Development of Cladded and Alloy Systems for Short and Long Term Deployment of Molten Salt Reactors

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The liquid fueled MSR is among the advanced reactor concepts being considered for development by the U.S. Department of Energy. Key attributes of this reactor concept include: (i) high degree of passive safety, (ii) atmospheric pressure operation, (iii) high thermal efficiency due to high volumetric heat capacity and thermal conductivity of liquid salts, (iv) lower spent fuel per unit of energy, (v) high solubility of most fission products in liquid salts and (vi) absence of fuel assemblies. Materials selection for liquid fueled MSRs is based on ASME Sec III Div 5 and thus present unique challenges because of the high Cr content of current qualified alloys. Consequently, and considering the short-term deployment of MSRs, it is necessary to independently improve corrosion resistance of current code codified alloys by surface treatments. On the other hand, if one considers long-term deployment of MSRs, novel code certified alloys would need to be developed. Indeed, although Hastelloy-N, a low Cr, high Mo alloy developed during the MSRE program, has shown remarkable corrosion resistance in molten fluoride salts, this alloy has limited creep-rupture strength, irradiation damage resistance and has shown corrosion induced embrittlement. Consequently, this study focuses on the down-selection of a series of cladded 316H stainless steels (SS) and novel alloys based on corrosion resistance in molten FLiNaK at 700°C for up to 1000 hours. Cladded systems include Ni weld-overlays, Ni electroplating and Mo cladded 316HSS, while novel alloy systems include TZM as well as carbide and solid solution strengthened Hastelloy-N. Hastelloy-N and 316HSS corrosion in the same conditions serve as a reference baseline to assess the improved corrosion resistance of these new cladded and alloy systems. In addition, the exposure of Hastelloy-N to FLiNaK will be monitored using electrochemical techniques to observe Cr depletion from the alloy and dissolution in the salt in-situ. Finally, since these corrosion tests are performed in static capsules, specific separate effects experiments are conducted to assess the influence of the capsule/sample materials couple on mass transport, which would affect corrosion results. Weight gain and SEM/EDS characterization data after salt exposure will be presented on these systems.