MICROSTRUCTURAL CHARACTERIZATION OF HAYNES® 242™ ALLOY

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HAYNES 242 alloy is an age-hardenable nickel-molybdenum-chromium superalloy that derives its good mechanical properties from a fine dispersion of $Ni_2(Mo,Cr)$ (Pt_2Mo-type) ordered precipitates. This superalloy exhibits low thermal expansion characteristics, good thermal stability, good oxidation resistance up to 815°C, good low-cycle fatigue properties and resistance to high temperature fluorine and fluoride environments. Haynes 242 is typically used for seal and containment rings, duct segments, casing, fasteners, rocket nozzles and pumps.

The composition of the commercial HAYNES 242 superalloy used in this investigation was Ni- 16.4 at. % Mo, 9.3% Cr, 1.3% Fe, 0.45% Al, 0.37% Mn, 0.14% Si, 0.018% B and < 0.01% P. The superalloy was given a standard anneal of 30 min. at 1066 °C and water quenched to room temperature prior to a two step heat treatments of 16 h at 704°C + 16 h at 650°C or a one step heat treatment of 48 h at 650°C. The superalloy was air cooled to room temperature after each stage. These heat treatments were designed to produce small $Ni_2(Mo,Cr)$ precipitates in a face centered cubic γ matrix. These two heat treatments produce materials with similar mechanical properties (yield strengths of 652 and 622 MPa, ultimate tensile strengths of 1015 and 1022 MPa, with elongations of 23.0 and 24.6% and reductions in areas of 27.6 and 32.1%, respectively).

The microstructural characterizations were performed with the ORNL energy-compensated optical position-sensitive atom probe and a Philips CM30 electron microscope equipped with a Gatan Imaging Filter. Atom probe tomography and energy-filtered jump ratio images revealed boron, molybdenum, chromium, phosphorus and carbon segregation to the grain boundaries. The $Ni_2(Mo,Cr)$ precipitates were found to be lenticular in shape with an aspect ratio of approximately 8:5:1 in the major, intermediate and minor dimensions. The major dimension of the precipitates was found to be significantly larger, ~150 nm, after the two step heat treatment compared to ~25 nm after the one step heat treatment. Molybdenum was found to partition to the $Ni_2(Mo,Cr)$ precipitates whereas iron, aluminum, silicon, manganese and nickel were found to partition to the γ matrix. Chromium was not found to partition significantly between the phases.

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