Liquid Sodium Stratification
Prediction and Simulation in a Two-Dimensional Slice

Robert Florian Langhans

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Y. Liu, Committee Co-Chair
M. J. Hampe, Committee Co-Chair
J. H. Bøhn
M. Schäfer

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Master Thesis
Co-Advisor Virginia Tech: Prof. Yang Liu
Co-Advisor TU Darmstadt: Prof. Manfred Hampe

Abstract
In light of rising global temperatures and energy needs, nuclear power is uniquely positioned to offer carbon-free and reliable electricity. In many markets, nuclear power faces strong headwinds due to competition with other fuel sources and prohibitively high capital costs. Small Modular Reactors (SMRs) have gained popularity in recent years as they promise economies of scale, reduced capital costs, and flexibility of deployment. One such SMR concept is the small size sodium cooled fast reactor such as the Advanced Fast Reactor (AFR) designed by Argonne National Lab. Fast sodium reactors commonly feature an upper plenum with a large inventory of sodium. When temperatures change due to transients, stratification can occur. It is important to understand the stratification behavior of these large volumes because stratification can counteract natural circulation and fatigue materials.

This work features steady-state and transient simulations of thermal stratification and natural circulation of liquid sodium in a simple rectangular slice using a commercial CFD code (ANSYS FLUENT). Different inlet velocities and their effect on stratification are investigated by changing the inlet geometry. Stratification was observed in the two cases with the lowest inlet velocities. An approach for tracking the stratification interface was developed that focuses on temperature gradients rather than differences. Other authors have developed correlations to predict stratification in three dimensional enclosures. However, these correlations predicted stratified conditions for all simulations even the ones that did not stratify. The previous models are modified to reflect the two-

dimensional nature of the flow in the enclosure. The results align more closely with the simulations and correctly rank the investigated cases.