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A SINGLE ROLL CASTER EQUIPPED WITH A SCRAPER

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Abstract

A single roll caster equipped with a scraper was designed and assembled. The effect of the scraper was investigated. A constant load of 1 N/mm was sufficient to push the scraper. The surface that did not contact to the roll was scribed by the scraper. The thickness distribution was improved. The heat transfer between the roll and the strip became greater and the strip was sufficiently cooled. A strip of 5182 aluminum alloy could be cast at the speed up to 40 m/min. Center line segregation did not occur, and no difference was found between the two surfaces after cold rolling.

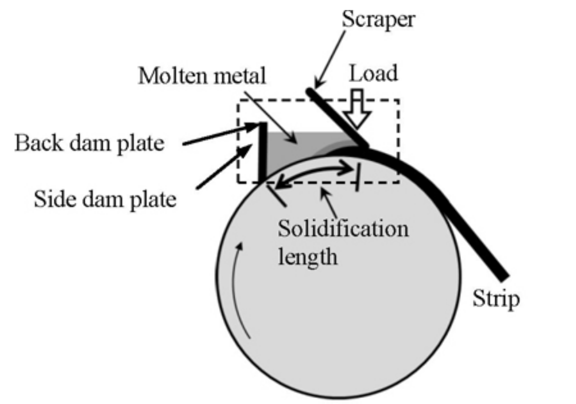
Introduction

Some problems of the strip casting of Al-Mg alloy by a twin roll caster are center line segregation and porosity at the center [1,2]. For example, the center line segregation makes mechanical properties and strip-surface worse. These are typical defects that occur in Al-Mg alloy strip cast by the twin roll caster, and the defects become significant as the Mg content increases. These defects do not occur with a single roll caster. However, the free solidified surface is not flat and the thickness distribution is not uniform [3,4]. A scraper was proposed to improve these defects caused by the single roll caster. The scraper scribes semisolid metal on the free solidified surface. In this paper, the properties of a single roll caster equipped with a scraper(SRCS) are shown.

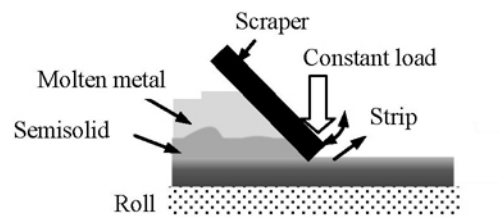
Experimental conditions

<u>A single roll caster equipped with a scraper</u>

A schematic illustration of a SRCS is shown in Figure 1. The scraper is attached to the roll. The scraper is moveable around the fulcrum, and contacts the strip by a constant load. The scraper scribes the semisolid metal on the free solidified surface. Two types of scrapers, referred to as A and B, were tested. These are shown in Figure 2. The core of both scrapers is mild steel plate. The tip of the type A scraper is covered by insulator sheet, whereas the mild steel plate at the tip of the type B scraper is exposed. A copper roll is used. The diameter of the roll is 300 mm and the width is 100 mm. The roll was cooled by water from inside. The roll-surface was polished by #1200 emery paper. Releasing material was not used on the roll-surface. The roll speeds were 10, 20, 30 and 40 m/min. The loads to push the scraper were 4, 6, 10 and 20 kg. The solidification lengths were 100 and 200 mm. The aluminum alloy used was 5182 and the pouring temperature of the molten metal was 655°C. The roll was rotated at the designated roll speed and the molten metal was poured on the roll. The initial gap between the scraper and the roll-surface was 1 mm. The effects of the roll speed, and the scraper load on the strip thickness were investigated. Mechanical properties were tested by the tension test and the cup test. The as-cast strip was cold rolled down to 1mm, then annealed at 380°C for 1.8 ks. Specimens for the tests were made from this plate.



(a) Schematic illustration of a single roll cater equipped with a scraper



(b) Schematic illustration of around the scraper

Figure 1. Schematic illustration of a single roll caster equipped with a scraper

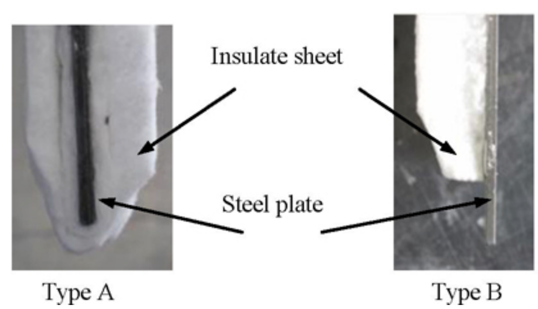
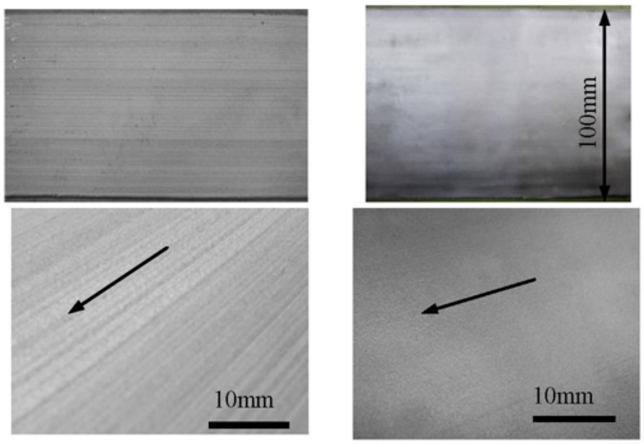


Figure 2. Two types of scrapers

Result and discussion

<u>Scribed surface</u>

The surfaces of the strips cast by the type A and the type B scraper are shown in Figure 3. For surfaces of the strip cast by type A scraper, the insulator sheet helped to prevent leaking of the molten metal. However, because the density of the insulator sheet was not uniform, deformation was not uniform in the width direction. As the result, a trace pattern formed on the surface as shown in Figure 3(a). The edge of the as-cast strip is shown in Figure 4. No burrs and edge cracks occurred. The appearance of the edge of the strip cast by the SRCS was better than that cast by the twin roll caster. The thickness distribution in the width direction of the as-cast strip cast by the type B scraper is shown in Figure 5. It is shown that the thickness distribution is sound. This result shows that the scribed surface was flat.



(a) Scraper: type A (b) Scraper: type B

Figure 3. Photograph of the scribed surfaces of the strip cast by the type A scraper and type B scraper. Arrows show casting direction.

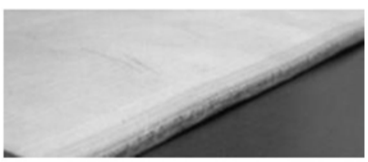


Figure 4. Photograph of the edge of the as-cast strip

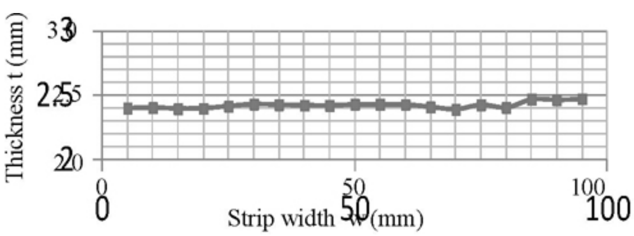


Figure 5. Thickness distribution at width direction of the as-cast strip cast by the type B scraper

Effect of casting condition on thickness

The relationship between the roll speed and the strip thickness is shown in Figure 6. The strip thickness became thinner as the roll speed became higher. This tendency is the same as that of the single roll caster without a scraper [3]. That is, the scraper did not affect the relationship between the roll speed and the strip thickness. Figure 7 shows scribed surfaces of the strips cast at speeds of 10, 20, 30 and 40 m/min by the type A scraper. The unevenness on the scribed surface of the strip at 10 m/mi was harder than the strip. No significant difference appeared on the scribed surfaces of the strips cast at 20, 30 and 40 m/min. The scribed surface was not affected by the roll speed when the roll speed was higher than 20 m/min. When the roll speed was 10 m/min, the thickness of the semisolid layer might be thicker than the strips cast at the higher roll speed. At this slower roll speed, the unevenness became harder. The roll contact surfaces of the as-cast strips are shown in Figure 8. The distance of the ripple marks became wider as the roll speed became higher. This is the same result as that of the conventional single roll caster.

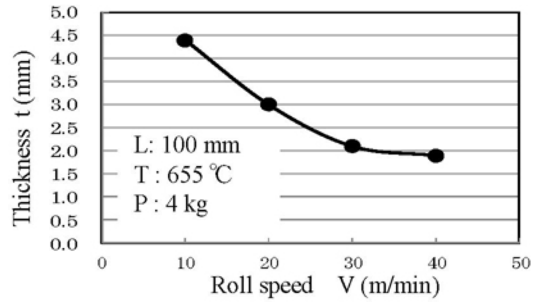


Figure 6. Relationship between the roll speed and strip thickness

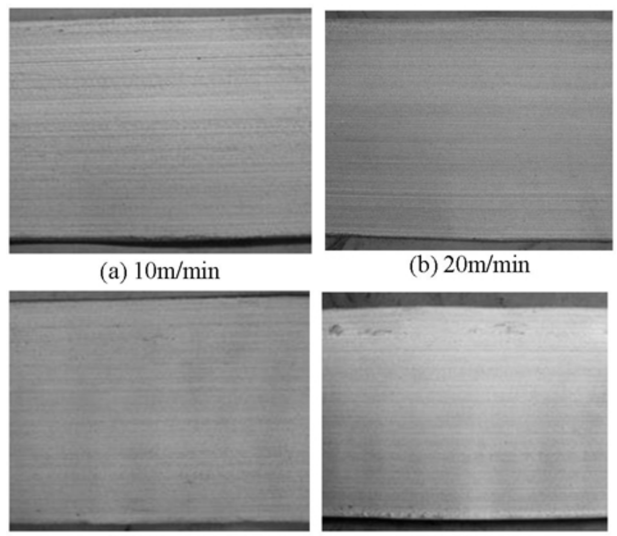
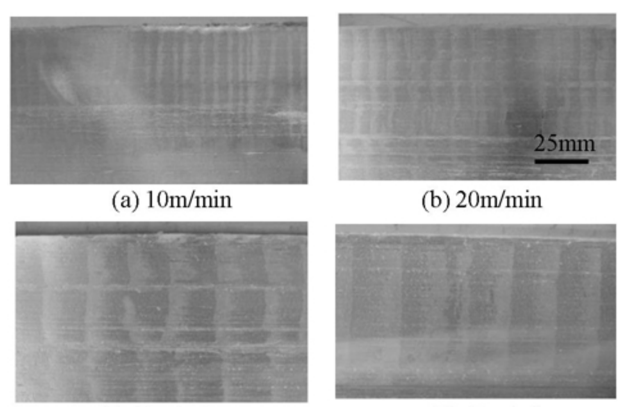

(a) 10m/min (b) 20m/min
(c) 30m/min (d) 40m/min

Figure 7. Influence of the roll speed on the scribed surface. Scraper was type A.



(a) 10m/min (b) 20m/min
(c) 30m/min (d) 40m/min

Figure 8. Influence of the roll speed on the roll contact surface of the strip. Scraper was type A.

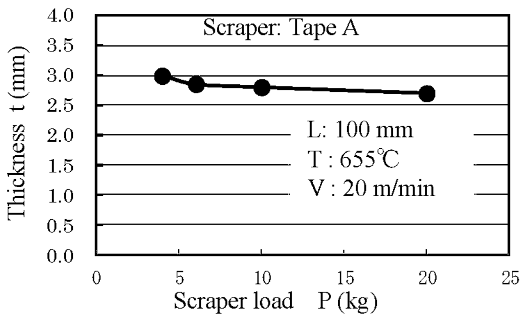


Figure 9. Relationship between the scraper load and the strip thickness.

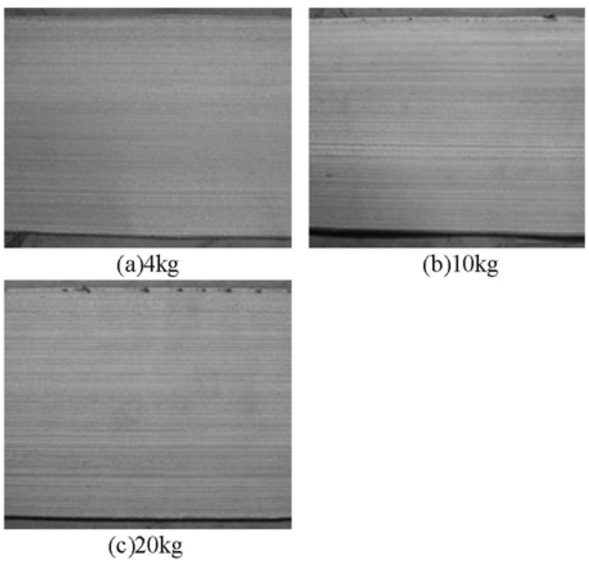


Figure 10. Influence of the scraper load on the scribed surface. Scraper was type A.

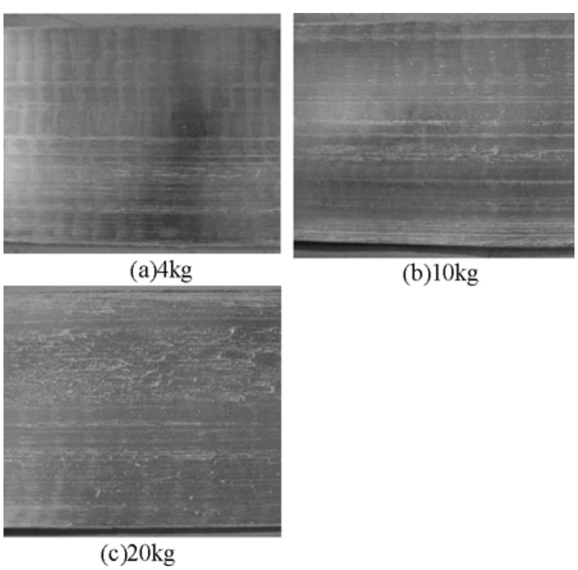


Figure 11. Influence of the scraper load on the roll contact surface. Scraper was type A.

The relationship between the scraper load and the strip thickness is shown in Figure 9. The influence of a scraper load of 6 kg to 20 kg, on the strip thickness was very small. This means that the thickness of the semisolid that was scribed by the scraper was not much influenced by the scraper load. The influence of the scraper load on the scribed surfaces is shown in Figure 10. The trace line by the scraper became gradually harder as the scraper load became heaver. However, no drastic difference was seen. The influence of the scraper load on the roll contact surfaces is shown in Figure 11. Chipping defect occurred when the scraper load was 20kg. Therefore, a scraper load, smaller than 20 kg, may be better.

Microstructure

A cross-section of the as-cast strip is shown in Figure 12. The grain near the roll contact surface was smaller than the other area. The grain size was almost same except the roll contact area. Porosities occurred near the scribed surface. The cross-sections of cold rolled strip with and without annealing are shown in Figure 13. With cold rolling and annealing, the grain became smaller and the non-uniformity of the grain size was reduced by the he cold rolling and annealing, too.

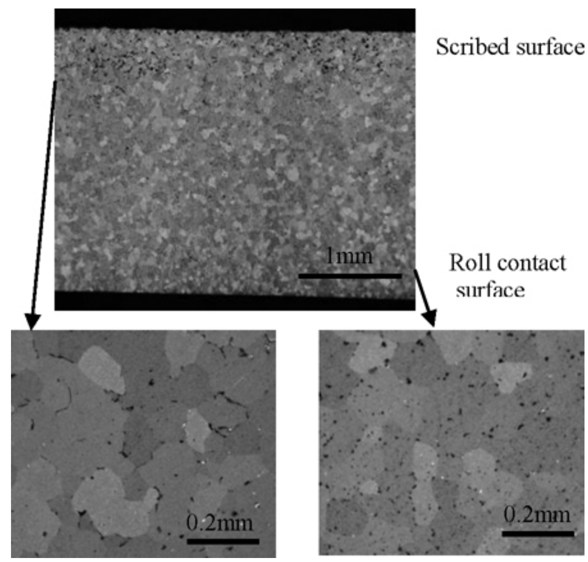


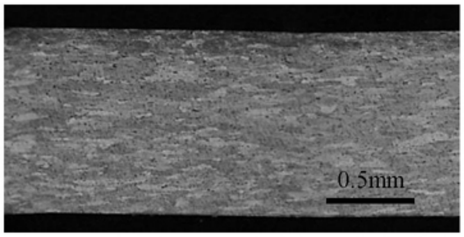
Figure 12. Cross section of as-cast strip

Surface of cold rolled strip

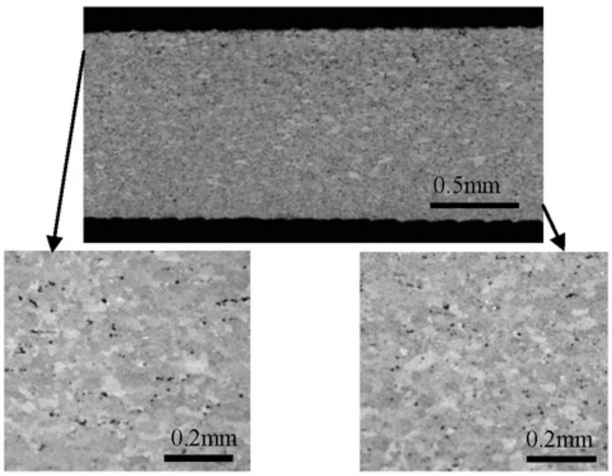
The surfaces of the cold rolled strip are shown in Figure 14. Both surfaces became flat and had a metallic luster. No difference was seen between the scribed surface and the roll contact surface after cold rolling.

Mechanical properties

The result of the tension test is shown in Table 1. The mechanical properties in the casting direction were better than those in the lateral direction. The cold rolling direction was the same as the casting direction. Therefore, the mechanical properties of the casting direction were better than the lateral direction. The result of the cup test is shown in Figure 15. The cup test was conducted under the conditions that either the scribed surface was the outer surface or the roll contact surface was the outer surface. The Limiting Drawing Ratio (LDR) reached to 2.0 under both conditions. No difference at the outer surfaces of the cups was seen. This result means that the appearance of the scribed surface became almost the same as that of the roll contact surface by cold rolling and annealing.

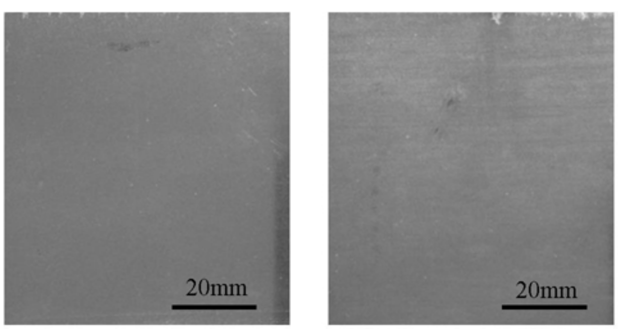


(a) cold rolled strip



(a) cold rolled and annealed strip

Figure 13. Cross section of cold rolled strip and annealed strip.

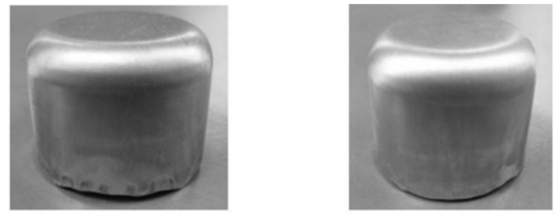


(a) scribed surface (b) roll contact surface

Figure 14. Surfaces of cold rolled strip

Table 1. Result of tension test

Testing direction	Tensile stress σ (MPa)	Proof stress $\sigma_{0.2}$(MPa)	Elongation δ (%)
Casting	304	155	26.5
Lateral	272	140	16.8



(a) scribed surface is outer (b) roll contact surface is outer

Figure 15. Result of the cup test

Conclusions

Property of the strip cast by a single roll caster equipped with a scraper was investigated. The strip could be cast at the speeds up to 40m/min. The strip thickness was controlled by the roll speed. The grain size became uniform at cross section by the cold rolling and annealing. The scribed surface became almost same as the roll contact surface by the cold rolling. There was not difference on the result of the cup test at the condition that either surface was outer.

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