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Continuous Castings of Al-7mass%Si Alloy and Al-1.5mass%Mn Alloy by the Electromagnetic Vibration Technique

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The electromagnetic vibration during solidification can refine the microstructures of cast aluminum alloys, cast magnesium alloys and gray cast iron etc. The purpose of this study is to develop the continuous casting using the electromagnetic vibration in aluminum alloys. It was found that the electro-magnetic vibration can refine macrostructures of continuous casting rods.

Keywords: *aluminum alloy, electromagnetic vibration, continuous casting, macrostructure , refinement*

1. Introduction

The electromagnetic vibration casting technique is that the melt is vibrated by Lorentz force that results from static magnetic field and alternating electric current during solidification. In the AIST, it was found that the electromagnetic vibration during solidification can refine the microstructures of cast aluminum alloys [1], cast magnesium alloys [2] and gray cast iron [3] etc. On the other hand, in wrought aluminum alloys, it is important that the microstructures of continuous casting rods are refined before wrought operation. The microstructure refinement of continuous casting rods improves the mechanical properties of wrought products. Thus, the purpose of this study is to develop the continuous casting using the electromagnetic vibration in aluminum alloys in order to apply the electromagnetic vibration technique to the continuous casting of wrought aluminum alloys.

2. Experimental Procedures

The electromagnetic vibration casting technique has been developed by using a superconducting magnet [1-3]. However, in this study, a normal electromagnet is used because that is easy to apply to a continuous casting apparatus. The electromagnet is with a distance between the magnetic poles of 50 mm and able to produce a lateral magnetic field of 1.1 T.

Aluminum alloys were melted in an alumina crucible by a furnace which is placed over the magnetic poles. Molten metal was treated by Ar gas bubbling method. This molten metal was solidified in a stainless steel tube (with an outer diameter of 15 mm and an inner diameter of 13 mm) which was connected to the alumina crucible, and cast continuously by pulling-down device. Temperature of the stainless steel tube was controlled by heaters, and a continuous casting rod which came out of the stainless steel tube was cooled by sprayed water directly. The stainless steel tube was set between the magnetic poles and fixed as firmly as possible against mechanical vibrations induced by the electromagnetic vibrations. Electric current for the electromagnetic vibrations was supplied to semi-solid mushy zone which was in the stainless steel tube, by an electrode of the pulling-down device and a carbon electrode which was put in the molten metal. The electromagnetic vibrations were applied by 1.1T stationary magnetic field and 300A alternating electric current with a frequency of 150Hz.

3. Results

3.1 Al-7mass%Si Alloy

Al-7mass%Si rods with a diameter of 13 mm and a length of 280 mm were able to cast continuously cooled under the electromagnetic vibrations and without the electromagnetic vibrations. Figure 1 shows macrostructures of (a) non-vibrated rod and (b) vibrated rod. In the non-vibrated rod, coarse unidirectional solidified macrostructure was observed. However, in the vibrated rod, fine dispersed macrostructure was observed. It was found that the electromagnetic vibration during continuous casting can refine the macrostructures of Al-7mass%Si alloy.

Effects of the electromagnetic vibrations on mechanical properties of Al-7mass%Si continuous casting rods were investigated by tensile testing. The electromagnetic vibrations didn't affect the tensile strength. However, it was found that the electro-magnetic vibrations improve scattering in the elongation and the reduction of area.

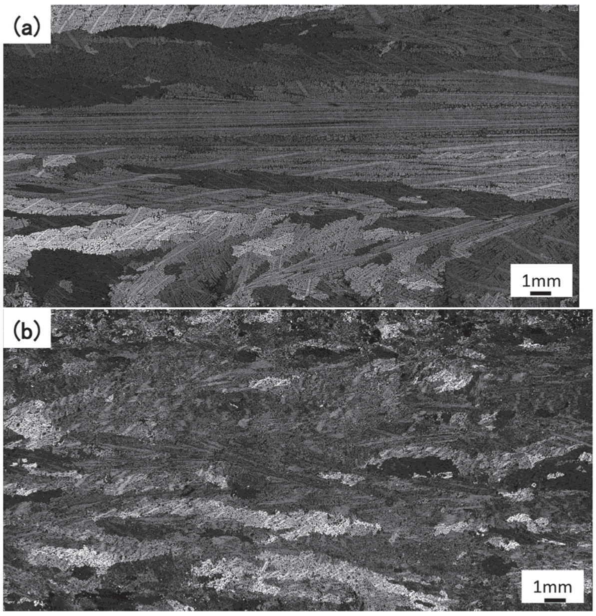

Fig.1 Macrostructures of (a) non-vibrated Al-7mass% Si rod and (b) vibrated Al-7mass%Si rod.

3.2 Al-1.5mass%Mn Alloy

Al-1.5mass%Mn rods with a diameter of 13 mm and a length of 280 mm were able to cast continuously without the electromagnetic vibrations. However, early in the continuous casting, surface wrinkle occurred, and defects on the surface occurred at the latter half. In contrast, when cooled under the electromagnetic vibrations, surface wrinkle decreased early in the continuous casting. However, at the latter half, defects on the surface became larger and the casting rod ruptured finally.

Figure 2 shows macrostructures of (a) non-vibrated rod and (b) vibrated rod. In the non-vibrated rod, coarse unidirectional solidified macrostructure was observed. However, in the vibrated rod, fine dispersed macrostructure was observed.

4. Conclusions

The continuous casting using the electromagnetic vibration in aluminum alloys has been developed. It was found that the electromagnetic vibration can refine macrostructures of continuous casting rods.

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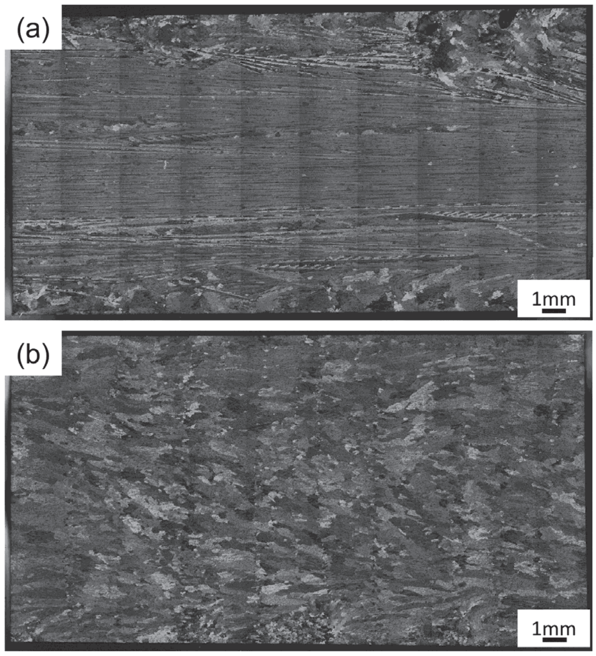

Fig.2 Macrostructures of (a) non-vibrated Al-1.5 mass%Mn rod and (b) vibrated Al-1.5mass% Mn rod.

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