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Corrosion Study of an Oxide Dispersion Strengthened Nickel-based Superalloy in a High Temperature Li_2O/LiCl Molten Salt under Oxidizing Conditions

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The Argonne Chemical Engineering Division is investigating advanced structural materials for the electrolytic reduction of spent oxide nuclear fuel in a molten salt electrolyte. The electrolytic reduction process involves the liberation of oxygen in a molten lithium chloride (LiCl) electrolyte, which results in a chemically aggressive environment that is too corrosive for typical structural materials. Nevertheless, the electrochemical process vessel, structural cell components, and the electrical supply materials must each be resilient in the presence of oxygen, the molten salt components, and various impurities at ~ 650ºC to enable high processing rates and an extended service life. A principal objective of this effort was to assess and select commercially available candidate materials for service in the electrolytic reduction process vessel. Alloys were chosen for this study based on their expected performance under the process-simulated conditions of up to 6% lithium oxide (Li_2O) in LiCl molten salt, a temperature range of 625°C to 725°C, and up to 10% oxygen in argon sparge gas.

This study evaluated 9 different commercially available Ni-based alloys and 2 nickel base metals chosen on the basis of high temperature performance, strength, and compositional compatibility with the expected conditions. By immersion corrosion testing in our specially designed apparatus that allowed for individual testing of each alloy, we eliminated those alloys which were the most susceptible to corrosion under the expected operating conditions.

Inconel MA754 is a mechanically alloyed oxide dispersion strengthened nickel-based superalloy. It is one of the alloys that formed the most continuous, most dense, and most adherent corrosion scale compared to other metal alloys tested under the anticipated actual conditions. After preliminary testing, a more detailed corrosion study was undertaken with selected parameters relevant to anticipated actual use. The parameters were: O_2 gas concentration in the argon gas (5% and 10% O_2), flowrate of the O_2/Ar gas mixture (2 and 33 mL/min), and duration of tests (3 and 9 days). Mass loss based on weight change and dimensional area, as well as thickness of the corrosion scale, was used to assess alloy performance.

The results for Inconel MA754 will be discussed as well as microstructural changes associated with corrosion, probable corrosion mechanisms, and those alloying agents related to corrosion resistance.

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