Mixing of helium with air in reactor cavities following a pipe break in HTGRs

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Collaborators:

Program: RC-5: Experimental Validation of High Temperature Gas Reactor Simulations

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ABSTRACT:

The next generation of nuclear power plants, such as HTGRs and Very High Temperature Reactors (VHTRs), has passive safety design features for off-normal operation. However, it is necessary to check the safety system performance by modeling the relevant phenomena computationally using system level or detailed 3D CFD codes, and by conducting separate effects experiments using scaled models to validate the computational results. The main objective of the proposed research is to obtain experimental validation data on mixing of helium and air in reactor building cavities during and after blowdown in High Temperature Gas Reactors (HTGRs), such as a General Atomics 350 MWt MHTGR. Measurements to be conducted include the spatial distributions of ***air and helium concentrations, and gas mixture velocity and temperature fields*** in the simulated reactor cavities. Experimental research will be conducted at City College of New York (CCNY) using an existing helium flow loop as the source of helium at high pressure (7 MPa) and high temperature (500 oC) for injection into reactor cavities. Transient mixing of helium with air inside the reactor cavity will be monitored using oxygen sensors, and gas velocity and temperature sensors distributed throughout the cavity. Experiments will be conducted using different break nozzle geometries and orientations to determine their effects on the spatial distributions of air and helium in reactor cavities under loss-of-coolant accident conditions. Different vent paths will also be tested to understand their effects on gas flow and concentration distributions in the cavities. The experimental data will be included in a V&V database for future validation of HTGR simulation codes. Our collaborator from the UK (University of Sheffield) will conduct numerical simulations using CFD codes including Nek5000 and validate the results using the experimental data obtained at CCNY.

A reactor cavity test facility will be designed, constructed and equipped with advanced instrumentation for measuring the air and helium concentrations, and gas-mixture velocity and temperature fields. The simulated cavities in the HTGR Reactor Building will be designed based on a scaling study using the General Atomics' 350 MWt Modular High Temperature Gas Reactor as the reference reactor. Helium will be discharged from the high pressure/high temperature helium flow loop through a simulated break nozzle into scaled reactor cavities initially filled with air at near ambient pressure and temperature. The reactor cavity test facility will be designed to allow for testing of different helium discharge locations and vent paths. The proposed experiments will be simulated by an analyst at the University of Sheffield in the United Kingdom (UK) who will apply for funding from the Engineering and Physical Sciences Research Council (EPSRC) to perform this US/UK collaboration.