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BERKUT –Best Estimate Code for Modelling of Fast Reactor Fuel Rod Behavior under Normal and Accidental Conditions

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The advanced version of code BERKUT designed for mechanistic modelling of oxide and nitride single fuel rod behavior under normal and accidental conditions of liquid metal cooled fast reactor operation, is under development at IBRAE RAN during the last five years in frame of "Codes of new generation"project included into the "BREAKTHROUGH"(or "PRORYV") project. The code models are grounded on the contemporary understanding of mechanisms governing the most important processes in fuel rods under irradiation, which substantially enhances the predictive ability of the code in comparison with the engineering analogs. The code is the multi-scale one simulating the processes characterized by the range varied from 1nm to 1 m.
At the micro-level the code describes evolution of fuel micro-structure in the fuel grain scale:
• vacancy/interstitial field, nucleation and development of dislocation network and gas filled porosity,
• fission product generation, their radioactive transformations, transport and release out of fuel grains,
• formation of chemical compounds, the fuel phase composition.
At the meso-level the code simulates the processes in the fuel pellet scale:
• mass transfer of fission products, oxygen or nitrogen within pellets,
• evolution of as-fabricated porosity and formation of columnar grains,
• fission product release by recoil and knockout mechanisms.
At the macro-level the code describes thermomechanical behavior of the fuel rod as a whole:
• heat transfer within the rods and heat exchange with the coolant,
• temperature distribution in fuel, fuel-cladding gap and cladding,
• evolution of the stress-strain state of fuel and cladding,
• fission gas composition and gas pressure within the cladding.
The code models describing the processes in oxide fuel, which are common for thermal and fast neutron reactors, have been validated against extensive experimental data set found in the literature. Some particular microscopic parameters have been defined through the theoretical estimates.
The calculations have been performed simulating oxide and nitride fuel rod behavior in BN-600 and BOR-60 reactors. Analysis of the calculation results and their comparison with the data of the post-reactor fuel rod examination has demonstrated that BERKUT describes satisfactorily the fuel and cladding geometry changes, fission gas release as well as porosity profiles and fission product concentration profiles within fuel pallets.
The calculation results obtained allow to make a conclusion that mechanistic fuel rod codes can be used both for safety justification and to predict ways of achieving the specified fuel rod characteristic.

Country/Int. Organization

Russia, Nuclear Safety Institute (IBRAE RAS)

Author: Dr BOLDYREV, Andrey (IBRAE RAS)

Co-authors: DOLGODVOROV, Alexey (IBRAE RAS); DOLINSKY, Ilia (IBRAE RAS); Dr CHERNOV, Sergey (IBRAE RAS); Dr OZRIN, Vladimir (IBRAE RAS); Dr TARASOV, Vladimir (IBRAE RAS)

Presenter: Mr BOLDYREV, Andrey

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