A study of stainless steel as a material of construction for a molten salt reactor

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Abstract

The aim of this work was to investigate the corrosion of stainless steel within a molten salt, with the possibility that it could be used as a construction material within a molten salt fuelled nuclear reactor. Four different metal compositions were used; stainless steel 316L, stainless steel 304L, LDX2101 and iron, and these were tested in two different molten salts, LiCl-KCl-NaCl and KCl-NaCl at 600 and 750°C. Stainless steel 316L was tested for one day, one, three, four and six weeks. The samples were analysed using SEM/EDX and XRD. It was found that in general, a lithium containing spinel formed on the surface of the stainless steel, $LiCrO_2$, with a large percentage coverage. As immersion time increased the bulk also showed signs of attack. The three week test showed the formation of five different corrosion products and analysis suggests they are a combination of numerous mixed oxides. The three week test was subsequently repeated and showed the formation of a lithium containing spinel as observed in the one week test.

Further testing investigated the role of lithium in the formation of the protective layer, a $LiCrO_2$ layer formed on stainless steel 316L in the presence of a ternary salt, whereas mixed oxides were generally observed in the binary salt. Again an anomalous result was obtained in the three week binary test, where a tabular crystal containing sodium iron and oxide was formed.

Finally compositional changes were examined, and the subsequent effect they had on the corrosion layer. It was found that increasing the chromium content does not necessarily increase the surface coverage and it is likely that other elements aid in the formation of the protective layer.

From the results obtained in this work it is possible that with extensive research a stainless steel, which has been specifically designed, could be utilised within a molten salt reactor.

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