

## Abstracts

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### **Identification of VK-50 Reactor Reactivity Measuring Equipment Dynamics when Using Neutron Capacity Control Pulse Channels**

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Experience is observed in defining an uncertainty source and diminishing this uncertainty in the experiments to measure the induced reactivity in the VK-50 at the minimum controlled reactor power. It is shown that the time lag of the measuring equipment contributes greatly to the uncertainty of the dynamic experiment. A procedure to compensate this uncertainty is proposed.

*Key Words:* VK-50 Reactor, Reactor Kinetics, Reactivity Measurement, Dynamic Uncertainty.

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### **Measurements of the Reactor Neutron Power in Absolute Units**

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Modernized correlation analysis method was used for measurements neutron power in absolute units of the space nuclear reactor “Yenisei” at land tests of its prototypes. Results of experiments are given. Those results were received in a series of the experiments during preparation of installation to tests. The acceptability of experimental results is confirmed by they comparison with results of measurements of the reactor neutron power in absolute units at nominal level obtained from thermal balance in the course of resource tests of land prototypes.

*Key Words:* Reactor, Correlation Analysis Technique, Neutron Power, Absolute Units.

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### **Verification of Statistical Method CORN for Modeling of Microfuel in Case of High Grain Concentration**

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In this paper two methods for modeling of double heterogeneity fuel are studied – deterministic positioning and statistical method CORN of MCU software package. The influence of distribution of microfuel in pebble bed on calculation result is studied. The results of the verification of the statistical method CORN for cases of microfuel concentration up to  $170 \text{ cm}^{-3}$  in pebble bed are presented. Admissibility of coating homogenization with graphite matrix is studied. The dependence of the reactivity on the relative location of fuel and moderator spheres in pebble bed is discovered.

*Key Words:* Criticality, Microfuel, TRISO, Regular Lattice, Monte-Carlo Method, Statistical Method CORN, Bench ASTRA, Bench HTR-PROTEUS, Benchmark, Verification, MCU Project.

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## **VEGA – a Code for Calculation of Reactor Neutron Parameters by Monte Carlo Method in Process of Fuel Burning-out**

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The method of calculation of reactor neutron parameters by method Monte Carlo in process of fuel burning-out is described. The analytical method of burning-out equations solving is presented.

*Key Words:* Monte Carlo, Reactor, Burn-up.

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## **The Possibility of Representative Loop Tests of Fuel Elements for Small-Size Fast Reactors in Channels of Thermal Research Reactors**

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For experimental confirmation of operability of the fuel elements for small-size fast nuclear reactors the possibility of representative loop tests of these fuel elements in the channels of thermal research reactors is discussed, using the IVV-2M reactor as an example. A description of a computational model for the loop channel with samples of the fast reactor fuel elements in the IVV-2M reactor is given. Neutronic calculations with the MCU code have been carried out for the purpose of providing the fast reactor typical conditions in the fuel elements under testing. For conducting the reactor tests shielding of the thermal neutrons incident on the surface of the test loop has been suggested, providing a fast neutron spectrum in the fuel of the experimental fuel elements.

*Key Words:* Possibility of Loop Tests of Fuel Elements for Fast Reactors, Calculations with the MCU Code, Thermal Research IVV-2M Reactor.

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## **Calculation Investigations of Isotope Equilibrium in Demonstration Subcritical Molten Salt Reactor**

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A calculation investigation was performed on implementation of subcritical molten salt reactor with external neutron source for transmutation and incineration of minor actinides from VVER-1000-type reactor spent fuel and for  $^{233}\text{U}$  conversion from  $^{232}\text{Th}$ . Reactor design is defined; requirements to external neutron source are posed; heavy nuclides equilibrium and fuel cycle main parameters are calculated.

*Key Words:* External Neutron Source, Minor Actinides Transmutation and Incineration, Target Assembly, Subcritical Molten Salt Reactor, Calculation Investigations.

UDC 621.039.5

## **Study of Hydrodynamics and Heat Exchange in Cavity Core of Molten Salt Reactor – Burner of Minor Actinides**

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High-flux fast reactor with molten fluoride salt fuel had been proposed by experts of NRC “Kurchatov institute” for burning of minor actinides. This reactor is a part of energy-technological complex of spent nuclear fuel reprocessing facility. Cavity core with free flow of molten salt coolant is a feature of reactor. Results of calculational study of core hydrodynamics and heat exchange are presented in this paper. It is shown, that there is no stationary flow in core, low-frequency pulsations of coolant temperatures and wall temperatures arise. Comparison of results, obtained by using different turbulence models, has shown a need of special experiments to specify models and their constants.

*Key Words:* CFD-Modeling, Minor Actinides, Cavity Core, Molten Salt Reactor, Thermal Hydraulics.

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## **Variants of Nuclear Fuel Cycle Closing**

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Influence of nuclear energy structure, fuel burn up conditions and accumulation of new fission isotopes on main parameters of closed fuel cycle are considered. Effect of breeding ratio, cooling time of spent fuel, separation of reproduction and burned areas on parameters of fuel cycle are analyzed.

*Key Words:* Closing of Fuel Cycle, Nuclear Energy Structure, Fast Reactors, Breeding Ratio, Natural Uranium Consumption, Cooling Time of Spent Fuel, Heterogeneous Fuel Pellet.

UDC 621.039.57-58

## **Prediction of Deposits Accumulation on the Fuel Rods of the Boiling Water Reactor**

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The developed methodology for predicting of deposits accumulation on the water-water reactors fuel rods is presented. The results of methods substantiation are exhibited in experiments. The experiments were performed at various stages of fuel rods operation in the boiling water reactor. The effect of deposits formation of the small iron particles is theoretically predicted and experimentally observed. The recommendations have worked out for reducing the iron corrosion products in BWRs transient modes. These recommendations were based on the results of theoretical and experimental studies. This rule's of procedure can decide the problems of radiation safety and stability of the BWR fuel assemblies more effectively.

*Key Words:* Vessel-Type Boiling Water Reactor, Iron Corrosion Products, Deposits in the Fuel Rods, the Magnus Force.

UDC 621.039.534

## **Generalization and Analysis of the Distribution Parameters for Non-Equilibrium Two-Phase Flows. Annular Channels and Pin Bundles**

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This study presents the main results of the analysis of the previously developed generalized hierarchical closed system of analytical closure relations for the distribution parameters (DPs) that are used in quasi-1D form of the conservation laws for mass, momentum and energy in non-equilibrium two-phase flows for non-uniform profile of void fraction. The main assumptions are: drift flux model, quasi-steady-state approximation, and power-mode approximations of the local profiles of the variables. These DPs  $C_{ks}$  quadrature directly reflect the principle of superposition, generalize and unify not only the Zuber – Findlay method, but also Hancox – Nicoll and Hibiki – Ishii methods. The revealed complementarity properties and mirror symmetry are particularly useful for the purposes of testing, validating and verifying DPs.

*Key Words:* Two-Phase Non-Equilibrium Flows, Drift Flux Model, Annular Channels, Pin Bundles.

UDC 621.039.513

## **Development of the Generalized Criterion for Density Wave Oscillation Threshold in Parallel Channels with Risers on the Base of Non-Equilibrium Drift Flux Model**

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The analytic form of the generalized criterion of the threshold of density wave instability (DWI) is derived. It is a function of not only traditional homogeneous model parameters described in classical studies (Morozov – Gerliga, Ishii – Zuber, etc.), but also new models, taking into account the effects of subcooled boiling and phase shift, influence of riser, pressure drop component due to friction, hydrostatics and heterogeneous profiles of variables. Asymptotic analysis showed that the new generalized criterion of DWI threshold was reduced to earlier results and criteria in limiting cases.

*Key Words:* Linear Analytical Model, DWI, Drift Flux Model.

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## **Anisotropy Measurement of Coated Particles Pyrolytic Carbon Layers**

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Testing and calibration of NRC "Kurchatov Institute" equipment for measurements of pyrolytic carbon layers anisotropy of GT-MGR coated particles (CP) is carried out. The optical anisotropic factor (OPTAF) dependence on the area size of measurements is investigated. OPTAF measurements on an aluminium mirror, a rutile crystal and available CP samples with the known characteristics measured earlier on ORNL equipment are resulted. Besides, measurements on CP fabricated by VNIINM are executed. Strong dependence of the received data on preparation quality of metallographic section is established. The conducted researches allow to make the conclusion about working capacity of the existing equipment for OPTAF pyrocarbon layers measurements on the NRC "Kurchatov Institute" equipment with a relative error nearby 1 %. It is shown that errors elimination caused by stochastic fluctuations in a measuring path by mathematical processing of a signal allows to decrease a relative error of OPTAF measurements to ~ 0,3 %.

*Key Words:* Microfuel, Pyrolytic Carbon, Anisotropy, Layers, Measurements Error.

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## **Study of Interaction in Nano Si-U<sub>3</sub>O<sub>8</sub> System**

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Interaction in nano Si-U<sub>3</sub>O<sub>8</sub> system has been studied with differential-thermal, X-ray phase, radiometric and bottle methods. On the basis of the achieved results it has been constructed the estimated state diagram of nano Si-U<sub>3</sub>O<sub>8</sub> systems. It is established that nano Si-U<sub>3</sub>O<sub>8</sub> interaction has a eutectic character. Eutectic in nano Si-U<sub>3</sub>O<sub>8</sub> system is formed at a concentration of about 50 mol. % U<sub>3</sub>O<sub>8</sub>. On the basis of the change in lattice parameters of the formed solid solutions it is assumed the formation of solid solutions of injection. It is revealed that within the research of temperature range the solubility of silica in U<sub>3</sub>O<sub>8</sub> reaches 1,0 мол. %. It has been studied patterns of dehydration and oxidation processes at heating of samples up to ~ 1000 °C in various media.

*Key Words:* Nano Si-U<sub>3</sub>O<sub>8</sub> System, State Diagram, Interaction, Eutectic, Dehydration, Oxidation Processes.

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## **A Concept of High-Temperature Gas-Cooled Nuclear Reactors in the Space Power Engineering**

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State of development of nuclear power engineering based on high-temperature gas-cooled reactors is considered. The possibilities of creating nuclear thermal power and propulsion (NTPP) reactors based on nuclear thermal propulsion (NTP) technology with NTP and power mode and realization of propulsion mode only by electric propelling agents are analyzed. A reactor concept enabling development of NTPP with a wide range of thrusts and electric powers is proposed.

*Key Words:* Nuclear Reactor, NTPP, NTP, IRGIT, Modularity, Power Production, Thrust, Electric Power, Thermal Stability.

UDC 519.24

## **Reveal of Regularities from Multidimensional Data Letter to the editors**

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## Seminar "Physics of Nuclear Reactors"

The seminar "Physics of Nuclear Reactors" is working in the NRC "Kurchatov Institute" since 1999 under the direction of the head of the Nuclear Reactors Physics Department S. M. Zaritskiy.

By the time of this journal issue there were 137 seminar meetings, the theme of which is not limited by the fact stated in seminar title.

The speakers and participants of the seminar are the scientists from NRC KI and other Institutions.

The information about the seminar is located on the site of NRC "Kurchatov Institute" ([www.nrcki.ru](http://www.nrcki.ru)), and is sending to the participants.

In 2012 there were 13 meetings of seminars, information on them was published in journal issue No.1 for 2013.

In 2013 there were 11 meetings of seminars (from 123 till 133). Information on 123-127 meetings was published in issue No.2 for 2013, information on 128-133 meetings – in issue number 4 for 2013.

This issue contains the information about 134 – 137 seminar meetings and abstracts of reports provided by speakers.