Nanostructured coatings to protect metallic materials at high temperatures

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High temperature oxidation is one of the main forms of material degradation besides solid particle erosion, phase transformation, hot corrosion, spallation of surface oxide, volatilization etc. Hence, metallic materials exposed to industrial atmospheres should be resistant to attack by the environment and if the component is load bearing, also resist deformation. It is often possible to choose a material with a suitable combination of properties but with increasing mechanical load and chemical severity of the environment, the scope to choose a material with the right combination of properties becomes limited. Designing the material with the right strength to bear the mechanical load and an optimized surface to resist the environment often resolves the problem. In this context, coatings have been widely used to protect metallic components. This paper presents experimental evidence of how the use of nanostructured coatings of: (a) rare earth (RE) oxides increases the high temperature oxidation resistance of chromium dioxide and alumina forming alloys; (b) chromium carbide based coatings enhance the high temperature erosion-oxidation resistance of metallic materials.

Nanocrystalline RE oxide coatings increased significantly the oxidation resistance of Fe20Cr alloy and to a lesser extent the oxidation resistance of Fe20Cr5Al alloy. The RE ion radius played a significant role in affecting oxidation resistance of chromium dioxide forming alloys. The hardness and fracture toughness of the Cr_3C_2-25(Ni20Cr) coatings prepared with milled nanostructured (NS) powders were approximately 26% and 36% higher respectively, compared with those prepared with as-received powders. Furthermore the erosion-oxidation resistance of the NS Cr_3C_2-25(Ni20Cr) coating was over 50% higher than that of the coating prepared with as-received powders at 800 ºC.