

Abstracts

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Energy Sine Ira et Studio

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This paper provides an overview of global energy status and prospects for the next 20—25 years, compares resource and environmental parameters of fossil, renewable and nuclear energy sources, suggests their development forecasts, and assesses investment returns from various energy sources.

Key Words: energy, development forecasts, energy sources, energy resources, renewable energy, nuclear energy.

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Preconditions for Creation of NPPs with Unlimited Safe Life

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The possibilities of NPPs module constructions and arrangements using for safe life prolongation and decommission simplification are under consideration. It is also considered the other advantages of these constructions for NPPs integral risks decreasing during project’s life cycle.

Key Words: NPP, safe life, decommission, module constructions.

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Influence of Design Solutions on Safety and Parameters of Small-Sized High-Temperature Gas-Cooled Reactors.

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Results of neutronic characteristics analysis of alternative reactor design solutions that influence main parameters, safety in standard and emergency situations and energy-producing are presented. Recommendations of the optimal design concept of the small-sized gas-cooled reactor are given.

Key Words: high-temperature gas-cooled reactor, core, neutronic calculations, energy-producing, neutron spectrum, safety.

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Construction of Two-Dimensional Elementary Solutions of the Neutron Transport Equation in Cylindrical Geometry

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The method of constructing two-dimensional regular and singular elementary solutions of the neutron transport equation in cylindrical geometry from plane elementary solutions (in the sense of K. Case) is

presented. Such a construction appears to be convenient when plane elementary solutions are expanded in a series in Legendre polynomials. Further, they are supposed to be used for construction of a two-dimensional Green's function, which will be used in the surface pseudo-source method for multigroup calculations of cells of VVER and RBMK nuclear reactors and preparing small-group matrixes of cell diffusion coefficients for the surface harmonics method.

Key Words: cylindrical geometry, two-dimensional eigenfunctions, one-group neutron transport equation, green's function, surface pseudo-sources method.

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Two-Dimensional Green's Function of the Neutron Transport Equation in Cylindrical Geometry

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The surface pseudo-sources method, using the angular moments of the Green's function of the neutron transfer equation for an infinite homogeneous medium, has been applied for multi-group calculations of cells of VVER and RBMK nuclear reactors and for preparation of few-group cell characteristics. In this paper, the biorthogonality of twodimensional regular and singular solutions of the neutron transport equation is proved for a cylindrical geometry. A twodimensional cylindrical Green function is constructed. A part of the constructed angular moments of the two-dimensional cylindrical Green function is used in the method of surface pseudo-sources for the multi-group calculation of cylindrical and cluster cells of VVER and RBMK reactors with or without fuel.

Key Words: neutron transport equation, surface pseudo-sources method, one-velocity approximation, green's function for infinity space.

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Results of Calculation of International Experimental JOYO, Superphenix and ZPR6/7 Benchmarks for Extension of JARFR Code Verification Matrix

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The paper presents the results of international experimental JOYO, Superphenix and ZPR6/7 benchmarks neutronphysical calculations with design code JARFR. Calculated neutron-physical parameters were compared with experimental data. MCNP5 calculation results are also presented for JOYO isothermal temperature coefficient and Superphenix core characteristics. The influence of absorber control rod insertion instead sodium filled channel on distribution of fission reactions rates was investigated on ZPR6/7 of assembly.

Key Words: research reactor, isothermal temperature coefficient, neutron-physical parameters, reaction rates.

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The VVER Thermal Power Measured Using Records of SPND

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There are discussed the technique of VVER fuel assembly power determination in a rhodium self-powered neutron detector (SPND) location and verification of the technique. Possible measurement of VVER power based records of SPND is described.

Key Words: self-powered neutron detector (SPND), in-core noise diagnostic systems.

UDC 573.6.011.6

An Estimate of the Possibility of Using the Classical Theory of Nucleation for Calculating the Limiting Superheat of a Metastable Liquid in the Region of the Onset of Bubbly Boiling

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It is presented the comparison of the VTI experimental data on the start of bubbly boiling of water in a uniformly heated pipe with a diameter of 5.77 and 6.34 mm at mass velocities $W_j = 1400—5000$ kg/(m²·s) and pressure $P = 9.81; 14.7; 19.62$ MPa with theoretical calculation, when the limiting superheating of fluid is obtained using the classical Gibbs formula [1] for the mechanism of homogeneous nucleation. An assumption is made about the influence of the thermodynamic instability of the process in the region under the spinodal on the disruption of metastable films of liquid with the formation of “holes” over its entire thickness, which leads ultimately to the formation of non-wettable “dry spots” (spinodal dewetting) and cause a spontaneous transition to the film boiling regime.

Key Words: reactor thermohydraulic code, ONB (onset nuclear boiling), homogeneous and heterogeneous nucleation, spinodal dewetting, classical theory of nucleation.

UDC 621.039.526.034

Thermophysical Features of High-Temperature Gas-Cooled Reactors

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Issues of required parameters realization of high-temperature gas-cooled nuclear reactors included in space systems are considered. The analysis of thermophysical processes in the reactor core made it possible to propose and justify solutions for specified reactor parameters realization in conditions of known regular nuclear power flux peaking and random disturbances associated with possible technological manufacturing errors in the core cooling system, realization of rated fissionable material concentration distribution.

Key Words: thermal physics, reactor, power density, peaking, hydraulic resistance, temperature.

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Development and Verification of MAVR-TA Code for Modelling of Fission Product Release and Transport in the Containment during Severe Accident on VVER

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The article is devoted to the method for fission products (FP) release calculation from the fuel and melt during the severe accident with fuel melting on VVER. This method is implemented in the MAVR-TA code which was developed in NRC “Kurchatov Institute”. The main results of code validation using experiments on FP release in the conditions of a severe accident are given. The results of FP release calculation obtained by the MAVR-TA code are presented for the accident scenario “LB LOCA with SBO” for the AES-2006 project.

Key Words: severe accident, VVER, fission products release, code verification, code development.

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Effect of Reactor Irradiation on Mo and W Interdiffusion

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It is established that reactor irradiation leads to a significant acceleration of the interdiffusion in the Mo-W alloy as compared to thermally activated diffusion at temperatures of ~ 1500 ° C. In addition, the concentration dependence of interdiffusion is weakened. An approximation procedure is developed that allows one to approximate the experimental data by varying one parameter. It is shown that the interaction of molybdenum and tungsten nuclei with fast neutrons, as well as with hard γ -radiation, can serve as a cause of the observed effects.

Key Words: diffusion, reactor irradiation, tungsten, molybdenum, fuel element cladding.

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Modeling of the Shape Change of RBMK Graphite Stacks at the Stage of their Resource Restoration

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The paper contains information about the repair of RBMK graphite stacks of the first generation of the Leningrad and Kursk NPP to restore their resource. The problems of modeling of graphite stack deformation are discussed. Examples of forecast calculations of channels deflections using stochastic model are presented. It is shown that a prediction of the further deformation of graphite stacks during the year with satisfactory accuracy is possible if the model is adjusted using the deflections measurements.

Key Words: reactor RBMK, graphite stack, resource recovery, stochastic model, forecasts and measurements of channel deflection.

UDC 621.039.536.2

The Study of Concrete Structures of Balakovo-1 NPP for the Justification of Save Operation after Annealing of VVER-1000 RPV

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In frame of substantiation of the possibility of Balakovo-1 reactor pressure vessel annealing it is necessary to confirm the save operation after annealing for RPV and RPV building surrounding structures, such as the reactor shaft and the support farm, and its filler which provides biological protection. The studies of the compressive strength of heavy concrete, similar to the concrete of the reactor shaft, after 30 years of operation and heating at temperatures of 90 and 110 °C for 100 hours has been done. Samples of heavy concrete, cut out in 2015 specifically for this work from the concrete cladding of Balakovo NPP-1 reactor, were used. The properties of the farm filler as a biological protection after annealing RPV were studied, because they can change due to the water loss when heated during annealing.

Key words: recovery annealing, heavy concrete, iron-serpentinite concrete, support farm, serpentinite gale.