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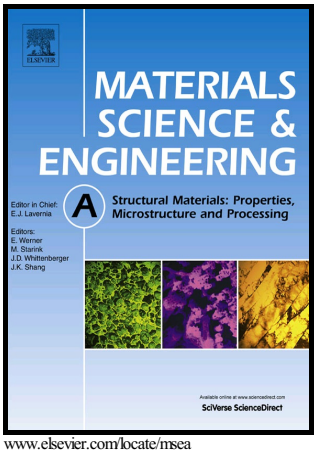

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Effects of pre-treatments on mechanical properties and fracture mechanism of a nickel-based superalloy

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Abstract

The effects of pre-treatments (interrupted and direct water-cooled methods) on the microstructural evolution, mechanical properties and fracture mechanism of a nickel-based superalloy are studied. It is found that the mechanical properties and fracture mechanism of the studied superalloy are sensitive to pre-treatment. The number and size of γ″(Ni_3Nb) and γ′(Ni_3Al) phases rapidly decrease with the increase of interrupted temperature. For the interrupted water-cooled superalloy, when the interrupted temperature is below 705°C, the microhardness is relatively high due to the precipitation of the γ″and γ′ phases. However, when the interrupted temperature is increased from 705 °C to 780 °C, the microhardness dramatically decreases. Meanwhile, the yield strength and ultimate tensile strength also rapidly decrease, while the elongation to fracture sharply increases. Additionally, the fracture mechanism of the studied superalloy transforms from brittle intergranular fracture to ductile transgranular fracture with the increase of interrupted temperature. Compared with the direct water-cooled superalloy, the microhardness, yield strength and ultimate tensile strength of the interrupted water-cooled superalloy are greatly improved when the interrupted temperature is below 780 °C.

Key words: Superalloy; Pre-treatment; Mechanical properties; Fracture mechanism

1. Introduction

Nickel-based superalloys with excellent mechanical properties and good corrosion resistance at high service temperatures are extensively used in aviation and aerospace industries [1-6]. In nickel-based superalloys, γ″ (Ni_3Nb) and γ′ (Ni_3Al) are the primary and secondary precipitation strengthening phases, respectively [7,8]. Additionally, δ precipitate (Ni_3Nb) is the equilibrium substitute of the metalstable γ″ phase [9-14]. It is well known that the mechanical properties of superalloys are significantly affected by the final microstructures [15-17]. Especially, the second phases (γ′, γ″, and δ precipitates) greatly affect the hot deformation behavior and mechanical properties of materials [18-25]. Ye et al. [26] found that the yield strength and ultimate tensile strength of GH4169 superalloy increase, while the elongation to fracture