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Isothermal Oxidation Behavior of Ni-Based Fe–Ni–Cr Superalloys: Role and Effect of Nb Alloying Element

Abstract

The isothermal oxidation of heat-treated Ni-based Fe–Ni–Cr superalloy at 500 ℃ was studied to further investigate the role and effect of Nb alloying element during oxide scale formation. The Ni-based Fe–Ni–Cr superalloys underwent a heat treatment process at two different temperatures, that are, 950 ℃ and 1100 ℃, for 3 h of soaking time, followed by water quenching. Heat-treated sample at 950 ℃ exhibited fine grain size, while heat-treated sample at 1100 ℃ exhibited coarse grain size. The heat-treated Ni-based Fe–Ni–Cr superalloys were subjected to an isothermal oxidation test at 500 ℃ for 500 h exposure. The oxidized heat-treated Ni-based Fe–Ni–Cr superalloys were analyzed in terms of oxidation kinetic, oxide phase formation and oxide surface morphology. The oxide phases were analyzed by using XRD technique. The surface morphology was examined by using SEM, FESEM and EDX techniques. Both oxidized heat-treated Ni-based Fe–Ni–Cr superalloys' samples followed a parabolic rate law, indicating a diffusion-controlled oxide growth mechanism. Several oxide phases were formed on the alloy surface after exposures at 500 h. The surface morphology of oxidized samples at 300 h exhibited the formation of continuous oxide scale with distributed overgrown Nb-rich oxides. Nb-rich oxides were formed on coarse-grained heat-treated alloys that developed excessively large Nb-rich oxides. This phenomenon will initiate a crack that propagates around the oxide.

Keywords

Fe–Ni–Cr superalloys; Heat treatment; Isothermal oxidation; Ni-based superalloys