High Speed Roll Caster for Aluminum Alloy Strip

Toshio HAGA, Masakazu KOUDA, Tomohiro KOBASHI
Hiroki MOTOYAM , Naoki INOUE and Shinsuke SUZUKI

Dept. of Mechanical Engineering, Osaka Institute of Technology
5-16-1 Omiya, Asahi-ku, Osaka city 535-8585, Japan

ABSTRACT Four types of high speed roll casters were devised. The same features of these casters are as below. Casting speed is higher than 30m/nin. Separating force is very small and strip doesn't stick to roll, so lubricant isn't used. Design of casting process was depend on aluminum alloy which condition is mashy state in semi-solid phase or not. And wetting condition between melt and roll is good or not. These tree types of casters is different from usual twin roll caster for aluminum alloy like 3C and super caster I.
Keywords: *strip casting, twin roll caster , melt drag, roll casting, belt casting*

1. INTRODUCTION

Twin roll caster has some merits. For example, rapidly solidified strip can be cast, and process is very compact. But, twin roll caster has demerits, too. They are low casting speed (up to 15m/min[1~3]), center segregation and defect on the surfaces(bleed[2,3], ripple mark). In this study, four types of casters were designed and tested. They are MELT DRAG TWIN ROLL CASTER, HIGH PRESSURE TWIN ROLL CASTER, DOWNWARD MELT DRAG CASTER and DOWNWARD MELT DRAG ROLL-BELT CASTER. These casters are different from usual caster for aluminum alloy, for example 3C and super caster I. Casting speed which is higher than 30m/min is attempted by these caster. Macro structure of the strip cast by these caster isn't columnar structure but equi-axed structure. There isn't continuous center segregation in the strip. Surface defects can be eliminated in the casting of the casters in this study.

2. MELT DRAG TWIN ROLL STRIP CASTER

Melt drag twin roll caster is shown in Fig.1. Open top type nozzle is used. The position of nozzle and meniscus of melt against the casting roll is upper than the original melt drag process. Forming roll(upper roll) doesn't interfere with nozzle. So, nozzle shape is free from forming roll. Forming roll contacts with melt with short contacting length. The solidification layer by forming roll is very thin. So, there is no bleeding and ripple mark on the forming roll surface of the strip (ref. Fig.5). Relation among widths of forming roll, nozzle width and strip width is shown in Fig.2. Width of nozzle is narrower than that of forming roll, but melt flows beside the forming roll, and width of the strip becomes wider than that of forming roll. Jumping edges of the strip are useful to keep temperature of the strip near the roll edges enough to roll the strip with very low separating force. Side dam isn't used, because melt doesn't spread by surface tension. Cross section of the strip is shown in Fig.3 and Fig.4. Center line segregation doesn't exist in the strip cast by melt drag twin roll process. There is

tendency that defect decreased with increasing roll speed and with decreasing separating force. Usually, macro-structure of the strip cast by twin roll caster is columnar structure and there is interface in the center of thickness, but that of the strip cast by melt drag twin roll process is equiaxed structure and there isn't interface. Fig.5 shows surfaces of the strip. Forming roll surface is better than solidification roll surface. Forming roll is useful for making surface sound. Relation between roll speed and strip thickness is shown in Fig.6. Strip thickness decreases with increasing the roll speed like the conventional twin roll process and melt drag process. Fig. 7 shows that strip is cast into good thickness distribution with low separating force.

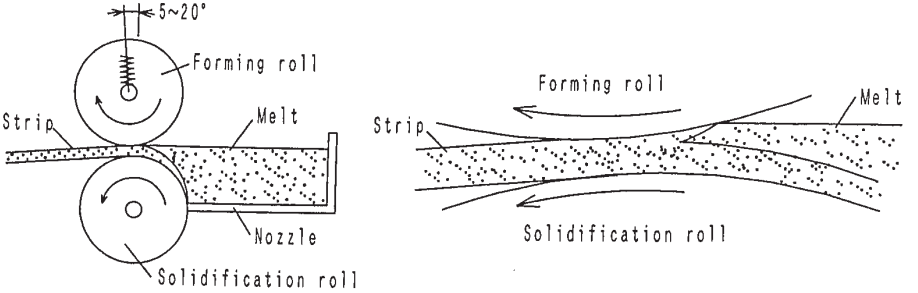
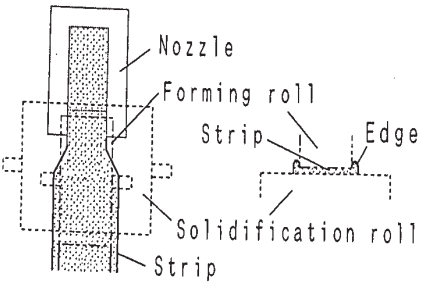


Fig.1 Schematic illustration of melt drag twin roll caster and enlarged view of around the roll gap.



(a) Top view (b) Front view

Fig.2 Relation among roll, strip and nozzle of hot edge method.

Table 1 Specification of melt drag twin roll caster

Solidification roll	ϕ 300×150mm
	copper
	30~120(300)m/min
Forming roll	ϕ 300×40mm
	copper
	30~120(300)m/min
Separating force	0.5~7kN
Nozzle	width 20mm
	melt height 20mm
Specimen	A5182
Casting temperature	660℃

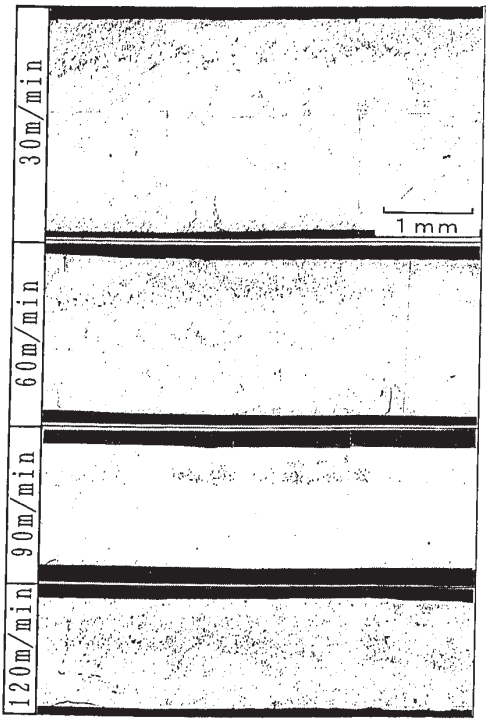


Fig.3 Cross section of the strip cast by melt drag twin roll process.

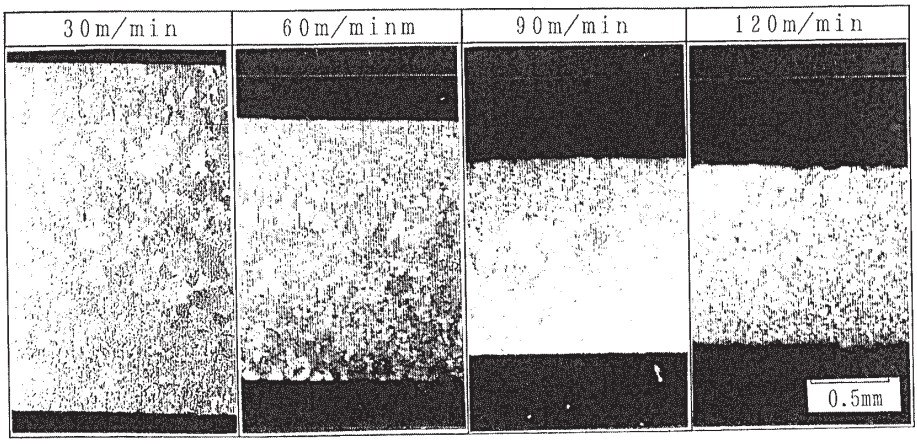


Fig.4 Cross section of the strip cast by melt drag twin roll process.

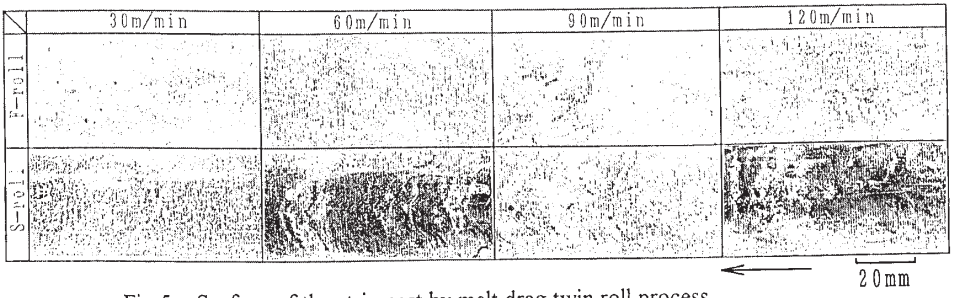


Fig.5 Surface of the strip cast by melt drag twin roll process.

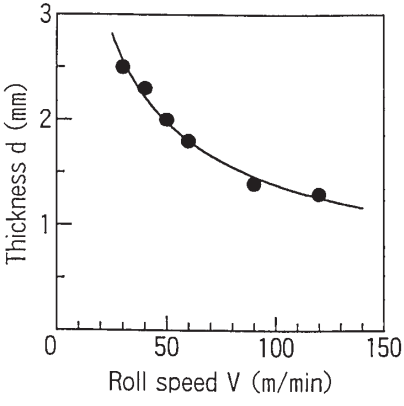


Fig.6 Relation between roll speed and strip thickness.

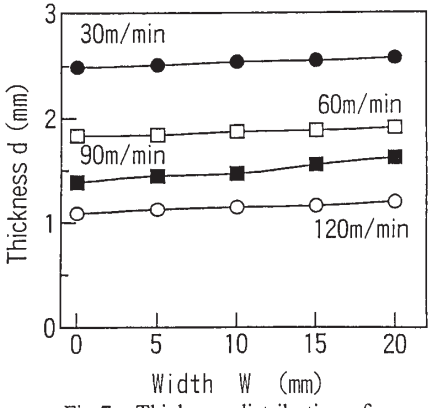
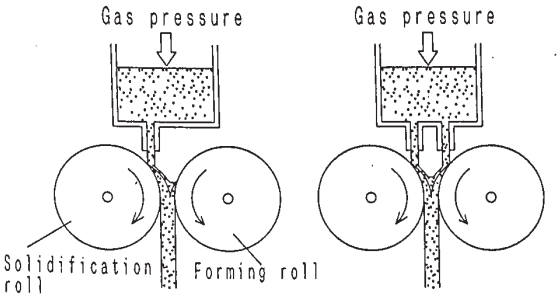


Fig.7 Thickness distribution of the cross section.

3. HIGH PRESSURE TWIN ROLL STRIP CASTER

High pressure twin roll caster is shown in Fig.8. Feature of this process is that molten metal is ejected from nozzles by gas pressure onto two rolls. As contacting pressure between roll and molten metal becomes higher, roll contacting surface becomes sound, so there is no ripple mark and bleed on the strip surface. Two nozzles are attached to the crucible, but strip can be cast by only a nozzle. When a nozzle is used, molten metal is ejected onto a roll as shown in Fig.8(a). Molten metal puddle is formed between rolls, so both surfaces of the strip are formed by roll. The surface which contacts to puddle and roll is better than the surface which contacts to roll on which molten metal is ejected. This is same as melt drag twin roll process. But the surfaces of the strip cast by this caster is better than that cast by melt drag twin roll caster. Fig.9 shows high pressure twin roll process in casting. Strip is A5182 aluminum alloy. Roll surface wasn't coated by lubricant, but strip didn't stick to roll. Because separating force is very small(0.5kN by spring). Cross section of the strip is shown in Fig.10. There isn't center segregation. Structure isn't columnar structure but equi-axed structure. Structure near the roll contacting surface isn't much different from the structure at the center. Strip of A5182 aluminum alloy can be cast at the speed up to the of 120m/min by this process. Strip surface is shown in Fig.11. Surface defects like ripple mark and bleed aren't formed. This process is suitable for high speed casting than melt drag twin roll process at the point of melt-roll contacting pressure which affects surface condition.



(a)Single ejection (b)twin ejection

Fig. 8 High pressure twin roll caster.

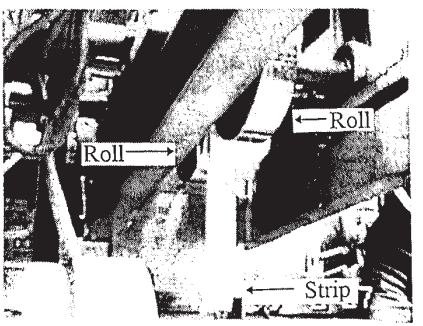


Fig.9 Casting of A5182 strip.

Table 2 Specification of high pressure twin

Roll	ϕ 250×40mm mild steel
slit nozzle	1×40mm
Gas pressure	0.1MPa
Specimen	A5182
Casting temperature	660℃
Separating force	0.5~7kN

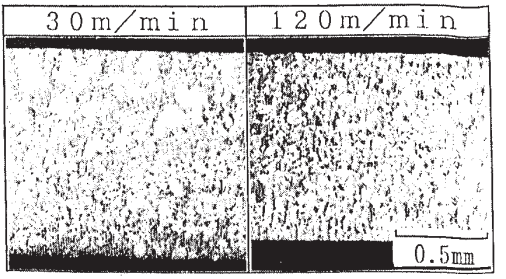


Fig.10 Cross section of the strip cast by high pressure twin roll caster

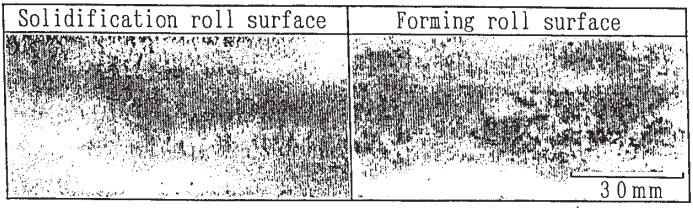


Fig.11 Surface of the strip cast by high pressure twin roll caster.

4. DOWNWARD MELT DRAG AND ROLL-BELT CASTER

Schematic illustration of the downward melt drag roll-belt caster and downward melt drag twin roll caster are shown in Fig.12. This process is suitable for high speed casting of the metal which has non-mashy condition in semi-solid phase. Melt drag twin roll caster and High pressure twin roll caster is suitable for mashy type metal, but they can't cast non-mashy type metal into the strip with sound surface. The feature of this process is dragging direction of strip. In melt drag process, strip is dragged toward upper direction, but in this process, strip is dragged downward. Shallow groove is cut on the casting roll at downward melt drag roll-belt caster(Fig.12(a)). Depth of the groove is equal to the thickness of strip. Puddle is formed on the forming belt. Belt is made of steel. But, belt is affected by heat and corrugated. Belt is enforced into flat by roll where belt contacts to roll. Puddle is small as shown in Fig.13, and solidification layer by belt is very thin. The thickness of the solidification layer by casting roll is nearly equal to the strip thickness. To increase the contacting pressure between solidification roll and molten metal at point A of Fig.12(b), nozzle is improved as shown in Fig.12(c) and contacting pressure of point B is higher than that of point A. The higher contacting pressure becomes, the better roll contacting surface becomes. The forming roll surfaces of A1050 strip cast by melt drag twin roll caster(Fig.1) and downward melt drag twin roll caster(Fig.12(b)) are shown in Fig.14. From Fig.14, it is clear that downward melt drag caster is useful for making the surface sound in casting of non-mashy aluminum alloy.

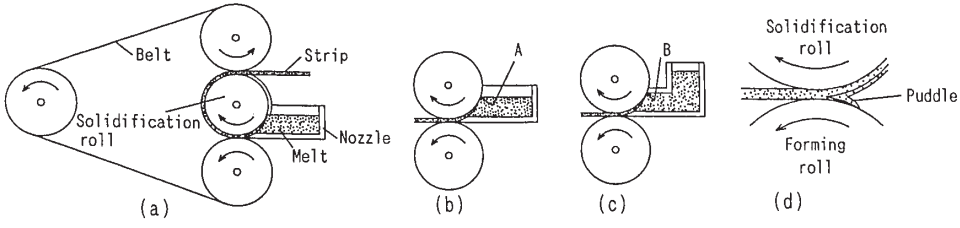


Fig.12 Downward melt drag roll-belt caster(a), downward melt drag twin roll caster (b),(c) and puddle on the forming roll.

Table 3 Specification of downward melt drag

Roll	ϕ 250×150mm
	mild steel
Nozzle	width 20mm
	melt height 40mm
Belt	0.6×100mm
	SK5(steel)
Separating force	0.5~7kN
Specimen	A1050,A3003
Casting temperature	720℃

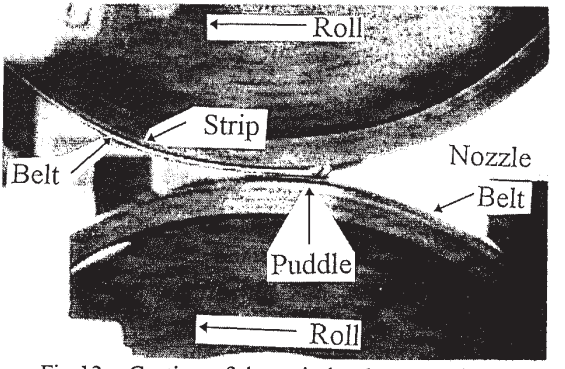


Fig.13 Casting of the strip by downward melt drag roll-belt caster.

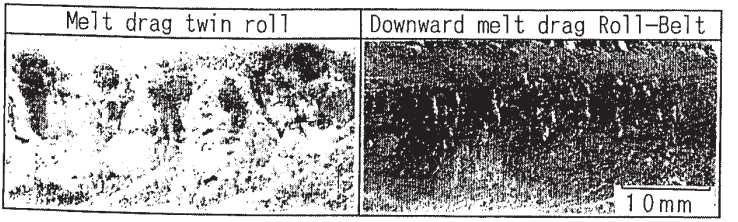


Fig.14 Forming roll surface of the strip cast by melt drag twin roll caster and downward melt drag caster.

5. CONCLUSION

Four types of high speed casters were designed and tested. A1050 and A5182 alloy could be cast at the speed more than 30 m/min. Macro structure of the strip was equi-axed structure. Center line segregation didn't exist in the strip. By using forming roll or ejection nozzle, bleed was eliminated from strip surface. Separating force was so small that the strip didn't stick to roll without using lubricant.

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