Development and Evaluation of High Temperature Lead-Bismuth Corrosion Facilities for Fast Reactor Material Development

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Liquid metals have been studied since the early development of fission energy as reactor core coolants for fast reactors and accelerator-driven systems (ADS). The fast reactor coolant is appropriately chosen to provide effective heat transfer, without a significant thermalization of the neutron spectrum. Conventional coolants used in these systems are liquid metals (ie. Na, Pb, Pb-Bi). Heavy liquid metals such as lead (Pb) and lead-bismuth eutectic (LBE: 44.5 wt.% Pb and 55.5 wt.% Bi) are considered promising candidates. LBE, due to its lower melting temperature (125°C compared to 327°C for lead), permits lower operating temperatures. Regardless of its use, LBE is extremely corrosive at elevated temperatures (500-700°C) to conventional steels used in reactors. Additionally, flowing LBE introduces more challenges in terms of mechanical, thermal-hydraulics, and corrosion. To address these challenges, Niowave has developed several LBE-based systems which support a growing number of corrosion stations to study materials in these harsh environments.

Niowave has two operational LBE corrosion stations, a stagnant system capable of reaching 700 °C and a flowing station capable of reaching 4 m/s and 500°C. To address high temperature corrosion, the stagnant station was developed using a refractory metal, niobium, instead of stainless steel. Several corrosion experiments have been performed in 700 °C LBE exploring advanced steels and refractory metals in this environment. Niowave's flowing corrosion test station consists of a sealed centrifugal pump and local constrictions exposing samples to 4 m/s LBE up to 500 °C. Niowave is planning to use this work to develop an LBE flowing station capable of reaching up to 700 °C and 5 m/s to expose advanced materials for the fast reactor community. Additionally, Niowave is also developing a bimetallic structure for high temperature heavy-liquid metal applications using a refractory metal inner protective layer and an ASME-code approved structural material. A prototype bimetallic component was completed in 2018 and tested in stagnant LBE. This presentation will focus on the development and evaluation of stagnant and flowing LBE systems at Niowave as well as future plans and capabilities