ABSTRACT AND REFERENCES

ENERGY-SAVING TECHNOLOGIES AND EQUIPMENT

RESEARCH ON MANOEUVRING CAPABILITIES OF A NUCLEAR POWER PLANT WHEN SWITCHING IN-USE CONTROL PROGRAMMES (p. 4-13)

Ievgeniia Kokol

The study is devoted to the development of object-oriented analysis for an automated control system to enhance the capabilities of manoeuvring a nuclear power unit with the WWER-1000 by switching the power control programmes of the NPP during its operation. The research was conducted to check whether the reactor unit was stable or not at the in-operation transition mode. According to the simulation results, control programmes during the operation of the nuclear power plant can be switched. The reactor unit remains in a stable state, which is evidenced by the values of the axial offset as a quantitative measure of the reactor stability. By using the suggestion and manoeuvring not only the capacity of the nuclear power plant but also the control programmes, it is possible to bring the consumption schedule of electric power to conformity with the schedule of electric power generation without affecting the safety of the nuclear power plant in operation.

Keywords: nuclear power plant, control programme, power, reactor stability.

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DEVELOPING OF METHODS CALCULATION OF COMUTATION OVERVOLTAGE IN SEMICONDUCTOR APPARATUS IN AC CIRCUITS (p. 14-22)

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The study focuses on switching overvoltage applied to semiconductor switches of semiconductor AC devices at the moment of switching electric circuits owing to the energy that has accumulated in the inductive elements of the mains and a disconnectable load.

Since the cost of power semiconductor devices is determined both by the current with which they are compatible and the class of the device that determines the amount of blocked voltage, it is important to use special measures that would reduce the voltage and make it closer to that of the network. Usually, the voltage is reduced with the help of protective RC-circuits and nonlinear surge suppressors (varistors).

The aim of the research was to refine the methods of calculating the switching overvoltage and parameters of protection circuits in semiconductor devices with account for the diversity of semiconductor switches and their dynamic characteristics since the current methods of calculation do not fully account for them and, therefore, are not fully precise.

The newly developed methods of calculating the switching surge consider dependence of the reverse recovery of power semiconductor devices on the rate of current decline in their circuit as well as high resistance of modern semiconductor devices to the effect of ultra-high voltage slew rates. The methodology also takes into account the conditions of the load switching with the help of these devices.

The developed methodology of selecting parameters for the RC-protective circuit accounts for the nature of any switching transients and significantly extends the range of protective circuit parameters.

The proposed surge suppressor for semiconductor AC switching devices is additionally supplied with a varistor that is connected in parallel to the RC-circuit, which allows a significant reduction in the capacitance of the circuit condenser and the leakage current and approximately 30 % reduction in the rate of switching surges. This would greatly reduce the class of power semiconductor devices.

Keywords: semiconductor device, switching overvoltage, protection RC-circuit, varistor/variable transistor, calculation methods.

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THE RESEARCH OF THE DYNAMIC PROCESSES OF CONTROL SYSTEM OF HYDRAULIC DRIVE OF BELT CONVEYORS WITH VARIABLE CARGO FLOWS (p. 22-29)

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The dynamic processes in the hydraulic drive control system of the conveyor with parallel hydraulic motors were studied using a mathematical model, constructed on the basis of physical phenomena occurring during the variable load acting on the hydraulic system.

The obtained results allow justifying the settings of the conveyor hydraulic drive control system, which provide continuous operation of the hydraulic drive system under short-term or long-term overloads and switching on and off the additional hydraulic motor in the given regimes depending on the moment of useful resistance on the drive conveyor drum.

The analysis of theoretical graphs showed that the shut-off-and-regulating element of the control unit provides the desired mode of the system with a delay in the friction clutch engagement after switching on the additional hydraulic motor for its acceleration in the idle mode, thereby the executive body effectively overcomes the short-term and long-term overloads of the drive system.

The influence of the specific volume of the additional hydraulic motor, relationships of the sealing areas of the shut-off element, plunger mass and damping coefficient of the control system, as well as the mode of the load changes on the control system transients was determined. The values of the specific volume of the additional hydraulic motor, relationships between the sealing areas of the shut-off element affect the stability of the sensor transients. To avoid a vacuum cavity in the additional hydraulic motor during the friction clutch disengagement, it is needed to install a check valve between the pressure and discharge lines. The mass change or damping of the plunger by connecting the parallel check valve and throttle provide vibration damping during the clutch disengagement. To prevent the adjustment overpressure in the sensor, it is needed to install the safety-relief valve in the hydraulic system, which limits the pressure in the pressure line. The efficiency of using a direct-acting valve with parametric control as a sensor in the control device, which allows regulating the closing pressure by the selection of the valve geometric characteristics independently of the mode of the load changes was proved.

The research results can be used for hydraulic drives of the machines of various technological purposes that operate under variable loads.

Keywords: hydraulic drive, control system, conveyor, variable cargo flows, dynamic processes, mathematical modelling.

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EXPERIMENTAL RESERCH OF THE EFFECTIVENESS OF A WORKING PROCESS FOR A VORTEX DIODE AGAINST A WATER HAMMER (p. 29-36)

Mykhailo Overko

If the main cause of water hammer in a long discharge line is the sudden shutdown of the pump, it is enough to increase the reverse resistance of the discharge line for the protection against high pressure using large-size inkjet diodes, which have no moving parts and therefore are reliable, which is important for safety valves. Vortex diodes, the most important parameter of which is diodicity - the ratio of the reverse hydraulic resistance to forward best meet the requirements for reducing the water hammer magnitude. The description of the design of a new vortex diode with a conical inlet, the bench, the methodology of the experiments and the results obtained is given. A characteristic feature of the proposed design of the vortex diode is a conical inlet to the vortex chamber and the end arrangement of the offset on the outer surface. The flow characteristics of the diode in the reverse and forward fluid flow are built. The dependence of the diodicity on the flow rate is determined. It is shown, in particular, that this dependence is a third-order algebraic equation. The maximum diodicity is 12 at a water velocity of 3.8 m/s. The vortex diode time constant, which amounts to 1.35 s at the fluid velocity of 3.54 m/s, which confirms the adequacy of the numerical method for calculating the dynamic characteristics of vortex diodes is determined. The data are obtained in the simulation of the vortex diode operation by the numerical method.

Keywords: water hammer, protection, diodicity, vortex diode, hydraulic resistance, experimental characteristics.

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AUTOMATED COMPARISON OF THE TECNICAL AND ECONOMIC EFFICIENCY FOR CRANE MECHANISMS (p. 37-49)

Victor Busher, Svetlana Savich, Svyatoslav Savich, Vadym Medvediev

Various types of the AC electric drive: traditional one with resistor control, with thyristor voltage converter and with frequency converter, the latter with power recovery are considered. The review of static and dynamic characteristics of each of the electric drives is presented, based on which recommendations are made concerning the application of a particular asynchronous electric drive of the proposed options in specific cases. Energy performance, loss in the motor circuits are calculated for specific crane hoist mechanisms.

The CAD-system for technical and economic comparison of the crane drives taking into account the main operation features: loads, moments of inertia with/without load, the relative operating time with reduced speed is developed. Due to the unification of approaches to the analysis of the operating conditions of the hoist and swing mechanisms, the program calculates the power consumption in static and dynamic modes. Known capital and depreciation costs and total annual power losses obtained in the CAD-system allow making decisions about the choice or necessity of reconstruction of the electric drive.

Keywords: electric drive, CAD-system for technical and economic comparison, resistor control, voltage converter, frequency converter, resistor braking.

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EVALUATION THERMODYNAMIC PERFECTION OF THE COGENERATION CASCADE MACHINES CYCLES (p. 50-55)

Larisa Morozyuk

One of the promising trends in the refrigerating engineering is building machines for industrial processes with the simultaneous use of two thermal effects (heat and cold). The fundamental possibility to build machines, operating on a complex reverse thermodynamic cycle with the production of low-grade cold and high-grade heat is considered. Such machines are called heating cascade machines. The synthesis of cyclic machine solutions for various pairs of materials, based on thermodynamic analysis by the “method of cycles” is carried out. The analysis of the supercritical cycle of the upper cascade with R744 by the entropy-cycle method is performed. It is shown that the compound Carnot-Lorenz cycle (“triangular”) should be chosen as the cycle model. The problem of determining the degree of thermodynamic perfection of the cascade cycle, which takes into account the simultaneous production of two thermal effects – cold and heat is solved. An example of the calculation of the machine characteristics under variable input parameters: temperature in the condenser-evaporator and the pressure in the gas cooler is given. The comparison with the characteristics of the cascade machine, operating in the same mode, but with one thermal effect – the production of cold, which showed the benefits of heating cycles is performed. It is proved that, given the simultaneous high temperatures of the heat produced and low temperature of the cold produced in the cascade heating machine, energy performance is quite high. General recommendations – in terms of energy saving, heating cascade units and machines, operating with R744 as a working substance of the upper cascade and the cycle in the supercritical region with the simultaneous heat and cold production should be designed.

Keywords: heating cascade machine, R744, supercritical cycle, degree of thermodynamic perfection.

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A STUDY OF THE RATES OF PORE NUCLEATION AND PORE GROWTH IN ALUMINA-BASED THERMAL INSULATION MATERIALS (p. 56-62)

Andriy Cheylytko

The study considers the Gibbs energy change at the time of pore nucleation. An equation is suggested for describing the critical radius of a pore nucleus. Since it is directly proportional to the surface tension, pores are formed in places with density irregularities or fluctuations. An analysis has revealed conditions for a pore to exist, the minimum work for a pore to nucleate, the time necessary for a pore to appear, and the likelihood of a pore nucleation. The undertaken laboratory tests concern the pore formation rate and the pore growth rate in aluminous materials. The study has determined the general dependencies of wetness changes in the material under its heat treatment and the dynamics of porosity changes in an intumescent material. It allows distinguishing between three stages of change in the number of pores in an intumescent alumina-based material: a stage of a declining number of generated pores, a stage of equable reduction of the number of pores, and a stage of pores overgrowth.

The obtained results are applicable to such thermal insulation materials as expanded clay and refractory materials as well as other aluminous materials that are produced by swelling.

The conducted experiments have identified the main patterns of changes in the number of pores and the total porosity in aluminous materials when they are heat-treated. It has consequently helped develop a system of equations that describe changes in the porosity of an alumina-based material. The devised equations suggest that the number of pores is directly proportional to the heat treatment temperature as well as to the difference between the surrounding pressure and the critical pressure of a pore. Besides, this system of equations can help predict the number of pores in an intumescent material, which facilitates control over thermophysical properties of the material.

The research findings are very important for developing new high-intensity technologies in various industries, in particular for improving the existing production technology of thermal insulation materials based on alumina. Besides, the obtained results can help create new insulating materials.

Keywords: pores, porous system, pore nucleation rate, Gibbs energy, alumina, expanded clay, refractories.

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