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Sodium cooled fast reactor key modeling and analysis for commercial deployment

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Program: RC-3 Computational Methodologies to support design and analysis of sodium-cooled gas reactors

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ABSTRACT:

The sodium fast reactor (SFR) is a leading candidate for the next phase of commercial deployment. However, to license and operate a commercial sodium cooled nuclear power plant, it is vital to ensure its safe operation. There have been several key technology gaps identified for SFRs including thermal stratification, thermal striping, as well as neutronic and thermal-hydraulic coupling for low Prandtl number fluids. The metal-fuel pool-type SFR configuration is the basis of most current designs being considered for potential SFR applications. This type of SFR incorporates within the sodium pool the primary coolant pumps, and the intermediate heat exchangers, and precludes below core level penetrations into the pool lowering the risk of loss of coolant accidents. This configuration, however does give rise to possible issues with thermal stratification and the ability to remove decay heat under accident conditions. This proposal will consider several of these issues and will develop high fidelity data, improve computational fluid dynamic calculations for liquid sodium and modify systems codes such as SAM and SAS4A/SASSYS-1 to better address some of these issues.

Overall Project Objectives:

1. Conduct a series of experiments with advanced temperature and fluid measurement instrumentation (optical fibers, ultrasonic Doppler imaging, magnetic flow sensors and hot wires) to obtain high fidelity data on thermal striping and thermal stratification in liquid sodium.
2. Use the STRUCT modeling approach along with URANS methods to analyze the low Prandtl number (sodium) heat transfer, thermal stratification and thermal striping experiments. Data from these simulations will be compared to the experiments and used to help understand the fundamental characteristics associated with the thermal stratification and striping mechanisms.
3. Development of improved models for thermal stratification and thermal striping to be implemented in system level codes such as SAM and SAS4A/SASSYS-1 which currently use weak models not useful for system-wide calculations. These new models would be based on the new understanding gained from the above experiments in concert with the CFD simulations.
4. Train several students in all aspects related to the SFR technology from working with sodium by conducting the experiments, to performing state of the art CFD calculations for the low Prandtl number fluids, and ultimately developing and implementing new models into relevant systems codes.