CONTEMPORARY METALLIC MATERIALS

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Chapter 017

Measurement of Oxygen Permeability in Bulk Alloys by Internal Oxidation of Dilute Constituent

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Keywords: Oxygen permeability, Ferritic Fe alloys, Internal oxidation, Metal-oxide interface.

Abstract: The oxygen permeability of Fe based binary alloys has been studied by means of internal oxidation of dilute constituents. The concentration of alloying elements and the shape of precipitated oxides affect the calculated oxygen permeability. It is demonstrated that higher amount of metal-oxide interface increases the oxygen permeability. It is understood that metal-oxide interface provides fast path for oxygen to diffuse.

Introduction

Internal oxidation is a phenomenon where dilute alloy constituent forms oxide in the metal matrix. It is of important in high temperature, and may alter the properties of the alloys. Wagner [1] has quantitatively analysed the formation of internal oxidation in binary alloy, and proposed the conditions in which oxides are form internally. It is experimentally observed that the growth of internal oxidation zone (IOZ) follows basically the parabolic rate law.

$$x^2 = 2K_p t \qquad (17.1)$$

where x is the depth of IOZ, t is the oxidation time and k_p is the parabolic rate constant. The parabolic rate constant could be determined from the slope of figure depth of IOZ versus oxidation time. The parabolic growth of IOZ indicates that diffusion is the rate controlling process.

Wagner [1] has proposed theoretical expression for the kinetics of internal oxidation. In case of Fe-Cr alloys;

$$x^2 = \frac{2N_O^{(s)} D_O}{\nu N_{Cr}} t \qquad (17.2)$$

where N_{Cr} is the original concentration of Cr. From equations (17.1) and (17.2), it is well understood that the parabolic rate constant, k_p is proportional to the oxygen permeability, $N_O^{(s)} D_O$. In this way, the permeability of oxygen in α-Fe in could be determined. Figure 17.1 shows the schematic diagram of the formation of internal oxide and external scale in Fe-Cr alloy. If Cr concentration in Fe-Cr alloy is low, then the internal precipitates of Cr_2O_3 in the alloy matrix (Figure 17.1(a)). From the equation (17.2), the growth rate of IOZ is decrease with the increase of Cr concentration in the alloy and the decrease of oxygen permeability, $N_O^{(s)} D_O$ in the alloy. By increasing the Cr concentration, the outward flux of Cr in the alloy is