A Computational-Experimental Study to Simulate Mixing and Thermal Stratification in SFRs

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ABSTRACT:

Thermographic imaging and Ultrasonic Doppler Velocimetry (UDV) techniques will be used to generate high fidelity thermal stratification and flow field data under various geometric and physical conditions for scaled models of outlet plena in sodium-cooled fast reactors (SFRs). These experiments will be aimed to recreate the temporally evolving thermal stratification fronts under forced and natural convection. The existing experimental test facilities at Kansas State University, which are currently used for understanding thermal stratification in packed beds with steam, air and water as heat transfer fluids, will be modified to accommodate the simulant fluid, Gallinstan, which acts as a low melting temperature and inert surrogate for liquid Sodium. Multi-dimensional experimental data on thermal stratification with Gallinstan (Prandtl number ~ 0.04) will be obtained for a scaled model of an outlet plenum in pool type SFRs under transient conditions of different time-scales. These experimental results will provide the validation data for existing computational models. The modeling aspect of this project will be to extend the existing in-house code at University of Illinois, developed and established by carrying out extensive CFD simulations on relatively large scale computing platforms to study mixing patterns and thermal stratification in liquid metals at different flow rates with capabilities of simulating transient behavior. Further natural circulation computations for different scales of the reactor model will be used to examine the mutually coupled effect of thermal stratification on the natural circulation flow rate and decay heat removal capabilities. Results of these experimental and modeling/simulation exercises will be compared with those obtained using 1D codes such as SAS4A/SASSYS-1. Experimentally validated 3D simulation results from the in-house code and Nek5000 will be used to devise a methodology to qualify the results obtained using 1D codes.