Bimetallic Composite (Incoloy 800H/Ni-201) Development and Compatibility in Flowing FLiBe as a Molten Salt Reactor (MSR) Structural Material

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ABSTRACT:

Much progress has recently been made on Molten Salt Reactor (MSR) conceptualization and technology development with the strategic support of the Department of Energy (DOE). However, detailed design, assessment of operational functionality, and evaluation of reliability and economics have been hampered by concerns regarding structural material compatibility with the flowing salt. Single alloy candidates may not be optimum choices for both chemical and mechanical reasons. Indeed, none of the commercially available structural alloys are considered to be entirely chemically compatible with hot flowing fluoride salts, because substantial amounts of alloying elements, particularly Cr, are susceptible to dissolution in liquid salts. Adherence to the use of a single alloy may result in unnecessarily restricting the functionality, reliability, and targeted lifetime of MSR systems. Therefore, it is imperative that a material system with the requisite high-temperature mechanical strength and chemical compatibility with flowing FLiBe be developed. The goal of this NEUP is to develop a bimetallic composite, Incoloy 800H/Ni-201, and test it under flowing FLiBe to investigate key high temperature mechanical behavior to support its ASME codification, and to quantify the performance gain of this bimetallic composite over single alloy candidates (Incoloy 800H, Hastelloy N, and SS 316).

The main goal of the proposed project is to develop a new bimetallic alloy (Incoloy 800H/Ni-201) structural material for the MSR, and compare its post-exposure mechanical performance in flowing FLiBe with single alloys SS 316, Hastelloy N, and Incoloy 800H, in the context of ASME codification. The specific objectives of the proposed research are to: (1) fabricate Incoloy 800H/Ni-201 on an industrial scale; (2) evaluate key mechanical performance gains of Incoloy 800H/Ni-201, compared to single alloy candidates (SS 316 and Incoliy 800H), required for the ASME codification; (3) quantify and validate attainable performance gains by using Incoloy 800H/Ni-201 in place of the current single alloy candidates in the context of ASME BPVC codification; and (4) assess the service time extension of key power plant components (i.e., heat exchangers, or pressure vessel) through stress modeling and simulation. This research will establish the scientific foundation of the triad: ‘flow affected alloying element dissolution-microstructure-mechanical behavior,’ in the context of ASME codification.

The performance comparison between our proposed Incoloy 800H/Ni-201 bimetallic composite versus Incoloy 800H, Hastelloy N, and stainless steel (SS) 316 will provide a significantly advanced basis for the strategic selection of material. In addition, each component in the MSR system possesses different coolant velocities. Our investigation on the effect of velocity on the alloy element dissolution will advance material choices for key nuclear components. These findings will enable nuclear engineers to design more detailed power plant operation schemes and economic assessments.