High-temperature oxidation and sulfidation studies were conducted on an oxide-dispersion-strengthened alloy of composition Fe-20Cr-16Ni-4Al-1Y₂O₃. The oxidation studies were conducted in air and low-PO₂ environments over a temperature range of 650-1200°C. Results are also reported on the sulfidation resistance of preformed oxide scales and the influence of reoxidation of preformed sulfide scales. Detailed microstructural results and x-ray diffraction analysis data are presented to substantiate the corrosion behavior of the alloy over the wide range of conditions anticipated in fossil-energy systems. Data are also presented on the corrosion behavior of the alloy in oxygen/sulfur mixed gas atmospheres, and the results are used to compare the corrosion behavior of the present alloy with other chromia- and alumina-forming alloys.

KEY WORDS: oxidation; sulfidation; mixed-gas environment; oxide-dispersion-strengthened alloy; yttria addition.

INTRODUCTION

Profound interest has been shown in recent years in the development of oxide-dispersion-strengthened (ODS) alloys for their exceptional creep resistance, high strength, and oxidation resistance at elevated temperatures. The mechanism of dispersion strengthening with suitable stable oxide particles offers the possibility of increasing the high-temperature strength of corrosion-resistant alloys without an associated loss in surface stability. The surface stability may include resistance to oxidation, sulfidation, and attack.

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by molten salts or ash. These processes are encountered in many industrial operations, such as the processing of glass and refractory ceramics, and in furnace atmospheres and gas turbine engines.

Extensive literature is available on the preparation of ODS alloys. The techniques of mechanical alloying and hot extrusion of powders are employed for the fabrication of oxide-dispersed alloys. Commercially available heat-resisting alloys are classified into two broad families—namely, ferritic and austenitic, depending on their crystal structure. The ferritic Fe–Cr–Al alloys, in addition to their lower raw material cost and generally superior oxidation resistance, have a higher melting point, lower density, and a lower coefficient of thermal expansion than the Ni- and Co-base alloys. However, their body-centered cubic structure renders them mechanically weak and provides poor creep resistance and a strong susceptibility to low-temperature brittleness. The more ductile and more creep-resistant austenitic Fe–Cr–Ni–Al alloys owe their ability to withstand high-temperature oxidation chiefly to their development of adherent oxide scales.

A considerable number of papers have been published over the past 15 years on the influence of oxide dispersions on the oxidation/corrosion resistance of Ni-, Co-, and Fe-base alloys. High-temperature oxidation studies conducted on Fe-base alloys containing oxide dispersoids generally reveal improvements in terms of scale adherence and oxidation resistance when compared with those without dispersoids. In a typical case represented by Fe–20Ni–25Cr–5Al–Y alloy, the alumina scales contain a certain amount of spinel, and Y enters via solid solution in the alumina layer, which seems responsible for improved adherence of the scales. A study on the effect of doping on the oxidation behavior of ferritic Fe–6Al–M and austenitic Fe–27Ni–4Al–M alloys (where M = Ti, Zr, V, Nb, W, B, Si) in H₂/H₂O atmospheres (PO₂ = 10⁻¹⁹ atm.) at 1000°C shows badly adherent scale layers with most of the dopants. However, on alloys with additions of 0.1 to 1.0 wt.% Ti, Zr, V, or Y, the oxide layers are fine-grained and adhere well. Ti-doped alloys show very protective layers due to the formation of a Ti(C, O) layer beneath the α-alumina.

There are several theories to explain the beneficial role of rare earths, other reactive elements, or dispersion of stable oxides in greatly improving the high-temperature oxidation resistance of alloys. Whittle and Stringer extensively reviewed the earlier studies on the subject and discussed at length the merits and drawbacks of various theories/models. Two major effects induced by the reactive elements or dispersion of stable oxides are improved adhesion between the scale and the substrate (which leads to better corrosion resistance under thermal cycling conditions) and, in some cases, reduction of the actual growth rate of the oxide. Of the various models, the most significant are based on mechanical keying of the surface