Elevated Temperature phase transition and grain growth study of Al Hot Dipped Fe-2.25Cr-1.6W-0.1Mo Steel during Oxidation

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Low alloy ferritic (2.25Cr-1.6W-0.1Mo)wt.% steel is used for pipelines of power and petrochemical plants owing to its superior high-temperature strength and creep resistance. It was developed based on (2.25Cr-1Mo in wt.%) steel by replacing Mo with W partially and micro-alloying with V, Nb, and B while reducing carbon to increase mechanical properties and weldability. However overall oxidation resistances of 2.25Cr-1Mo and 2.25Cr-1.6W-0.1Mo steels are poor mainly due to their low Cr concentrations. To increase their service life and operating temperature for efficiency, hot-dip aluminizing has emerged as a promising cost-effective, convenient coating technique having excellent adhesion strength for the substrate. It was hot-dip aluminized and oxidized from 700-1000 °C for up to 20 h in the air in order to find the effect of aluminizing on microstructure, hardness, and oxidation resistance of 2.25Cr-1.6W-0.1Mo steel. Specimens were inspected with an optical-microscope (OM), a high-power X-ray diffractometer (XRD) equipped with Cu-Kα target at 40 kV and 150 mA, a field-emission scanning-electron-microscope (FE-SEM) equipped with an energy-dispersive-spectrometer (EDS), and a field-emission electron-probe-microanalyzer (FE-EPMA). Microhardness was measured using Vickers microhardness. Aluminizing effectively increased the oxidation resistance of P23 steel by forming protective α-Al_2O_3 scales. During oxidation, outward diffusion of substrate elements and inward transport of Al and oxygen occurred simultaneously. Oxidation and interdiffusion formed voids in the coating, lowered microhardness, and transformed original (Al-rich topcoat)/($Al_{13}Fe_4$-layer) to (thin α-Al_2O_3-scale)/(Al_5Fe_2-layer)/(AlFe-layer)/($AlFe_3$-layer)/(α-Fe(Al)-layer) at 700-800°C and (thick α-Al_2O_3-scale)/($AlFe_3$-layer)/(α-Fe(Al)-layer) at 1000 °C. At 900-1000 °C, Fe_2O_3 also formed in addition to α-Al_2O_3 scale owing to the enhanced outward diffusion of Fe, and the generation of cracks in the coating was suppressed.

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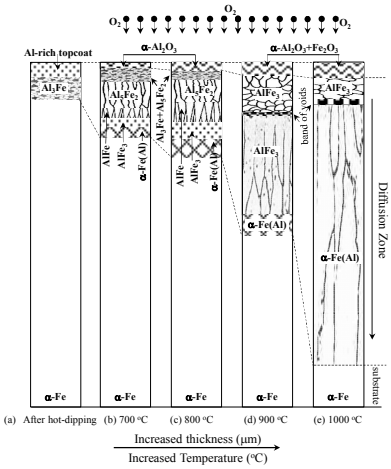


Figure. Schematic diagram showing the phase transition and coating thickness variation of Al hot-dipped 2.25Cr-1.6W-0.1Mo steel. (a) before oxidation, and after oxidation for 20 h at (b) 700 °C, (c) 800 °C, (d) 900 °C, and (e) 1000 °C.

Recent Publications

1. ***Abro M.A***, Hahn J, and Lee D.B (2018) High-temperature Oxidation of Al Hot-dipped 2.25%Cr-1%Mo Steel, Korean Journal of Metals and Materials 56:350-359.
2. ***Abro M.A***, Hahn J, and Lee D.B (2018) High-Temperature Corrosion of CrAlSiN Thin Films in N_2/0.1%H_2S Gas, Korean Journal of Metals and Materials 56:272-279.
3. ***Abro M.A***, Hahn J, and Lee D.B (2018) High-temperature Oxidation of Hot-dip Aluminized T92 Steels, Metals and Materials International 24:507-515.
4. Lee D.B, ***Abro M.A***, and You B.S (2017) High-Temperature Oxidation of AZ91-0.3%Ca-0.1%Y Alloys in Air, Metals and Materials International 4:720-725.
5. ***Abro M.A***, and Lee D.B (2017) Microstructural Changes of Al Hot-Dipped P91 Steel during High-Temperature Oxidation, Coatings 7:31.



Biography

Dr. Abro has led research and covered a wide range of research topics with a focus on high temperature and lightweight materials, surface engineering, high-temperature oxidation and corrosion, protective coatings, Tribology, and Nanocrystalline Materials. He holds hands-on working experience on microstructure analysis techniques such as OM, SEM, EDS, EPMA, FIB, TEM, XPS, AES, XRD, etc, and mechanical testing techniques i.e. Nano-indentation, micro-hardness, etc, besides high-temperature oxidation and corrosion measurement such as cyclic thermogravimetry (TGA), high-temperature oxidation and sulfidation analysis, and electrodeposition. He also acts as a reviewer for some international journals. He is teaching courses to undergraduate and graduate students on Materials Science, Manufacturing Technology and Processes, Strength of Materials, and Thermodynamics of Materials. He is also active in international high-temperature oxidation and corrosion and surface engineering activities including visiting professorships, invited/keynote speakers to national and international conferences, the organization of national and international conferences.

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