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U.S. Department of Energy

Experimental thermofluidic validation of TCR fuel elements using distributed temperature and flow sensing

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Program: Integrated thermofluidic experimentation and modeling for TCR CT-3.1

ABSTRACT:

This project aims to experimentally measure the performance of additively manufactured components of the Transformational Challenge Reactor (TCR). This goal will be accomplished using the existing high-temperature helium flow loop facilities at the Kansas State University (KSU) and the City College of New York (CCNY). Thermal transport capabilities of the additively manufactured (AM) ceramic core structures will be experimentally measured, and the data generated will be used to qualify computational physics models. KSU has developed an infrared thermal imaging-based measurement technique that will be used to obtain a high-fidelity temperature scan of the TCR fuel elements. Advanced Bragg grating-based flow and temperature sensors, invented by the University of Pittsburgh collaborator, will be embedded in the additively manufactured TCR fuel elements provided by ORNL. Data from specific sensor locations will be overlaid and mapped to the rest of the fuel domain using a graph-based machine learning method previously developed by the KSU team.

High fidelity experimental data are needed for validating safety analysis models for TCR core and for TCR core/component design optimization. The proposed work will undertake forced and natural circulation experimental studies for the TCR core's AM test specimens. The state-of-the-art temperature and flow sensors will be customized, calibrated, and embedded in the test specimens. Instrumented TCR specimens will be placed in the high temperature, helium-cooled, natural, and forced circulation test facilities. The KSU team will conduct high temperature (1100°C) forced flow and depressurized loss of forced cooling (DLOFC) experiments in existing experimental facility. High-resolution thermographic imaging access to the solid fuel test surface is a unique feature of this facility and will allows for monitoring of TCR AM test specimen during the DLOFC event. The CCNY's experimental facility will be operated at prototypical temperature and pressure conditions with helium coolant to obtain convective heat transfer data in the the coolant channel of AM test specimen.

Without any spatial constraints due to their miniature size, the advanced sensors developed by the Pitt Co-PI's team have been demonstrated to operate at high temperatures (above 800°C) and can simultaneously capture flow and temperature data. These sensors are uniquely suitable to measure flow/temperature data in the advanced coolant channel designs as well as temperature data in the solid region of TCR specimens.