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Rapid texture measurement of cold-rolled aluminum sheet by X-ray diffraction

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Abstract

A new technique is proposed for rapid and accurate texture measurement of AA3104 aluminum sheet, in which the diffraction data along three lines in pole figures are measured according to the texture characteristics. Eight texture parameters are obtained after a new fitting treatment based on the Gaussian distribution. The reproduced pole figures based on the eight parameters are in good agreement with those obtained by the conventional method. An industrial technology for on-line texture determination could be developed based on this technique.

Keywords: Texture; Aluminum; X-ray diffraction

1. Introduction

Texture measurement is required in industrial processing in order to check those properties that are related to texture, such as the quality of metal strip or sheet. However, the outcomes of many research and development efforts have not been completely successful [1–5]. The key to the industrial application of on-line texture determination is the requirement for both high velocity and high accuracy, which is very difficult to achieve simultaneously.

The conventional technique for texture measurement is based on X-ray diffraction, and involves determining several pole figures, which normally takes a few hours in the laboratory. Two-dimensional X-ray detectors (area detectors) can capture large amounts of diffraction data simultaneously and thus shorten the measuring time significantly [6,7]. However, for rapid measurement, the rotation of the detector is required, which is not easy to carry out during industrial processing [8]. Some of the other X-ray methods are focused on the measurement velocity, but very limited diffraction data can be obtained—not enough to assess the actual texture [1,3,5].

A new technique for the rapid and accurate texture determination in annealed aluminum sheet has been proposed [9], in which only a few but important pole figure data were selected according to the characteristics and the symmetry of the texture components in the sheets. However, in industry applications, many products, for example AA3104 cold-rolled sheet, have very complicated texture configurations compared to annealed aluminum sheet in which only the Cube and R textures are included. The current technique for rapid and accurate texture determination has to be improved to take account of industrial products with complicated texture configurations.

2. Principle of the rapid texture determination of cold-rolled aluminum sheet

It is well known that each texture component has several equivalent density peaks in pole figures because of crystallographic and sample symmetry. In principle, the pole

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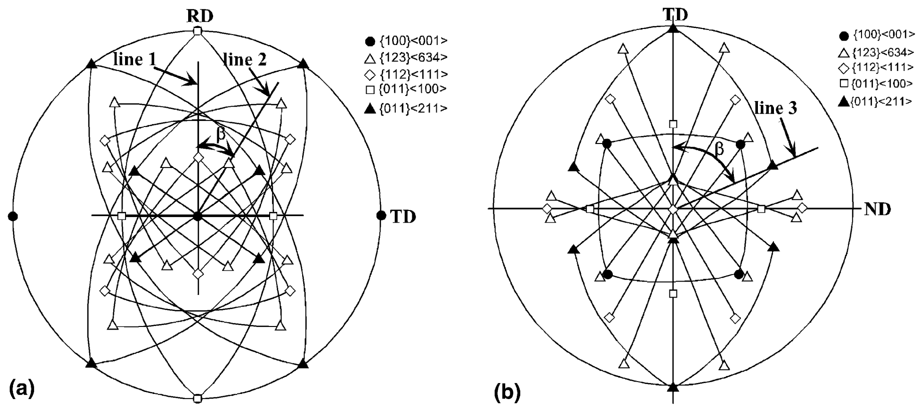

Fig. 1. Positions of texture components in pole figures. (a) RD–TD {200}, (b) TD–ND {111}.

figure can be deduced if one density peak of each component is obtained according to the geometric principle of the pole figure being projected based on the assumption that the density peaks are distributed in a Gaussian form [9]. In the AA3104 cold-rolled aluminum sheet, there always are four main texture components, described as Cube {0°, 0°, 0°}, S {61°, 34°, 64°}, Brass {35°, 45°, 0°} and Copper {90°, 30°, 45°}, simultaneously. The positions of these components in pole figures in the rolling direction–transverse direction (RD–TD) {200} and TD–normal direction (ND) {111} are illustrated in Fig. 1. The density peaks of the Cube, Copper, S and Brass texture components can be captured along lines 1, 2 and 3, respectively, in which the overlapping of density peaks of different components is avoided. The pole figure data along line 1 and 2 (Fig. 1(a)) can be measured by the X-ray reflection technique and those along line 3 (Fig. 1(b)) can be obtained by the transmission technique.

3. Experimental procedures

An AA3104 aluminum sheet with a thickness of 0.27 mm was used as the experimental material. The incomplete pole figures {111}, {200}, {220} and {311} were measured using an X-ray diffractometer (type: D-5000 Siemens) based on the conventional reflection method and the orientation distribution function (ODF) was calculated. The re-computed {111} and {200} pole figures are shown in Fig. 2.

The diffraction data along the three lines in Fig. 1 were obtained by reflection and transmission techniques with 2° intervals using a D-5000 diffractometer. The experimental data were corrected to eliminate the background and the absorption effect against the α angle. The pole figure coordinate parameters (α, β) according to Bunge [10] were used (Fig. 1). The diffraction data were determined by the X-ray reflection technique in the range of 0–44° for α, at $\beta = 0°$ and 30° for lines 1 and 2, respectively (Fig. 3(a) and (b)), and by X-ray transmission technique in the range of 0–80° for α at $\beta = 68°$ for line 3 (Fig. 3(c)). The corrected diffraction data I_i along the three lines are shown in Fig. 3 (solid symbols).

4. Quantitative texture determination

The volume fraction of texture components can be calculated based on Gaussian distribution fitting treatment. The Gaussian density distribution I of one texture component is described as

$$I = I_0 \exp[-(\alpha - \alpha_0)^2/\psi_0^2], \quad (1)$$

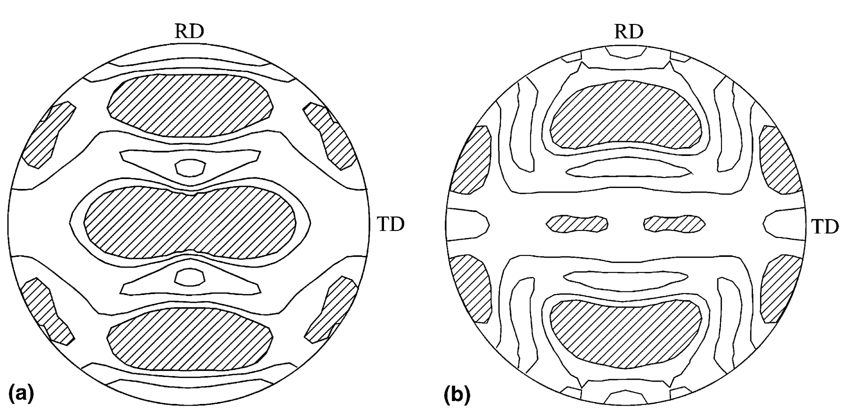

Fig. 2. Re-computed pole figures of the AA3104 sheet, level: 0.5, 1, 2, 4. (a) {111}, (b) {200}.