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Experimental and Computational Investigations of Plenum-to-Plenum Heat Transfer and Gas Dynamics under Natural Circulation in a Prismatic Very High Temperature Reactor

PI: Muthanna Al-Dahhan- Missouri University of Science and &Technology

Collaborators: Rizwan-Uddin-University of Illinois, Shoab Usman- Missouri University of Science and Technology, P. Jain- Oak Ridge National Laboratory, Brian Woods- Oregon State Univesity, Finis Southworth- AREVA

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ABSTRACT:

The main objectives of the proposed work are: 1) to develop a unique separate-effects high pressure and high temperature experimental setup that is equipped with sophisticated measurement techniques implemented in a novel way to measure simultaneously or separately heat transfer coefficients and coolant dynamics in scaled down prismatic blocks in reference to HTTF/MHTGR operated under different intensity of natural circulation, 2) to advance and address experimentally and computationally the gaps in scientific and engineering knowledge and understanding about the natural circulation phenomena in the VHTR core. Heat transfer probes along with an array of hot wire probes or thermocouples will provide detailed information about local heat transfer coefficients and temperature field during natural convection operation. Gaseous tracer technique will provide vital global information about gas phase buoyancy-driven behavior, non-idealities such as bypassing, channeling and dead zones, if any in the core. For local information, a hot wire anemometry technique will be used to determine local velocity and its distribution of gaseous coolant in a region of interest in the core; 3) to provide the very much needed experimental benchmark data for verification and validation of CFD and system analysis codes (e.g. RELAP5-3D, Star CMM+, or Fluent) which are being used to analyze gas cooled reactor thermal-hydraulics behavior, to benchmark any system specific correlations and to perform safety analyses and assessment. These codes and models will be validated against the obtained data and will be used to guide the design of the separate-effects experimental setup and the experiments matrix. The experimental and computational uncertainties will be quantified using the recently developed Point- Collocation Non-Intrusive Polynomial Chaos (NIPC) method. This work will complement the capability of the High Temperature Test Facility (HTTF) at Oregon State University (OSU). The relationship of the obtained data to the HTTF/MHTGR will be determined and the extension of the key development and techniques to HTTF will be assessed.