Research Article

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Horizontal Twin Roll Strip Casting of Aluminum Alloy A7075

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ABSTRACT

Twin roll strip casting of aluminum alloy A7075 using commercial scale machine was operated. 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 sheet 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. Aluminum alloy A7075 has high tensile strength, and it is known as a material for aerospace application. The sheet is manufactured in small quantities comparing to the other sheet aluminum alloy. It is supposed that the demand of high tensile strength aluminum sheet such as A7075 is going to increase for weight saving of structural material. The aims of this study are to investigate the effect of roll speed on the strip. Strip could not be produced continuously at roll speed of 10 m/min, so the load limit of this experimental apparatus was exceeded. However, a good strip without cracks was produced. Continuous strip was produced at a roll speed of 20 m/min. The strip was consisted of a mat part and a metallic luster part. However, cracks were observed in the white mat part of the board. Continuous strip was produced at a roll speed of 30 m/min. However, rolling cracks were observed at the edges of the strip. It is necessary to control the solidification distance by installing the nozzle.

Keywords
Twin roll casting process, Aluminum alloy A7075, Castability, Surface condition, Strip thickness.

Introduction
It is important that the improvement of fuel efficiency of transport machine such as automobile through the viewpoint of the global environment and the resource protection. The methods of improving fuel efficiency are the several ways such as improving of power drive system and reduction of running resistance and weight. Among them, weight saving of car weight is an effective method of improving fuel efficiency. Therefore, Aluminum for car structural material is attracted attention from the view point of the weight reduction. Aluminum demand in Japan is increasing for recent years. Especially the demand of aluminum for transport machine is increasing in last years. It is supposed that the demand of high tensile strength aluminum sheet such as A7075 is going to increase for weight saving of structural material [1]. In addition, it is supposed that the reducing the manufacturing cost of Aluminum strip is needed.

This paper describes a vertical type twin roll strip casting process for producing aluminum alloy strip of A7075. Aluminum strip [2] is generally produced by multi process such as DC casting, scalping, hot rolling of 200 mm ~ 600 mm thickness slab, repeated cold rolling and annealing. Form the above, the manufacturing cost of Aluminum strip become high because of the number of processes.

The vertical twin roll strip caster was used in this study. It is possible to produce an Aluminum strip continuously from molten metal directly by twin roll strip casting. The molten metal was solidified on the roll surface and formed to strip. Strip thickness is about 1~ 3 mm. Strip casting process is a rapid cooling solidification process. So that the mechanical properties improve. The roll speed is generally high in twin roll casting such as 60 ~ 150 m/min. Thus, it is possible to reduce the strip manufacturing cost compared with the conventional rolling process because of the highly productivity. Strip casting process has some disadvantages. Casting speed depends on the material properties. It is difficult to determine the casting conditions.

Aluminum alloy A7075 has high tensile strength, and it is known as a material for aerospace application. The sheet is manufactured in small quantities comparing to the other sheet aluminum alloy. Because some defects likely occurs on A7075 alloy sheet production such as solidification and hot cracking during casting and rolling. A lot of study of twin roll casting is reported [3]-[6]. In this study, continuous casting method of vertical twin roll strip of aluminum alloy A 7075 using large equipment for practical use of strip casting was studied. In this study, the influence of the roll circumferential speed was investigated. The continuity, surface condition, sheet thickness, rolling load, internal structure of the strip were evaluated.

Experimental Device and Condition

Figure 1 (a), (b) and (c) show photographs of the experimental apparatus. Figure 1 (a) is a front view of the device. Figure 1 (b) is a top view. Figure 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, and it 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 circumferential speed is variable using an inverter and can be varied from 5 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.

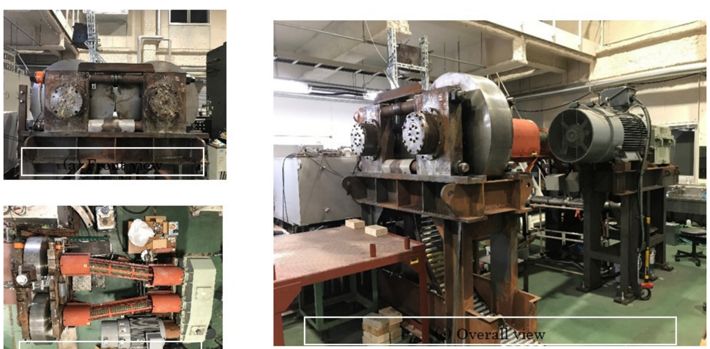


Figure 1: Twin roll strip casting machine.

Figure 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. Figure 3 shows a photograph of the side dam. The side dam is formed from a mild steel strip and five layers of heat resistant cloth. Heat resistant cloth was pasted to mild steel strip using spray glue (3M, 88). Approximately 2 kg of A7075 alloy was melted in a crucible furnace. Figure 4 shows a photograph of the pouring mechanism. We installed a wire in the crucible box and pour the wire by tilting the box by pulling the wire from the mezzanine level of the laboratory for safety. Because the amount of dissolution is small, we have not used nozzles this time. Also, no release agent to the roll was used. The experimental conditions are shown in Table 1. The initial roll gap was 1.0 mm. The roll gap was manually adjusted by tightening the nut and confirmed with a thickness gauge. According to preliminary experiments, the pouring temperature was 640°C (5°C on the liquidus line). Roll speed was 10m/min, 20m/min, 30m/min. In the preliminary experiments, it was confirmed that the molten metal did not solidify but passed through the roll gap portion at a roll speed of 30m/min or more.

Figure 2: Load cell.


Figure 3: Side dam strip.

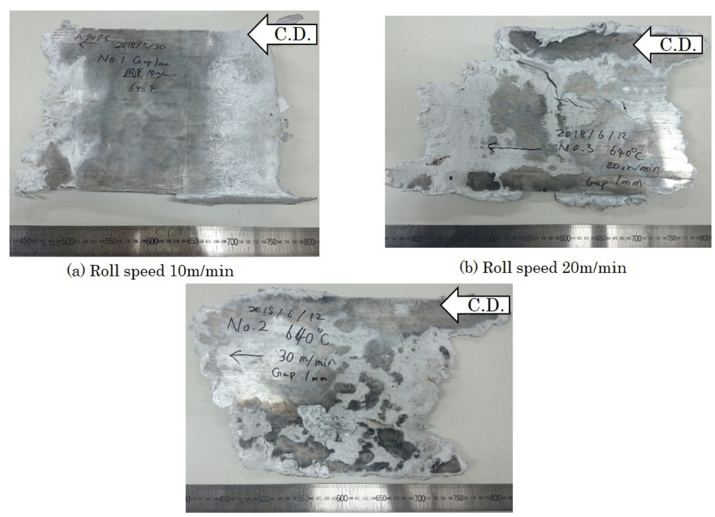

Figure 4: Pouring device.

Material	A7075
Pouring temperature [°C]	640
Initial roll gap [mm]	1.0
Roll speed [m/min]	10, 20, 30

Table 1: Experimental conditions.

Results and Discussion

Figure 5 (a), (b) and (c) show photographs of strips produced. At the circumferential speed of 10 m / min there was no crack in the surface of the strip. The roll surface was transferred. It had metallic luster. At a roll speed of 20 m/min, a metallic luster part and an opaque part were observed.



(a) Roll speed 10m/min

(b) Roll speed 20m/min

(c) Roll speed 30m/min

Figure 5: Produced strips.

Figure 6 shows an enlarged photograph of the strip surface with a roll speed of 20 m/min. Solidification cracks were observed in the white turbid part. This was insufficient because the contact with the roll was insufficient in the white turbid part, so cooling was insufficient. It is considered that cracking occurred because the solidification was not completed and the rolling force of the roll was received. Figure 7 shows an enlarged photograph of the strip surface with a roll speed of 30 m/min. Even at a roll speed of 30 m/min, a metallic luster part and an opaque part were observed. At a roll speed of 30 m/min, hot cracks were observed in the glossy portion of the strip edge portion. This is because there is no nozzle, the coagulation distance couldn't be controlled and the amount of solidification near the edge increases. Therefore, it seems that it occurred because the apparent rolling reduction increased.

Figure 6: Produced strips (roll speed 20m/min).

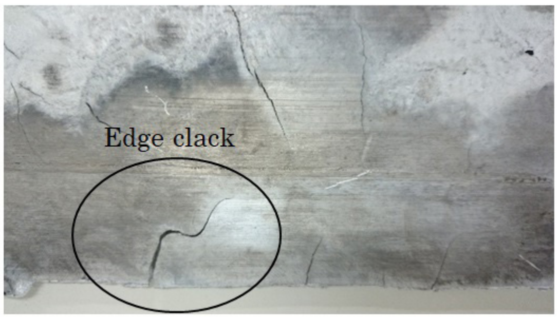


Figure 7: Produced strips (roll speed 30m/min).

Table 2 shows strip thickness, strip length and maximum rolling load. The difference between the initial roll gap and the strip thickness can be solved by grasping the actual elastic deformation amount of the apparatus by preliminary experiment and reflecting it on the initial roll gap. Continuous strips could be produced at roll speeds of 20 m/min and 30 m/min. Roll speed of 10 m/min, the equipment automatically stopped beyond 75 tons, which is the load limit of the equipment. No continuous sheet was produced. Generally, as the roll speed rises, the fluidity of the molten metal tends to be high and the load tends to decrease. In this experiment, the load increased at a circumferential speed of 20 m/min than the circumferential speed of 30 m/min. This is thought to be due to the fact that the coagulation distance is not constant because the nozzle is not used. Figure 8 (a) and (b) show microstructural photographs at a roll speed of 10 m/min. There were less precipitates and precipitates than the general microstructure of A7075. It is considered that supersaturated α-Al solid solution was formed by rapid solidification. Many crystallized substances and precipitates were observed in the vicinity of the center from the vicinity of the roll surface.

Roll speed [m/min]	10	20	30
Strip length[mm]	160	390	430
Strip thickness [mm]	2.2	1.6	1.6
Rolling load [t]	90	28	34

Table 2: Strip thickness and rolling load.

Summary

In this study, we conducted experiments on strip casting of aluminum alloy A 7075 using twin roll machine of actual machine size. Surface properties, surface properties, strip thickness and effects of roll circumferential speed on microstructure were investigated.

The conclusion is as follows.

- A 7075 strip could be fabricated at any circumferential speed.
- When the peripheral speed was 10 m/min, a continuous strip was not produced because the load limit of the device was exceeded. However, metallic luster was observed on the entire strip without cracking.
- Solidification cracking occurred in the white turbid part at the peripheral speed of 20 m/min. In addition, edge cracking occurred at a peripheral speed of 30 m/min.
- There was a difference in initial roll gap and sheet thickness.

The cause is a skill level with respect to the apparatus, and this problem can be solved by setting an initial roll gap with respect to the intended thickness in consideration of the elastic deformation etc. of the apparatus. It is thought that developing a nozzle for this device and controlling the solidification distance leads to an improvement in the quality of the strip.

Acknowledgment

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References

1. Light Metal Society edition: Microstructure and properties of aluminum 1991.
2. Engler, C. Schäfer, H. J. Brinkman, J. Brecht, P. Beiter and K. Nijhof, Journal of Materials Processing Technology. 2016; 229: 139-148.
3. Toshio Haga, Hideki Inui, Hisaki Watari, et al. Casting of Al–Si hypereutectic aluminum alloy strip using an unequal diameter twin roll caster. Journal of Materials Processing Technology. 2007; 191: 238-241.
4. Haga T, Ikawa M, Watari H, et al. 6111 Aluminium alloy strip casting using an unequal diameter twin roll caster. Journal of Materials Processing Technology. 2006; 172: 271-276.
5. T. Haga, K. Takahashi, M. Ikawaand and H. Watari, Journal of Materials Processing Technology. 2004; 153: 42-47.
6. Haga T, Suzuki S. Study on high-speed twin-roll caster for aluminum alloys. Journal of Materials Processing Technology. 2003; 143-144: 895-900.