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Mechanistic code BERKUT-U: self-consistent modeling of fuel rods thermomechanical behavior and processes in the fuel of fast breeder reactors

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The BERKUT-U mechanistic fuel performance code has been designed at Nuclear Safety Institute of the Russian Academy of Sciences (IBRAE RAN) since 2012 in frame of "Codes of new Generation"subproject of "Proryv"project. The code is intended for self-consistent computational simulation of the stress-strain state and temperature distribution in fuel rods with nitride or oxide fuel, with a gas or liquid metal sublayer under irradiation in fast reactors with liquid metal coolant under normal and transient operational conditions.
The BERKUT-U code has a modular structure, the main modules of the code are:
• Thermophysical module –simulates the distribution of heat fluxes and temperatures inside a fuel rod with known sources of heat release and heat transfer conditions at the border «external surface of the fuel rod cladding-to-coolant».
• Thermomechanical module –simulates the evolution of the stress-strain state of fuel pellets and fuel rod cladding, predicts the mechanical state of the cladding and fuel rod performance.
• Fuel module MFPR –self-consistently simulates a set of processes occurring in fuel: microstructural changes and swelling, production and radioactive transformations of fission products, their intragranular and intergranular migration, accumulation and release of gaseous fission products under the fuel rod cladding, distribution of fission products and fuel components over molecular and phase states, takes into account the influence of fission products on the thermophysical properties of the fuel.
• Module describing the fuel-to-cladding gap –simulates the redistribution of radioactive fission products over the phase (condensed and gaseous) states and their transfer along the fuel-to-cladding gap, for the gas of fuel-to-cladding gap calculates the thermal conductivity of the gas mixture depending on the gas composition, for the liquid metal sublayer simulates the dissolution of the cladding and the transfer of corrosion products in liquid lead or sodium.
• Database module of thermophysical and mechanical properties of fuel rod materials –calculates the mechanical and thermophysical properties of materials of fuel rod of fast reactors and issues them upon request of all code modules.
The validation of the BERKUT-U code carried out over the past three years on the data of post-irradiation studies of about fifty fuel rods indicates that the developed fuel performance code BERKUT-U makes it possible to reliably predict the behavior of fuel rods under irradiation in fast reactors. The some of the calculation results obtained in comparison with experimental data are represented in the contribution.

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