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Graduation Term:FS 2015
Department:Mechanical & Aerospace Engineering
Degree:PhD
Title:Development and Experimental Benchmarking of Numeric Fluid Structure Interaction Models for Research Reactor Fuel Analysis

As part of the Global Threat Reduction Initiative (GTRI) reactor conversion program, five U.S. High Performance Research Reactors (HPRRs) are currently studying a novel Low Enriched Uranium (LEU) foil based fuel to replace their current High Enriched Uranium (HEU) dispersion fuel. The proposed fuel uses a monolithic U-10Mo foil meat clad in aluminum, whereas the current HEU fuel meat is comprised of Uranium dispersed in an aluminum matrix, before being clad in aluminum. Along with a change in the physical structure of the fuel, the fuel plate thickness has been significantly decreased. Given that these fuel plates are subject to high velocity coolant flow, these changes in the plate design have led to a need to characterize the structural response of the plates in presence of high velocity flow.
The proposed method for completing this analysis is to use novel fluid-structure interaction (FSI) simulations. These simulations are carried out using commercial CFD and FEA solvers Star-CCM+ and Abaqus, and iteratively coupling their solutions together at the interface between the plate and the fluid. Given the unique nature of these simulations, it is necessary to first benchmark and qualify the codes for this analysis.
To generate benchmark quality data, a flow loop and test section have been constructed for studying plate deflection and channel pressure drop under a variety of fluid flow conditions. Similar experimental analysis which considered equally sized fluid channels has been studied by a number of individuals in the past. The work presented here differs however, by intentionally offsetting the plate and creating fluid channels of different thickness. This offset effectively simulates manufacturing tolerances of a real fuel assembly.
A method for generating ‘As-Built’ numeric models of the experiment geometry is presented. These As-Built numeric models have been shown to dramatically improve matching between experiment and numeric solutions, particularly at low- to mid-range flow rates. At higher flow rates, the experiment exhibited a dynamic ‘snap’ behavior that could not be replicated numerically. Additional interrogation of the boundary conditions revealed a possible explanation for this snap, however numeric methods do not yet exist for recreating this behavior. In earlier works which considered equally sized channels, plate deflection was not examined in detail and was found to be largely unpredictable and reliant upon the manufacturing tolerances of the experiment. In the numeric and experimental work presented here, plate deflection behavior at low to mid-range flow rates is qualitatively consistent with theoretical expectations.