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著者(和文)	グエン タイ ハー
Author(English)	NGUYEN THAI HA
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（博士課程）
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論 文 要 約

THESIS OUTLINE

系・コース： Department of, Graduate major in	材料 材料	系 コース	
学生氏名： Student's Name	NGUYEN THAI HA		

申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of （ 工学 ）
指導教員（主）： Academic Supervisor(main)	熊井 真次
指導教員（副）： Academic Supervisor(sub)	村石 信二

論文要約
Thesis Outline

The present thesis entitled "Microstructure of high-manganese Al-Mn based alloy strips fabricated by high-speed twin-roll casting and mechanical properties of their cold-rolled sheets" consists of six chapters. The structure of the thesis is shown in Fig. 3. The overview of each chapter is described as follows.

- Chapter 1: General introduction

This chapter overviewed the research background and purpose of the present study.

- Chapter 2: Microstructure of Al-Mn-Si based alloy strip fabricated by high-speed twin-roll castings.

In this chapter, the characteristic microstructure of Al-Mn-Si strips fabricated by HSTRC was characterized by using the color etching technique with Weck's reagent. Various kinds of observation and analyses were carried out to investigate the topography, morphology and chemical composition of the etched samples. The correlation between the color difference and micro-segregation of the alloying elements was examined in detail, and the formation behavior of the central band as well as the origin of the globular grains in the central band were discussed. Based on the microstructure observation, the origin of globular grains observed in the central band in the high-speed twin-roll cast Al-Mn-Si alloy strip was discussed in detail. With the help of Weck's reagent, the globular grains located in the central band could be classified into Type-I and Type-II based on the presence of the core structure. Type-I grains were observed in both central band and the solidified shell at sub-surface region. It is considered that the origin of Type-I grains is the floating crystals, which nucleated in the melt pool or on the roll surface. A part of the crystals is trapped in the solidifying shells from both roll surface, and the other crystals are sandwiched between the solid growth fronts at the roll gap to form the central band. Type-II grains were observed only in the central band. They are considered to be originated from the broken twiggy dendrite branches at the location near the minimum roll gap. They grow to globular gains in the final solidification region, i.e., in the central band.

- Chapter 3: Fabrication of high Mn containing Al-Mn-Si strips by HSTRC, and the mechanical properties of their cold-rolled sheets

Several kinds of high Mn containing Al-Mn-Si alloy strips were fabricated by using HSTRC. The alloy strips containing up to 4wt%Mn and 2wt%Si were successfully obtained. The solidified structure of the cast strips consisted of three layers. Two solidified shells with a columnar dendrite structure grew from the roll surfaces

toward the strip center. In the mid-thickness region, the band structure consisting of equiaxed dendrites and globular grains was observed between the solidified shells. Very fine primary particles were observed in the matrix near the strip surface, while relatively coarse particles with blocky and needle-like shapes were observed in the central band. The electric conductivity measurement was performed for the as-cast strips and Mn solubility in Al matrix was estimated. The estimated Mn solubility of the as-cast strips was considerably high. It was between 1.5 ~ 1.8wt% Mn in the Al-2Mn-xSi strips and about 2.2wt%Mn in the Al-4Mn-xSi strips. The strips were cold-rolled to the sheets and annealed at various conditions. They were subjected to tensile tests, and the mechanical properties of the sheets were evaluated. The stress-strain response of Al-2Mn-xSi and Al-4Mn-xSi sheets was similar to those of precipitation-hardened heat-treatable aluminum alloys. This behavior is considered to result from very fine and uniformly distributed dispersoids formed by annealing at 400˚C for 24h. The sheets fabricated from HSTRC strips show a superior mechanical strength compared to conventional non-heat-treatable 3000 and 5000 aluminum alloys.

- Chapter 4: Effect of large particles in the central region of Al-4Mn-1Si HSTRC cast strip on elongation of subsequent cold-rolled and annealed sheet

The large particles located in the central band of the Al-4wt%Mn-1wt%Si strips were examined. Microstructure and chemical analyses revealed that they were primary Al_6Mn and β-AlMnSi. These particles are considered to be formed in the solidification process of the residual liquid, which was slowly cooled after the strip left from the roll gap during HSTRC. In order to cool the residual liquid rapidly, the compressed air was blown to the strip surface immediately after the strip left the roll gap. The number and size of large particles in the central band region were reduced. As a result, the refined and homogenous microstructure of the cold-rolled and annealed sheets was obtained. Consequently, improvement of both strength and elongation was achieved successfully.

- Chapter 5: Influence of high Mn and Si on dispersion hardening effect in the cold-rolled and annealed sheets collected from HSTRC cast strips

The influence of Mn and Si on the precipitation of dispersoids were investigated from the distribution manner of constituent particles. The content of Mn and Si changes the cast strips' microstructure. The original microstructure at the as-cast condition controlled the distribution of constituent particles in the as-rolled condition. The dense distribution of very fine dispersoids was obtained under the condition of the sparser distribution and larger interspacing of constituent particles. The reason for the enhanced strength of cold-rolled and annealed sheets collected from HSTRC cast strips was examined in detail. The dispersion hardening by dispersoids which were precipitated from high supersaturated Mn solid solution was attributed to the increase in strength. The dispersion hardening effect was explained by the Orowan bowing mechanism. The overall contribution of dispersion hardening was enhanced with increasing Mn content, while it has been decreased with the higher content of Si. The most pronounced dispersion hardening effect was achieved in the 4wt% Mn and 1wt% Si containing sheets.

- Chapter 6: Conclusions

The findings in the present work were summarized and conclusions of this study were provided.