doi:10.1017/S1431927619004859
Microsc. Microanal. 25 (Suppl 2), 2019

Analyses of the Morphological Stability of γ' Particles in Turbine Blades Removed from Service Manufactured from a Ni-based Superalloy

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The heat-resistant alloys are of interest for the manufacture of structural components of gas turbines, such as blades [1]. The manufacturing process of blades have evolved in order to improve the resistance to high temperatures for prolonged periods of time, which consequently increases the efficiency of the turbine [2-3]. In this investigation first stage blades of a gas turbine were characterized. The blades were fabricated from a Ni-based superalloy (SA). These superalloys are known for their high resistance at high temperatures and at severe environments of service [1]. The manufacturing method of the Ni-based SA was directional solidification. This method is followed by the application of heat treatments that promote an increase in the mechanical properties of the SA by mean of the precipitation of a hard phase, γ' particles in this case. Different studies have shown that γ' particles have a cuboidal shape aligned along the elastically softest <100> direction [4-5]. The bimodal occurrence of γ' precipitates in Ni-based SA, subjected to different heat treatment conditions, has been identified and has been shown that this occurrence improves the mechanical properties of the SA [2,5]. The bimodal morphology consists of spherical and cuboidal γ' particles and, the size distribution of γ' cuboidal has been identified from 500 to 1000 nm [4-5].

The specimens were prepared from blades, removed from service by preventive maintenance, cutting cross sections of 2x0.8x1 cm. These were characterized by optical microscopy (OM), in a Carl Zeiss model Axiobserver D1m microscope, and by scanning electron microscopy (SEM), in a model JSM-6300 Jeol-Thermo Scientific brand equipped with EDS, after metallographic preparation using Carapella as attack reagent [6]. High resolution SEM (HR-SEM) was also performed. Image-J software was used to identify the average size of γ' precipitates.

Figure 1 (a-c) shows the micrographs obtained. Clearly, particles of γ' cuboidal can be identified on the γ-matrix and carbides of the MC type. All these microconstituents are expected in Ni-based SA [2,5]. In Figure 1(c) is evident that γ' particles show a bimodal occurrence, in spite of the blades were removed from service, and the average size of γ' cuboidal was approx. 658 nm, Figure 2. An element-imaging SEM analysis of the Ni-based SA is shown in Figure 3, and it is in agreement with the microconstituents before mentioned. Thus, these results confirm the high dimensional stability and morphological of γ' particles.

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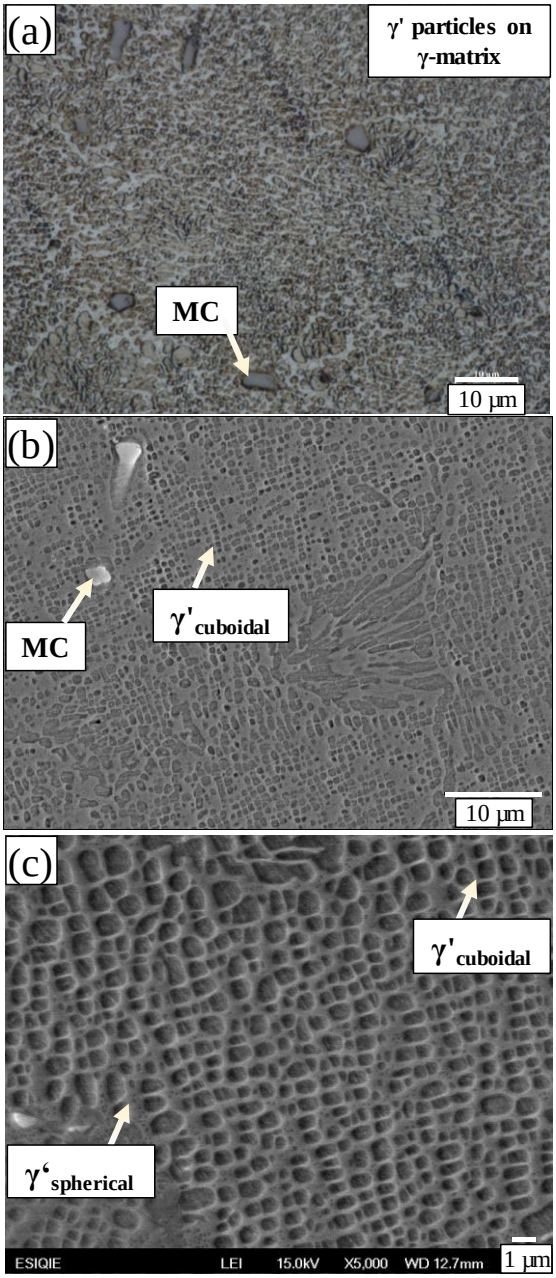

Figure 1. Micrographs of cross sections of a blade, Ni-based SA, removed from service by preventive maintenance obtained by:
(a) OM, (b) SEM and (c) HR-SEM.

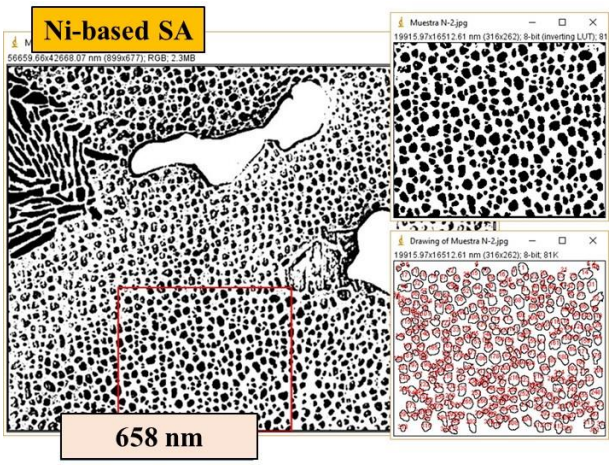

Figure 2. Analysis of the average size of γ' particles obtained by Image-J software.

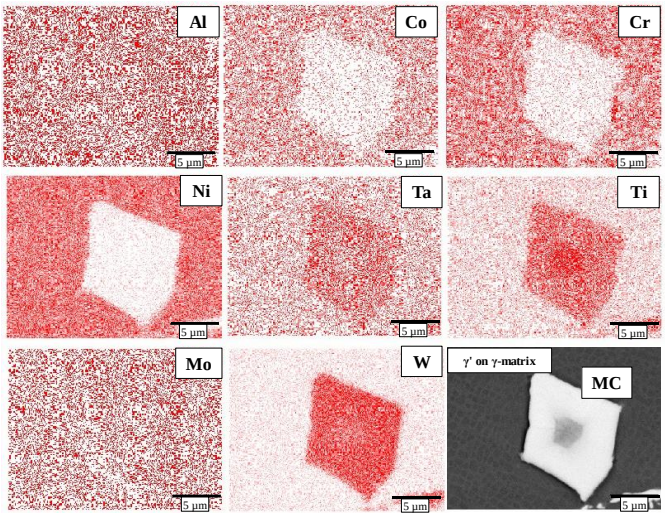

Figure 3. Element-imaging SEM analysis of Ni-based SA.

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