

CANDU Fuel Element Behaviour Modelling

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The modelling of the behaviour of CANDU nuclear fuel elements under normal and defective conditions has been underway at the Royal Military College of Canada for the past several years. The interrelated heat transport and fission gas diffusion are considered in a physically evolving fuel element, including the effects of grain growth, gap closure, and pellet-sheath interaction. Correlations employed by industry, as well as mechanistic-based considerations are involved.

The effects of a sheathing breach on fuel performance are presently being considered through the introduction of a previously developed fuel oxidation treatment. A separate, stand-alone code with a customised numerical solver is used to predict the fission product inventory and coolant activity concentration in the primary heat transport system. This model has been validated against coolant activity concentration data from operational power reactors. In addition, a mechanistic treatment for the prediction of sheath hydriding in defective elements is presently in an advanced state of development. Furthermore, in the event that linear power ramps may be exceeded during CANDU bundle shifting operations, a phase-field model, incorporating the effects of the non-congruent melting in the case of an oxidized fuel, is used to predict incipient melting.

The systems of highly-coupled time-dependent partial differential equations comprising these treatments are solved primarily using the finite element software package COMSOL Multiphysics, with the intention of providing a platform for research and industrial applications for the design of fuel behaviour experiments and the better prediction of safe operating margins.

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