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An unequal diameter twin roll caster for aluminum alloy strip

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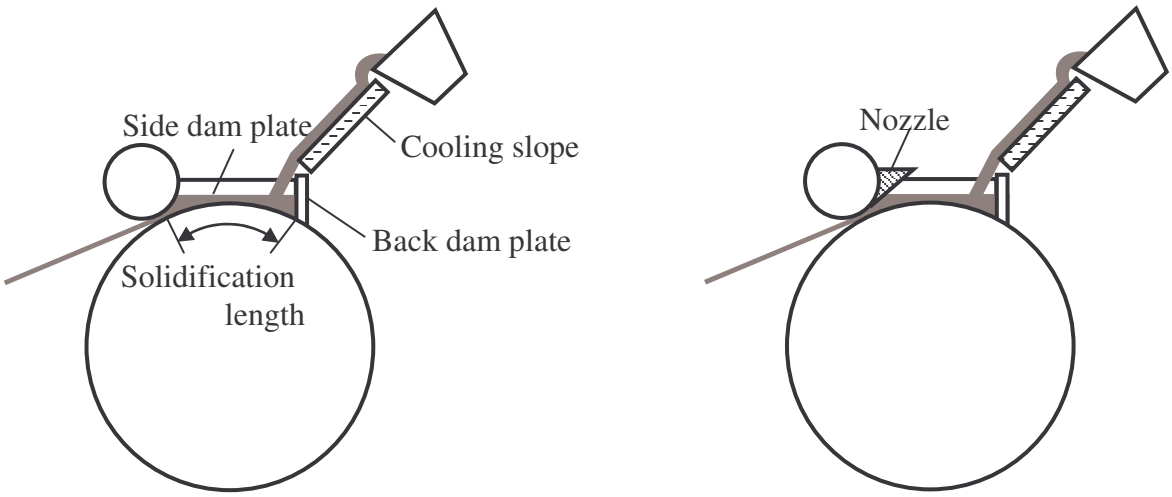
An unequal diameter twin roll caster was devised in order to increase productivity of the strip. This caster could cast the strip thicker than 6mm at the speed of 5m/min. The feature of this caster is that the lower roll was four times larger than the upper roll. The solidification length of the strip could be set longer easily than the conventional twin roll caster for aluminum alloy. Low solidification rate semisolid casting and low superheat casting were adopted. These were effective to increase the casting speed without decreasing the thickness of the strip. In the present study, the unequal diameter twin roll caster was designed and assembled. The test castings were operated and the characteristics of this caster were shown.

1. INTRODUCTION

Strip casting using the twin roll caster has some advantages. For example, they are low equipment cost, low running cost, energy saving and space saving, etc. However, the strip casting using the twin roll caster has disadvantage, too. They are low casting speed, limitation of alloys and poor mechanical properties[1,2]. The low casting speed becomes cause of low productivity. This is the important problem. In the conventional twin roll caster for aluminum alloy, increase of the roll speed is attempted to improve the low productivity. Decreasing of the thickness of the strip is adopted in order to increase the roll speed. The strip is decreased until 1mm, and the roll speed is increased up to 15m/min[1,2]. The as cast strip, which is thinner than 1mm, is useful for some purpose. However, the as cast strip, which is thicker than 3mm, is needed for other purpose. The increasing of the roll speed without decreasing the thickness is required. The thickness of the strip is governed by the solidification time. The shorter the solidification time, the thinner the strip. In the conventional twin roll caster for aluminum alloys, the solidification time becomes short as the roll speed becomes fast. The reason is that the solidification length is constant. The solidification length must be set longer as the roll speed becomes higher in order to prevent becoming thin of the strip. However, the conventional twin roll caster is not suitable to increase the solidification length. In the present study, an unequal diameter twin roll caster, which is easy to increase the solidification length, was devised.

2. AN UNEQUAL DIAMETER TWIN ROLL CASTER

The conventional twin roll caster is classified into two categories. One is the horizontal type twin roll caster and the other is vertical type twin roll caster. In general, the horizontal type is used for the aluminum alloy, and the vertical type is used for the steel. The unequal diameter twin roll caster is different from both of them. The lower roll is four times larger than the upper roll. The melt pool is made on the lower roll by the upper roll, the side and back dam plates. The lower roll solidifies the most of the thickness of the strip. The solidification length can be set longer than the conventional twin roll caster, especially than the horizontal type twin roll cater. The solidification length is adjusted by the position of the upper roll and the back dam plate. The tip (nozzle) of the horizontal type twin roll caster is machined to fit the roll curvature. The tip is complex and the tip is expensive. The dam plate is only the plate and the shape is rectangular. The side and back dam plates of the unequal diameter twin roll caster are simple. At first version of the unequal diameter twin roll caster shown in Fig. 1(a), the meniscus of the molten metal directly contacted to the upper roll. The bouncing of the meniscus affects the solidification length. When the bouncing happens, the solidification length is not uniform. This means that the thickness of the solidification layer of the roll is not uniform at the longitudinal direction. The bouncing of the meniscus affects the thickness of the strip. The thickness of the solidification layer by the upper roll is thinner than that by the lower roll. Therefore, the effect of the bouncing of the melt on the thickness is not so large. The bouncing of the meniscus does not affect the solidification length of the lower roll. In the vertical type twin roll caster, the bouncing of the meniscus affects the solidification length of the both rolls. The effect of the bouncing of the unequal diameter twin roll caster is smaller than that of the vertical type twin roll caster. At second version of the unequal diameter twin roll caster shown in Fig. 1(b), the nozzle plate was attached to the upper roll. The effect of the bouncing the meniscus on the thickness of the solidification layer was eliminated. The nozzle plate is moveable with the upper roll. Therefore, the clearance between the nozzle plate and the upper roll can be kept constant for the casting. In the unequal diameter twin roll caster, the hot rolling is not operated like the horizontal type twin roll caster for aluminum alloy. The thickness of the surface skin of the roll is 8 mm. The water for the cooling flows under the surface skin of the roll. The lubricant was not used at the experimental casting. However, the strip did not stick to the roll. The low superheat casting and the semisolid casting were adopted. The solidification rate was smaller than 5 % in the semisolid casting. The low superheat casting is useful not only for improvement of the microstructure but also for the increasing both of the casting speed and the thickness of the strip. The low superheat casting and the semisolid casting were operated using the cooling slope. The cooling slope was made from the mild steel. The lubricant was coated on the surface of the cooling slope in order to prevent the sticking of the solidified metal. When the solidified metal sticks to the cooling slope, the molten metal that flows on the solidified metal is not cooled. When the surface temperature of the cooling slope is too low, the sticking of the solidified metal easily happens. The mild steel is suitable for as the material of the cooling slope.



(a) without a nozzle (b) with a nozzle

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

3. RESULT AND DISCUSSION

The strip could be cast continuously at the conditions shown at Table 1. Figure 2 shows the relationship among strip thickness, roll speed and solidification length. The thickness of the strip cast by the conventional twin roll caster for the aluminum alloy is shown in Fig. 2, too[1,2]. The unequal diameter twin roll caster could cast thicker strip at higher roll speed than the conventional twin roll caster for aluminum alloy. The strip, which thickness was 8 mm, could be cast at ten times higher speed compared to the conventional twin roll caster for aluminum alloy. This shows that it is possible to solve the problem of the low productivity of the twin roll caster for aluminum alloy by the unequal diameter twin roll caster. The upper and lower surfaces were not same at as cast condition. The reason is that when the upper side was solidified, the solid fraction of the semisolid slurry became higher than the solid fraction of the semisolid slurry poured through the cooling slope. However, the upper and lower surface became same condition after cold rolling. Figure 3 shows the microstructure of the cross section of as cast condition. The microstructure was not uniform at thickness direction. The microstructure of the strip cast by the conventional twin roll caster for the aluminum alloy is usually columnar structure. The microstructure of the present study was near to the equiaxed structure and very fine. This is the effects of the rapid solidification and the semisolid casting. This strip could be operated the cold rolling after the homogenization with out occurring the edge clack. The microstructure became almost uniform at thickness direction. The eutectic Si was very fine and globular after T6 heat treatment. The mechanical properties after T6 are as below. Tensile strength is 278 MPa, yield stress is 203 MPa and elongation is 17%.

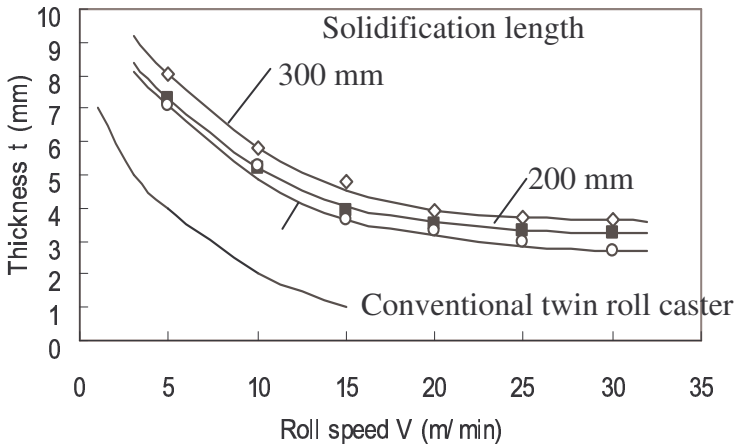


Fig. 2 Relationship among strip thickness, roll speed and solidification length

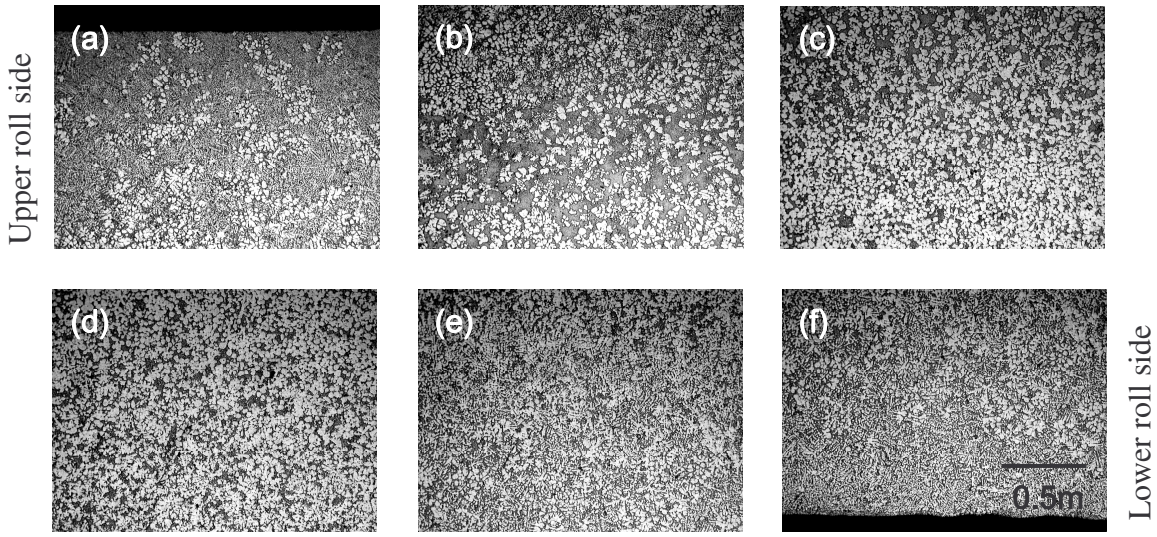


Fig. 3 Cross section of as cast strip of A356. Roll speed: 5m/min, Solidification length: 200mm

4. SUMMARY

The unequal diameter twin roll caster was devised to cast the thicker aluminum alloy strip at higher speed than the conventional twin roll caster. The caster of the present study could cast the strip of 8 mm thickness at 5 m/min. It is shown that the twin roll caster of the present study has the ability to improve the low productivity of the twin roll caster for aluminum alloy.

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