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Production of Copper alloy sheet by twin-roll casting

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Abstract

Currently, copper strips are produced by hot and cold rolling. But it needs many processes to satisfy its remained thickness and occur a great deal of costs as well as material cost. So the destination of our study is to reduce the production cost of copper strip by shortening process flow and saving energy with twin-roll casting process, one of continuous strip casting process.

Twin-roll casting process is a continuous strip casting process, which is able to produce strips directly from molten metal. Because of this, produced strip by this process are rapidly solidified, so grains become fine. Therefore, mechanical properties of strip will be increased. When experimental condition No.3, Copper alloy sheet had smooth surface.

Introduction

Currently, copper strips are produced by hot and cold rolling. But it needs many processes to satisfy its remained thickness and low production rate, low yield rate. In constant, Twin-roll casting process is a continuous strip casting process, which is able to produce strips directly from molten metal. Twin-roll casting process is rapid solidification process by two solidification roll. Furthermore, strips produced by this process are rapidly solidified, so grains become fine. Therefore, mechanical properties of strip will be increased.

Purpose of this study is to research whether twin-roll casting process is applicable to copper alloys. Moreover, we investigate the effects of experimental factors (roll velocity, molten metal temperature, initial load, presence or absence of preheating) on surface condition of copper strips . Experimental material was phosphor bronze (copper with 8% of tin).

Experimental device and conditions

Fig.1 shows a schematic illustration of the Twin-roll casting process. In Twin-roll casting process, there is a horizontal type and a vertical type. Twin-roll casting process of vertical type is adopted in this study. Because, production rate of vertical type is higher than horizontal type. Twin-roll casting process of vertical type is a method of supplying the molten metal from the top of the device. And the copper alloy sheet material is put out to the vertical direction from the under of the device. The solidification roll is a brass. The solidification roll size is diameter 300mm, width 100mm. Nozzles and side dam plates are made of steel plate. These contacting surfaces of the molten metal are pasted on carbon sheets. Left nozzle moves along with the left coagulation roll. And moving left solidification roll is applied molding load. Side-dams are held on solidification rolls side by spring. Preheating temperature of devices (nozzle, Side-dam plate) is 100℃ and heated by gas burner. Table 1 shows Experimental condition. Experimental material is phosphor bronze. Roll velocity is adopted two types (60m/min, 100m/min) for the purpose of high production rate.

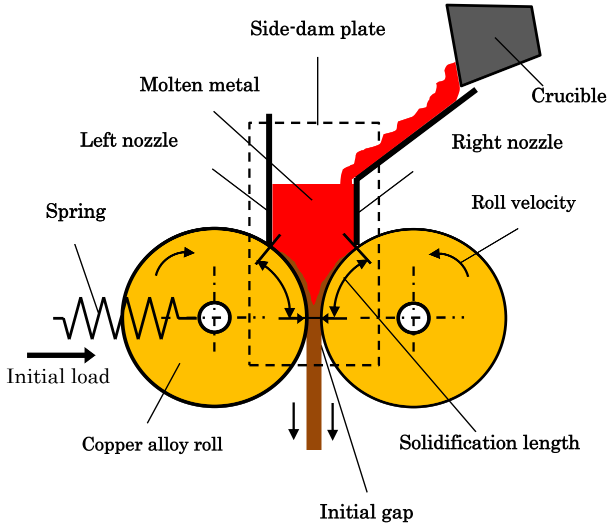

Fig.1 Schematic illustration of experimental device

Table1 Experimental condition

Experimental number		No.1(12	No.2(13	No.3(20	No04(16
Experimental material		Phosphor bronze			
Molten metal temperature [℃]		1310	1260	1050	1231
Roll velocity [m/min]		60			100
Roll	Initial load [kN]	28		56	
	Initial gap [mm]	0			
Solidification length [mm]		40			
Preheat (nozzle, Side-dam plate)		×	○	○	×

Table2 Average thickness of sheet

Experimental number	No.1(12	No.2(13	No.3(20	No.4(16
Average thickness [mm]	1.25	1.51	1.52	1.03

Results and discussion

Table 1 shows Experimental condition. Table 2 shows Average thickness of sheet. No.4 of Experimental condition went to investigate the influence of surface condition by effect of roll velocity. Fig.2 shows manufactured copper alloy sheet. This copper alloy sheet is 1.03mm of average thickness. This copper alloy sheet was the thinnest sheet in the sheet. But, this sheet was not manufactured with the roll width. And this sheet had porous surface. This cause is that the molten metal did not filled in the nozzle because of a high roll velocity (100m/min).

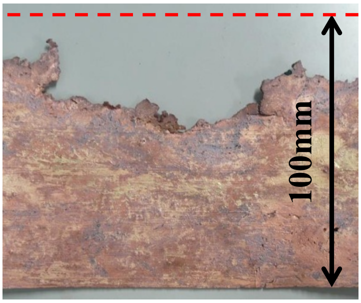

Figure.2 Surface of strip (No.4)

Fig.2 shows manufactured copper alloy sheet (No.1 of Experimental condition). Average thickness of manufactured sheet is 1.25mm. This sheet is manufactured no.1 of experimental conditions (molten metal temperature 1310℃, roll velocity 60m/min, spring load 28kN). Because this molten metal temperature was lower than No.4 of experimental condition and molten metal was sufficiently flowed in nozzle. And cooling time of molten metal increased in a roll gap position. Surface of manufactured sheet was porous surface. Its issupposed holes were considered to be that cooling of molten metal was not a sufficient for low spring load. And surface of sheet was observed two color parts (oxblood-red, yellow). Oxblood-red parts have a high percentage of copper. Conversely, yellow parts have a high percentage of stannum. It is suppposed surface yellow parts are inverse segregation of stannum.

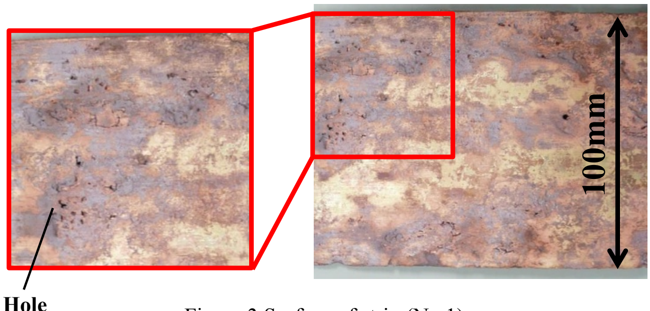

Figure.3 Surface of strip (No.1)

Fig.4 shows manufactured copper alloy sheet (No.2 of Experimental condition). Average thickness of manufactured sheet is 1.51mm. This sheet is thickener than the sheet of no.1 experimental condition. Suppose sheet is considered to be that freeze layer of molten metal was thickened for low molten metal temperature. Surface color of manufactured sheet is totally yellow than sheet of no.1 of experimental condition. Therefore, cooling rate of No.2 was larger than the No.1 by solidification roll than the sheet of No.1 of experimental condition. This surface of sheet is not observed holes. Because this sheet was well cooling and molten metal temperature was low.

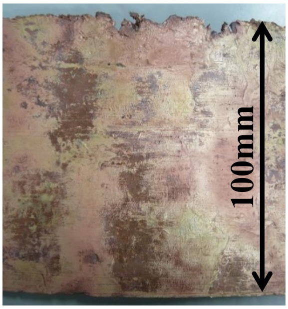

Figure.4 Surface of strip (No.2)

Fig.5 shows manufactured copper alloy sheet (No.3 of Experimental condition). Fig.5-(a) shows surface of sheet. Fig.5-(b) shows surface of sheet after penetrant inspection. Penetrant inspection is a widely applied method to locate surface-breaking defects in all non-porous materials. Average thickness of manufactured sheet is 1.52mm. This experimental condition is lower temperature (1050℃) than molten metal temperature of No.2 of experimental condition. And this spring load is higher spring load (52kN) than spring load of No.2 of experimental condition. This load in roll gap was heavy load and molten metal was sufficiently accumulated in nozzle. Therefore, sheet width is manufactured 100mm of roll width. And penetrant testing result of this sheet was not observed a crack on the surface of sheet.

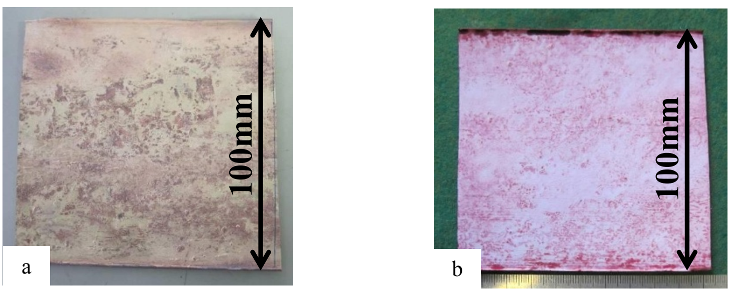

Figure.5 Surface of strip (No.3)
(a) Photograph of Surface (b) Photograph of penetrant testing

Conclusion

Sheet (experimental condition No.3) with 1.52mm sheet thickness of Copper alloy was successfully produced by twin-roll casting process.

Penetrant testing result of the sheet (experimental condition No.3) was not observed a crack on the surface of sheet.