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Fusion Energy System ARC System Modeling using SAM

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As the push to deploy fusion energy systems continues through public and commercial initiatives, the determination of the design and accident scenarios figures of merit with the highest influence on design and safety is required. Current fusion energy system designs involve either solid or liquid blanket systems that serve the purpose of tritium (fuel) management, neutron multiplication, and heat removal for power conversion. One concept, involving the use of fluoride based molten salts in fusion breeder blankets has become a potential option. This is the Affordable, Robust, and Compact (ARC) energy system that involves a liquid immersion blanket (LIB) design for fuel cycle and heat management. LIBs involve a molten salt (i.e. FLiBe) as the working fluid, coolant, and fuel source in the heat transport system that removes heat from the plasma facing components and blanket components. At the time of writing, a significant gap exists in both systems and component level information for LIBs needed for open-source research and development of different enabling technologies.

To address these gaps, the authors have investigated FLiBe based LIBs using system & component modeling with MOOSE based tools and experimental investigations. The modeling work involves using the US Department of Energy's MOOSE based System Analysis Module (SAM) code developed by Argonne National Laboratory. Leveraging the capabilities for modeling molten salt reactors in SAM, the system behavior of a prototypical ARC LIB has been analyzed for start-up, shutdown, steady state, and pump failure transients for the heat transport systems. For each scenario, the potential for structural failure of plasma facing components and heat transport system components is analyzed to determine inappropriate design choices. In the reported work, we will discuss both operational transients and accident scenarios modeled using SAM and how future coupling with MOOSE tools will be useful for fusion energy system design. Additionally, the authors will discuss how the data produced from this study has provided a foundation for component level studies using other DOE NEAMS tools and experiment efforts.

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