Experimentally Validated Numerical Models of Non-Isothermal Turbulent Mixing in High Temperature Reactors

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ABSTRACT

The Very High Temperature Reactor (VHTR) is a Generation IV reactor which currently calls for Helium as the coolant and core outlet temperatures reaching 850°C with future targets of 1000°C. Critical for mission success is the need to address cutting edge performance and safety issues by establishing experimentally validated computational models for use in thermal hydraulics analysis of the VHTR. This proposal focuses on one of the unresolved thermal hydraulics problems known as thermal striping in the lower plenum of advanced gas cooled reactors such as the VHTR. Non-uniform heating and flow maldistribution in the core cause differences in flow rates and exit temperatures from channel to channel. The turbulent mixing of these jets results in temperature oscillations in the flow and on the supporting structure in the lower plenum. The focus of the proposed work here will be to develop a comprehensive, experimentally validated computational framework for the turbulent mixing in the lower plenum. This will lay the groundwork for future incorporation of stress analysis as well as fatigue and failure studies for multiple VHTR components. An additional emphasis is placed on reduced order models of the lower plenum which will help to balance computational expense and accuracy and enable future work in uncertainty quantification.

The primary objectives of the proposed work will be accomplished through CFD modeling and detailed experimental validation on both fundamental (e.g., free jet flow, confined parallel jet flows) and applied (e.g., scaled portion of lower plenum domain) levels. Experimental measurements will be made to characterize full field velocity and temperature. The research team is comprised of members from the University of Pittsburgh, Pittsburgh Supercomputing Center, and Westinghouse Electric Company, and represents a strategic alliance enabling complimentary areas of expertise for successful completion of the project goals. The proposed work also includes formal plans for graduate students to conduct summer and/or regular weekly research onsite at Westinghouse. Faculty at the University of Pittsburgh and Pittsburgh Supercomputing Center will also participate in onsite summer research opportunities. These interactions with representatives from industry having multi-decade experience will allow the generational transfer of knowledge so critical in nuclear related fields and will serve the purpose of training the workforce (graduate students) before they officially enter into their field.