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A Comprehensive Safety Analysis for a Pressurized Water Reactor Fueled with Mixed-Oxide Fuel as an Accident Tolerant Fuel

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Abstract : The viability of utilising mixed-oxide fuel (MOX) (($U_{0.9}$, rg$Pu_{0.1}$) O_2) as an accident-tolerant fuel (ATF) has been thoroughly investigated. MOX fuel provides the best example of a nuclear waste recycling process. The MCNPX 2.7 code was used to determine the main neutronic features, especially the radial power distribution, to identify the hot channel on which the thermal-hydraulic (TH) study was performed. Based on the computational fluid dynamics technique, the simulation of the rod-centered thermal-hydraulic subchannel model was implemented using COMSOL Multiphysics. TH analysis was utilised to determine the axially and radially distributed temperatures of the fuel and cladding materials, as well as the departure from the nucleate boiling ratio (DNBR) along the coolant channel. COMSOL Multiphysics can simulate reality by coupling multiphysics, such as coupling between heat transfer and solid mechanics. The main solid structure parameters, such as the von Mises stress, volumetric strain, and displacement, were simulated using this coupling. When the neutronic, TH, and solid structure performances of UO_2 and (($U_{0.9}$, rg$Pu_{0.1}$) O_2) were compared, the results showed considerable improvement and an increase in safety margins with the use of (($U_{0.9}$, rg$Pu_{0.1}$) O_2).

Keywords : mixed-oxide, MCNPX, neutronic analysis, COMSOL-multiphysics, thermal-hydraulic, solid structure
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