Texture Inhomogeneity through the Thickness of a Copper Tube

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Introduction

As production of seamless tube, the first step is the piercing of the billet, for example by extrusion or three-roll-mill process. Tubing process is a combination of elongation in length and reduction in cross-section [1, 2]. Because of vibration of the mandrel, tolerance by positioning the die and the billet, and possible temperature inhomogeneities in the billet this step inherently results in variation of thickness over the length, as well as eccentricity and ovality, this lead to inhomogeneous material flow around the perimeter also through the thickness[3]. Synchrotron diffraction with high photon energy is one of the options to study the texture variation because of the small wavelength (0.05Å-0.2 Å), excellent brilliance and high intense with similar penetration power as neutron [4]. When the reduction in wall thickness and circumference are same crystals have the typical wire texture along deformation axis. When tube has been reduced largely in wall thickness the texture is similar to rolled sheet [2].

Experimental procedure

Three rectangular samples were cut from a copper ring at minimum, maximum and middle thickness with the dimensions shown in table 1.

Sample name	Thickness (mm)	a(mm)	b(mm)	Measured Points
Min. thickness	9.57	5.16	4.72	5
Mid. thickness	10.00	5.85	4.85	5
Max. thickness	10.36	5.85	4.25	5

Table 1: Samples Dimensions

The sample was fixed on steal pin and mounted on the sample stage so the arrow (rolling direction) to the direction of detector as shown in figure (1). Synchrotron beam of energy 174.52 keV and wavelength of 0.07105 Å and beam size of 0.5×0.5 mm^2 was used for local texture measurement, sample detector distance was 1168 mm and the detector was two dimensions detector. The phi motor was derived from -90° to 90° in step of 5°, the exposure time of 4 seconds. The data analyses was carried out by software package written by Yi [5] to extract the pole figures from area detector images and by ISEM (Iterative Series Expansion Method) to calculate the orientation distribution function (ODF) [6]. The measurement was started from inside diameter (starting from Z1) to outside diameter to (Z5).

Result and discussion

The texture of the Cu-tube consists of following texture components Cube {001}<100>, Rot C_{RD} {013}<100>, Copper {112}<111>, Brass {110}<112>, and S{123}<643>. Copper-, Brass- and S-component represent the β-fibre. The texture strength of the copper component is between 1.6mrd and 8.7 mrd (mrd – multiple of random). The stronger cube component varies between 6.5 mrd and 21.2 mrd.
As shown in fig. 2 the cube and copper components have remarkable variation of the orientation density through the thickness. In the case of cold rolled FCC materials with high stacking fault energy (γ_{SFE}) like pure copper and Cu alloys with only low amounts of alloying elements the typical deformation texture component is the copper type texture. The recrystallization texture of pure

copper is mainly composed by the cube orientation [7-9]. This copper tube was described as hot deformations that mean recrystallization occur during and after extrusion. A correlation to the starting texture of the Cu-tube before extrusion could not be given, because the starting texture is unknown.

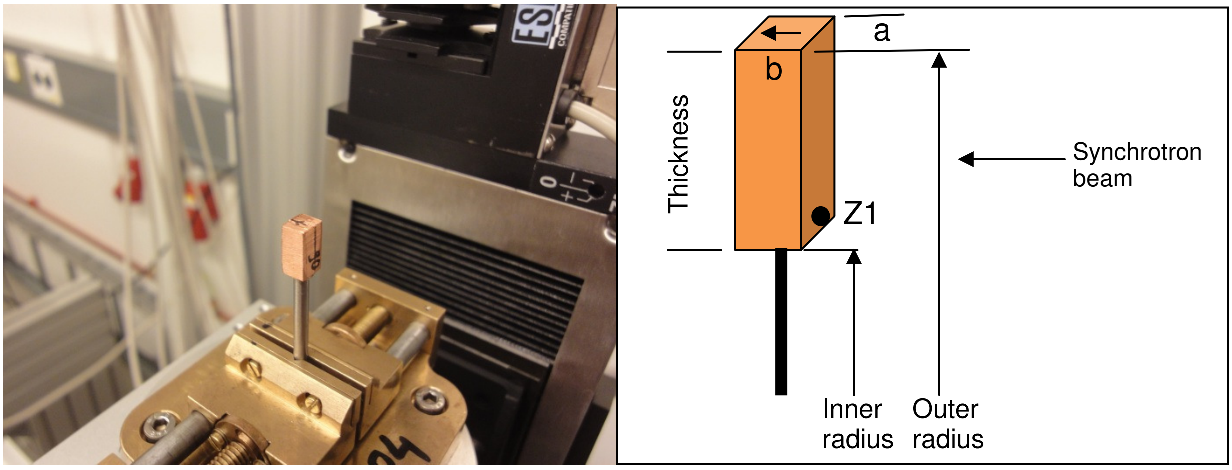

Figure 1: Copper sample cut from ring; sample fixed on sample stage (left) and schematic draw (right)

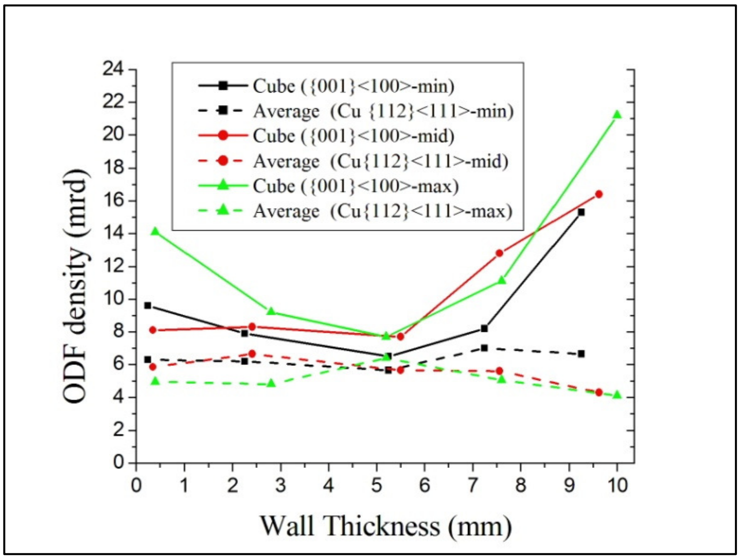

Figure 2: Cube and copper texture component for the minimum, middle and maximum tube thickness

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