

15. Nuclear Corrosion

Effects of steam injection parameters on high temperature steam oxidation behavior of PEO-coated zirconium alloy

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Abstract The evaluation of high-temperature steam oxidation performance of zirconium alloys is important in predicting their behavior under loss of coolant accident (LOCA) conditions and improving the safety of nuclear power plants. It is meaningful to explore critical steam injection conditions without steam starvation in order to reduce the tentative oxidation tests of Zr alloys before the reasonable steam injection parameters are chosen. In this work, a compact oxide coating of 7 μm thick on ZIRLO zirconium alloy was fabricated by plasma electrolytic oxidation (PEO). The effects of steam concentration and flow rate with Ar carrier gas on the steam oxidation behavior of PEO-coated ZIRLO alloy at 1000 $^{\circ}\text{C}$ and 1200 $^{\circ}\text{C}$ were evaluated by thermogravimetric analysis (TGA). The morphologies, compositions, phase constituents before and after the steam oxidation were characterized. The hydrogen depth distribution after steam oxidation was measured. It is found that the critical steam concentration without steam starvation for PEO-coated ZIRLO alloy at 50 ml/min flow rate is 35% at 1000 $^{\circ}\text{C}$. Meanwhile, the critical flow rate at 50% steam concentration is 35 ml/min at 1000 $^{\circ}\text{C}$ and 150 ml/min at 1200 $^{\circ}\text{C}$. A dimensionless number ($P=39$) is suggested corresponding to the critical steam concentration and flow rate. It means that the minimum mass of steam injection is about 39 per unit mass gain of sample, in order to avoid the steam starvation for Zr alloys after 3600 s steam exposure. The steam oxide layers consist of monoclinic zirconia ($M\text{-ZrO}_2$) and a little tetragonal zirconia ($T\text{-ZrO}_2$) phase at different temperatures, steam concentrations and flow rates.

Keywords ZIRLO zirconium alloy, steam oxidation, Plasma electrolytic oxidation, Steam starvation.

Reference

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