

Mechanical Properties of 5083 Aluminum Alloy Sheets Produced by Isothermal Rolling

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The microstructure and mechanical properties of AA5083 aluminum alloy sheets consisting of well developed β -fiber texture were investigated. In order to maintain rolling textures after final annealing, the materials were rolled isothermally at 623 K by making use of heated rolls and reheating process every pass up to final thickness of 1 mm. The isothermal rolled sheets consisted of fine subgrain structures through the thickness with a high proportion of low angle boundary less than 15° . Tensile properties showed anisotropy clearly regarding elongation and Lankford value. In the isothermal rolled sheets, the elongation of 0° to rolling direction was below 20% and Lankford value of 45° to rolling direction was over 1.5. Therefore, the average Lankford value showed 1.0. The yield strength of the isothermal rolled sheets was about 40% higher than that of the cold rolled sheets because of subgrain structures. The low ductility of 0° to rolling direction on the isothermal rolled sheets seemed to reduce drawability at room temperature. The warm drawability of the isothermal rolled sheets improved and was superior to the cold rolled sheets because of increasing ductility and keeping higher strength than the cold rolled sheets.

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Keywords: isothermal rolling, aluminum-magnesium-manganese, Lankford value, drawability

1. Introduction

It was known in low-carbon steels that Lankford (r) value had a good relationship with drawing formability.¹⁾ High Lankford value leads to excellent deep-drawability. It was also known that Lankford value was related to texture strongly in aluminum alloy sheets²⁾ as well as low-carbon steels.³⁾ Generally, main component in O-temper of aluminum alloy sheets is a {001}(100) Cube component. In such case, it is predicted by Taylor model that Lankford value is below 1.0, especially a significantly smaller one of 45° to rolling direction.²⁾ Meantime, the texture consisted of the β -fiber ({011}(211) + {123}(634) + {112}(111)) after cold rolling in aluminum alloy sheets,^{4,5)} and it was expected according to Taylor model that the β -fiber increased Lankford value of 45° to rolling direction.²⁾ Such cold rolled sheets are not suitable for press forming because of low ductility. If a sheet is prepared with thermal stability in microstructure, high Lankford value with adequate ductility is gained by remaining β -fiber after a specified heat treatment.

In prior studies,^{6,7)} it was revealed that AA7475 based aluminum alloy sheets containing zirconium by controlled warm rolling have the strong {011}(211) Brass component after the solution heat treatment at 753 K. These sheets had high Lankford values of 45° to rolling direction and increased strength by subgrain structure less than 3 μm . It is hard to examine formability on heat-treatable alloy such as AA7475 aluminum alloy. The thermal stability of AA5083 aluminum alloys has been investigated by making use of plane strain compression test.⁸⁾ Due to this study, it was found that AA5083 aluminum alloy sheets deformed at not lower than 623 K and under control of strain rate in 5 s^{-1} and below have the property of thermal stability.

In the present work, AA5083 aluminum alloy sheets were

prepared under control of temperature and strain rate according to the above results of the plane strain compression test. These materials were also investigated about microstructures and drawing formability comparing with conventional AA5083 aluminum alloy sheets produced by cold rolling.

2. Experimental Procedures

Samples of AA5083, of which the composition is given in Table 1, were prepared according to the procedure shown in Table 2. The alloy AA5083 was cast into slabs by a standard semi-continuous direct chill technique. The slab was homogenized at 738 K for 43.2 ks followed by machining with dimensions of 30 mm high, 170 mm wide and 170 mm long. The rolling equipment used in this work has two $\phi 260$ mm work rolls mounted eight cylindrical heaters per roll⁹⁾ to keep roll temperature near sample temperature. In this experiment, the peripheral velocity of the work rolls was 5 m/min, and the rolls were heated at $643 \text{ K} \pm 1.5 \text{ K}$ in order to manufacture sheets isothermally to the final thickness of 1 mm. The above material machined was rolled at 623 K with re-heating at 623 K for about 900 s after every pass. Average strain rate of every pass was calculated roughly by the following equation.¹⁰⁾

$$\dot{\epsilon} = \frac{U_R}{\sqrt{R} \cdot h_0} \cdot \frac{2\sqrt{\epsilon}}{2 - r} \quad (1)$$

Here, U_R is the peripheral velocity of roll (m/s), R is the radius of roll (m), h_0 is the sample thickness before rolling (m) and r is the rolling reduction per pass. Then, the average strain rate per pass should be under 5 s^{-1} . Commercial machine oil was used in the isothermal rolling process. In

Table 1 Chemical composition of specimens (mass%).

Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
0.04	0.05	<0.01	0.63	4.38	0.16	<0.01	0.02	Bal.

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