

ANALYSIS OF THE POTENTIAL FOR FLOW-INDUCED DEFLECTION OF NUCLEAR REACTOR FUEL PLATES UNDER HIGH VELOCITY FLOWS

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ABSTRACT

The University of Missouri Research Reactor (MURR) is one of five High Performance Research Reactors in the U.S. that still utilizes high enriched uranium (HEU) fuel. Currently, a novel LEU fuel is under consideration to replace the current HEU fuel. Questions have been raised about how the thinner laminate sandwich structure of the LEU fuel plates will hydro-mechanically respond under the high velocity coolant flows within the reactor core. If the fuel plates deform such that the flow of coolant is choked off the temperature of a fuel plate could increase enough to cause it to rupture and potentially release fission gas into the coolant system.

The purpose of this research was to develop a set of numerical tools to access the flow-induced deformation of the proposed LEU fuel by coupling the commercial computational fluid dynamics (CFD) code, Star-CCM+, with the finite element analysis (FEA) code, Abaqus to build fluid-structure interaction (FSI) models. In particular, flow-induced deformation was evaluated by taking into account the manufacturing tolerances of the fuel plate assemblies. These tolerances can cause the plates to become offset within the flow channels, causing uneven flow distribution, and a possibility for large plate deformation.

Methods were developed for calculating stable temporal step sizes and for predicting the numeric stability of the FSI models. The results of the stabilized FSI models were then benchmarked against experiments conducted using a hydro-mechanical flow loop. A plan for future experiments and FSI models is also discussed to help facilitate convergence of the experimental data with the model's solution. A successful benchmarking will allow these numerical tools to be utilized in complicated models for qualifying the safe-use of the proposed LEU fuel