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ROLLING TEXTURE OF AL-MG ALLOYS

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ABSTRACT

The development and the transition of texture in rolled Al-Mg alloys have been followed by determining pole figures for the alloys with various Mg contents and with various degrees of rolling reduction.
Al-Mg alloys containing 0.5, 1.0 and 2.0 % Mg were prepared by melting in an argon atmosphere and rolled into sheets of 1 mm thickness. The rolling reductions were 70, 82.5, 90 and 95 %. Pole figures were determined with 111, 200 and 220 difractions. The results were analyzed using the orientation distribution function.
For low reduction of rolling, pole figures for all Al-Mg alloys were almost the same as that for pure aluminium, that is, the copper type. For high reduction of rolling, pole figures for the alloys containing up to 1 % Mg were the copper type. However, the alloy containing 2 % Mg showed the pole figure of different type. The main component of this texture was represented as {001}<110>.

INTRODUCTION

It is known that the texture transition from pure aluminium type occur by alloying Mg into aluminium[1]. The formation of shear bands as well as the deformation bands are associated with the development and the transition of rolling textures. Deformation bands have been observed in aluminium rolled more than 80 %[2]. On the other hand, the formation of shear bands in rolled Al-Mg alloys has been reported[3)4)]. The distinguished feature of the shear bands is that they are not restricted within grains and formed penetrating the grain boundaries with increasing deformation. The shear bands are an important deformation mechanism in large strain deformation.

This paper reports a study of the development and the transition of rolling texture in Al-Mg alloys with changing rolling reduction and Mg content.

EXPERIMENTAL

Al-Mg alloys containing 0.5, 1.0 and 2.0 % Mg were prepared by melting pure aluminium and magnesium in an argon atmosphere. Rolling was carried out by reversing end for end between the passes to the final thickness of 1 mm. Rolling reductions were 70, 82.5, 90 and 95 % in thickness. The specimens for texture determination were prepared by grinding and chemical polishing from both sides of the rolled sheets. Pole figures were determined by the transmission and the reflection method with 111 , 200 and 220 diffractions. The data were analysed using the orientation distribution function. Microstructures were also observed on the cross-sections of the rolled sheets.

RESULTS

The rolling texture of copper type developed in Al-Mg alloys after 75 % rolling reduction. The texture of cold rolled Al-Mg alloys containing up to 1 % Mg did not alter the appearance up to 95 % rolling reduction. However, the alloy containing 2 % Mg showed the texture transition, from copper type to the other type, with increasing rolling reduction. The changes in pole figures for 95 % cold-rolled Al-Mg alloys are shown in Fig. 1. In the case of Al-2%Mg alloy, the texture transition at 95 % rolling reduction is remarkable.

The ODFs for all specimens are shown in Fig. 2. According to the ODF, the main components of the rolling texture for the alloys containing up to 1 % Mg were $\{4\ 4\ 11\}\langle 11\ 11\ 8\rangle$, $\{1\ 1\ 0\}\langle 4\ 4\ 11\rangle$ and $\{1\ 1\ 0\}\langle 1\ 1\ 2\rangle$, though the pole figures appeared as the copper type. The other types of texture components were observed in Al-2%Mg alloy rolled 95 %. The main component of the final texture in cold rolled Al-2%Mg alloy was $\{0\ 0\ 1\}\langle 1\ 1\ 0\rangle$, which is a kind of fiber structure. This texture is different from the copper type and also from the brass type.

The optical micrographs of the longitudinal cross-sections of cold rolled sheets are shown in Fig. 3. With increasing rolling reduction, the layer structure pallalel to the sheet surface was formed from the region near the surface and increasingly covered the central portion of the sheets. The layers increased in number with decreased thickness. The formation of these layers was associated with the traces like shear bands.

DISCUSSION

The rolling texture developed at the low rolling reduction of 75 % and the further reduction did not alter the appearence in Al-Mg alloys containing up to 1 % Mg. Though the pole figures of rolled those alloys were similar to the copper type, the main components of the rolling texture were $\{4\ 4\ 11\}\langle 11\ 11\ 8\rangle$, $\{1\ 1\ 0\}\langle 4\ 4\ 11\rangle$ and $\{1\ 1\ 0\}\langle 1\ 1\ 2\rangle$. The component $\{4\ 4\ 11\}\langle 11\ 11\ 8\rangle$ is near the copper type texture component $\{1\ 1\ 2\}\langle 1\ 1\ 1\rangle$ and the component $\{1\ 1\ 0\}\langle 4\ 4\ 11\rangle$ is near the brass type texture component and the component $\{1\ 1\ 0\}\langle 1\ 1\ 2\rangle$ is that of brass type. Therefore, the rolling texture of Al-Mg alloys containing up to 1 % Mg can be regarded as the mixture of the copper type and the brass type texture.

In Al-2%Mg alloy, an abrupt change in texture was observed around the rolling reduction of 90-95 %. The changes in orientation density with cold rolling reduction near the above mentioned orientations are shown in Fig. 4. In both cases, the changes in Al-2%Mg alloy are distinguished. It has been reported that the shear band formation could be related to the texture development in cold rolled Al-Mg alloys[3,5,6]. In the present study, the development of layer structure observed on the longitudinal cross-sections corresponded to the change in texture. The development of layer structure can not be directly related to the shear band formation, however, the texture transition is attributed to the shear band formation with increasing deformation.

The same type of layer structure as in the present study has been reported in rolled Al-Mg alloys[7]. In the present study, however, the layer structure developed up to the central portion of the rolled Al-2%Mg sheet. The development of layer structure is affected by the thickness of the initial material, the total rolling reduction and the reduction of one pass. Furthermore, the cast structure in the starting materials also has the influence on the later rolling. Therefore, the critical reduction for the texture transition may not be definitive.

CONCLUSIONS

(1) The rolling texture of Al-Mg alloys containing up to 1 % Mg developes at the low rolling reduction of 75 % and the texture is unchanged in appearance up to the rolling reduction of 95 %. The main components of the rolling texture are {4 4 11}<11 11 8>, {1 1 0}<4 4 11> and {1 1 0}<1 1 2>.

(2) The rolling texture of Al-Mg alloy containing 2 % Mg varies at the rolling reduction of 90-95 %. The main component of the final rolling texture can be represented as {001}<110>.

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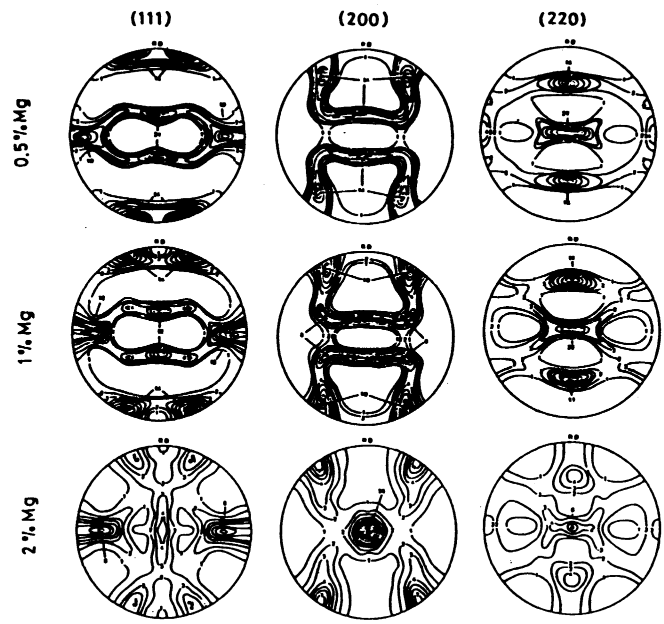

Fig. 1 Pole figures of 95 % cold-rolled Al-Mg alloys.

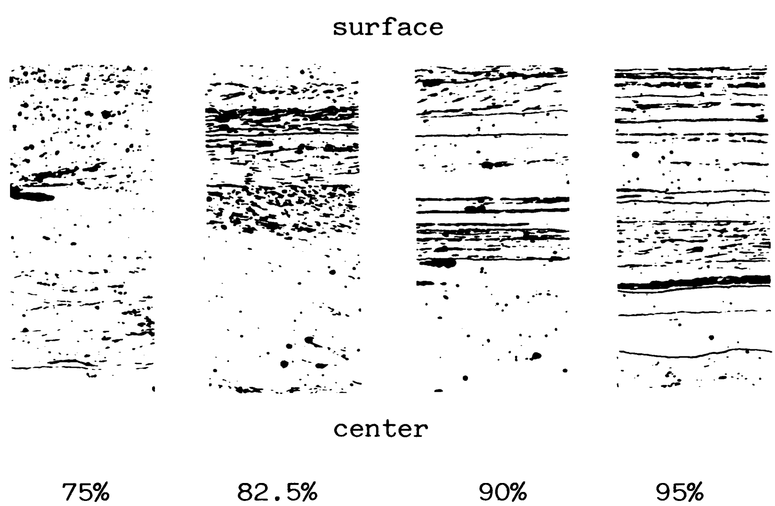

Fig. 3 Longitudinal cross-sections of cold-rolled Al-Mg alloys.

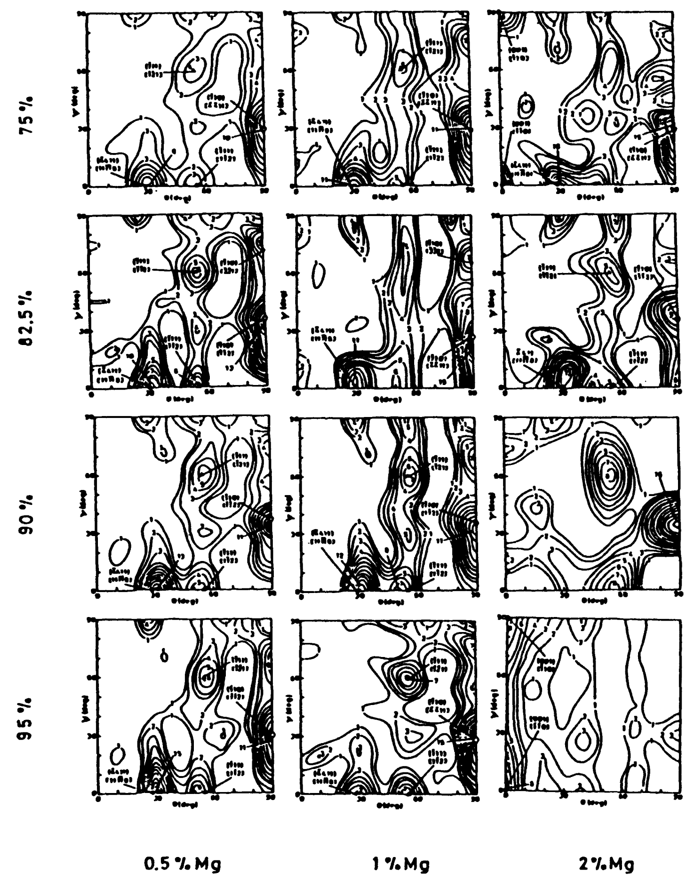

Fig. 2 ODF for cold-rolled Al-Mg alloys. ($\phi = 45^{\circ}$)

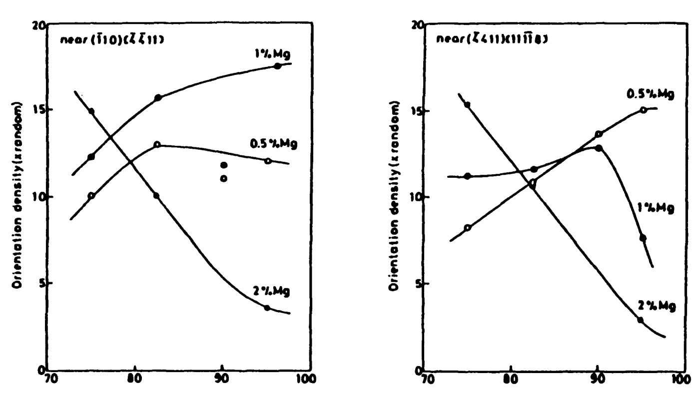

Fig. 4 Changes in orientation density with rolling reduction.