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U.S. Department of Energy

Radiative Heat Transport and Optical Characterization of High Temperature Molten Salts

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Program: Program Supporting: Nuclear Reactor Technologies: Molten Salt Reactor (MSR) Scope (RC-4.3)

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ABSTRACT:

The goal of the proposed research is to experimentally investigate radiative heat transport in molten salts, and to add functionality to a thermal-hydraulics system code for radiative heat transport in participating media. This work has direct applicability to molten salt reactors (MSRs), and salt-cooled reactors (FHRs).

This project will generate the much-needed measurements of molten salt optical properties in the infrared, and will establish a user facility in which fuel-bearing salts can be analyzed. It will also include measurements of the high-temperature emissivity of solid materials immersed in salt. Establishing the capability for infrared spectroscopy of molten salts will also further the development of *in-situ* optical sensors to measure molten salt composition, temperature, and other thermo-physical and physico-chemical parameters. The prioritization of the salts, solids materials, and salt impurities to be used for measurements will be done with input from our industry collaborators.

Thermal-hydraulic data from a natural circulation and a forced-circulation flibe loops will be obtained. Analysis of this loop data will be conducted with the use of computational fluid dynamics (CFD) models that incorporate radiative heat transfer in molten salts. The construction and operation of these salt loops continues to build infrastructure in the United States to aid the development of molten salt reactor technology, trains students in the proper techniques to handle molten salts, and expands the thermal hydraulic database on high-Prandtl-number fluids at high temperature. In addition, these loops will help to develop and assess components and instruments, including a hermetically sealed pump, pressure transducers, and the use of novel spatially resolved fiber-optic temperature sensors for use in high-temperature salt loops.

Closure models for the implementation in thermal-hydraulic system codes of radiative heat transfer in the molten salt participating media will be proposed, based on emissivity data from the infrared measurements, and on heat transfer data from the molten salt loops, in conjunction with CFD models. This data will be used for calculation of scaling distortions between flibe and low-temperature simulant fluids, and between flibe and other salt melts; a list of other molten salt melts to be included in this analysis will be generated with input from the industry collaborators. Modules will be developed in the MOOSE-based code SAM to incorporate the proposed closure models. The capabilities of the SAM module will be demonstrated using a test problem provided by one of our three industry collaborators.

CFD code-to-code comparison exercises will be performed, in collaboration with two of our industrial partners, with definition of a simple benchmark problem for radiative heat transport in molten salts; a key purpose of these exercises is the exchange of knowledge and experience with the industrial collaborators, by engaging them in analysis with a tool of their choice.

In summary, the proposed project will generate critical data, establish valuable infrastructure, train students in experimental methods, modeling, and theoretical aspects of heat transfer in molten salts, and will benefit companies working to commercialize MSR technology.