

A Microstructural Study of the Oxide Scale Formation on ODS Fe-13Cr Steel, D.T. Hoelzer, B.A. Pint, I.G. Wright (Oak Ridge National Laboratory)

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Extended Abstract

The high-temperature oxidation behavior of an Y_2O_3 -oxide dispersion strengthened (ODS) Fe-13Cr steel was investigated in air at temperatures of 700°, 800°, and 900°C for 10,000 h. The specimen-only mass gains shown in Figure 1 indicated that the oxidation closely followed a parabolic rate law at each temperature and that the oxidation rate was lower than other studies based on shorter test times. Oxidation at 700°C and 800°C resulted in very low mass gains and intermediate mass gains at 900°C due to CrO_3 evaporation. Parabolic rate constants were derived from the kinetic data for the ODS Fe-13Cr steel.

The microstructural analysis of the oxide scales formed at 700° and 800°C was conducted using cross-section light microscopy and analytical electron microscopy (AEM) using cross-sectional thin foils; at the time of reporting, the 900°C specimen was not ready for characterization. The surface scales that formed on the ODS Fe-13Cr steel during oxidation at 700°C and 800°C were relatively uniform in thickness and adherent to the steel. In general, the scale thickness was $<1\mu m$ at 700°C and $<5\mu m$ at 800°C. The AEM analysis showed that the main scale was a continuous Cr-oxide and that an underlying amorphous silica layer formed at both temperatures, despite the low Si content (0.05wt.%) in the alloy. The surface scales consisted of $(Fe,Cr)_3O_4$ at 700°C and Cr_2O_3 (chromia) at 800°C. The underlying silica layer was nearly continuous but showed that areas of contact still existed between the Cr-oxide scale and steel. The silica layer was non-uniform in thickness and the thickness depended on the oxidation temperature; the layers were $\sim 0.3\mu m$ at 700°C and $\sim 0.9\mu m$ at 800°C.

The excellent oxidation behavior of the ODS Fe-13Cr steel could not be attributed solely to the formation of a continuous Cr-oxide surface scale at all temperatures, since the oxidation rates were found to be significantly slower than expected for rate control by a chromia scale. Two possible factors could have influenced the scale formation and kinetics of oxidation at 700°C and 800°C; the Y-oxide dispersion and the silica layer. The dispersion of small stable Y-oxide particles resulted in a fine grain microstructure which allowed rapid diffusion of Cr by grain boundary diffusion to the surface where it could react with O to form the Cr-oxide scale. The formation of the silica layer acted as a diffusion barrier to inward migrating O and outward migrating metallic elements such as Fe and Cr.

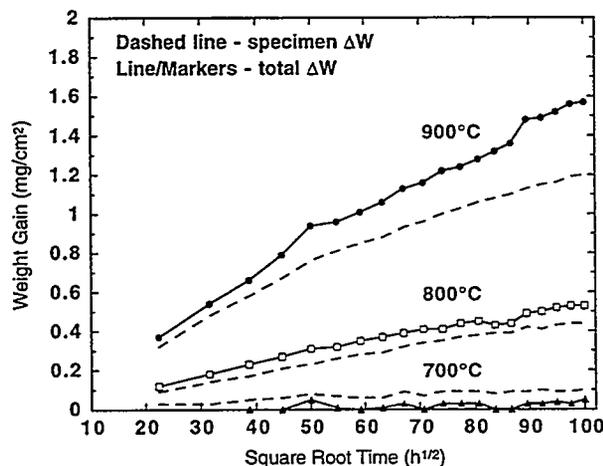


Figure 1. Parabolic plot of weight gain against the square root of time at each temperature.