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Abstract

Metal oxidation is sustained by continuous diffusion of ions in the scale layer. At the same time, stresses are induced in the scale layer and the base metal due to internal oxidation and volumetric change when metal ions are oxidized. Such stress may in return affect the diffusion of ions in the oxide layer, thus changing the oxidation kinetics. In this paper, a continuum thermodynamic model is developed to account for such stress–diffusion interaction in the oxidation of Cr–Fe alloys. The model predicts that the compressive stress in the scale layer has a rather nonlinear distribution across the layer thickness with its maximum at the metal–scale interface. Such stress significantly slows down the rate of oxidation. Consequently, the growth kinetic is not strictly parabolic. It is found that the distribution of stress and diffusive ions in the scale layer can be normalized by the oxidation rate constant so that, with proper scaling, the numerical solutions given in this paper are applicable to any value of the rate constant.

Keywords

Cr–Fe alloys, Oxidation, Stress, Couple