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Electrochemical Monitoring of Oxygen Potential on Fe-Cr Alloy Surface During High Temperature Oxidation in Dry and Humid Conditions

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Abstract

The formation of an external Cr2O3 scale is important to obtain the oxidation resistance of Fe–Cr alloys at high temperatures. It is well known that the critical concentration of Cr to form a protective external scale of Cr2O3 in humid conditions is higher than that in dry conditions, and the criterion is expressed as Wagner's equation (Rapp in Acta Metall 9:730, 1961) [1]. A lot of mass gain data and metallographic surveys are required to determine the above criterion experimentally. A method of continuous monitoring of surface oxygen potential by oxygen concentration cell using stabilized zirconia has been applied to the oxidation of Fe-Cr alloy in order to check the protectiveness of the scale. The objective of this study is to measure surface oxygen potentials on Fe-0-17 wt% Cr alloys in Ar-21% O2 gas in dry condition and Fe-10-22 wt% Cr alloys in Ar-20% O2-20% H2O gas in humid condition at 1073 K up to 20 ks. In dry condition, the surface oxygen potentials of Fe with more than 10 wt% Cr alloys were close to the oxygen potential of the atmosphere immediately after the heating period. It indicates that a protective Cr2O3 scale formed on these alloys at the early stage of oxidation. However, the surface oxygen potentials of these same composition alloys were lower in humid conditions than that in dry, which suggests a higher oxidation rate. This paper demonstrated that the protectiveness of scales formed on Fe–Cr alloys can be evaluated in situ in a few hours, which is beneficial to assess the high temperature oxidation of metals. © 2023, The Author(s), under exclusive license to Springer Nature Singapore Pte Ltd.

Author Keywords

High temperature oxidation; Oxygen sensor; Surface oxygen potential

Index Keywords

Binary alloys, Chromium alloys, Iron alloys, Oxidation resistance, Oxygen sensors, Zirconia; Cr alloys, Critical concentration, Dry condition, Electrochemical monitoring, FeCr alloys, Highest temperature, Humid conditions, Oxygen potential, Surface oxygen, Surface oxygen potential; Thermooxidation

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