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PHASE CHARACTERIZATION IN A NICKEL-BASED SUPERALLOY (WASPALOY) BY TRANSMISSION ELECTRON MICROSCOPY (TEM)

M.C.B.V. Soares * ; G.D.A. Soares ** and A.H. P. Andrade ***
* IEN / CNEN-RJ, Rio de Janeiro; CEP 21945-970; RJ; msoares@cnen.gov.br
** COPPE / UFRJ; Rio de Janeiro; CEP 21945-970; RJ; gloria@metalmat.ufrj.br
*** IPEN / CNEN-SP; São Paulo; CP11049; CEP 05422-970; SP.

Waspaloy is a wrought nickel base superalloy used in air jet engines for turbine discs that operate at lower temperature then turbine blades. Changes in operating conditions of modern aircraft led to requirements for high strength, good fatigue resistance, ductility and notch strengthening while creep performance is considered less important.

In order to achieve these properties by thermo mechanical process (T.M.P) it is necessary to establish a well defined sequence of forging and ageing heat treatments. The optimized microstructure consists of a face centred cubic matrix gamma, strengthened by intermetallic compound, Ni_3 (Al, Ti), called gamma prime, and by a dispersion of carbides in the form of MC, $M_{23}C_6$, M_6C, ...[1]

The morphology and size of the phases precipitated in a Waspaloy was carried out on a TEM operating at 200 kV with EDS detector. Thin foils were produced in a Jet Polishing unit using a 5% perchloric-acetic acid solution at 10 °C with a 70 V potential. The TEM observation have shown a bimodal gamma prime precipitation exhibiting fine particles (from 20 to 70 nm) together with medium size precipitates (200 nm), as can be seen in Figures 1 and 2. The EDS analysis showed in Figure 3 confirms the nature of gamma prime particles found in Waspaloy as nickel plus aluminium-titanium rich phase. The fine precipitates increases tensile and fatigue strength of waspaloy at low temperatures while medium size precipitates are good for creep resistance and to reduce notch sensitivity. [2].

Carbides in Waspaloy act as grain boundaries reinforcement against intergranular fracture and them also increase resistance to grain boundary slip during creep. For this, carbides must be dispersed as discrete globular particles along grain boundaries. TEM observation has shown continuous films on grain boundaries (Figure 4), all of them chromium rich type (Figure 5). These continuous or nearly continuous films are detrimental to fracture resistance and could be responsible for the intergranular fracture verified in low cycle fatigue tests at room temperature. [3]

References

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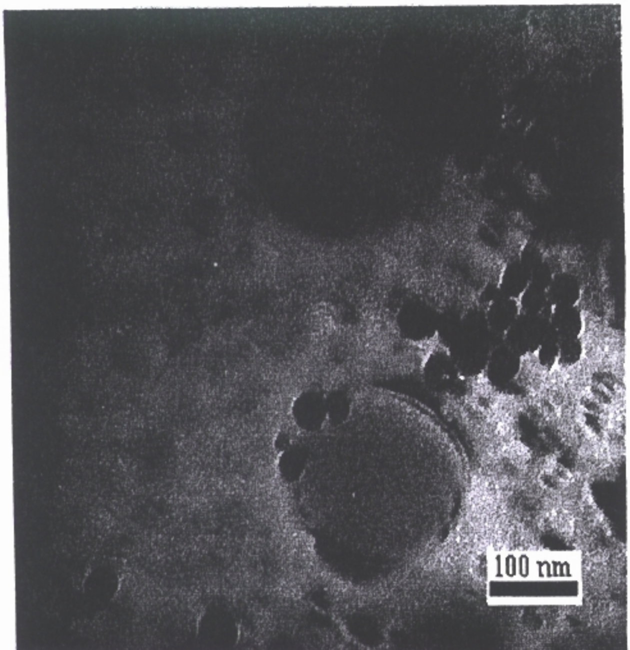

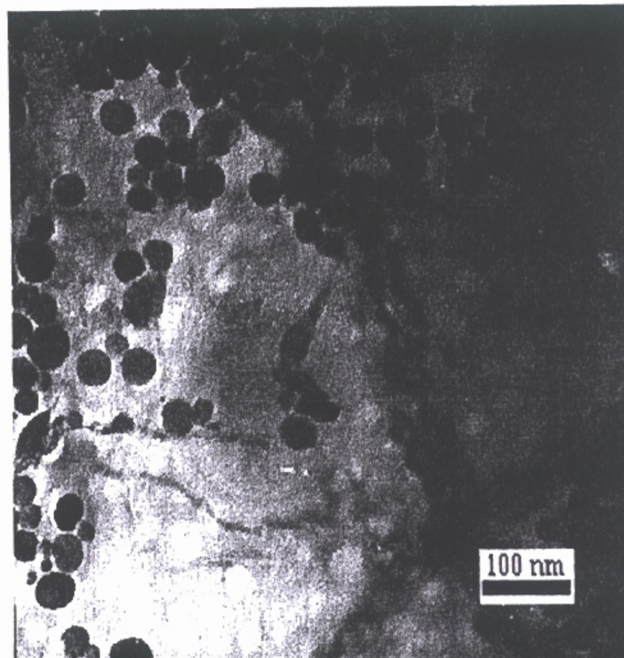

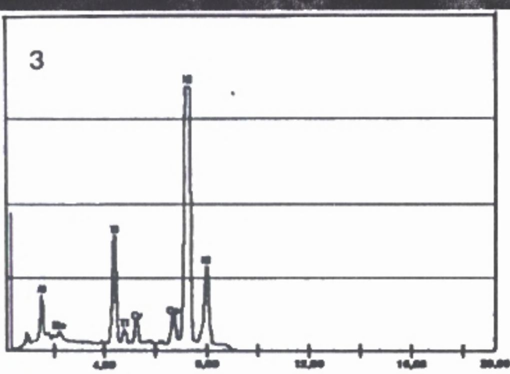

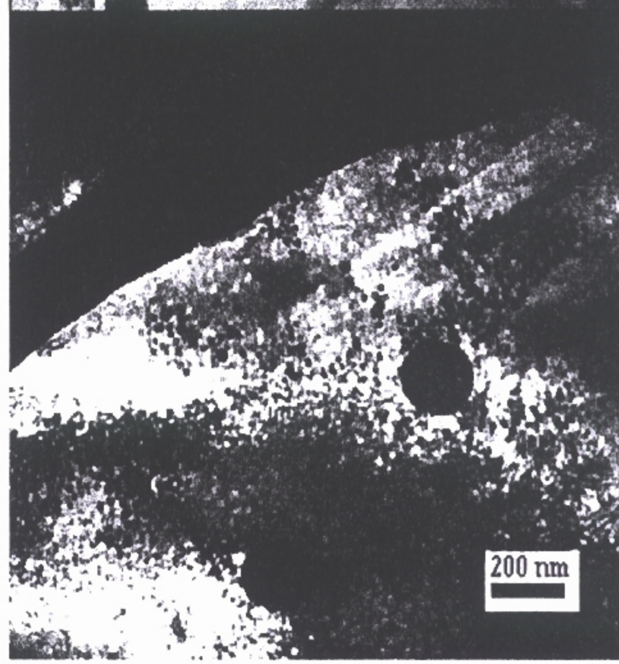

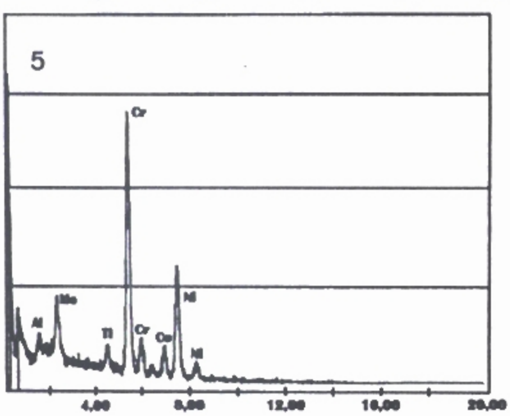

Figure 1. TEM Image of Bimodal Gamma Prime Precipitation.
Figure 2. TEM Image of Fine Gamma Prime Particles.
Figure 3. EDS Spectra from Gamma Prime Particles.
Figure 4. TEM Image of Continuous Film on Grain Boundary.
Figure 5. EDS Spectra from Grain Boundary Precipitate.