In Situ Assessment of Molten Salt Transport into Nuclear Graphite Microstructures using Ultrasonic Sensors

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ABSTRACT:

Understanding the interactions of molten salts with nuclear graphites and the resulting impact on graphite properties is important for the design and operations-monitoring of molten salt reactors (MSRs). Various design concepts for MSRs include graphite as a key structural component of the reactor core. The graphite is essentially surrounded by molten salt during reactor operation, but the nuclear community has limited understanding of the interactions between the salt and graphite, and no concept has been put forward for in-core, sensing or monitoring salt penetration into the graphite. Under the proposed project, a sensor scheme based on ultrasonics will be developed to perform *in situ* measurements of salt intrusion into graphite surfaces. We will develop ultrasonic methods for sensing graphite material property changes, especially elastic modulus variations, associated with intrusion of molten salt into graphite microstructures. This work will assess the role that various graphite microstructural features play in this process as well as the effects of temperature and pressure on the transport of salt. A combination of experimental studies coupled with physics-based simulations will be used to develop strategies for *in situ* sensing of salt intrusion in the reactor environment. We will develop models for the elastic responses of graphite-salt composites and perform experimental investigations to assess their validity under operational pressures and temperatures for the nuclear service environment. Three separate task areas for investigation will be pursued to improve our understanding of salt-graphite interactions:

1. Computational and Experimental Studies of Molten Salt + Graphite Composite Modulus
2. Molten Salt Transport into Graphite Microstructures
3. Ultrasonic Studies of Graphite-Salt Interfacial Regions.

The first area will establish the elastic properties of composites formed by filling pores in graphite with molten salts and will develop baseline properties that can be used in ultrasonic models for graphite-salt interfacial regions. This will require measurement of the elastic modulus of molten salts since extensive studies of salt properties using state-of-the-art simulations have failed to accurately predict their elastic properties. The second area will provide results for the rate of molten salt transport into model systems using buoyancy measurements and will provide baseline data for assessing depths of salt penetration. The third area will establish the overall approach for ultrasonic sensing of molten salt intrusion into graphite and will be used to form sensing strategies that can be used in the reactor environment. Two different sensing approaches will be investigated: 1. Interface reflectivity acoustic spectroscopy, and 2. Scholte wave speed measurements. Both of these approaches have the ability to assess changes in the penetration of molten salts into graphite and can form the basis for sensors that perform real time monitoring of salt migration. This type of sensing is needed to monitor the integrity of the reactor core and will enhance the long-term viability and competitiveness of molten salt reactors that will be entering service.