Methods to Predict Thermal Radiation and to Design Scaled Separate and Integral Effects Testing For Molten Salt Reactors

PI: Per F. Peterson, UC Berkeley
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Collaborators: Simo Mäkiharju (co-PI, UC Berkeley); Emilio Baglietto (co-PI, MIT); Charles Forsberg (co-PI, MIT); Yang Zou (foreign partner, Shanghai Institute of Applied Physics)

ABSTRACT:

Molten salts have high potential for use as fission reactor coolants, due to their high chemical stability and heat capacity, low pressure, and capability to retain fission products. Today, multiple start up companies in the United States are pursuing the development of liquid fueled (Terrapower, Terrestrial Energy U.S.A., Elysium, Thorcon) and solid fuel (Kairos Power) molten salt reactors. All of these proposed designs implement passive safety, as have the most recent U.S. light water reactor (LWR) designs (AP1000, ESBWR, NuScale, etc.) The general principals used in code validation for the licensing of passive LWRs can be adapted to model molten salt cooled (FHR) and fueled (MSR) reactors, including the use of Phenomena Identification and Ranking Tables (PIRTs) and the Code Scaling, Applicability and Uncertainty Analysis (CSAU) methodology.

The major problem in applying the CSAU methodology to validating codes for FHRs and MSRs involves the need for molten-salt specific thermophysical property data with quantified uncertainty, along with separate effect test (SET) and integral effect test (IET) data for code validation. In particular, thermal radiation heat transport (RHT) is known to provide a key potential source of scaling distortion in simulant fluid experiments. All halide salts have an absorption band in the infrared with a tail that extends into shorter wavelengths. Absorption and emission at wavelengths in this absorption band, as well as at wavelengths where contaminants absorb, results in RHT.

No established methodology exists to scale SET and IET experiments for FHRs and MSRs, nor to systematically identify and quantify scaling distortions. The lack of an established methodology creates significant technical risk for FHR/MSR vendors preparing license applications that use code results validated by simulant fluid experiments.

This project involves four key tasks, to perform experiments with molten salts to measure molten salt IR absorption properties, to apply multi-physics simulation to quantify RHT for key FHR/MSR geometries and operating conditions, to develop and test a rigorous scaling methodology for the design of SET and IET experiments, and to demonstrate the application of the methodology in scaled experiments to study molten salt heating phenomena using simulant fluids. By performing these tasks, this project directly addresses MSR Scope RC-4.3.