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Structural characterization of new VDM-780 Ni-based superalloy by means of X-ray diffraction and Neutron diffraction

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Ni-based superalloys based on the gamma/gamma´ system are widely used for high temperature applications, as parts for jet engines, due to their good mechanical properties at high temperatures. In these materials, the austenitic matrix (gamma phase) is strengthened by intermetallic precipitates of Ni3Al (gamma´, fcc L12 structure) and Ni3Nb (gamma´´, bct DO22 structure) and it has been also observed the existence of co-precipitates of both phases with different morphologies (plate, needle, cube or disc shape). Other phases that can also be formed are Ni3Nb-based (delta, orthorhombic DOa structure) and Ni3Ti-based (eta, hexagonal DO24 structure). The existence of the different phases and the quantity and shape of the different precipitates and co-precipitates depend on composition, heat treatment and processing conditions. Especially, it is crucial to control the evolution of the different phases at high temperature in order to tailor the mechanical properties at high temperatures.

In this work we present the first structural studies on VDM-780 superalloy. By means of neutron diffraction (ND) we have determined the different phases present in this material as prepared and the differences induced by two different aging conditions performed for setting up different microstructures. First measurements performed by X-ray diffraction (XRD) have shown, apart from the gamma matrix, the presence of the gamma´ and delta (or eta) phases, depending on the temperature history. But XRD patterns do not allow to distinguish between the orthorhombic delta phase and the hexagonal eta phase. Both phases are usually present at the grain boundaries and the correct identification of them is crucial for the high temperature applications, as a small amount of delta phase is essential for a good workability of the alloy.

Neutrons are essential for the identification of the different phases as present important advantages compared to XRD. Due to the structural factors we expect higher number of reflections (as the one of the eta phase at 35°) and with higher intensity, more evident at higher angles. Furthermore, we can choose higher wavelength of 2.4 Å with high penetration in the sample, while by measuring with XRD we have to select Mo (0.709 Å) in order to obtain some information from the interior of the material and not only from the surface. Last but not least neutrons allow to study a real bulk volume of the order of ~ 0.5 cm3.

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