Chemistry Department
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The Effect of Rare-Earth Metal Addition on the Oxidation and Hot Corrosion Resistance of Chromo-aluminized Nickel-Base Super Alloy

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By

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Title of M.Sc. Thesis

The Effect of Rare-Earth Metal Addition on the Oxidation and Hot Corrosion Resistance of Chromo-aluminized Nickel-Base Super Alloy

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Statement

This thesis is submitted in partial fulfillment of the M.Sc Degree, Faculty of Science, Ain Shams University.

In addition to the work carried out in this thesis the candidate, **Mohamed Ali Mahmoud** has attended postgraduate studies in the following topics and passed successfully in the final examination in the academic year 2010-2011:

621	Coordination Chemistry
622	Radiochemistry and Separation Techniques
623	Electrochemistry and Electrochemical Analysis
624	Group Theory and Computer Programming
625	Spectroscopic Methods for Structural and Analytical Chemistry
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Abstract

Nimonic 75 alloy was coated with two different types of coatings; Chromo-aluminized coating and Zr-doped Cr-Al coating. Diffusion coating was carried out by pack cementation process at 1000 °C for 8 h. Cyclic oxidation tests of Nimonic 75 and its coated specimens were conducted at 900 °C, 1000°C and 1100°C in air for a total period of 100 h. The structures of the coated Nimonic 75 alloy before and after high temperature oxidation were investigated using light microscopy LM, scanning electron microscopy/energy dispersive spectroscopy SEM/EDS, and X-ray diffraction XRD characterization techniques. Cyclic hot corrosion tests of Nimonic 75 and its coated system deposited with 2-4 mg / cm² Na_2SO_4 were conducted at 900 °C in air for 150 h at 10 h cycle. The results indicated that Zr-doped Cr-Al coating is expected to be more effective in increasing the oxidation and hot corrosion resistance of Nimonic 75 alloy. The role of zirconium can be attributed to an improvement of the adherence of the oxide scales and reducing voids formation at the coating/metal interface during cyclic oxidation. The parabolic oxidation rate constants K_P for cyclic oxidation of uncoated alloy, Cr-Al coated and Zr/Cr-Al coated are (1.7, 0.77, 0.61) 10^{-6} $mg^2.cm^{-4}.s^{-1}$ at 900°C, (10.08, 5.2, 3.91) 10^{-6} $mg^2.cm^{-4}.s^{-1}$ at 1000 °C and (41.27, 26.69, 18.13) 10^{-6} $mg^2.cm^{-4}.s^{-1}$ at 1100 °C. XRD analysis of the surface of uncoated Nimonic-75 alloy specimen after cyclic oxidation in air at 1000 °C for total period of 100 h identified the presence of Cr_2O_3 and non-protective oxide scale containing NiO and $Ni(Cr_2O_4)$ phases. On the other hand, the XRD analysis of the surface of Cr-Al coated specimen after cyclic oxidation at 1000 °C, for 100 h identified the presence of protective oxide scale containing α-Al_2O_3 and β-NiAl phases. XRD analysis of the surface of Cr-Al-Zr coated specimen after hot corrosion at 900 °C, for 150 h identified the presence of protective oxide scale containing α-Al_2O_3 and β-NiAl phases but Al completely consumed in Cr-Al coating and not appeared Al phases in its XRD analysis.

Keywords: *superalloys, diffusion coating, pack cementation, Zr-doped, oxidation, hot corrosion.*

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Aim of the work

The aim of the present work is to study the effect of simultaneous chromium and aluminum deposition by pack cementation method on the surface structure and composition and high temperature oxidation and hot corrosion resistance of NIMONIC-75 Ni-base superalloy. The effect of Zirconium reactive element addition on the surface modification of the coating layer, and the improvement of high temperature oxidation and hot corrosion resistance of the chromo-aluminized Ni-base superalloy was also investigated.

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