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# MICROSTRUCTURE OF BINARY Mg-Al EUTECTIC ALLOY WIRES PRODUCED BY THE OHNO CONTINUOUS CASTING PROCESS

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*Directionally solidified binary Mg-Al eutectic alloy wires of approximately 5 mm in diameter were produced by the Ohno continuous casting (OCC) process and the microstructure was examined. It was found that the wires possess obvious unidirectional growth characteristic along its axial direction. The microstructure consists of parallel columnar grains that resulted from the competitive growth of equiaxed grains solidified on the head of dummy bar. Each columnar grain comprises regular eutectic α-Mg and β-$Mg_{17}Al_{12}$ phases, which grew along the axial direction of the wires. The morphology of the eutectic is mainly lamellar, meanwhile rod eutectic exists. The formation of rod eutectic was attributed to the "bridging effect" caused by incidental elements in the alloy.*

**KEY WORDS** *Mg-Al alloy; Eutectic structure; Directional solidification; OCC process*

## 1. Introduction

Ohno continuous casting (OCC) process is a unique metallic material-forming technique, which integrates directional solidification with continuous casting[1]. One of the characteristics of this process is the use of a heated mould held just above the solidification temperature of the metal to be cast opposite to the conventional water-cooled mould within which solidification takes place. In the OCC process, due to the application of external heat to the mould, the free nucleation on the surface of the mould is prevented. An axial temperature gradient exists between the heated mould and the separated cooler, and heat is extracted only through the wires or rods being cast, thereby the condition for directional solidification is created. As the liquid metal in the mould is overheated, the melt solidifies at the mold exit or outside the mould. The solid-liquid interface is flat or convex to liquid. Consequently, friction between the mould surface and the cast product is totally eliminated, thereby facilitates to cast small diameter wires without breakage. Furthermore, solidification shrinkage in OCC process is easily fed by liquid metal, without shrinkage holes or porosity in the continuously solidified ingot wires or rods. Therefore, the OCC process can be considered as a potential near net-shape metal forming method to cast directional structure metals with infinite length and mirror-smooth-surface and

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without internal shrinkage and porosity.

Up to now, several efforts have been performed to produce ingots of Cu, Al, Zn, Co and Bi alloys and their composites by OCC process, but only less for the production of magnesium alloys[2–8]. Ohno[9] first produced a pure magnesium ingot plate using this process. Onaka *et al*.[10] studied crystal orientation and yield strength of a pure magnesium ingot continuously cast using the OCC process and found that the ingot consists of elongated subgrains parallel to the direction of solidification. The disorientation angles between neighboring subgrains are very small. Anisotropy of plastic deformation was observed for the ingot.

AZ91 and AZ31 magnesium alloys processed by conventional directional solidification method were prepared by Mabuchi *et al*.[11] and Zou *et al*.[12], respectively. Their study showed that the directionally solidified AZ91 magnesium alloy exhibited higher strength and larger elongation at room temperature than the non-directionally solidified AZ91 Mg alloy. The directionally solidified AZ31 alloy ingot showed higher room-temperature mechanical properties and plastic deformation along the direction of solidification.

Better understanding of the principle of the OCC process facilitates to utilize the merits of the process in the production of metal rods and wires. In this article, directionally solidified binary Mg-Al eutectic alloy wires were produced by OCC process. The microstructure of the wires was studied, and the crystal growth mechanism of the alloy in the process was investigated.

## 2. Experimental

The nominal chemical composition of the binary Mg-Al eutectic alloy is Mg-32.3%Al (wt pct). The Mg-32.3%Al ingots were produced by melting industrial pure magnesium and pure aluminium in a graphite crucible at a temperature of 700°C. After the ingots were solidified and cooled in a graphite mould, they were polished and rinsed in spirit solvent to remove the possible stains. Then a proper amount of ingots was put in a furnace attached to the OCC apparatus and were remelted. Fig.1 shows a schematic diagram of the experimental equipment of OCC process. The equipment consists of a graphite crucible furnace with a melt level control system, a heated graphite mould with a 5 mm diameter channel, a cooling device, and pinch rolls for the withdrawal of the cast wire. The temperature of the crucible is controlled by a thermocouple placed in the furnace chamber. The melt temperature in the channel is controlled by another thermocouple positioned close to the channel at the exit side of the mould. The Mg alloy melt was protected from oxidation by a mixture of $CO_2$ with 0.3 vol. pct $SF_6$ during melting and casting. To begin casting, a pure copper dummy rod of 5 mm in diameter with a tapered head was inserted into the channel to bring the liquid metal to the exit. After ensuring good contact between the copper rod and the liquid metal, the cooling water was turned on and the casting was initiated by moving the pinch rolls. During casting, the level

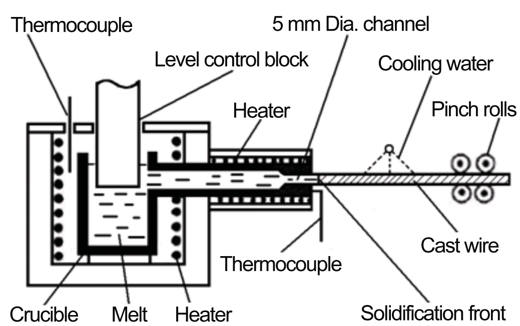


**Fig.1** Schematic diagram of the OCC process equipment.