Proceedings of the 12th International Conference on
Aluminium Alloys, September 5-9, 2010, Yokohama, Japan

pp. 703-708

Casting of Three Layers of Aluminum Alloy Clad Strip Using a Vertical Type Tandem Twin Roll Caster

Ryoji NAKAMURA[1], Toshio HAGA[2], Shinji KUMAI[3] and Hisaki WATARI[4]
[1]Graduate school of Osaka Institute of Technology, 5-16-1 Omiya Asahiku Osakacity, 535-8585 Japan
[2] Osaka Institute of Technology, 5-16-1 Omiya Asahiku Osakacity, 535-8585 Japan
[3] Tokyo Institute of Technology, 4259, Nagatsuda,
Midoriku, Yokohama City, Kanagawa, 226-8502 Japan
[4] Gunma University, 1-5-1, Tenjin Cho, Kiryu City, Gunma, 376-8515, Japan

A roll caster to cast three layers clad strip was devised. In this process, two twin roll casters were set at the vertical tandem position. This vertical type tandem twin roll caster was assembled, and the casting was tried. The material of the base strip was AA8079 or AA3003. The material of the overlay strip was AA6022 or AA4045. The fabrication process of the three layers clad strip is as blow. The base strip was cast by the upper caster. This strip was drawn into the lower caster. When the base strip went into the roll-bite of the lower caster, the melt of the overlay strips was poured to the lower caster. The three layers of clad strip could be cast by the vertical type tandem twin roll caster of the present study. The clad strip was made directly from molten metals. The interfaces between the base strip and the overlay strips were clear and flat. It became clear that the base and overlay strips were bonded firmly from the bending test.

Keywords: *Casting, Aluminum alloy, Three layers clad strip, Twin roll caster*

1. Introduction

Recently, the energy saving in the factory is essential to protect the global warming. The process saving is very useful for the energy saving. The many processes are needed to fabricate the clad strip in the conventional method. The single strip is made from the slab by the processes as below; homogenization, scraping, hot rolling and cold rolling. The cladding process is as below; track welding, pressure welding and rolling. The clad strip is made by many processes than single strip. In this way, the clad strip is fabricated by many processes. Therefore, the energy saving of fabrication of the clad strip is required. In this study, the process to fabricate the clad strip directly from molten metal was devised. It is thought that the twin roll caster is useful for energy saving as the process to make the strip[1]. The reason is that the strip can be cast directly from the molten metal[2-4]. The vertical type twin roll caster was utilized for the process of the present study. The vertical type tandem twin roll caster was devised and assembled to cast the three layers clad strip. Two twin roll casters were set at the vertical tandem position. The casting of the three layers clad strip was tried by the vertical type tandem twin roll caster. Effects of the conditions on the interface of this clad strip were investigated. The cold rolling of as-cast strip was tried.

2. Vertical type tandem twin roll caster

A vertical type tandem twin roll caster to cast three layers clad strip was designed and assembled. Figure 1 shows the schematic illustration and the photograph of the vertical type tandem twin roll caster. This apparatus was composed of two vertical type twin roll casters. A vertical type twin roll caster was mounted on the other one. The base strip was cast by the upper caster. The overlay strips were cast by the lower caster. The diameter of rolls was 200mm. The material of rolls was copper.

The width of rolls of the upper caster was 40mm. The width of rolls of the lower caster was 50mm. The width of rolls of the lower caster was wider than that of the upper caster to make the base strip easily go into the lower caster. The nozzle plate and the side dam plate were used at the upper and lower caster. The material of the nozzle and the side dam plate was the mild steel. The thickness of the nozzle and side dam plate was 3.2mm. The liquidus line of the base strip was higher than that of overlay strips. This reason was that the base strip was remelted by the heat of the molten metal of the overlay strips when the liquidus line of the base strip was lower than that of overlay strips. Advantages of this caster is as below. The clad strip was rapidly solidified by copper rolls[5,6]. The interface between strips was flat as the base strip cast by rolls. The effects of their factors on the connecting were investigated.

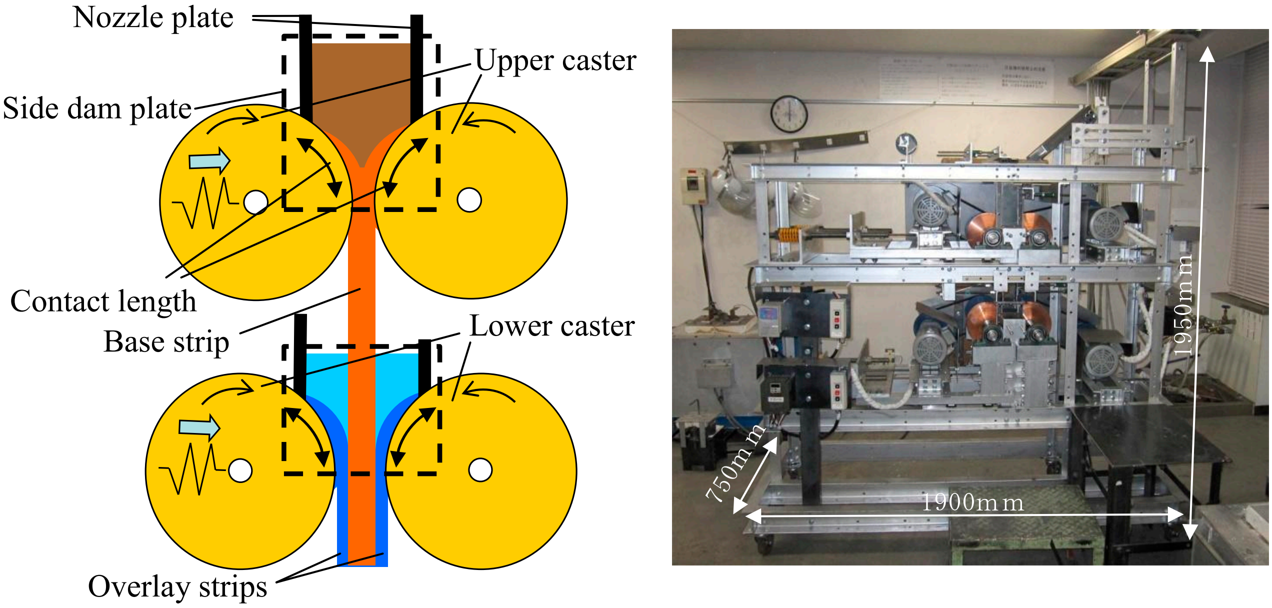


Fig.1 Schematic illustration and the photograph of the vertical type tandem twin roll caster

3. Process of the cladding of the strips

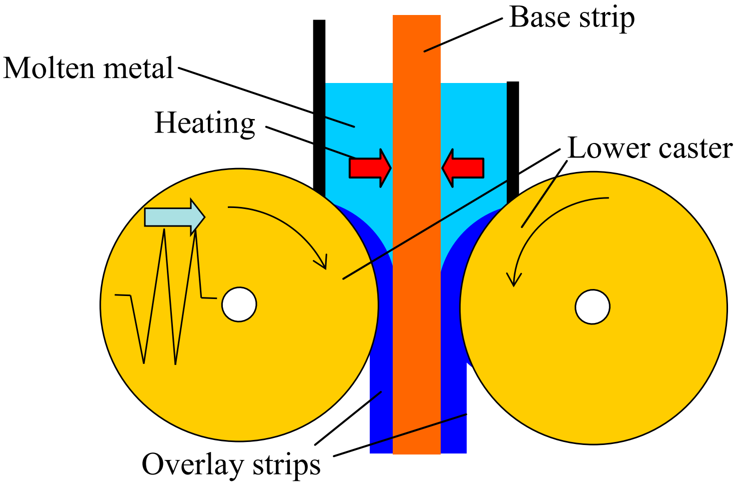


Fig.2 Schematic illustration showing the connecting process of the vertical type tandem twin roll caster

The connecting process of the vertical type tandem twin roll caster is shown in Fig.2. Procedure of casting of three layers clad strip in this study is as below. The base strip is cast by the upper caster. When the base strip goes through roll gap of the lower caster, the molten metal of overlay strips is poured in the nozzle. The surface of the base strip contacts the molten metal of overlay strips. The surface of the base strip is heated by the molten metal of overlay strips. The base strip and overlay strips are connected at the roll gap of the lower caster. It was thought that important factors to connecting of the strips was as below. They were temperature of the surface of base strip, the temperature of the molten metal of overlay strips and roll speed.

4. Experimental conditions

The experimental conditions of clad strip assembled from AA8079 and AA6022 strip are shown in Table 1. The material of the base strip was AA8079 and the material of overlay strips was AA6022. The contact length of the upper caster was 40mm. The contact length of the lower caster was 80mm. The melt temperature of the base strip was 700°C. The melt temperature of the overlay strips was 670 °C, 700 °C and 750 °C. The roll speed was 20m/min, 30m/min and 40m/min.

The experimental conditions of the clad strip assembled from AA3003 and AA4045 strip are shown in Table 2. The material of the base strip was AA3003. The material of overlay strips was AA4045. The contact length of the upper caster was 60mm. The contact length of the lower caster was 80mm. The melt temperature of the base strip was 670°C. The melt temperature of overlay strips was 670 °C. The roll speed was 40m/min.

Table1 The experimental conditions of clad strip assembled from AA8079 and AA6022 strip

Upper caster	Roll[mm]	Diameter: 200, width: 40, material: copper
	Material	AA8079
	Melt temperature[°C]	700
	Contact length[mm]	40
Lower caster	Roll[mm]	Diameter: 200, width: 50, material: copper
	Material	AA6022
	Melt temperature[°C]	670, 700, 750
	Contact length[mm]	80
Roll speed[m/min]		20, 30, 40

Table2 The experimental conditions of clad strip assembled from AA3003 and AA4045 strip

Upper caster	Roll[mm]	Diameter:200, width:40, material: copper
	Material	AA3003
	Melt temperature[°C]	670
	Contact length[mm]	60
Lower caster	Roll[mm]	Diameter:200, width:50, material: copper
	Material	AA4045
	Melt temperature[°C]	670
	Contact length[mm]	80
Roll speed[m/min]		40

5. Result and discussion

5.1. The clad strip assembled from AA8079 and AA6022

5.1.1. Surface of the clad strip

The roll casting of the clad strip was operated. The clad strip could be cast by this caster. Figure 4 shows the surface of three layers clad strip. There was not difference at the surfaces of the clad strip cast by three kinds of roll speeds. The thickness of the clad strip cast by the roll speeds of 20, 30 and 40m/min was 5.0mm, 4.5mm and 3.8mm respectively.

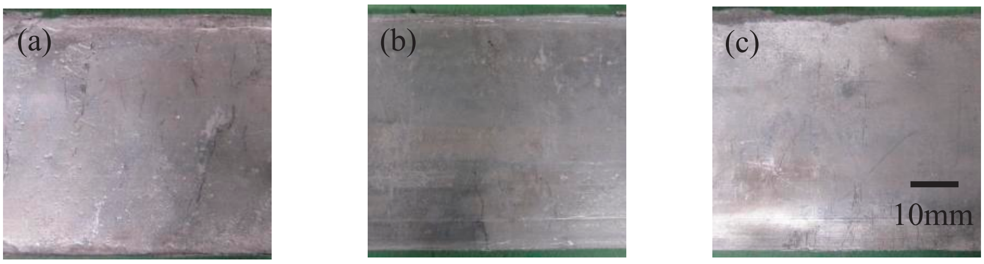


Fig.3 Surface of three layers clad strip. (a) Roll speed was 20m/min. (b) Roll speed was 30m/min. (c) Roll speed was 40m/min.

5.1.2. Effect of the roll speed on the clad strip

The cross sections of the clad strip cast by three kinds of roll speeds were shown in Fig.4. When the roll speed was 20m/min, the clad strip was not connected between the base strip and overlay strips as shown in Fig.4 (a). This reason is that the contact time between rolls of the upper caster and base strip was long, and the surface temperature of the base strip became too low. Therefore, the base and overlay strips was not connected at the interface. The cross section of three layers clad strip of Fig.4 (b) was cast at the roll speed of 30m/min. When the roll speed was 30m/min, the base strip and overlay strips could be connected. The interface of this clad strip was clear and flat. This reason is that the temperature of the base strip was suitable for the cladding. When the roll speed was 40m/min, the interface of this clad strip was not clear and two metals were mixed as shown in Fig.4 (c). This reason was that the cooling of the base strip was not sufficient, and the base strip was remelted by the molten metal of overlay strips. Therefore, the mixed area existed.

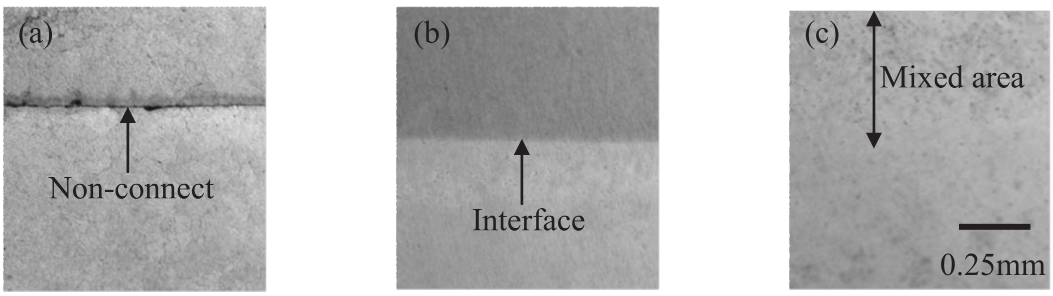


Fig.4 The cross section of the clad strip. (a)Non-sound clad strip cast by the roll speed of 20m/min. the base strip was not connected with the overlay strips. (b) Sound clad strip cast by the roll speed was 30m/min. (c) Non-sound clad strip cast by the roll speed of 40m/min. The remelting of the base strip was occurred.

5.1.3. Effect of the melt temperature of overlay strips on the clad strip

The cross sections of the clad strips cast by three kinds of melt temperatures of the overlay strips were shown in Fig.5. The melt temperature of the overlay strips was 670^{o}C at Fig.5 (a). In Fig.5 (a), the base strip and the overlay strips were not connected. This reason was that the melt temperature of overlay strips was too low, and the base strip was not heated up to suitable temperature for cladding.

When the melt temperature of the overlay strips was 700 °C, the base strip was connected with the overlay strips as shown in Fig.5 (b). The interface between the base strip and overlay strips was clear and flat. When the melt temperature of the overlay strips was 750 °C, the base strip was remelted by the molten metal of the overlay strips as shown in Fig.5 (c). This reason was that the melt temperature of overlay strips was too high, and mixed area existed.

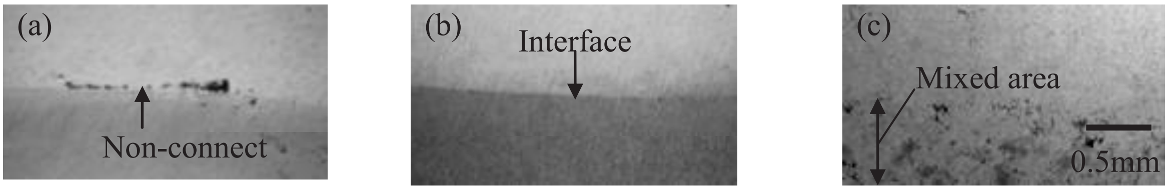
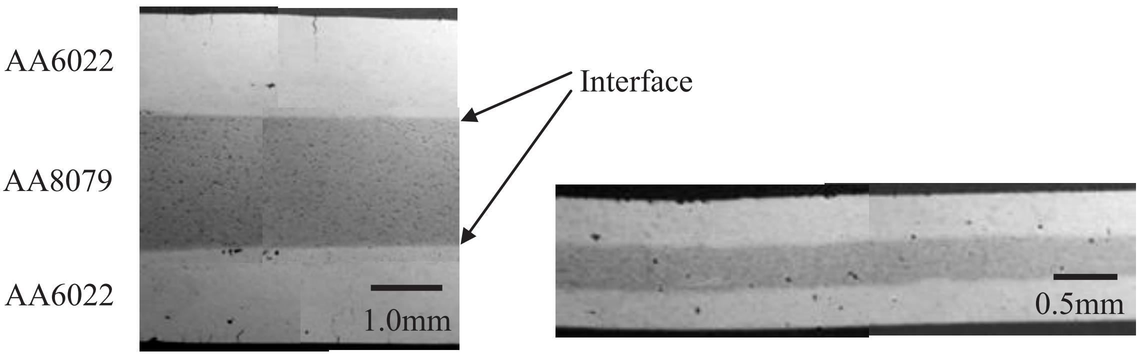


Fig.5 Cross section of the clad strip cast by three kinds of melt temperature of overlay strips. (a) 670°C, Non-connected area existed. (b) 700°C, Sound clad strip. (c) 750°C, The base strip was remelted.

5.1.4. Cold rolling of three layers clad strip

Figure 6 (a) shows the cross section of three layers clad strip assembled from AA8079 and AA6022 strip. The interfaces of this three layers clad strip were clear and flat. The cross section of the clad strip after cold rolling is shown in Fig.6 (b). The as-cast strip was cold rolled down to 1mm without annealing. If the joining strength was weak, the crack occurs at the interfaces between the base and overlay strips. The crack did not occur at the interfaces between the base strip and overlay strips after cold rolling. The base strip and overlay strips were connected firmly. The clad ratio of as-rolled strip was as same as that of as-cast strip.



(a) as cast strip (b) as rolled strip

Fig.6 Cross section of the three layers clad strip assembled from AA8079 and AA6022 strip

5.2. The clad strip assembled from AA3003 and AA4045

5.2.1. Cross section of three layers clad strip

The cross section of three layers clad strip assembled from AA3003 and AA4045 strip was shown in Fig.7. The material of the base strip was AA3003, and the material of overlay strips was AA4045. The interface of three layers clad strip was clear and flat. Figure 8 shows the cross section of three layers clad strip after bending test. If the connecting of three layers clad strip was not enough strength, the crack occurred at the interfaces between the base and overlay strips. Three layers clad strip was not peeled at the interfaces by the bending test. It is thought that three layers clad strip was joined firmly at the interfaces. The cross section of three layers clad strip after cold rolling is shown in Fig.8. The as cast strip was cold rolled down to 1mm without annealing. The crack did not occur at the interfaces between the base strip and overlay strips.

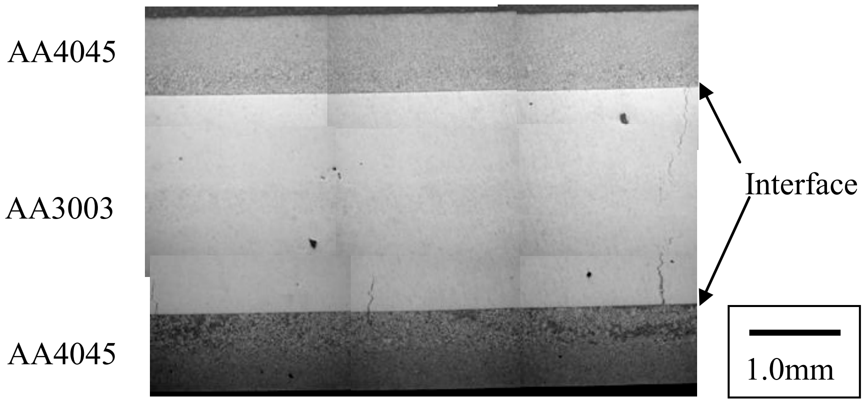


Fig.7 Cross section of three layers clad strip assembled from AA3003 and AA4045 strip

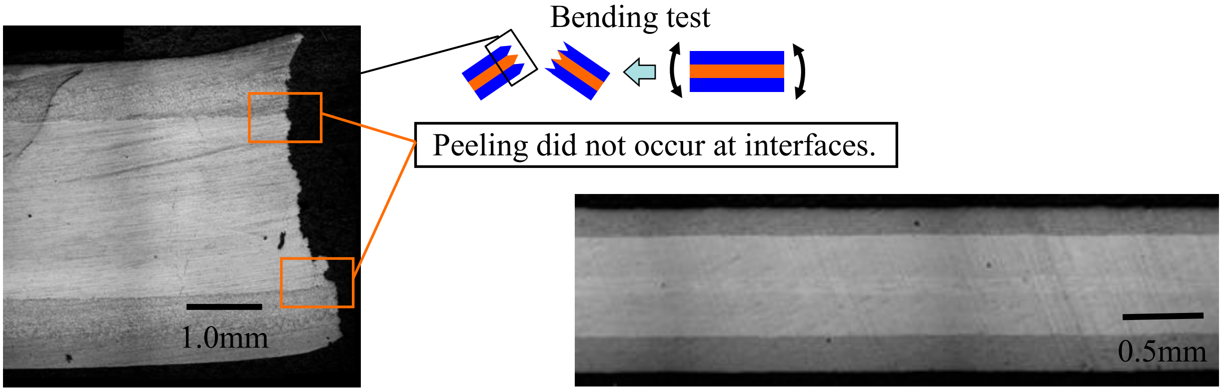


Fig.8 Cross section of the clad strip after the bending test and cold rolling

6. Conclusions

The vertical type tandem twin roll caster to cast three layers clad strip was devised and assembled. The casting of three layers clad strip was tried using the vertical type tandem twin roll caster of the present study. Two kinds of three layers clad strips could be cast by this caster. One was assembled from AA8079 strip and AA6022 strip. The other was assembled from AA3003 strip and AA4045 strip. The interfaces between the base strip and overlay strips was clear and flat. The as-cast strip could be cold-rolled down to 1mm. The interfaces of this clad strip were not peeled by the bending test. This clad strip could be connected firmly at the interfaces.

References

[1] X. M. Zhang, Z. Y. Jiang, X. H. Liu and G. D. Wang: Journal of Materials Processing Technology 162-163 (2005) 591-595.
[2] J.D. HWANG, H. J. LIN, J. S. C. JANG, W. S. HWANG and C.T. HU: ISIJ International, Vol.36-No.6 (1996)690-699.
[3] S. H. Seyedein and M. Hasan: Numerical Heat Transfer, Part A, 31(1997)393-410.
[4] C. G. Kang and Y. D. Kim, Journal of Materials Processing Technology, 84 (1998)210-224.
[5] N. M. Zapuskalov, Int. J. Cast Metals Res. 9(1996)153-156.
[6] T. MIZOGUCHI, K. MIYAZAWA and Y. UESHIMA: ISIJ International, Vol. 36-No.4 (1996) 417-423.