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Project Title

Experimental Validation Data and Computational Models for Turbulent Mixing of Bypass and Coolant Jet Flows in Gas-Cooled Reactors

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ABSTRACT:
Recently selected for prototyping per the Department of Energy's Next Generation Nuclear Plant (NGNP) initiative, the very-high temperature reactor (VHTR) is a Generation IV reactor concept which employs helium as a coolant medium at temperatures up to 1000°C. Within the core of prismatic VHTRs, helium flows through thousands of coolant channels which serve as conduits through vertical columns of active hexagonal fuel blocks. Recent studies have focused on experimental and numerical modeling of the lower plenum where coolant jets enter at different temperatures due to non-uniform heat generation in the core and at different velocities due to flow mal-distribution in the coolant channels themselves. This already complex flow is further complicated by bypass flow through the gaps between neighboring hexagonal fuel columns. However, in order to truly quantify the turbulent velocity and temperature fluctuations in a realistic lower plenum environment, both the mean and velocity profiles and the spectrum of turbulent fluctuations at the jet inlets need to be provided. These will, in turn, depend on the complicated flow paths upstream of the jet (hundreds of coolant channels collating into a single jet which also interacts with core bypass flow). Before any conceptual VHTR design can be successfully implemented, it is critical that the complex interaction between core bypass and coolant jet flows be fully captured and understood. To this end, the proposed work herein aims to provide empirical data and develop properly validated computational models of the thermal-hydraulics phenomena present upstream of the lower plenum inlet for both normal and transient/accident operating conditions. This investigation will provide an unprecedented look into the effect core bypass flow plays on temperature fluctuations within the support structures present in the lower plenum. This work provides a critical link between two heavily investigated areas of the VHTR (active fuel region and lower plenum) and will serve as a benchmark with which to evaluate future numerical thermal-hydraulics models. In addition to bolstering previous understandings of the complex fluid-structure interaction in the lower plenum region, this work will allow for higher fidelity thermal fatigue and failure analyses that couple the reactor core with thermal fluctuations near the support structures.