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Influence of the Ageing Conditions and the Initial Microstructure on the Precipitation of α Phase in Ti-17 Alloy

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Abstract

The precipitation of α phase during ageing was investigated in the near-β titanium alloy Ti-17 considering either a fully $\beta_{metastable}$ initial microstructure or a 35% $\alpha_{primary}$ + 65% $\beta_{metastable}$ initial microstructure. In-situ electrical resistivity and high energy X-ray diffraction measurements revealed the influence of the initial microstructure, with different α morphologies (size and distribution of $\alpha_{primary}$), as well as the heating rate on the precipitation sequences and kinetics following the decomposition of the β-metastable phase. Various amounts of metastable phases ($\omega_{isothermal}$ and $\alpha"_{isothermal}$) precipitate in temperature ranges that increase with the heating rate. From temperatures about 500 °C, the orthorhombic $\alpha"_{isothermal}$ structure evolved towards the hexagonal close-packed α as temperature increased. SEM microstructure characterisations showed that slow heating rates promoted a fine and dense α precipitate distribution through the formation of $\omega_{isothermal}$ and/or $\alpha"_{isothermal}$, leading to higher hardness values. A higher heating rate restricted the precipitation of $\alpha"_{isothermal}$ and shifted to the one of α at a higher temperature, leading to coarser precipitates. Furthermore, precipitation kinetics of $\alpha"_{isothermal}/\alpha$ were quicker considering an initial intragranular α precipitation as compared to α colonies.

Keywords: metals and alloys, phase transitions, crystal structure, microstructure, X-ray diffraction

1. Introduction

Titanium-based alloys provide a very good combination of high specific strength and excellent corrosion resistance which results in a wide range of aerospace applications such as the manufacturing of engine blades, landing gears or pylons [1] [2] [3]. In the aeronautical industry in particular, new environmental targets require weight reductions in structural parts, resulting in the increasing use of these alloys in substitution of stainless steels and nickel-based alloys. As a result of improved engine performances, these parts are exposed to higher operating temperatures that question the microstructural evolutions of near-β alloys, including Ti-17. This class of titanium alloys has been of much interest in the recent past due the refinement of microstructures as compared to more commonly used α/β alloys. This refinement exhibits a much higher strength [4] due to a fine scale distribution of α precipitates in the β matrix, associated with a high density of α/β interfaces [5]. The formation of such microstructures requires the control of the thermal paths and in particular the ageing stage.