Modelling Of Fuel Oxidation Behaviour For Defected Fuel

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ABSTRACT

With a defected fuel element, a leak path exists so that coolant can contact the fuel, permitting oxidation of both the fuel and inner surface of the sheath. Since deuterium is a product of UO_2 oxidation by D_2O, the fuel sheathing can also deteriorate as a result of secondary deuteriding.

The objective of the current work is to develop a mechanistic model for prediction of the fuel-oxidation behaviour in operating defected fuel elements in order to better assess the performance of defected fuel. A theoretical treatment has been developed to account for steam/hydrogen transport in the fuel-to-clad gap to provide an estimate of the hydrogen-to-steam partial pressure ratio (i.e., oxygen potential) in the gap. An improved thermodynamic treatment has also been incorporated into the model for describing the equilibrium state of the oxidized fuel (which is used as a boundary condition). The fuel oxidation kinetics model accounts for multi-phase transport including both normal diffusion and thermodiffusion for interstitial oxygen migration in the solid, and gas-phase transport of hydrogen and steam in the fuel cracks. The fuel oxidation model is further coupled to a (time-dependent) heat conduction model. A numerical solution of the coupled transport equations has been accomplished using a finite-element technique with the FEMLAB 3.1 software package.

With the improved numerical framework, both a two-dimensional (azimuthally-symmetric) and complete thee-dimensional model is being developed. The model is therefore able to provide a three-dimensional profile of the oxygen-to-uranium (O/U) ratio in the defective element. The model has been benchmarked against a larger database of O/M profile data obtained with a coulometric titration method, as performed at the Chalk River Laboratories, with pellet samples taken from ten spent defective elements discharged from the NRU and commercial reactors.

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