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Long term fuel assembly material and hydraulic behavior in HLM systems

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During a series of fuel assembly (FA) tests at the refurbished MEXICO facility at SCK CEN, extensive research was conducted to evaluate the material behavior and performance of heavy liquid metal (HLM)-cooled wire-wrapped fuel assemblies. The primary objective was to assess long-term material compatibility such as corrosion resistance, and thermal-hydraulic behavior under representative operating conditions, which are crucial for the sustained viability of HLM-cooled systems like the MYRRHA reactor.
The experimental setup was designed to replicate MYRRHA's operational parameters, including maintaining an oxygen concentration of 2 x 10^{-7} wt.%, nominal FA inlet flow rates, and thermal-hydraulic conditions to simulate the reactor's maximum cladding temperature. These conditions were maintained over a six-month testing period, effectively simulating two operational cycles. Precise control of oxygen concentration was achieved through advanced cold trap technology, ensuring minimal oxygen variation and stable chemical conditions within the HLM coolant.
Post-experiment material analysis revealed a thin, non-uniform spinel oxide layer on the fuel pin cladding, with an average thickness of approximately 500 nanometers. Minor material degradation was observed, with a maximum damage depth of around 40 microns. These findings suggest that the materials used in the FA exhibit acceptable corrosion resistance under MYRRHA reactor nominal operating conditions.
Key findings from the tests also include the stability of the FA's thermal-hydraulic performance over time, attributed to the controlled oxygen concentration. This resulted in minimal oxide particle formation within the coolant, reducing the risk of oxide deposition/accumulation and its potential impact on FA heat transfer.
Finally, the data collected provide an invaluable dataset for validating numerical simulations related to both chemical and thermal-hydraulic modeling. This validation is crucial for enhancing predictive capabilities and ensuring the accurate assessment of material performance over the reactor's lifecycle, particularly for systems like MYRRHA that rely on heavy liquid metals as coolants.

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