Experimental report

16/04/2020

Proposal: **1-01-173**

Council: 4/2019

Title: Texture gradient determination in aluminum alloy extruded bars and evolution with heat treatments

Research area: Materials

This proposal is a new proposal

Main proposer: **Gaspar GONZALEZ DONCEL**

Experimental team: Sandra CABEZA
Ines PUENTE ORENCH
Gaspar GONZALEZ DONCEL
Ricardo FERNANDEZ
LAURA MILLAN GARCIA

Local contacts: Bachir OULADDIAF
Ines PUENTE ORENCH

Samples: Aluminum alloys (3005Al, Al-Mn, and 5085Al, Al-Mg)

Instrument	Requested days	Allocated days	From	To
D1B	2	2	07/02/2020	09/02/2020

Abstract:

This experiment is framed in an ongoing project aimed at determining the microscopic residual stresses, m-RS, resulting from thermo-mechanical treatments in aluminum alloys. The method which will be developed will require not only data from diffraction peaks of different hkls for different directions but also detailed data of the macro- and micro-texture (EBSD) at different locations of the sample. Finally, evolutionary algorithms will be used to calculate, from the above data, the triaxial stress state of individual grains (of known spatial orientation) from a representative group. A stress map will be, finally constructed. The present proposal will concentrate on the determination of the texture and texture gradient aluminium alloy extruded cylindrical bars. Extruded bars have been selected for their simple revolution symmetry that should lead to the development of fiber textures.

Experimental Report; exp. 1-01-173/CRG-2654

The aim, of this experiment was the determination of the texture gradient and texture gradient evolution with annealing of, initially, 5083 and 3005 aluminum alloys (non-heat treatable alloys). This experiment is framed in an ongoing Project aimed at determining the microscopic residual stresses, m-RS, resulting from metal forming processes and/or thermo-mechanical treatments. The alloy 3005 (Al-Mn) was finally dismissed due to its low mechanical strength and, hence, capacity to accumulate, both, macroscopic and microscopic residual stresses.

One of the key information for the above objective is a detailed description of the texture of the sample under investigation. For this purpose, D1B was the instrument selected for the experiment provided the large detector, spanning 128º, able to obtain a complete set of diffracted peaks for any sample orientation (determined by χ and φ angles) with respect the laboratory reference system. In this way, the complete set of diffracted peaks (which includes the 111, 200, 220, and 311 reflections) for the different sample orientations, usually needed in texture analysis of aluminum alloy samples, can be obtained simultaneously with a clear time saving (by a factor of four) in comparison to other instruments. Figure 1 is one the spectra obtained (at an arbitrary sample orientation) where these diffracted peaks are seen.

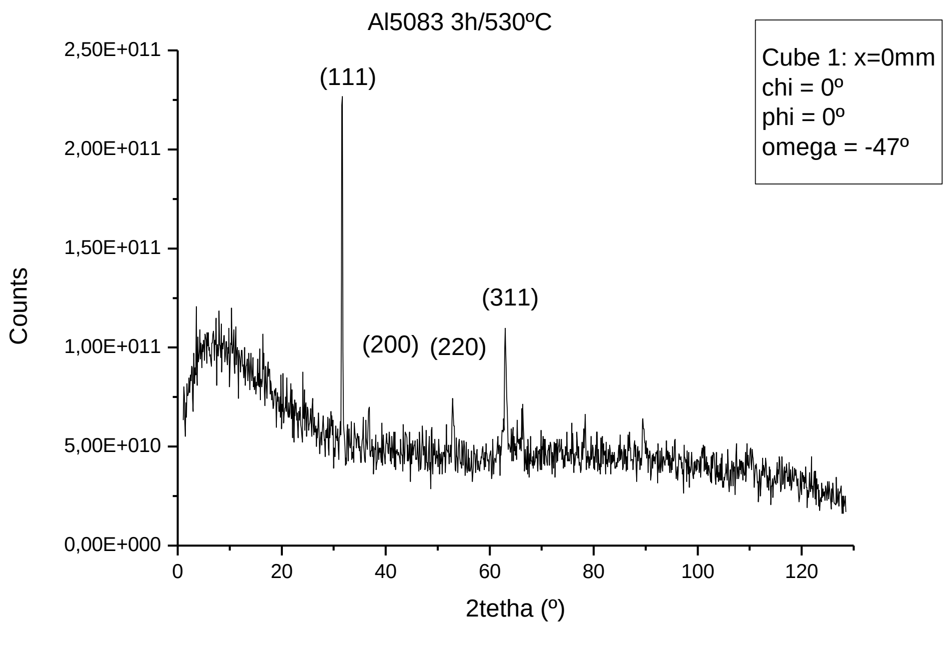

Figure 1.- Example of a typical spectra obtained for a given sample orientation. The intensity of reflections 111, 200, 220, and 311 is obtained simultaneously. For a given hkl, the intensity collected at all orientations (χ and φ angles) allows constructing the corresponding pole figure. Each spectra was obtained after 2 min. time exposure.

A total of three days (including the time allocated for the two experiments; 1-01-173 and CRG-2654) were assigned. This time period allowed a total of four scans corresponding to the texture measurements of samples extracted at r=0 mm and at r=12 mm from the 25 mm rod in the quenched and slow cooled condition (following the 3h/530ºC annealing treatment). Furthermore, the data from the measurement of a texture-less powder sample, which is being used as a reference, was also collected in the experiment. In each scan the sample was rotated for different χ_i and φ_j angles. The χ_i angle ranged from 0º to -90º at increments of -5º, and the φ_j angle ranged from 0º to 170º at increments of 10º (which supplies the corresponding intensity in the stereographic projection for any reflection), provided an Eulerian cradle that allowed sample rotation at any sample orientation, figure 2.

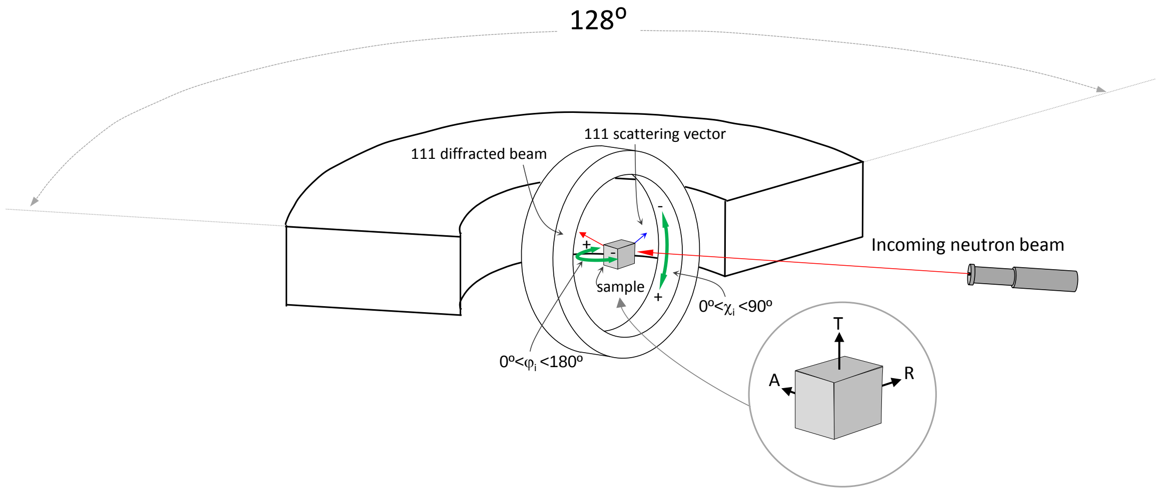

Figure 2. Scheme of the experiment configuration; The Eulerian cradle allowed sample rotation about χ_i and φ_j angles. Detail of sample geometry where A, T, and R denote Axial, Tangential, and Radial direction, respectively, of the original cylinder from which the 4x4x4 mm^3 cubes for texture measurements were extracted.

The measurement of a complete spectrum (which included the diffracted intensity for the different *hkl* reflections, figure 1) for every χ_i, φ_j orientation lasted 2 minutes.

Samples were in the form of small cubes, of 4x4x4 mm^3 in size. To avoid possible errors due to geometrical effects, the powder (reference texture-less sample) was measured inside a cubic can of similar size/dimensions.