Examinations of a Haynes 242 Superalloy Using Electron Backscatter Patterns (EBSP)

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Introduction

Microstructure evolution occurs and residual strain is developed in conduit material for high-magnetic field cable-in-conduit superconducting magnet system when the conduit is deformed and heat-treated. In situ microtextural measurements yield a comprehensive view of the total microstructure and stress status and give better data for design of the high field magnets [1].

Results and Discussion

This study examines the grain size distributions and image qualities, and investigates the feasibility of measuring the strain in conduit materials with EBSP in combination with the X-ray analyses. Conduit was fabricated from long flat rolled strips of approximately 1.64 mm thickness, bent into tubing and seam welded, and then deformed into rectangular shape. The conduit was then bent to a plastic strain of approximately 3 percent and then heat-treated for the required schedule of the superconducting wire. The longitudinal cross-section was final polished by 0.05-micrometer colloidal silica and etched with a hydrochloric and nitric acid solution. The sample was analyzed by an EDAX Orientation Imaging Microscopy (OIM) analysis system on a JEOL 6380 Scanning Electron Microscope. Grain orientation of the tension side of the conduit on the longitudinal view was shown in Fig. 1a. The conduit wall was found to have three distinct zones; highly deformed grains in the top and bottom, medium sized grains approximately 1/3 in depth, and finer grains in the middle. In the vicinity of the surface of the conduit wall the OIM image qualities have smaller numbers, indicating residual strains stored in these regions. The measurements of the (200) planar lattice indicate a variation of the lattice parameters. This may be highly localized and will be averaged by the surrounding grains in the similarly stressed region and plane. An overall strain measurement can be obtained by extending this method to include grains in the same tensile direction and position in the conduit wall. The grains must be of a size to include 10 points of good quality. Refinement of measurement parameters needs to be based on the quality of pattern and the size of the grains. X-ray provides another approach to measure the residual strain. It appears that the residual strain indeed results in the shift of the peaks, as shown in Fig. 1b.

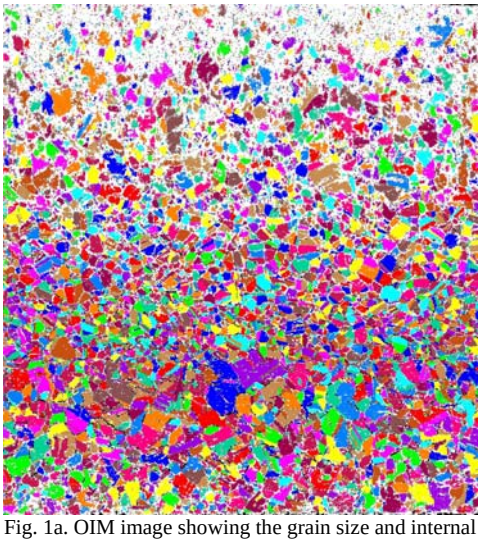

Fig. 1a. OIM image showing the grain size and internal stresses

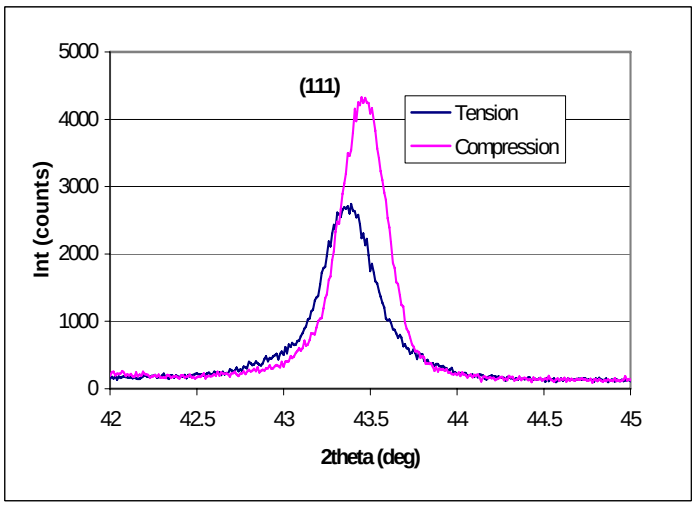

Fig.1 b. XRD results showing the shift of the peak due to the internal stresses..

[1] Goddard, R. E. et al, Microscopy and Microanalysis 2007 Proceedings, 13, Supp. II, 940CD (2007)