Effect of Mould Tilt Angles on the Mechanical Properties of As-Cast Al-S

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Abstract

A near shape casting technique to produce as-cast aluminium-silicon alloy metal bars has been designed and fabricated.In this technique molten aluminium alloy was poured from a moving tundish into a D-Shape groove of a tilted copper mould. The base of the mould was cooled by water spray. The copper mould was tilted at 1°, 2° and 3°. The as-cast aluminium alloy bars were tested in accordance to ASTM standards to determine their mechanical properties namely hardness and tensile strength. The results show that decreasing mould tilt angle will increase the mechanical properties of the as-cast aluminium-silicon alloys bars.

Keywords: Near shape casting, Aluminium alloy

1. INTRODUCTION

An aluminum-silicon alloy bar is conventionally manufactured by continuous casting and then cold rolled[1]. An attempt to increase the mechanical properties of the aluminum–silicon bar and which may save cost by a near shape casting technique has been designed and fabricated[2,3,4]. In this technique (Fig.1), the molten metal is poured from a moving tundish into the D-groove of copper mould. The base of the mould was cooled by water spray. Unlike other techniques, the mould can be tilted at various degrees in order to control grain size during solidification. The product produced from the technique is in the form of as-cast D-shaped bar. In the present work the molten metal was cast at tilt angle of 1°, 2° and 3° mould at constant tundish speed and mould temperature. The as cast D-shape bar were tested in order to know its mechanical properties namely hardness and tensile strength. Thus the aim of this research is to investigate the of effect of mould tilt angle on the mechanical properties of aluminium-silicon alloy.

2. EXPERIMENTAL METHOD

An Al-Si Alloy with 11 % Si is used in this experiment. The metal is melted in a furnace and held for 10 minutes at 750 °C. The molten metal was then poured into the

tundish at 700 °C. After pouring the tundish was immediately pulled by the motor and the plunger was automatically opened. The molten metal flowed through the tundish hole into the D-groove of the tilted mould. The base of the mould was sprayed by cooling water 2 minute before pouring process and stopped when the solidification was completed. The experimental parameters are shown in Table 1.

The as-cast products were cut for metallography studies and tensile test specimens. Tensile test was conducted in accordance to ASTM E-8. Specimens for metallography studies were mounted, ground, polished and etched using 1 % HF reagent [5].

Table 1. Experimental Parameters

Mould tilt angle (degree)	Tundish speed (mm/sec^2)	Cooling water temperature (°C)	As-cast specimen code
1	32	29	RM31
3	32	29	RM33
1	32	6	ZM31
2	32	6	ZM32
3	32	6	ZM33
1	44	6	ZH11
2	44	6	ZH12
3	44	6	ZH13

3. RESULTS AND DISCUSSION

The hardness results are shown in Figures. 2. The hardness results shows that higher mould tilt angle reduces hardness value when other casting parameters such as mould temperature and tundish speed were constant. For example, when cooling water was constant at 29 C the hardness value of 1 degree is about 62.34 Hv and it decreases to 60.85 Hv where mould tilt angle was 3°. See Figure 2

The tensile test results are shown in Figure 3. It shows that increasing mould tilt angle reduces tensile strength when the others the casting parameters such as tundish speed and mould temperature are constant. When the mould temperature at 18 °C and the tundish speed was about 44 m/s, reducing tensile strength still appears as the effect of increasing mould tilt angle. The tensile strength of 1° is about 191.75 MPa, the tensile strength of 2° is about 171.5 MPa and of 3° is 163.37 Mpa.

Lower mould tilt angle reduces the grain size of as-cast metal. Figure 4 shows that grain size of 42.6 micron (at 3°) reduces to 36.7 micron (at 1°) when the cooling water temperature was 29 °C. Figure 4 also shows that the grain size of 43.5 micron (at 3°) reduces to 38.4 micron (at 2°) and to 35.2 micron (at 1°), when the cooling water temperature was 6 °C and tundish speed was 32 mm/s. Figure 4 still shows that the grain size of 43.03 micron reduces to 35.1 micron and to 34.2 micron, when the tundish speed was 44 mm/s and cooling water temperature was 6 °C.

Figure 5 shows effect of mould tilt angle on the cooling rate. It can be seen that cooling rate reduced at higher mould tilt angle and thus reduces the number of nuclei formed during solidification. As a result the grain size of the as-cast product increases

which affects the hardness and tensile strength of the metal. Both mechanical properties decrease when the metal grain size increases [6].

4. CONCLUSIONS

a) Increasing mould tilt angle decreases mechanical properties of aluminium-silicon as-cast D-shaped bar.
b) Increasing mould tilt angle also reduces the cooling rate which increases the grain size structure of the metal

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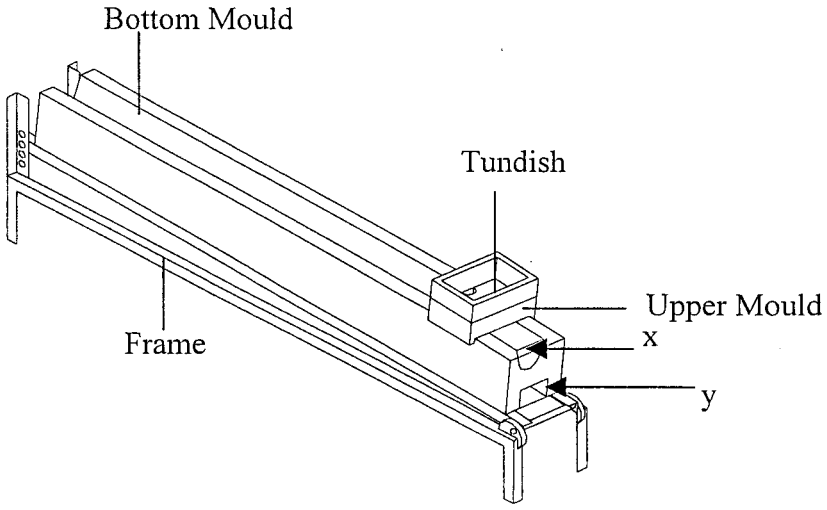

Fig.1 Schematic drawing of the near shape casting machine

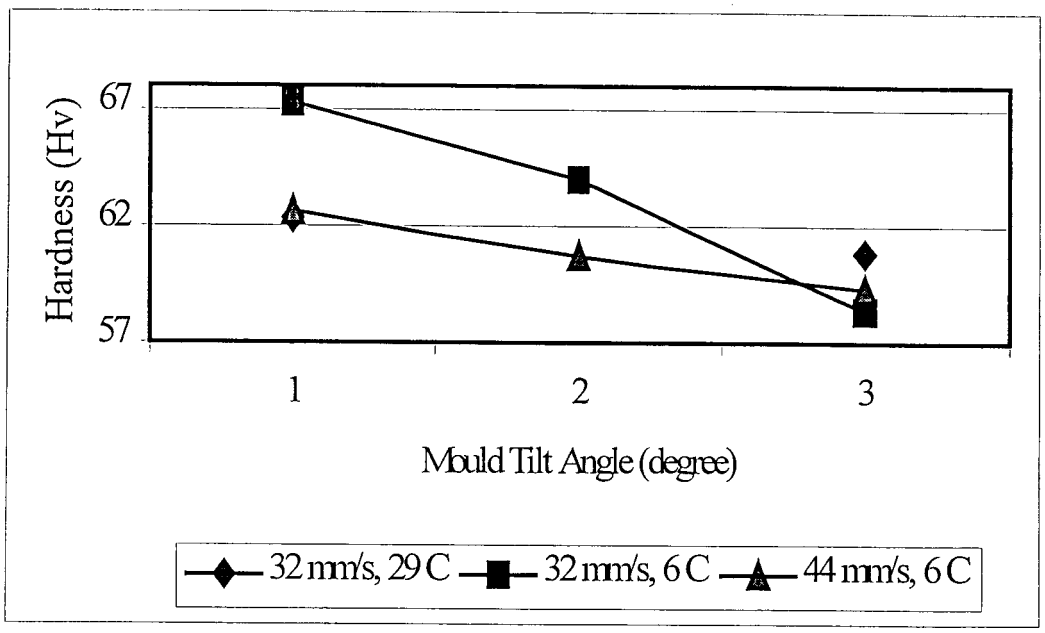

Figure 2. Hardness result.

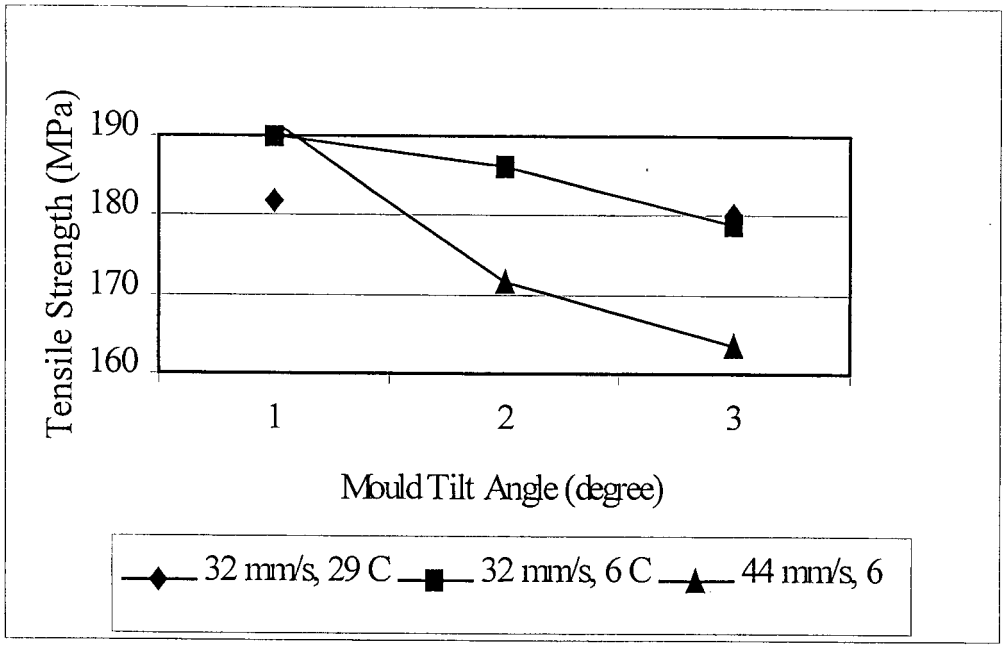

Figure 3. Tensile strength result

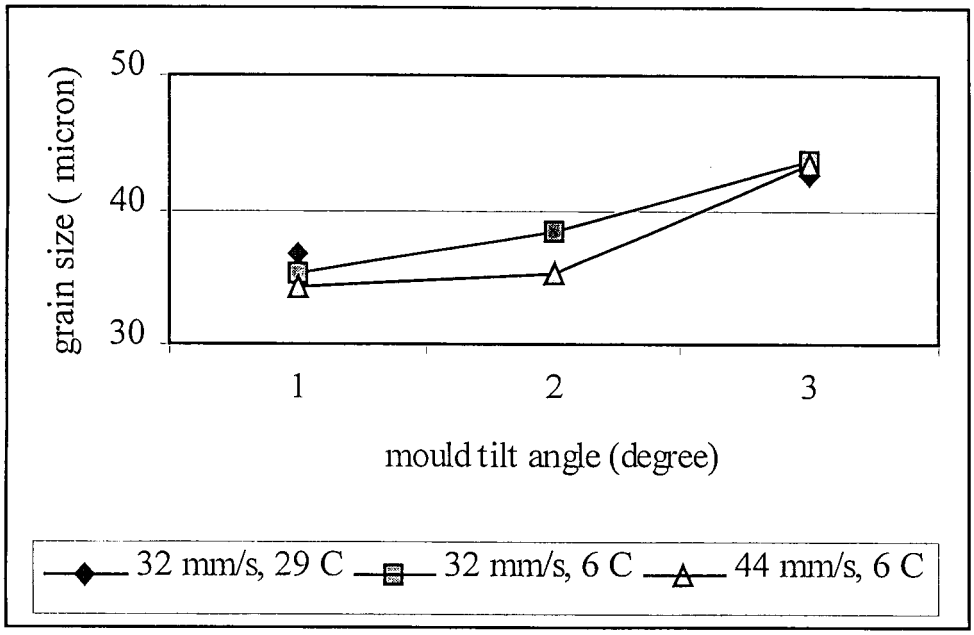

Figure 4. Grain size of as-cast product Vs mould tilt angle

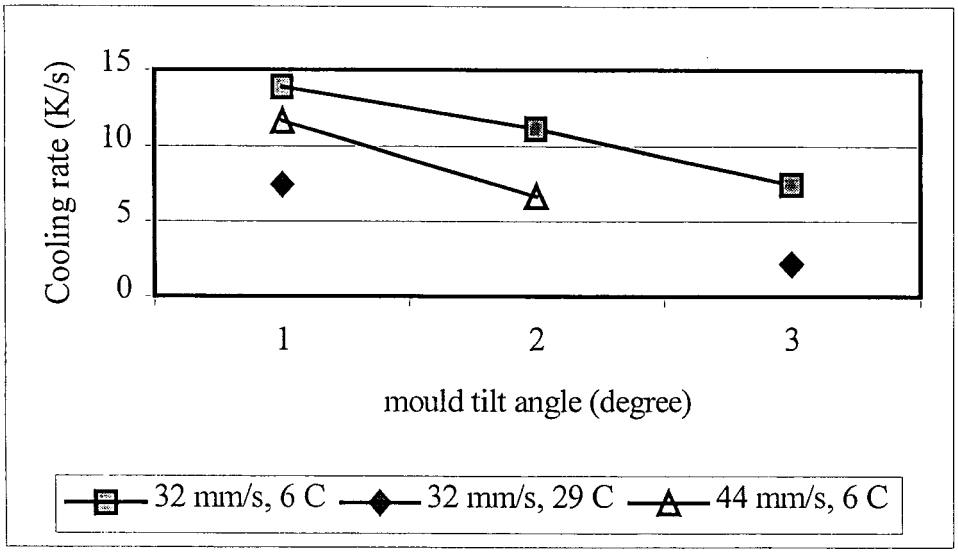

Figure 5. Cooling rate VS mould tilt angle