Enhancing Yellowjacket for Modeling the Impact of Radiation and Stress on the Corrosion of Molten-Salt-Facing Structural Components

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ABSTRACT:

There are a number of advanced reactor designs that use molten salt, either as a fuel-bearing solvent salt or as a coolant. However, corrosion directly impacts the lifetime of any molten-salt-facing component in such reactors, include component depletion and void formation. The US DOE Nuclear Energy Advanced Modeling and Simulation (NEAMS) program is employing a multiscale approach to develop the capability to model component corrosion due to molten salt at the engineering scale, including developing the Mole code, a mass transport code that will predict both leaching and deposition, and adding new capability to Grizzly, the NEAMS code for structural component integrity and degradation. In order to account for the impact of the materials' microstructure in these engineering-scale codes, NEAMS is also developing the mesoscale Yellowjacket code. Yellowjacket predicts depletion and void formation due to interactions with molten salt. It explicitly represents the microstructure of the structural material and accounts for the accelerated elemental depletion at grain boundaries and other microstructural features. The results from Yellowjacket will be used to train computationally-efficient surrogate models for use directly in the Mole and Grizzly codes, providing a multiscale means of accounting for the impact of microstructure at the engineering scale.

The goal of this work is to fundamentally advance the capabilities of Yellowjacket and its ability to interface with the Mole and Grizzly codes. We will also validate the new capability added to the codes. We will add the capability to Yellowjacket to capture the impact of stress and radiation on the corrosion of molten-salt-facing structural components and we will add the capability to predict the degradation of the effective elastic constants and yield stress of the structural alloys due to depletion and void formation. In addition, we will develop an approach to create efficient surrogate models from Yellowjacket simulation results that will be implemented in Mole and Grizzly. We will develop surrogate models for the change in the yield stress and elastic constants near the surface of the structural components that will be implemented in Grizzly and a surrogate model of the mass flux into the molten salt for Mole. We will validate the new capabilities in Yellowjacket and the surrogate models for Mole using literature data and using new data specifically for 316H SS in FLiNaK molten salt. 316H SS is an ASME codified alloy and is being considered by multiple molten salt reactor (MSR) manufacturers as the principal salt facing structural material for first generation MSR designs. The new validation data will be obtained from experiments performed in this project that include stress and radiation. These goals are summarized in Fig. 1.

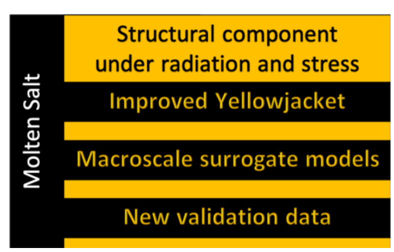

Figure 1: Summary of the goals of this project