-100-6, 7 Designed for the Construction of a Full-Scale Pilot Power-Generation Unit KT-100-6 with the Reactor Plant LBFR-100** [Text] / V. L. Shvetsov, I. I. Kozheshkurt, S. A. Palkov, I. A. Palkov // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 5–15. – Bibliogr.: 6. – ISSN 2078-774X.

This scientific paper presents a new steam turbine unit KT-100-6,7 intended for the construction of a full-scale pilot power plant with the reactor plant LBFR-100 (lead-bismuth fast reactor), which is a prototype of serial nuclear systems used for regional and local power networks and one of the first of the world commercial reactors of a low power of the fourth generation. The consideration was given to the structural peculiarities of the turbine, its main parameters, technical characteristics, schematic thermal diagram, and also the main issues related to the heat supply from takeoffs with uncontrolled pressure. It has been shown that the steam-turbine plant can work both in condensation and heat-extraction operation conditions. The conclusion is made about the appropriateness of design and circuitry-related solutions with regard to the turbine plant KT-100-6,7, and a high degree of the unification of its elements developed and used for the production and operation by power stations.

**Key words:** Turbine, reactor plant, thermal diagram, nuclear system, capacitor, and rotor.

**Developing the Flow Pass for the Intermediate-Pressure Cylinder of the Steam Turbine T-125/150-12,8 Using New Computer-Based Technologies** [Text] / A. V. Rusanov, A. L. Shubenko, A. Yu. Kultyshev, V. N. Bilan, M. Yu. Stepanov, A. V. Senetsky, N. V. Paschenko // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 16–29. – Bibliogr.: 10. – ISSN 2078-774X.

The results of the computation of three-dimensional flows for two modifications of intermediate-pressure cylinders (IPC) used for heat-extraction turbines T-100, in particular T-120/130-12,8 is the turbine, which is already in use and T-125/150-12,8 is a new turbine. The numerical research was done using the bundled software IPMFlow. Initial gas-dynamic data required for the numeric investigation were taken from the data of thermal computations done by the Urals Turbine Works. A preliminary design of the new turbine was done using the methods that were developed by the specialists of the Urals Turbine Works. The flow pass of the intermediate – pressure cylinder for the T-120/130-12,8 turbine was designed using a new method of parameterization and analytical profiling of the blades. It has been shown that an essential increase in the efficiency factor was achieved for the developed intermediate-pressure cylinder of the steam turbine using up-to-date profiles and seals and reshaping meridian contours. The efficiency factor was increased by 2,9 % in the case, when humidity losses were not taken into consideration, and by 2,2 % when humidity losses were taken into consideration and it made up 92,3 % and 90,1 %, accordingly.

**Key words:** steam turbine, intermediate-pressure cylinder (IPC), flow pass, three-dimensional flow, design studies.

**Influence Produced by the Conservation Technique of the Flow Capacity of the Guiding Cascade on Spatial Optimization Data** [Text] / A. V. Boiko, Yu. N. Govorushchenko, V. S. Barannik // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 30–34. – Bibliogr.: 5. – ISSN 2078-774X.

A spatial optimization of the standard profile of the turbine cascade was performed taking into consideration constraints provided for the flow rate of actuating medium and the profile strength. The optimization was carried out in two stages, in particular (i) search for an optimal option with the objective function of minimum integral losses (ii) change of the angle of setting for the optimal option obtained at the first stage to preserve flow rate of the actuating medium. The following geometric parameters were varied: profile setting angle, geometrical angle of flow output, the taper angle of entrance edge and the taper angle of the exit edge. An opportunity of an increase in the aerodynamic efficiency of the considered turbine profile has been demonstrated. In addition, for more detailed analysis of the results the diagrams for the distribution of losses along the turbine blade height have been given. The consideration has always been given to the method of the construction of turbine profiles using the Bezier curve.

**Key words:** spatial optimization, turbine blade, functional constraints, initial shape of the blade, optimal shape of the blade, integral losses, Bezier curve.

**On Aerodynamic Efficiency of the Cascade of Nozzle Blades of Powerful Steam Turbines** [Text] / A. V. Lapuzin, V. P. Subotovich, Yu. A. Yudin, A. Yu. Yudin, V. L. Shvetsov, I. I. Kozeshkurt, V. A. Konev // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 35–42. – Bibliogr.: 9. – ISSN 2078-774X.

One of the main reasons for high end losses in the cascades of nozzle blades without extensions are a low height of the blades and high axial forces that act on the diaphragms of high pressure sections of powerful steam turbines. High axial forces result in the need for an increase in the axial width of cascades. The data of our experimental investigations and other experimental investigations of the cascades of nozzle blades were summarized and analyzed, and these showed positive influence on the aerodynamic cleanness of the cascades of extensions for standard profiles. It has been proved experimentally that the optimal design of the swivel blocks of blade channels for the cascade with relatively short blades done using the inverse aerodynamic problem allowed for a considerable decrease in total losses due to the certain share of end losses. The field of the application of the standard cascades of H4 and H4Y type and the cascades with a wavy profile shape has been established. For the full-strength nozzle cascades a quantitative assessment of the influence of the shape of extensions on integral losses has been given. The consideration has been given to the influence produced by the inlet extension of the standard profile H4 on the profile losses and end losses.

**Key words:** nozzle profile cascade, extension, end and profile losses, blade strains, and inverse aerodynamic problem.

**The Influence Produced on the Nonstationary Loadings and Vibrations of the Blades by the Partial Input into the Three-Stage Compartment of Axial Compressor** [Text] / V. I. Gnesin, L. V. Kolodyazhnaya, R. Rzadkowski, O. O. Kolisnyk // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 43–52. – Bibliogr.: 9. – ISSN 2078-774X.

To simulate aeroelastic behavior of the blade rings of the three-stage compartment of axial compressor we used the partially integral method to solve the coherent problem of the nonstationary aerodynamics and elastic vibrations of the blades. The three-dimensional nonstationary ideal gas flow is described by the Euler equation. A model approach was used for the dynamic analysis. The data of the numeric analysis of nonstationary aerodynamic loadings and aeroelastic oscillations of the blades in the three-stage compartment of the axial compressor which were exposed to the three dimensional flow of ideal gas at complete and partial input were given using the proposed method for the solution of the coherent problem of nonstationary aerodynamics and elastic vibrations of the blades. It has been shown that the average strain values of the blades at complete and partial input are actually the same, the partial input results in an increase of the vibration amplitude of the blades by a factor of 3 to 4 in comparison with the complete input.

**Key words:** axial compressor, partial input, coherent problem, blade, nonstationary aerodynamic loadings, aeroelastic vibrations of the blades.

**Double Jet Film Cooling of the Flat Surface: the Influence of External Turbulence** [Text] / A. A. Khalatov, N. A. Panchenko, I. I. Borisov, Yu. J. Dashevskyy // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 53–60. – Bibliogr.: 8. – ISSN 2078-774X.

Improvement of the thermal efficiency of contemporary gas turbines can be reached through an increase in the cooling efficiency of applied cooling technologies. Traditional systems with angular parallel holes are characterized by the origination of secondary vortex structures that damage the cooling film. These phenomena are known to be mitigated by the use of the new configurations of film cooling with holes of complicated (shaped) profile. However, the manufacture of such holes faces specific process-related difficulties. The improvement of film cooling systems is required to reduce the influence of secondary structures, to maximally arrange the cooler in the transverse direction, and to decrease its mixing with the main flow. Such decisions were used for the double-jet system of angular parallel holes with composite double-jet supply angles of the cooler, in which complex interaction of cooling jets occurs. This scientific paper presents the results of experimental research of the advanced diagram for the double-jet film cooling of the flat surface. At low ( $m = 0,50$ ) and moderate ( $m = 1,0$ ) values of a blowing parameter the efficiency of the film cooling of the plate is by 20 % higher in comparison with the standard two-row system of parallel holes and corresponds to it at  $m = 1,50$ . The external turbulence of the flow ( $\approx 7\%$ ) actually produces no influence on the efficiency of the film cooling of the plate, using the double-jet system of holes.

**Key words:** double-jet film cooling, cooling efficiency and external turbulence.

**Physical Peculiarities of the Intensification of Heat Exchange for Media with High Prandtl Numbers in the Transition Region** [Text] / M. A. Gotovsky, Yu. G. Sukhorukov, N. V. Georgievsky // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 61–71. – Bibliogr.: 19. – ISSN 2078-774X.

The heat exchangers with highly viscous media realize the motion with Re numbers that correspond to laminar and transition regions for the smooth channel. The use of artificial roughness (AR) allows us to achieve the degree of intensification, which depends on the Pr number, the higher this number the higher the intensification degree. To explain these results it is important to establish the difference between the progress of turbulence in intensified and smooth channels. New data obtained by Hao, Evold and Olsen allowed us to establish how quickly the distribution of the pulsations of transverse velocity and tangential stresses approaches the steady state as the Re number increases, after the transition to the turbulence. The turbulence origination zone in the smooth channel is situated in the range of  $30 < y^+ < 40$ . The comparison of AR scales that specify a decrease in  $Re_{kr}$  and the position of this zone in the smooth tube allowed us to make a conclusion that the vortex formation zone for the AR is situated closer to the wall as compared to the case of the turbulence generation according to the ordinary scenario. Thus, we can assume that the influence of vortexes generated on AR elements will produce a stronger influence on the heat emission of liquids with high Pr numbers, because for them the main thermal resistance is concentrated in a relatively thin layer. The described scheme allows for the explanation of experimental data provided by many authors and to provide a reliable prediction of the efficiency of heat exchange intensification as a function of Pr number.

**Key words:** artificial roughness, heat exchange intensification, Prandtl number, and turbulence.

**Taking into Account the Temperature Factor for the Computation of Gas Turbine Cooling** [Text] / A. I. Tarasov, A. I. Dolgov // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 72–81. – Bibliogr.: 8. – ISSN 2078-774X.

The analysis of the cooling system of gas turbines is based, as a rule, on the equations for heat emission coefficients that usually neglect the changeability of air properties. However, some experiments showed that heat emission coefficients in round section channels depend on the temperature factor, i.e. the relation of the channel wall temperature to the average air temperature in each of the channel sections. The use of these relations for flat channels required the computation of the cooling system for the guide blade of the gas turbine. As a result it was established that the introduction of the temperature factor for the computation of heat exchange in flat cooling channels results in an increased temperature of the blade surface by several tens of degrees ( $(30-60)^\circ\text{C}$  for this particular case). To prove the necessity of the use of the temperature factor for the computation of heat exchange in the cooling channels of other types we performed *CFD*-analysis. The heat exchange in the smooth round channel and in the round channel with cross ribs of low height, and also in the channel with square cross section and with the  $180^\circ$  turn of air flow has been analyzed. The cases were established, in which the temperature factor should be used for the computation of heat exchange in the cooling channels.

**Key words:** temperature factor, gas turbine, cooling system, and heat emission coefficient.

**CFD Simulation of the Film Deposition of the Plate with Input Cylindrical Section** [Text] / V. Yu. Petelchyts // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 82–89. – Bibliogr.: 7. – ISSN 2078-774X.

The results of the numeric simulation of the film deposition of the plate with the multirow system of plain bores for the input cylindrical section have been given and the results of computed and experimental data have been compared. The simulation was done using the programming system *ANSYS CFX*. In addition to the *RANS*-simulation of the flow using different turbulence models the *DES*-simulation based on the direct modeling of the vortex structure of the flow was performed. The use of the *DES*-model recommended by many researchers provided the computational results very close to those obtained for the *SST* model. This paper gives also consideration to the use of the Reynolds Stress model of the *BSL* turbulence, which takes into account the anisotropy of turbulent viscosity. To increase the reliability of the results obtained during the computation of the efficiency of the film cooling we also considered the possibility of the adaptation of the *SST*-model of the turbulence through the updating of its constants. The proposed adaptation of the *SST* model of the turbulence allows for the approximation of the computational results of the efficiency of the film cooling to the experimental data.

**Key words:** film deposition, turbulence model, film deposition efficiency, and a row of cylindrical openings.

**Developing the Methods Used for the Computation of the Characteristics of Nonstationary Operating Processes in the Low-Emission Combustion Chambers of Gas Turbine Engines [Text] / S. I. Serbin, G. B. Mostipanenko, A. V. Kozlovskiy, V. G. Vantsovsky, V. V. Vilkul // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 90–94. – Bibliogr.: 7. – ISSN 2078-774X.**

The use of the contemporary tools offered by computational hydrodynamics to study pulse processes that occur in the combustion chamber due to the specific features of the structure of heat tubes and the aerodynamic interaction of a compressor, combustion chamber and turbines has been discussed. The purpose of this scientific paper is to study and predict nonstationary processes that occur in the combustion chambers of gas turbine engines. The numeric experiment was carried out to determine the level of pressure pulsations in the combustion chamber of gas turbine engine. The results of numeric experiments that were carried out using three-dimensional mathematical models for combustion chambers operating on gaseous fuel adequately show physical and chemical processes of nonstationary combustion and can be recommended for the optimization of geometric and operational parameters of low emission combustion engines. The use of similar mathematical models is appropriate both for the development of the new types of combustion engines that operate on the depleted fuel-air mixture and also for the modernization of available chambers to develop constructive measures that can be taken to decrease the probability of the initiation of the pulsating combustion modes.

**Key words:** gas turbine engine, combustion chamber, turbulent combustion, pulsating combustion, numeric methods, and mathematical simulation.

**Using a Priori Information for the Synthesis of Engine Start Models [Text] / S. V. Yepifanov, F. F. Sirenko, S. I. Sukhovii // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 95–103. – Bibliogr.: 4. – ISSN 2078-774X.**

This scientific paper is devoted to some aspects of the actual problem related to the simulation of processes that occur at the stage of starting the gas-turbine engine. Such models are required to create computer-aided control systems for engines and simulators. It has been shown that the traditional approach based on the extrapolation of the characteristics of units to the starting region has serious drawbacks. An alternative approach has been proposed at which the starting process is simulated using the linear dynamic model, which is identified on the basis of simplified statistical model with the broad application of experimental and a priori knowledge. The structure of the start model, which coincides with that of the mathematical model of the engine with regard to operating modes and also its mathematical formalization have been given. The sources of the a priori information have been analyzed and the place occupied by it during the formation of the model using the identification has been determined. Special attention was paid in this paper to the synthesis of simplified statistical characteristics done on the basis of a priori and experimental information.

**Key words:** gas-turbine engine start, linear dynamic model, simplified statistical model, a priori information, gas-turbine engine characteristics.

**Peculiarities of the Methods used for the Design of Control Valves Operating on the Boiling up Water Used for High-Pressure Heaters of Home and Foreign Nuclear Power Stations [Text] / M. G. Ukhanova, N. N. Trifonov, F. A. Svyatkin, S. B. Esin, E. B. Grigorieva // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 104–108. – Bibliogr.: 6. – ISSN 2078-774X.**

The control valves (CV) of the heaters of the regeneration system are designed to control the level of the heating steam condensate in the steam space of the body of high pressure heater through the partial opening or closing of the valve in statistical and dynamic operating modes of the turbine plant. A peculiar feature of the CV is that it operates on the bubbling flow, which results in the intensive erosion-caused wear of the flow pass and valve body and it is accompanied by cavitations, noise and vibrations that affect the longevity and reliability of the fittings. This paper gives the description of the technique proposed by the PJSC "NPO CKTI" to design the valves that regulate the level in heat exchangers and the peculiarities of the technique. The structures proposed for new control valves and the results of the computation of technical characteristics of the valves and their influence on the operation of high-pressure heaters of a chamber type have been described.

**Key words:** control valve, high pressure heater, nuclear power station, computational methods, throttling and bubbling.

**Investigation and Analysis of the Use of the Programming System FlowVision HPC for the Computation of Characteristics of the Jet Turbine** [Text] / S. M. Vanyeyev, V. V. Getalo, S. C. Korolov // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 109–116. – Bibliogr.: 8. – ISSN 2078-774X.

As of today the problem of energy saving in different branches of industry is of great importance. One of the main ways of the solving of this problem is considered to be the use of secondary power carriers, in particular in gas and chemical branches of industry. The utilization of the energy of compressed gases is a promising and important aspect which is taken into consideration during the solution of the energy-saving problem in the contemporary world. The jet turbine-based turbogenerators can be used for the utilization of the energy of compressed gasses, for example, for gas distribution stations. These systems provide simultaneous decrease and regulation of gas pressure and the performance of mechanical work on the turbine shaft converting it into the electric power. It should be noted that the electric energy production by gas distribution stations using turbogenerators is an energy intensive and ecologically friendly technology. This paper is devoted to the computation of the gas flow and plotting the characteristic of the jet turbine using the programming system FlowVision and it also compares the obtained results with those of processed experimental data.

**Key words:** jet turbine, numerical simulation, torque moment, power, and efficiency factor.

**Comparison of 2D and 3D Design Models Used for the Assessment of the Residual Resource of the High Temperature Elements of the Steam Turbine** [Text] / O. Yu. Chernousenko // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 117–124. – Bibliogr.: 6. – ISSN 2078-774X.

The comparison of 2D and 3D design models used for the assessment of the residual resource of high-temperature elements of the steam turbine of a high power to prolong the life time of power generating units has been carried out. It has been shown that 2D models can be used for the estimated assessment of the residual resource of the rotors of high-pressure cylinders (HPC) and average pressure cylinders (APC). For HPC and APC bodies and for automated stop valves (ASV) of HPC and APC 3D models should be used due to the complexity of their structure, availability of flanges of horizontal joint and the peculiarities of the flow of actuating medium inside the bodies. The comparison of 2D and 3D models for the estimated assessment of the residual resource of high temperature elements of the steam turbine of 200MW showed that HPC and APC rotors can be examined in terms of resource characteristics using 2D models. The divergence of the results for the mode of deformation is within 2 to 5 %. This allows for the reduction of costs required for the numerical experiment, which is of great importance for the creation of program packages for the computer-aided systems of technical diagnostics and the resource counter. HPC and APC bodies and ASV bodies of HPC and APC require the use of 3D models due to the complexity of their structure, availability of flanges of horizontal joint and the peculiarities of the flow of actuating medium inside HPC and APC bodies and automated stop valve bodies of HPC and APC. The divergence of the results for the mode of deformation of 3D models is one order of magnitude higher in comparison with the data for 2D models. Such a difference will result in considerable degradation of resource characteristics and shortened time of the operation of HPC and APC bodies and automated stop valves bodies of high pressure cylinders and average pressure cylinders.

**Key words:** residual resource, high temperature elements of steam turbine, rotor, body, high pressure cylinder and average pressure cylinder.

**Estimation of the Creepage of the Body of the Control Valve for the Steam Turbine K-325** [Text] / N. G. Shulzhenko, A. S. Kolyadyuk // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 125–131. – Bibliogr.: 6. – ISSN 2078-774X.

The numerical study of the mode of deformation and the creepage of the valve body of the steam turbine K-325 with the stationary operation mode has been performed. Temperature fields and pressure produced on body walls are determined using the numerical solution of Reynolds-averaged Navier-Stokes equations for the current of a viscous compressed heat conduction steam in the steam distribution system. The creepage equations are integrated using the explicit Euler's scheme. The model of implicit creepage with the reinforcement taking into consideration initial and steady creepage was used. The maximum values of elastic strains caused by the joint influence of the temperature and steam pressure in the valve are within  $\sigma_{\max} = 82$  MPa. The creepage deformation is observed at the internal walls of the valve body, the surfaces of external walls are actually not exposed to the creepage. It is shown that the creepage phenomenon is not the main reason for the formation of cracks in the valve body.

**Key words:** computation, steam flow, creepage, steam distribution system and a turbine.

**Steam Turbine Resource** [Text] / V. P. Sukhinin, T. N. Pugachova // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 132–138. – Bibliogr.: 8. – ISSN 2078-774X.

The problems related to the overhaul-period renewal for steam turbines as the time of their operation is gradually increased become more and more topical. The consideration has been given to the issues related to the peculiarities of the state of high-temperature elements of the steam turbine and the factors that affect their efficiency and resource. The rotors of the steam turbines are responsible for the elements that actually define the resource of the steam turbine. The conditions of their operation, for example high temperatures and stresses specify the character of the creepage processes and a low-cycle fatigue. The factors that determine the duration of the reliable operation of the turbine plant, in particular the exhaustion of stress rupture ductility due to the material creepage, and the accumulation of damages in critical rotor zones due to the low-cycle fatigue have been analyzed. Depending on the operation conditions the main factors that limit the accident-free operation of the structure exposed to the sustained loading can be ultimate strains or failure stresses. The analysis of the practical data of the long-term operation of the rotors and the investigation of their thermally stressed state allow us to reveal the most dangerous zones inside them due to the formation of operation cracks.

**Key words:** resource, steam turbine, thermally stressed state, creepage, durable strength and low-cycle fatigue.

**Vibration Characteristics of the Starters of Powerful Turbogenerators** [Text] / Yu. K. Petrenia, O. V. Antonyuk, S. N. Gavrillov, A. V. Gaev // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 139–144. – Bibliogr.: 9. – ISSN 2078-774X.

Emphasis is placed on the great practical importance of the problem related to the determination of intrinsic frequencies and mode shapes of the elements of the frontal part of powerful turbogenerators. The results of the analysis of different techniques taking into consideration the degree of reliability of the design performances of the vibratory state and their matching with the results of the bench tests and field experience have been given and that allowed us to reveal a considerable dependence of the computational results on the subset and conditions of the statement and solution of the problem related to the determination and control of the vibratory state of the turbogenerator. The results of the numerical simulation carried out to determine intrinsic frequencies of the output end and a portion of the ring of joint buses of the stator for the three-dimensional problem statement were obtained using the method of finite elements. A strong dependence of design performances both on the used design algorithms and correct statement of edge conditions was demonstrated. An increase in the reliability of the numerical simulation requires taking into consideration the experimental data of bench tests and full-scale experiments for the computation procedures; therefore it is necessary to provide the transition from the methods of numerical computation and simulation to experiment-calculated methods of the determination of the vibratory state of powerful turbogenerators.

**Key words:** turbogenerator, stator, head portion, intrinsic frequency, vibration form, numeric simulation.

**Using the Block-Hierarchical Approach to Design and Optimize the System of the Input Control Unit for the Centrifugal Compressor** [Text] / G. A. Bondarenko, I. V. Yurko // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 145–153. – Bibliogr.: 6. – ISSN 2078-774X.

This paper gives the results of the optimization of the system of the input control unit (ICU). The block-hierarchical approach to the design was used. The algorithm used for the successive fragmentation of the global problem of the optimization into several local problems has been given. Formal macromodels of the object that

were formed at each hierarchically -subordinated level on the basis of numerical investigations have been given. The numeric investigation was carried out using the bundled software *ANSYS CFX* and the methods of the experimental design theory. To optimize the main geometric parameters of the elements of ICU we used the method of golden section. The use of the obtained formal macromodels allows for the design of the optimal system of ICU, which can provide the efficient regulation of the compressor unit in the broad operation range.

**Key word:** centrifugal compressor, regulation, ICU system, blade cascade, optimization, and formal macrosimulation.

**To the Issue of the Algorithm Formation for the Diagnostics of the Technical State of Steam-Compression Cooling Machines** [Text] / E. L. Snihovsky, A. S. Klepanda, I. I. Petukhov, A. V. Sherstyk // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 154–159. – Bibliogr.: 8. – ISSN 2078-774X.

The state and the actuality of the problem at the contemporary stage of the development of the diagnostics of cooling equipment have been described. The actuality of the use of the microcontroller as the control link for the diagnostics of the cooling equipment has been substantiated. A basic set of measuring tools required for the diagnostics has been formed. Key working parameters that should be described in the mathematical model of the cooling machine for its diagnostics have been selected. The algorithm used for the diagnostics of steam-compressor cooling machines (SCCM) based on the thermostatic expansion valve (TEV) with the external compensation, receiver, compressor, capacitor and the evaporator has been given. A table of the behavior of working parameters of SCCM in the case of malfunction has been compiled. The investigation state of the influence of the combination of several defects on the working parameters of SCCM has been analyzed. The sets of several malfunctions whose studies are the most promising and require further research have been selected. The diagnosing program in the MatLAB Simulink design medium has been formed for the microcontroller programming. The program operation principle and the method of transfer to the microcontroller have been given. The microcontroller whose functional allows for the solution of the stated problem has been selected.

**Key words:** cooling machine, diagnostics, processes identification, automation.

**New Approach to the Solution of the Inverse Problem for the Centrifugal Pump** [Text] / S. D. Kostornoy, A. K. Davidenko, L. K. Marchenko // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 160–168. – Bibliogr.: 6. – ISSN 2078-774X.

A contemporary level of the development of the pump equipment requires the creation of reliable physical and mathematical models that give qualitatively and quantitatively correct description of the operation process in the elements of the stage of hydraulic machines. In this paper we give an algorithm and the results of the solution of the inverse problem for the impeller of the single-stage centrifugal pump as applied to the design of the flow pass for the prescribed shape of the meridian flow. A fundamental distinction from the known statements of the solution of such a problem is the consideration of the influence produced by all the elements of the flow pass on the meridian flow, in particular: input, spiral venting and exit cone. A computer realization of this approach allows us to select at the design stage the optimal combination of geometric parameters for the impeller and stationary elements meeting the requirements of the engineering task; this excludes the need for physical experiment.

**Key words:** inverse problem, direct problem, mutual influence, flow pass elements, meridian flow.

**The Analysis of the Methods of Heat Utilization of the Combustion Gases of Boilers Used for the Mobile Blocks of Thermal Power Stations** [Text] / L. A. Kyesova, T. V. Sheleshey, K. A. Drohalchuk // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 169–175. – Bibliogr.: 17. – ISSN 2078-774X.

The consideration has been given to the issues related to the reliable and efficient operation of thermal power stations using low cost technologies for the utilization of the heat of output gases. Circuit diagrams used for the realization of this technology have been given. Economic and ecological effects yielded due to the introduction of different technologies for the utilization of the heat of exhaust gases have been given. The technology of the blocks of increased efficiency contributes to an increase in the boiler efficiency (due to the drop in the temperature of released gases and more integrated use of the fuel heat); the production of additional electric energy using heat (due to the forced out steam samples), replacement of the peak reserve power in the energy system through an increase in the condensation production of electric energy by thermal power stations; a decrease in environmental emissions; a decrease in the efficiency factor of electric filters through a decrease in the temperature of combustion gases.

**Key words:** combustion gases, release gases, utilization, mobile power blocks of TPS, "blocks of increased efficiency", turbine economizer.

**Studying the Cooling of Viscous Oil Products during the Period of their Storage and Transportation in the Railway Tanks** [Text] / S. S. Titar, D. V. Zaycev // Bulletin of NTU "KhPI". Series: Power and heat engineering processes and equipment. – Kharkiv: NTU "KhPI", 2014. – № 11(1054). – P. 176–180. – Bibliogr.: 4. – ISSN 2078-774X.

This scientific paper describes the combination of measures taken to transport, discharge and store liquid and viscous products, taking bitumen as an example. The bitumen production in petrochemical branch of industry requires relatively high temperatures (~140 to 150 °C). At these temperatures this material has a liquid state and its viscosity is comparable with the water viscosity. Due to this reason bitumen is transported from the place of production to the place of consumption in railway tanks (ordinary tanks, thermos-type tanks, steam jacket tanks). The viscosity of this material is considerably increased with the drop in temperature and very often it cannot be discharged from the tank without additional heating. The most complicated problem is related to the determination of the parameters of bitumen, which is cooled during the transportation. For this purpose we need to determine correctly the factor of heat transfer from hot bitumen through the tank wall to the environment and it is also necessary to know the coefficients of heat emission from bitumen to the wall and from the wall to the environment during the tank motion. The consideration was given to two possible physical models of the bitumen and environment heat exchange. In the future we plan to carry out laboratory research and full-scale monitoring of the bitumen cooling during the tank motion at the unloading site and bitumen storage site.

**Key words:** heat exchange, heat transfer coefficient, convection, heat emission coefficient and temperature.