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Grooved roll for a high speed twin roll caster

T. Haga [a,*], K. Hirooka [a], H. Watari [b], S. Kumai [c]

[a] Osaka Institute of Technology, 5-16-1 Omiya Asahiku Osakacity, 535-8585 Japan
[b] Gunma University, 1-5-1, Tenjin Cho, Kiryu City, Gunma, 376-8515, Japan
[c] Tokyo Institute of Technology, 4259, Nagatsuda, Midoriku, Yokohama City, Kanagawa, 226-8502, Japan
* Corresponding author: E-mail address: haga@med.oit.ac.jp

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ABSTRACT

Purpose: Purpose of this paper is investigation of the effect of roll-surface on the strip-surface. Improvement of small cracks on the strip-surface was tried and effect of groove at the roll surface on the strip surface was shown.

Design/methodology/approach: Method used in the present study was high speed twin roll caster with grooved roll. Two kinds of grooves were used: one was parallel groove and the other was cross groove machined by knurling and bite attached to a lathe.

Findings: Findings of this research are that grooved roll was effective to eliminate the small cracks on the strip surface. The contact condition between the roll and the melt became uniform by the small groove on the roll surface. Contact area became small, and heat transfer between the melt and roll became small, too. As the result, chill structure did not become columnar, and crack did not occur. Groove pattern on the strip surface could be erased by the cold rolling.

Research limitations/implications: Research limitation is that groove life could not be investigated.

Practical implications: Practical implications are as below. The roll load was small and strip was not hot-rolled in a high speed twin roll caster. The grooved roll made strip-surface sound. Grooved 600mm width roll was tested, and usefulness of the grooved roll was shown.

Originality/value: In the present study effect of the grooved roll on a high speed twin roll caster was investigated.

Keywords: Casting; Twin roll caster; Grooved roll; Roll surface

MATERIALS MANUFACTURING AND PROCESSING

1. Introduction

The conventional twin roll caster for aluminum alloys is horizontal type [1-12]. A vertical type high speed twin roll caster was used in the present study [13-16]. Some devices were adapted to the high speed twin roll caster to cast sound strip at high speed. For example, they were nozzle, copper rolls, no-use of parting material, and a cooling slope. The wetting condition between aluminum alloy and copper roll was better than that between aluminum alloy and steel roll. Therefore, the use of copper roll was useful at the point not only rapid solidification but also soundness of the strip surface. The vibration of the meniscus of the melt at melt toll contact point could be maintained constant by hydrostatic pressure of the melt. Melt head was gained by the nozzle. The strip surface became sound as the meniscus was free from the vibration. In this way, some devices were induced to make strip-surface sound. However, defects were observed on the strip cast by the high speed twin roll caster. One is white area and small cracks. The contact of the melt to the roll was not good at white area. Thickness at white area was thinner than other area. Crack was observed at white area and small cracks were observed at other area, too. Small cracks were happened at grain boundary at chill structure. Elimination of small columnar structure at chill area might be useful to get rid of small cracks.

The grooved roll was adopted to improve the white area and small cracks. In the present study effect of the grooved roll on a high speed twin roll caster was investigated.

2. Experimental conditions

Figure 1 shows a vertical type high speed twin roll caster. In one case copper roll was used. The diameter was 300 mm and width was 50 mm. Molten-metal was aluminum alloy 6061. Melt temperature at pouring was 660 ^{O}C and semisolid casting was operated by a cooling slope [17]. Roll speed was 60 m/min. Roll-load was 14 kN. Figure 2 shows the surface of two kinds of grooved rolls, figure 3 shows the shape of the groove. The shape of the cross groove and parallel groove was the same.

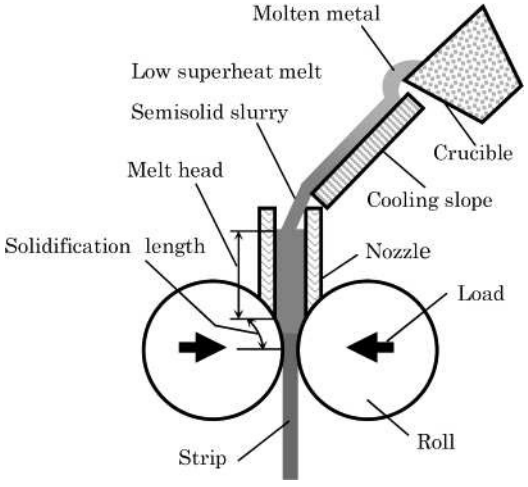

Fig. 1. High speed twin roll caster

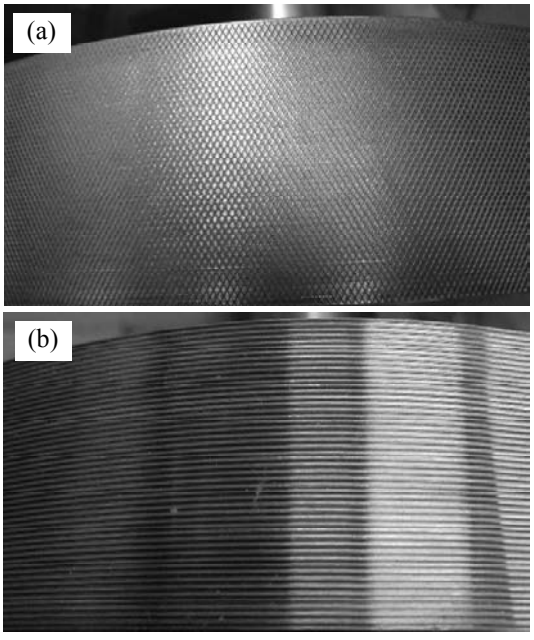

Fig. 2. Grooved roll used at a vertical type high speed twin roll caster. (a) cross groove roll, (b) parallel groove roll

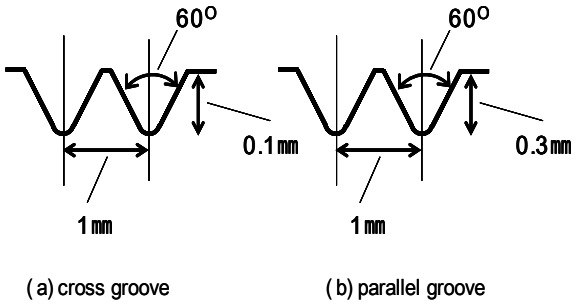

Fig. 3. Shape of the groove on the roll surface

3. Result and discussions

Figure 4 shows the shape of the bulge formed on the strip surface. Rotation of the roll was stopped in the course of operation of casting, and the bulges were observed. Figure 4 (a) shows the bulge on the strip surface before, and (b) after loading by the rolls. The height of the bulge was low before the loading by the roll. Melt was inserted in the groove by the melt head when the melt contacted to the roll. Therefore, the melt did not fill the groove, and the height of the bulge was lower than the depth of the groove. Melt could not insert fully in the groove by the surface tension. When the load was given by the roll at roll bite, metal inserted in the groove deeply. The strip surface was deformed. The deformation area was very thin and narrow. When the strip was deformed, strip surface might be semisolid condition as the melt did not contact to the roll.

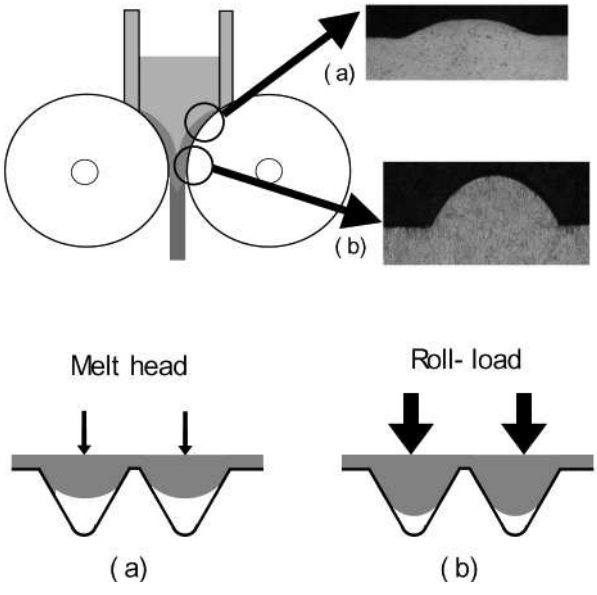

Fig. 4. Cross section of the bulge on the roll surface at the point before and after roll loading

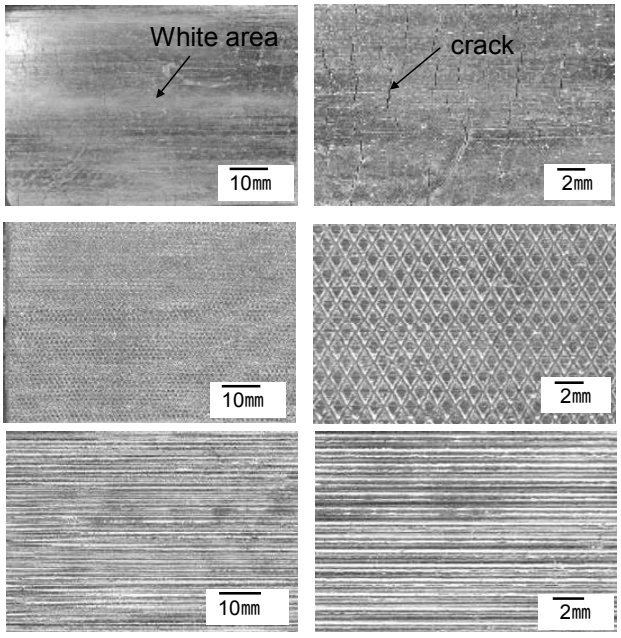

Fig. 5. Surface of as-cast strip. upper: flat roll, middle: cross groove roll, lower: parallel groove roll

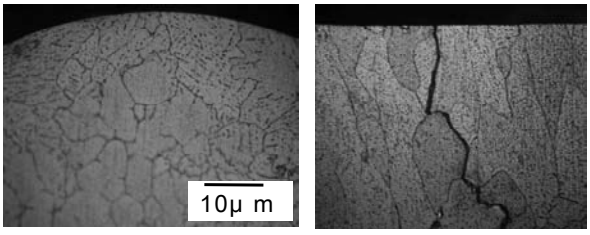

Fig. 6. Cross section around the bulge of the strip cast by the grooved roll, and crack of the strip cast flat roll.

Figure 5 shows the surface of the as-cast strip. There was white area and crack on the strip-surface casted by the flat roll. The white area of the strip casted by the flat roll was thin. There was a white area on the surface of the strip cast by the grooved roll. However, the strip was not thin at the white area when the grooved roll was used. The meniscus at roll tip was dragged by the roll and meniscus became large when the white are was formed. The contact condition between the melt and the roll was worse at white area than other area. In the grooved roll, the roll was governing factor to the contact condition of the melt. In the grooved roll, the contact condition was not good at groove. Difference of the contact condition between the areas was small in the grooved roll. The effect of the grooved roll was larger than that of meniscus-vibration. The contact condition between white area and other area was small, too. The heat transfer became uniform by the groove. The surface of the strip deformed as the roll rotated, and surface became uniform.

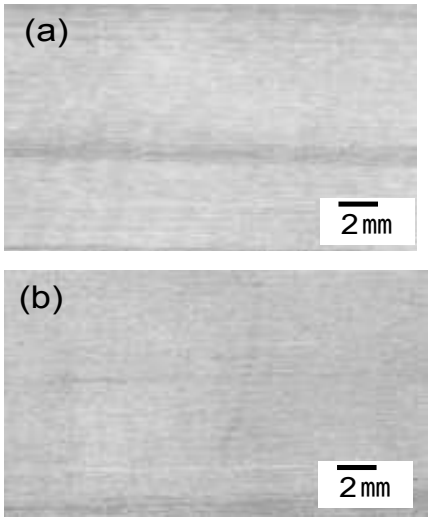

Fig. 7. Strip surface of the cold-rolled strip. The as-cast strip was cold-rolled down to 1mm. (a) cross grooved roll, (b) parallel grooved roll

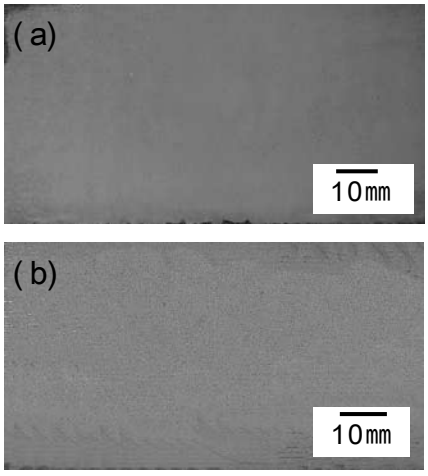

Fig. 8. Result of the color check on cold rolled surface of the strip cast using the grooved rolls

Figure 6 shows the cross section around the bulge of the strip cast by the grooved roll, and the crack of the strip cast by the flat roll. The microstructure of the chill area of the strip cast by the flat roll was columnar structure. The crack occurred at grain boundary. On the other hand, the structure in the chill area of the strip cast by the grooved roll was not columnar but globular structure. Crack did not occur at the bulge. The globular structure resisted the crack. The heat transfer became lower at the grooved roll as the melt did not contact to the roll at the grooves. Therefore, the microstructure became globular.

Figure 7 shows the surface of the cold rolled strip cast using the grooved roll. The as-cast strip was cold rolled down to 1 mm. The bulge was erased by the cold rolling. There was no difference

on the rolled surface between the strip cast by flat roll and the strip cast by the grooved roll.

Figure 8 shows the result of the color check. This shows that there was no crack on the surface. The crack was not occurred where the bulge was pressed by the roll. This result shows that the bulge on the surface did not become defect.

The strip cast using the grooved roll can be used to improve the defects on the surface of the strip. This method can be used to make concave and convex on the surface of the strip like the embossing. This process may become new process to make the decollated strip or embossed strip. This process (method) can be called "roll cast printing process".

4. Conclusions

Effect of the grooved roll on the surface of the strip cast by a high speed twin roll caster was investigated to improve the surface. Two types of groove patens, which were cross grooves and parallel grooves, were tested. The thickness at the white area of the strip, where the contact condition between the melt and the roll was wore, did not become thin when the grooved roll was used. The grooved roll was useful to improve the thickness distribution of the strip.

The microstructure of the chill area of the strip cast using the grooved roll was not columnar but globular. This shows that heat transfer between the grooved-roll and the melt became lower than that of the flat-roll. The crack that occurred at the grain boundary was eliminated by the grooved roll.

The bulge made by groove could be erased by the cold rolling. The surface of the strip cast by grooved roll could be flat without special operation. Crack did not occur at the budge after cold rolling.

The grooved roll was useful to get rid of small cracks on the strip surface and thin area of the strip thickness in the high speed twin roll caster.

The grooved roll could be used like the embossing. This method can be called "roll cast printing process". By this process the decollated strip can be cast directly from the melt.

References

[1] 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.

[2] M. Cortes, Pechiney-Junmbo 3CM, The new demands of thin strip casting, Light Metals (1995) 1161-1164.

[3] B. Taraglio, C. Romanowski, Thin-gage/high-speed roll casting technology for foil production, Light Metals (1995) 1165-1182.

[4] 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.

[5] 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.

[6] P.Y. Menet, R. Cayol, J. Moriceau, Pechiney Jumbo 3CM 'TM' start-up of the Neu-Brisach thin strip caster, Light Metals (1997) 753-756.

[7] P.M. Thomas, P.G. Grocock, J.M. Bouzendorffer, Dynamic strip caster-An update on the operation of the roll caster at Eurofoil, Metal Plant Technology Institute 20 (1997) 44-52.

[8] 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.

[9] J. Benedyk, Thin strip casting for aluminum alloy sheet applications developed by Pechiney at Neuf-Brisach, Light Metal Age 59 (2001) 28-30.

[10] S. Hamer, C.Romanowski, B.Taraglio, Continuous casting and rolling of aluminum: Analysis of capacities, products ranges, and Technology, Light Metal Age, 60 (2002) 6-17.

[11] M. Duendar, OE. Keles, B. Kerti, N. Dogan, Crystallographic texture development of twin-roll cast aluminum strips, Light Metal (2004) 723-724.

[12] 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.

[13] 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.

[14] T. Haga, M. Ikawa, H. Watari, S. Kumai, High speed twin roll casting of Al-3Si-0.6Mg strip, Journal of Achievements in Materials and Manufacturing Engineering 17 (2006) 337-340.

[15] 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.

[16] 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 21/1 (2007) 7-12.

[17] T. Motegi, N. Ogawa, Continuous casting of semisolid Al-Si-Mgalloy, Proceedings of the International Conference on Aluminum Alloys"ICAA-6" Toyohashi Japan, 1998, 297-326.