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Microstructural Characterization of a Precipitation Strengthening Fe-Ni Alloy

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Austenitic high-temperature Fe-Ni alloys precipitation strengthened by intermetallic phases, display numerous characteristic properties such as: excellent mechanical behavior, considerable creep resistance and heat resistance at high elevated temperatures, corrosion resistance and high ductility at low temperatures. This group of metallic materials have found a wide range of applications in aviation technology, chemical and petrochemical industries, cryogenic engineering, etc. [1-3].

In general, the strengthening process is performed in three steps: solution annealing, rapid cooling and precipitation or age hardening. The principal strengthening phase is the intermetallic ordered fcc γ´ [$Ni_3(Al,Ti)$], which is coherent with the austenitic matrix and is formed during ageing stages. This precipitation is observed at 730ºC [3]. Further exposure at this temperature as well as an overaging generates diffusive processes of growth and coagulation of the γ´particles, which is related to the γ´→η [Ni_3Ti] transformation. This process can occur during the stage of ageing or while using in service [4].

An overheating leads to a degradation of mechanical properties, decreasing of hardness and modifying the creep behavior.

In this work the precipitation-hardened Fe-Ni alloy A286, used in turbine jet engines, has been characterized, before and after using in service conditions.

This alloy is unstable after short ageing treatments at 730ºC because the metastable γ´phase dissolves and the stable η phase is formed, degrading the good mechanical performance of the material. Therefore A286 alloy must be used at temperatures below that critical temperature.

Samples of material were treated at different conditions of temperature and periods of time. Optical, scanning electron micrographs were acquired. Thin foil specimens for transmission electron microscopy were prepared, analyzing the phases by energy dispersive x-ray spectroscopy. Microhardness measurements were obtained from the specimens that had been aged.

The authors have studied the influence of ageing in microstructure, size and distribution of precipitates as well as austenitic grain size (see Figures 1-4). The η phase nucleates at the original austenite grain boundaries and grows into the austenite matrix. The precipitation of carbides is also observed, carboborides of titanium are identified in Figure 2 and $M_{23}C_6$ in Figure 3. EDS spectrum of η phase, Ni_3Ti, is presented in Figure 5.

References:

[1] H. De Cicco *et al.*, Materials Characterization, **52** (2004) p. 85.
[2] K.J. Ducki, Journal of Achievements in Materials and Manufacturing Engineering, **21** (2007) p. 25.
[3] C. Stallybrass, A. Schneider, G. Sauthoff, Intermetallics, **13** (2005) p. 1263.
[4] Vu The Ha, Woo Sang Jung, Materials Science & Engineering A, **558** (2012) p. 103.

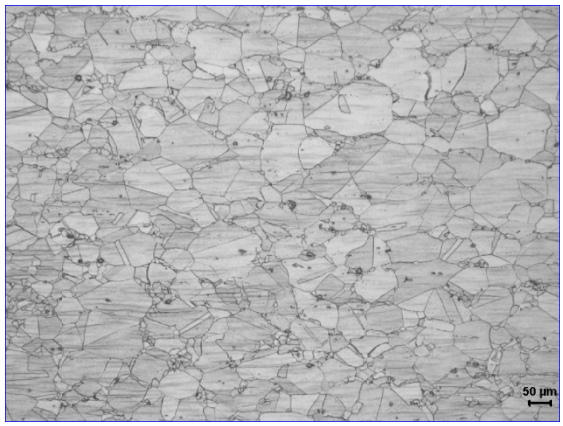

Figure 1. Optical micrograph showing austenitic grain size of as aged sample

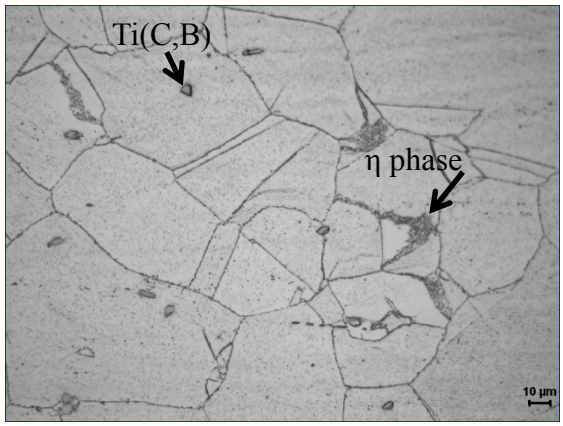

Figure 2. Optical micrograph showing carboborides of titanium into the grain and η phase

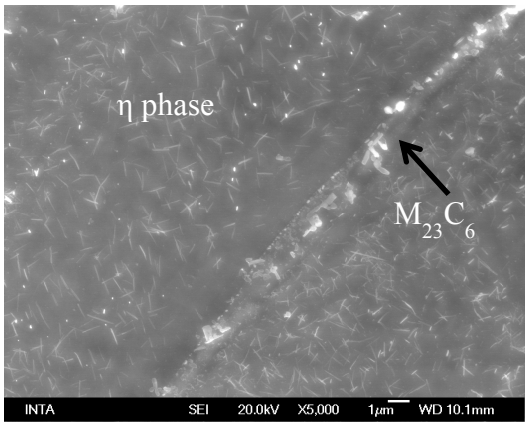

Figure 3. FE-SEM micrograph showing chains of carbides $M_{23}C_6$ type in boundary grain and disoriented lamellar constituents, η phase, into the matrix.

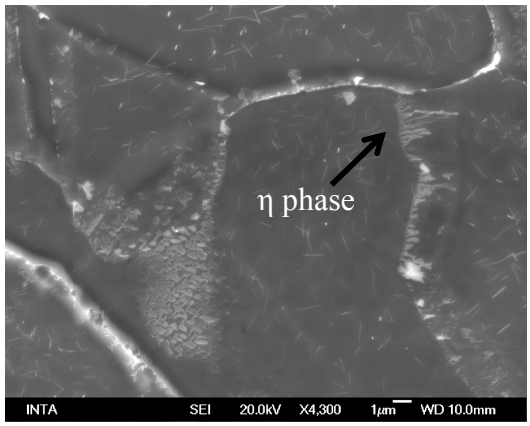

Figure 4. FE-SEM micrograph showing the growing of η phase in austenite grain boundary.

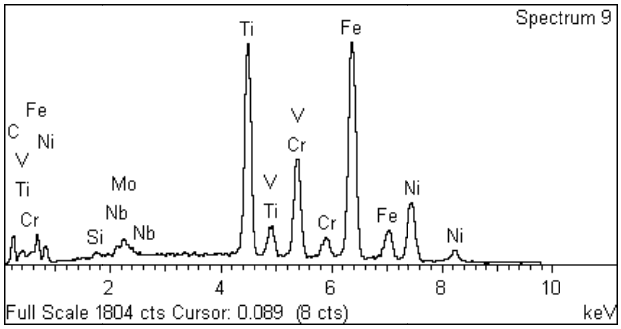

Figure 5. EDS spectrum of η phase (Ni_3Ti) in a Fe-Ni matrix.

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