NUCLEAR ENERGY UNIVERSITY PROGRAMS

Investigation on the Core Bypass Flow in a Very High Temperature Reactor

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Collaborators:
None

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Abstract

Uncertainties associated with the core bypass flow are some of the key issues that directly influence the coolant mass flow distribution and magnitude, and thus the operational core temperature profiles, in the very high-temperature reactor (VHTR). Designers will attempt to configure the core geometry so the core cooling flow rate magnitude and distribution conform to the design values. The objective of this project is to study the bypass flow both experimentally and computationally. Researchers will develop experimental data using state-of-the-art particle image velocimetry in a small test facility. The team will attempt to obtain full field temperature distribution using racks of thermocouples. The experimental data are intended to benchmark computational fluid dynamics (CFD) codes by providing detailed information. These experimental data are urgently needed for validation of the CFD codes. The following are the project tasks:

- Construct a small-scale bench-top experiment to resemble the bypass flow between the graphite blocks, varying parameters to address their impact on bypass flow. Wall roughness of the graphite block walls, spacing between the blocks, and temperature of the blocks are some of the parameters to be tested.
- Perform CFD to evaluate pre- and post-test calculations and turbulence models, including sensitivity studies to achieve high accuracy.
- Develop the state-of-the art large eddy simulation (LES) using appropriate subgrid modeling.
- Develop models to be used in systems thermal hydraulics codes to account and estimate the bypass flows. These computer programs include, among others, RELAP3D, MELCOR, GAMMA, and GAS-NET.

Actual core bypass flow rate may vary considerably from the design value. Although the uncertainty of the bypass flow rate is not known, some sources have stated that the bypass flow rates in the Fort St. Vrain reactor were between 8 and 25 percent of the total reactor mass flow rate. If bypass flow rates are on the high side, the quantity of cooling flow through the core may be considerably less than the nominal design value, causing some regions of the core to operate at temperatures in excess of the design values. These effects are postulated to lead to localized hot regions in the core that must be considered when evaluating the VHTR operational and accident scenarios.