

Effect of Si, Mn, Ti and Ce on oxidation behaviour of Fe-20Cr alloy in water vapour at 750°C

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Abstract Water vapour is commonly present in some important industrial processes. It is generally recognized that water vapour will accelerate alloy oxidation. However, the effect of minor alloy elements on oxidation behaviour of chromia-forming alloys in water vapour is still unclear. This work investigated the oxidation behavior of Fe-20Cr and Fe-20Cr alloy doped with 1 Si, 2Mn, 1Ti, and 0.1Ce (wt.%) in Ar-5H₂O and Ar-20H₂O at 750°C for up to 300h. The reacted samples were analysed by weight gain kinetics, optical microscopy, X-ray diffraction, scanning electron microscopy, and Raman spectroscopy.

Fe-20Cr exhibited rapid breakaway oxidation, resulting in the formation of a thick Fe-rich oxide scale and inner layer of FeCr₂O₄ spinels. The addition of Ti, Si, Mn, or Ce significantly improved the oxidation resistance by reducing weight gain kinetics. Fe-20Cr-1Ti formed mainly protective Cr₂O₃ scales with needle-like Ti-rich precipitates underneath the chromia layer. Fe-20Cr-2Mn formed a thin and adherent duplex scale mainly consisting of Mn₂O₃, MnCr₂O₄, and Cr₂O₃ layers. Fe-20Cr-0.1Ce also exhibited protective behavior, forming a Cr₂O₃ layer. There was no Ce external oxide formation, but some Ce-rich precipitates appeared in the alloy matrix. Fe-20Cr-1Si performed best in all these alloys, showing the lowest oxidation kinetics in both water vapor atmospheres. However, the formation of SiO₂ led to the decreased adhesion of the oxide scale and the onset of scale spallation.

Increasing water vapour from 5 to 20 vol% slightly increased weight gain kinetics of all alloys and promoted external iron-rich nodule/scale formation for the alloys doped with Ti, Mn, and Ce. The effects of alloying elements and water vapour content on Fe-20Cr oxidation were discussed based on their influences on diffusion in the oxidation process.