Studies of Deteriorated Heat Transfer in Prismatic Cores Stemming from Irradiation-Induced Geometry Distortion

PI: Brian Williams – Idaho State University

Collaborators: Richard Schultz & Donald McEligot – Idaho National Laboratory

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ABSTRACT

The "bypass flows" in a prismatic gas-cooled reactor (GCR) are of potential concern because they reduce the desired flow rates in the coolant channels and, thereby, can increase outlet gas temperatures and maximum fuel temperatures. In existing literature, bypass flows of 1–30% of the total flow rate have been estimated. Consequently, it is appropriate to account for bypass flows in reactor thermal gas dynamic analyses. To resolve and characterize the prismatic bypass flow fully, at least three research and development (R&D) stages are needed: characterize isothermal bypass flow, characterize heated bypass flow and heat transfer without distorted geometries, and characterize the bypass flow and heat transfer with irradiation-induced distorted geometries. Previous studies in the existing literature have focused on the isothermal bypass flow condition. The objectives of this proposed research are to understand bypass flow and heat transfer fundamentally; develop improved estimates of associated loss coefficients, surface friction and heat transfer for systems and network codes; and obtain related data for assessment of computational fluid dynamics (CFD) codes, which can be employed in predictions for a GCR for normal power, reduced power, and residual heat removal operations. The primary tasks to be completed in order to meet the project objectives are (1) to develop an experiment for measuring flow resistances, loss coefficients, and convective heat transfer in realistic gap configurations in order to provide improved assessment of CFD predictions for reasonable GCR designs over an appropriate range of flow rates, and (2) to employ it to obtain needed measurements. For this purpose, a concentration on "individual" gap geometry is recommended instead of an overall core test. The experiment will focus on heated bypass flow (Stage 2 of the R&D plan), with input from the existing literature and ongoing research in order to account for expected geometry distortions due to irradiation. Parallel tasks, to be performed by the national laboratory collaborator, will be carried out concurrently but will not be considered within the cost-scope of this proposal. These tasks would include assessment of systems code and CFD predictions for flow and heat transfer in comparable geometries by comparison to available measurements and analyses, employment of experimental data from the proposed experiments to assess CFD capabilities in order to provide improved information (e.g., correlations) needed by systems safety codes to treat bypass flows, and improvement of systems safety codes as needed.