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Twin roll casting of high Mg contained aluminum alloy using commercial scale machine

Makoto Hagiwara[1], Shinichi Nishida[1], Daichi Uematsu[1], Shogo Imai[1], Mizuki Kawawa[1], Kyohei Ogawa[1] Takahiro Shiga[1] and Toshio Haga[2]
[1](*Gunma University, Department of Mechanical Science and Technology, 29-1 Honcho Ota City Gunma, 373-0057 Japan)*
[2]*(Osaka Institute of Technology)*
snishida@gunma-u.ac.jp

ABSTRACT *Twin roll casting process is able to produce a strip from molten metal directly. Thus this process has a possibility to reduce total cost of strip making comparing to conventional rolling process. Strip casting process has some disadvantages. Casting speed depends on the material properties. It is difficult to determine the casting conditions. Twin roll casting of high Mg contained aluminum alloy using commercial scale machine was operated. The aim of this study is to investigate the effect of the pouring temperature. Continuous strip could be produced at the every pouring temperature. However, solidification cracks were observed in all the strips.*

KEYWORDS **–** *Vertical type twin roll casting process, Aluminum alloy, Castability, Surface conditions, Strip thickness*

I. INTRODUCTION

This paper reports on the twin roll casting of aluminum alloy Al-3 mass% Mg using commercial scale machine. In general, a number of processes, including casting, rolling and heat treatment, are required to manufacture strips. Twin-roll casting can produce a strip directly from molten metal. [1] Therefore, the manufacturing cost can be reduced in comparison with the conventional thin plate fabrication. Although many laboratory-scale studies have been reported, there are only a few reports of studies using full-scale equipment. [2-10]

This study was conducted on vertical twin-roll casting of aluminum alloy Al-3 mass% Mg using a commercial scale machine for the purpose of practical application of strip casting. In this report, the effect of pouring temperature of molten metal was investigated. The continuity, surface properties and thickness of the strips were evaluated.

II. EXPERIMENTAL DEVICES AND CONDITIONS

Fig. 1(a), (b) and (c) show pictures of the experimental apparatus. Fig. 1(a) is a front view, Fig. 1(b) is a top view, and Fig. 1(c) is an overall view. This device was manufactured by IHI Co., Ltd. and transferred to Gunma University Ota Campus. This device was manufactured for magnesium alloys. In this time, some modifications were made in conducting experiments on aluminum alloys. The roll material is SKD 61, the roll diameter is 1,000 mm, the roll width is 240 mm, which is a solid material. The maximum rolling load on the design is 75 tons, and it is possible to apply loads up to 312.5 kgf / mm when converted per unit width. The roll gap is fixed type. The roll speed is variable using an inverter and can be varied from 3 m / min to 100 m / min. The capacity of the motor is 3 phases 400 V, 80 kW, and the roll is rotated through the gear box and the universal joint. Fig. 2 shows a photograph of the load cell. Two load cells are installed and it is possible to successively measure the rolling load during twin roll casting that changes every minute. In this study, only the maximum load in the experiment is shown. Fig. 3 shows a photograph of a side dam. The side dams are made of mild steel plates and five heat resistant cloth. Fig. 4 shows a photograph of the installed side dam. The top was bolted in place by a bolt and secured from the side by the axial force of the bolt using a metal block and a bolt. About 2 kg of Al-3 mass% Mg alloy was melted in a crucible furnace. Fig. 5 shows a pouring device. A wire was attached to the crucible box, and the box was tilted by pulling the wire from the mezzanine floor of the laboratory for safety. Fig. 6 shows a photograph of the nozzles. The nozzles are made of a mild steel plate, heat-resistant cloth, and a carbon sheet. The nozzles was used to control the solidification length. Graphite spray (Fine Chemical Japan Co., Ltd.) was used as a mold release agent for the rolls. Table 1 shows the experimental conditions. The initial roll gap was set at 1.5 mm. The roll gap was adjusted by tightening the nuts and checked with a thickness gauge. The solidification length is 100 mm. The pouring temperature was set at 660 °C, 670 °C, and 680 °C, and the roll peripheral speed was set at 10 m / min.

(a) Front view

(b) Top view

(c) Overall view

Fig. 1 Twin roll strip casting machine

Fig.2 Load cell

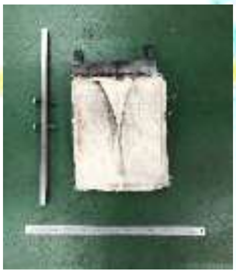

Fig. 3 Side dam plate

Fig. 4 Side dam plate location

Fig. 5 Pouring device

Fig. 6 Nozzles

Table 1 Experimental conditions

Material	Al-3 mass%Mg
Pouring temperature [□]	660,670,680
Liquidus temperature [□]	657
Initial roll gap [mm]	1.5
Solidification length [mm]	100
Roll speed [m/min]	10

III. RESULTS AND DISCUSSIONS

The Fig. 7(a), (b) and (c) show the strips. Table 2 shows the results of the measurements of strip thickness, length and maximum rolling load. The width of the strips coincided with the width of the roll. The strip could be produced continuously at 660 °C. The surface consisted of a metallic luster and a cloudy area. The strip could be produced continuously at 670 °C. The surface consisted of a metallic luster and a cloudy area. The strip could be produced continuously at 680 °C. The surface consisted of a metallic luster and a cloudy area. Solidification cracks appeared in the white part of the thin plate in all three conditions. Fig. 8 shows an enlarged photograph of the strip with the pouring temperature of 670°C. In the cloudy areas, there was in sufficient contact with the rolls. Therefore, cracks are considered to have occurred because of the tensile stress caused by the rotation of the rolls before solidification was completed due to insufficient cooling. The cause of the difference between the initial roll gap and the strip thickness is a matter of proficiency in the equipment, and this problem can be solved by setting the initial roll gap for the target strip thickness, taking into account the elastic deformation of the equipment and other factors. There was a tendency for the length of the strips to become shorter as the pouring temperature increased. This is considered to be because the higher the pouring temperature, the greater the amount of molten metal that passes through the gap without solidifying during pouring.

(a) 660 / ℃

(b) 670 / ℃

(c) 680 / ℃

Fig. 6 Produced strips

Fig. 7 Solidification cracks

Table 2 Strip thickness and rolling load

Pouring temperature [□]	660	670	680
Strip length [mm]	1395	983	822
Strip thickness [mm]	2.04	1.87	1.83
Rolling load [t]	60.2	53.0	37.6

IV. CONCLUSION

A In this study, twin-roll casting of aluminum alloy Al-3 mass% Mg was tested on a large scale machine to investigate the effects of pouring temperature on the continuity, surface properties and thickness of the thin plate. The conclusions are as follows.

[1] Strips could be produced continuously at all pouring temperatures.
[2] The every surface of the strips consisted of metallic luster and cloudy area.
[3] Solidification cracks were observed in the white part of all the strips.
[4] There was a difference in the initial roll gap and strip thickness. This is due to the level of skill of the equipment, and can be solved by setting the initial roll gap for the target strip thickness.

V. Acknowledgements

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