MODELS DESCRIBING EVOLUTION IN UO_2 FUEL PROPERTIES UNDER IRRADIATION

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The report reviews physical mechanisms and existing theoretical concepts on the evolution of the microstructure and thermo-mechanical properties of UO_2-based fuels irradiated in a nuclear reactor. The main parameters determining the rates of physico-chemical and thermomechanical processes are the temperature and specific fission rate of heavy-atom nuclei in the uranium dioxide fuel.

Modern fuel performance codes take into account the dependence of the thermal conductivity of nuclear fuel on temperature, burnup, porosity, stoichiometry, and the concentration of the dopants. The basic mechanisms of energy transfer in uranium dioxide are considered. Taking into account gas parameters in the fuel-pellet gap, as well as the spatial distribution of the plutonium isotopes build-up, is necessary for calculating temperature distribution. The report presents physical models for evolution of porosity and grain size in nuclear fuel under irradiation. Particular consideration is given to the effect of the formation and growth of a fine-grained rim-layer on the peripheral surface of the fuel pellets when certain burnup values are reached.

Since most of the physical processes in nuclear fuel are interdependent, it is necessary to develop fuel performance codes that are capable of correct modeling of the thermomechanics of fuel rods. The capabilities of the modern RTOP fuel performance code and its applications for the tasks of fuel cycle assessment at NPPs with WWER reactors and justifying the safe operation of nuclear fuel are discussed. In many countries with highly developed nuclear power sector, research and development work is performed to increase safety and economic efficiency in the operation of nuclear fuel, and in subsequent stages of SNF storage and processing. To implement these tasks, modern computer technologies are used and new digital platforms are being developed.

The report presents several computational complexes for solving the problems of operating nuclear fuel, justifying the technology of dry storage of SNF produced in Russia, carrying out design works for justifying and introducing new fuels. These computational complexes are based on the series of RTOP codes, a thermal-hydraulics module and a StatVerSet module for performing probabilistic analysis and estimating the sensitivity of calculation results to the uncertainty of the parameter values.