CFD and System Code Benchmark Data for Plenum-to-Plenum Flow Under Natural, Mixed and Forced Circulation Conditions

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ABSTRACT:

The collaborative activities will generate Mixed Effects Test experimental data relevant for the complex plenum-to-plenum flow in a gas reactor under loss of flow accident conditions. The work will be focused on strongly heated flow, which is prone to relaminarization as well as instabilities that result from a viscosity that increases with temperature. Given the parallel-path geometry of plenum-to-plenum flow, the changes in flow resistance associated with relaminarization and other property variation effects pose serious challenges for CFD and systems codes. These same physics are not present in light-water reactors, but the same numerical tools are often used to analyze gas reactors nevertheless. Currently, there is a critical gap in available experimental data for validation of such simulations, and the proposed work will fill this gap.

The experiments will be carried out in the USU Rotatable Buoyancy Tunnel, which was originally funded by an NEUP infrastructure grant and is specifically designed for validation benchmark data studies. The unique design of the tunnel allows for both "buoyancy opposed" and "buoyancy aided" flow in the same facility by rotating the entire tunnel 180 degrees. A new test section will be designed and constructed as part of this work that provides three parallel paths of variable size between four heated and highly instrumented plates. A novel experimental technique will be used that provides simultaneous, highly resolved, velocity and temperature field data. With data acquired in this fashion, important contributions can also be made in terms of developing appropriate turbulence and mixing models, where the temperature and velocity fields are tightly coupled. Reynolds-averaged Navier-Stokes (RANS) and large-eddy simulation (LES) models will be constructed, evaluated, and compared against available numerical and experimental data and then validated using the bypass gap width experiments conducted as part of this research. This rigorous validation process will help quantify the ability of the modeling approach to accurately capture the aforementioned complex physics. USU will focus mainly on experiments while TAMU will lead the computational work. These complementary efforts will be highly integrated with personnel from TAMU spending time at USU to collaborate on the experiments.

The outcomes of this work will be a comprehensive data set for natural, mixed, and forced convection conditions applicable to the VHTR, as well as experimentally validated modeling approaches for these scenarios. All data will be online and publically available.