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Casting of aluminum alloy strip using an unequal diameter twin roll caster

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ABSTRACT

Purpose: of this paper is to clear the property and ability of an unequal diameter twin roll caster to cast commercial size strip. Therefore, 400mm-width strip was cast as first step. Surface-condition, microstructure and mechanical property of the strip was investigated.

Design/methodology/approach: Method used in the present study was an unequal diameter twin roll caster. This method was devised to realize easy operation of the twin roll casting and increase of casting speed.

Findings: are that 400-width-strip of 3084, 5182 and 6022 could be cast at speed of 20 m/min. This strip was about 4 mm-thick. There were some defects on the surface. As cast strip could be cold-rolled down to sheet of 1 mm-thick. 180 degrees bending test was operated on the 6022 sheet after T4 heat treatment. Crack did not occurred at the outer surface when strip was bent at width-direction.

Research limitations/implications: is that the quantity of the melt was 21kg and investigation of the properties was not enough for practical use. The larger weight of melt must be cast for production.

Practical implications: are as below. The 400mm-width strip can be cast easily by the unequal diameter twin roll caster. This caster can be adapted to 3083, 5182 and 6022.

Originality/value: as below. The economy sheet with 400mm width can be produced by the unequal diameter twin roll caster. 3083, 5182 and 6022 can be cast at the speed of 20m/min. The thickness of the strip was about 4mm.

Keywords: Casting; Unequal diameter twin roll caster; Strip casting; Sheet metal

MATERIALS MANUFACTURING AND PROCESSING

1. Introduction

An unequal diameter twin roll caster was devised to realize easy roll casting and the high speed casting [1]. The unequal diameter twin roll caster could not cast the strip higher than a vertical type twin roll caster [2-4]. However, the operation of the casting of the unequal diameter twin roll caster was easier. In the previous research, the width of the roll was 100mm. This width was narrow for the industrial use in the factory. As the second step of the research of the unequal diameter twin roll caster, a laboratory size twin roll caster with 400mm-width-roll was assembled to investigate the influence of the width of the roll on the casting and properties of the strip. The 400mm-width roll is near to the roll of the smallest size twin roll caster used in the factory. The aluminum alloys; 3083, 5182 and 6022 were cast to investigate properties of the caster and strips. These aluminum alloys are typical alloys used at the shape at sheet.

The concept of the unequal diameter twin roll caster is as below. The aluminum alloy strip is not hot-rolled by heavy load like the conventional twin roll caster for aluminum alloy [5-16]. The roll speed is 20m/min, which is much higher than that of the conventional twin roll caster. The thickness of the solidified layer by the upper and lower roll is not same; microstructure is not symmetry at thickness

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direction. Property and ability of the high-speed and the light-load roll casting was investigated, when the width became wider.

2. Experimental conditions

A schematic illustration of the unequal diameter twin roll caster is shown in Fig.1. The diameter of the upper roll was 300mm and that of lower roll was 1000mm, and width of the both roll was 400mm. The material of the roll was mild steel. In this process, the strip was not hot-rolled by heavy load. The upper roll was supported by the springs to cast with light load. Therefore, mild steel rolls could be used instead of tool steel rolls. The thermal conductivity of the mild steel is larger than that of the tool steel. Therefore, the mild steel is suitable for the rapid solidification. The thickness of the shell of the roll was thinner than that of the roll of the conventional twin roll caster (ref. Fg.2). The thickness of the shell was usually from 25mm to 60mm in the conventional roll. The thickness of the shell was 6 mm in the present study. Thin shell is suitable for the rapid solidification, too. The parting material was not used on the roll surface to prevent the sticking of the strip to the roll. The parting material becomes heat resistance. The non-use of the partial material makes the heat transfer between the metal and roll larger.

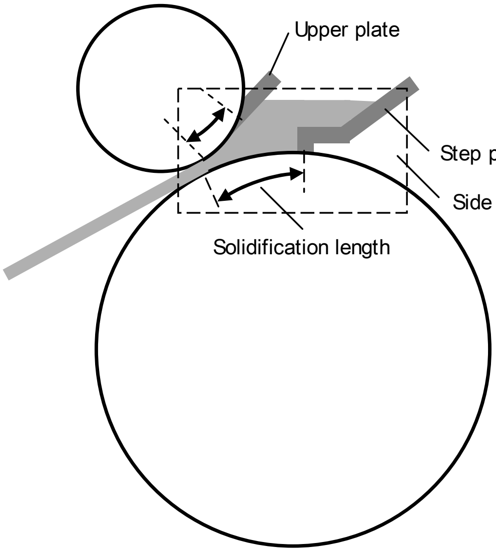

Fig. 1. Schematic illustration of an unequal diameter twin roll caster

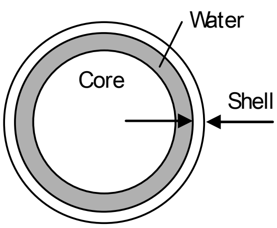

Fig. 2. Schematic illustration of the cross section of the roll

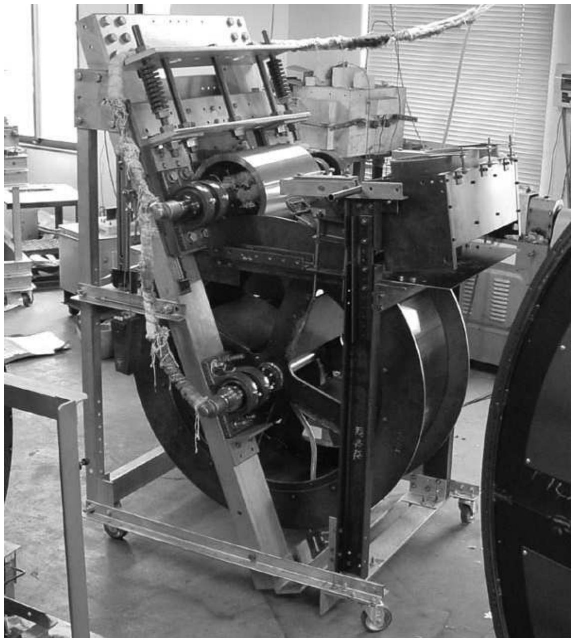

Fig. 3. Photograph of an unequal diameter twin roll caster with 400mm-width roll

In this process, the tip was not used. Non use of the tip was suitable for easy maintenance of the nozzle. The melt was not poured on the roll directly but on the step plate. The puddle of the melt was formed by four plates on the roll. They are two side dam plates, one upper plate and one step back plate. This method acts usefully to uniform the temperature at width direction.

The inclination angle of the upper roll was 15 degrees. Solidification length, which is same as the set back of the conventional twin roll caster, is 60mm and 200mm, respectively.

The rolls were rotated at casting speed and melt was poured on the step back plate though the launder. Aluminum alloys, which are used as plate, were cast as trial casting. They were 3084, 5182 and 6022. Mechanical property 6022 was investigated by tension test and 180 degrees bending test.

Weight of the melt was 21 kg. The melt was poured from the three crucibles. The low temperature casting was adopted in this process. The superheat of the melt was 10^{O}C, and a cooling slope was used [1-4]. The low temperature casting affected rapid solidification, heat load of the roll, increase of the casting speed and prevention of the strip-sticking. Figure 3 shows the laboratory size unequal diameter twin roll caster with 400mm-width-rolls.

3. Result and discussion

Three kinds of aluminum alloys, 3084, 5182 and 6022 were could be cast into the strip continuously. Start of casting was very easy. Special operation for start was not needed. Figure 4 shows twin roll casting in operation. There was not trouble which occurred by use of wide roll. The roll speed of 20 m/min was attained. Figure 5 shows the surface of as cast strip. The surface was different by the alloy. The upper and lower surface was different, too. This is the influence of the contact and wetting condition between the roll and the melt. Some defects were observed on the strip surface.

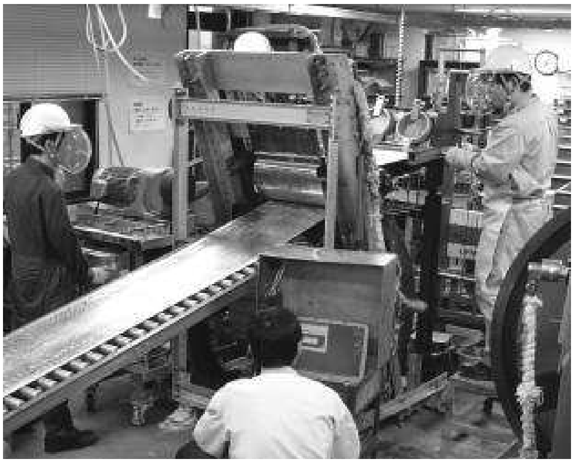

Fig. 4. Twin roll casting in operation at 20m/min

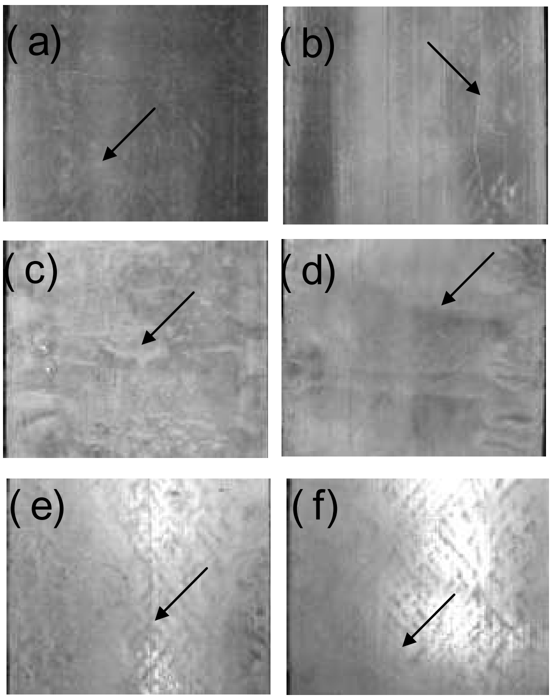

Fig. 5. Surface of as-cast strip. (a),(c) and (e) is upper roll side surface. (b), (d) and (f) are lower roll side surface. (a),(b): 3083, (c),(d): 5182, (e),(f): 6022

The arrows in Fig.5 show white area. The contact condition between the melt and the roll was not good at white area. Cracks existed at some white area. Solidification might not be completed at white area when the strip released from the roll.

Figure 6 shows thickness distribution at width direction. Both edges were thicker than inside. This might be influence of the heat crown of the rolls on the strip-thickness.

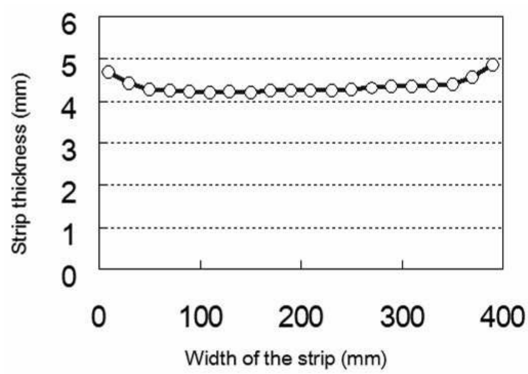

Fig. 6. Thickness distribution of the strip at width direction.

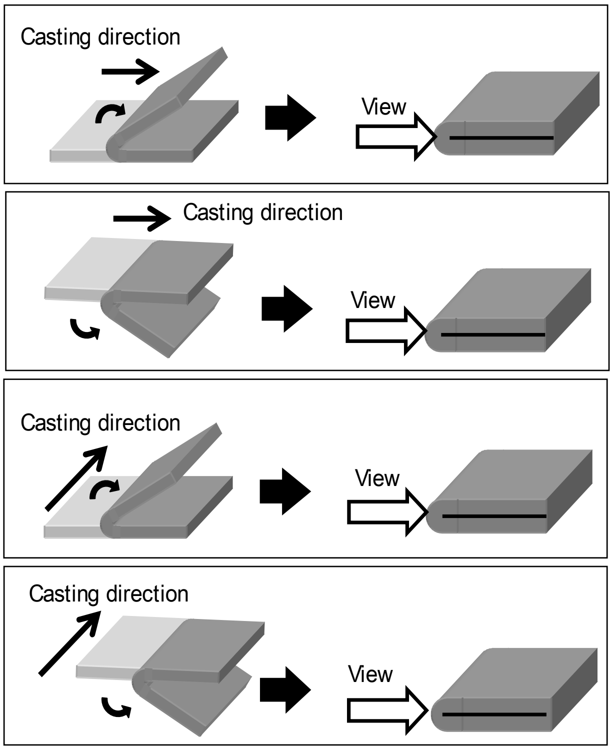

Fig. 7. 180 degrees bending test. The as-cast strip was cold-rolled down to1mm, and T4 heat treatment was operated. 5% of strain was induced before bending

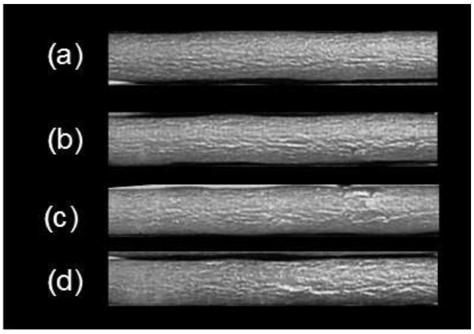

Fig. 8. Result of 180 degrees bending test shown in Fig.7. Material is 6022.The as-cast strip was cold rolled down to 1mm, and T4 heat treatment was operated. 5% strain was induced before 180 degrees bending

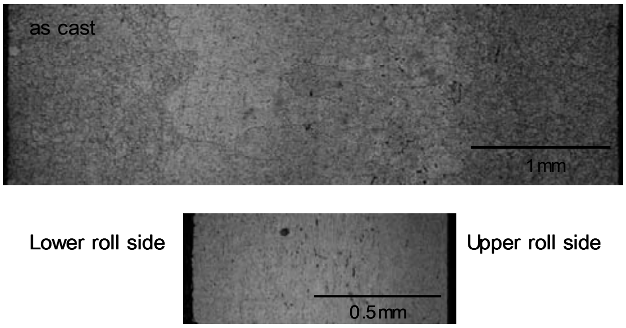

Fig. 9. Microstructure of the cross section of as-cast 6022 strip (upper) and T4 heat treated 6022 strip after cold rolling (lower)

Table 1.
Result of tension test of T4 heat treated strip (gage 5 mm)

Tensile stress[MPa]	Proof stress[MPa]	Elongation[%]
194	102	22.4

Figure 7 shows the way of the 180 degrees bending test. The result is shown in Fig.8. There was not difference in result between upper and lower surface. The result was worse when the strip was bent parallel to the casting direction (rolling direction). This might be influence cold rolling, as the microstructure was stretched to the rolling direction.

Figure 9 shows the microstructure of as-cast 6022 strip and T4 heat treated 6022 strip after cold rolling. The microstructure of the as-cast strip was not uniform at thickness direction. Moreover, the microstructure was not symmetric by the difference of the upper and lower solidification length. However, the microstructure became almost same and symmetric after cold rolling and T4 heat treatment.

Table 1 shows the result of the tension test of the 6022-T4 strip. The result was lower than that of strip made by D.C. casting. One of this reason might be crack on the surface. This can be improved by the grooved roll.

4. Conclusions

Low–roll-load and high-speed-casting were adopted to an unequal diameter twin roll caster. 400mm-width-3084, 5182 and 6022 aluminum alloy strip could be cast by the laboratory size unequal diameter twin roll caster. This result showed the unequal diameter twin roll caster had the ability that wide strip could be cast. Some defects, for example, white area and small crack must be improved.

References

[1] T. Haga, H. Sakaguchi, H. Inui, H. Watari, S. Kumai, Aluminum alloy semisolid strip casting using an unequal diameter twin roll caster, Journal of Achievements in Materials and Manufacturing Engineering 14 (2006) 157-162.
[2] T. Haga, H. Watari, S. Kumai, High speed twin roll casting of Mg alloy strip by a vertical type twin roll caster, Journal of Achievements in Materials and Manufacturing Engineering 15 (2006) 186-192.
[3] T. Haga, M. Ikawa, H. Watari, S. Kumai, High speed twin roll casting of 6016 strip, Journal of Achievements in Materials and Manufacturing Engineering 18 (2006) 371-374.
[4] T. Haga, M. Ikawa, H. Watari, S. Kumai, High speed twin roll casting of recycled Al-3Si-0.6Mg strip, Journal of Achievements in Materials and Manufacturing Engineering 18 (2007) 7-12.
[5] R. Cook, P.G. Groock, P.M. Thomas, D.V. Edmonds, J.D. Hunt, Development of the twin-roll casting process, Journal of Materials Processing Technology 55 (1995) 76-84.
[6] M. Cortes, Pechiney-Junmbo 3CM, The new demands of thin strip casting, Light Metals (1995) 1161-1164.
[7] B. Taraglio, C. Romanowski, Thin-gage/high-speed roll casting technology for foil production, ibid (1995) 1165-1182.
[8] A.I. Nussbaum, Three-state-of-the-art Thin –gage high-speed roll caster for aluminum alloy sheet products Part III, Light Metals Age 55 (1997) 34-39.
[9] O. Daaland, A.B. Espedal, M.L. Nedreberg, I. Alvestad, Thin gage twin-roll casting, process capabilities and product quality, Light Metals (1997) 745-752.
[10] P.Y. Menet, R. Cayol, J. Moriceau, Pechiney Jumbo 3CM start-up of the Neu-Brisach thin strip caster, Light Metals (1997) 753-756.
[11] P.M. Thomas, P.G. Grocock, J.M. Bouzendorffer, Dynamic strip caster-An update on the operation of the roll caster at Eurofoil, Metall Plant Technology Intitute 20 (1997) 44-52.
[12] S. Hamers, D. Smith, C. Romanowski, G. Yildizbayrak, B. Taraglio, Twin roll casting of aluminum at 2.5mm gauge. Production experience and process improvement, Light Metals (1999) 931-937.
[13] J. Benedyk, Thin strip casting for aluminum alloy sheet applications developed by Pechiney at Neuf-Brisach, Light Metals Age 59 (2001) 28-30.
[14] S. Hamer, C. Romanowski, B. Taraglio, Continuous casting and rolling of aluminum: Analysis of capacities, products ranges, and Technology, Light Metals Age 60 (2002) 6-17.
[15] M. Duendar, OE. Keles, B. Kerti, N. Dogan, Crystallographic texture development of twin-roll cast aluminum strips, Light Metals 34 (2004) 723-724.
[16] Ch. Gras, M. Meredith, J.D. Hund, Microdefects for mation during the roll casting of Al-Mg-Mn aluminum alloys, Journal of Materials Processing Technology 167 (2005) 62-72.