Casting of product of Al-25%Si with thin fins

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Die casting using Al-25%Si is proposed to cast a product with thin fins. The characteristics of this casting are presented. A conventional die-cast machine was used. Super cooling was used to reduce the casting temperature. The huge latent heat of the Si was utilized because of its excellent flow ability. A model of a heat sink, which was 0.5mm thick, 50mm high with 0.5 mm draft angle, was could be cast by the proposed process.
Fluidity of Al-25%Si was investigated to cast a product with thin fins. It became clear that the Al-25%Si had excellent flow ability in comparison with that of A383, which is popular aluminum alloy for die-casting. The fluidity of the semisolid Al-25%Si was better than that of the liquid A383 under the condition that the thickness of the die-cavity was thinner than 1mm.
Thermal conductivity of Al-25%Si was better than A383. Density of Al-25%Si is lower density than A383.

KEYWORDS: AL-25%SI - THIN FIN - FLUIDITY - THERMAL CONDUCTIVITY - T DENSITY

INTRODUCTION

Recently, die-casting of product with thin fins for a heat sink has been in demand. A383 aluminum alloy is a popular alloy for die-casting, and it has excellent flow ability. However, an A383 product thinner than 1 mm is very difficult to make by a conventional die-cast machine. A high-speed die-cast machine, which has the ability to cast thin fins thinner than 1 mm, is very expensive. Therefore, the use of the conventional die-cast machine is preferred. If an aluminum alloy with better flow ability than that of A383 is used, the products with thin fins can be cast. In this study, attention was paid to the huge latent heat of Si. It was estimated that the temperature drop of the metal became gradual and the flow ability was improved in the casting of hyper-eutectic Al-Si alloy. By taking account of the liquidus line temperature which becomes higher as the Si content increases, it was decided that 25mass%Si is the upper limit. The lower solidification temperature is suitable for the longer die life. Super cooling and low solid fraction semisolid casting (simple rheocasting) were adopted[1-4]. In this study, the flow ability of Al-25mass%Si was investigated and a model of a heat sink with thin fins was produced.

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EXPERIMENT

Cooling curve

It was considered that super cooling might occur in hyper-eutectic Al-25%Si. Therefore, as the first step, the cooling curve was measured to learn the temperature at which the crystallization of primary Si starts. Molten metal of Al-25%Si at 830 oC was poured into the sleeve of the die-cast machine and the cooling curve was measured.

Die-cast machine

A small cold chamber die-cast machine having die clamping force of 500 KN and sleeve diameter of 45 mm was used. The aluminum alloy was melted in a gas furnace.

Fluidity test

The fluidity was investigated by the spiral die shown in Fig. 1. The influences of the gap of the die cavity, the plunger speed and the temperature of the metal on the fluidity were investigated. The width of the die cavity was 7 mm constant and the gaps were 0.5, 1 and 2 mm. The length of the cavity was 800 mm. The plunger speeds were 0.5 and 0.8 m/s. The pouring temperature of the molten metal into the sleeve was 830 °C, and the casting temperatures were 650 °C, 700 °C and 740°C. A383 and Al-25%Si were cast under same conditions. The chemical compositions and properties of A383 and Al-25%Si are shown in Table 1 and Table 2. The flow ability of the model of the heat sink was tested.

Tab. 1 - chemical compositions of A383 and Al-25%Si

Alloy	Cu	Si	Fe	Zn	Mg	Ni	Al
A383	1.88	10.91	0.77	0.85	0.26	0.06	bal.
Al-25%Si	0.00	25.24	0.72	0.00	0.01	0.01	Bal

Tab. 2 - properties of A383 and Al-25%Si

Alloy	Thermal conductivity (W/mK)	Coefficient of line expansion ($\times 10^{-6}$)	Solidus line (K)	Liquidus line (K)
A383	100	21.0	853	833
Al-25%Si	135	16.7	833	1033

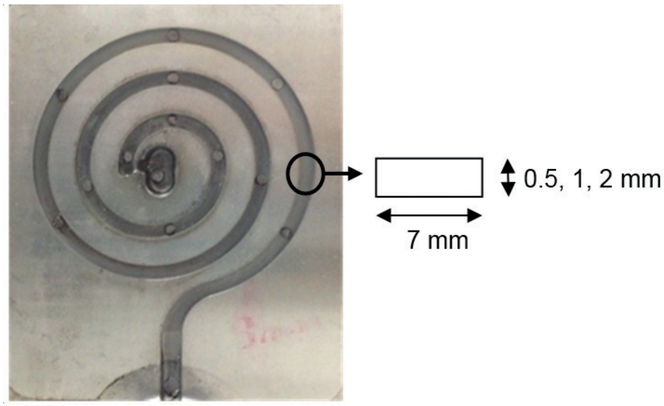

Fig.1 - photograph of a spiral die used for investigation of fluidity

RESULT AND DISCUSSIONS

Cooling curvature

The cooling curve is shown in Fig. 2. From this figures, it was estimated that crystallization started at approximately 700 °C. The liqudus line temperature of Al-25%Si is 760°C. Therefore, super cooling occurred at approximately 60°C. This means that the casting temperature 740 °C was a liquid condition in Al-25%Si. The Al-25%Si was semisolid for the low solid fraction at 700oC. Al-25%Si was semisolid at 650°C. However, A383 was in the liquid condition at these three casting temperatures. In the casting temperatures at 650°C and 700°C, this die-casting was rheocasting. Molten metal of Al-25%Si was cooled in the sleeve until semisolid, and special equipment to make a semisolid slurry was not used. This rheocasting process is very simple.

Fluidity

The results of the fluidity test are shown in Fig. 3. The effects of the casting temperature, the gap of the die cavity and the plunger speed on the fluidities of A383 and Al-25%Si were investigated. The fluidities of A383 and Al-25%Si generally became better at a higher casting temperature, a wider gap and a higher plunger speed. The A383 was liquid at 740 °C, and the Al-25%Si was semisolid at 650°C. In Fig. 3(a), the fluidity of the semisolid Al-25%Si at 650 °C was better than that of liquid A383 at 740°C. This tendency was the same in Fig. 3(b) and (c). However, this tendency was not possible under the condition that the gap was 2 mm. These results show that semisolid Al-25%Si has better fluidity than liquid A383 under the condition that the gap is thinner than 1 mm. These results confirm that Al-25% Si is suitable for die-casting of a product with the thin fins, even in the semisolid condition. In addition, from the point of die-life, the lower casting temperature is better. The melting point of the Al-25% is higher. Therefore, semisolid casting is an advantage for Al-25%Si.

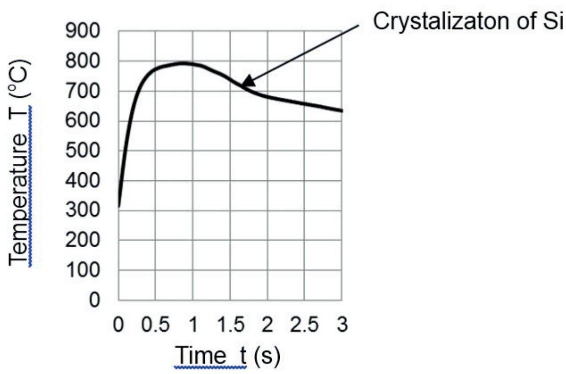

Fig.2 - cooling curves of Al-25%Si in the sleeve of the die-cast machine

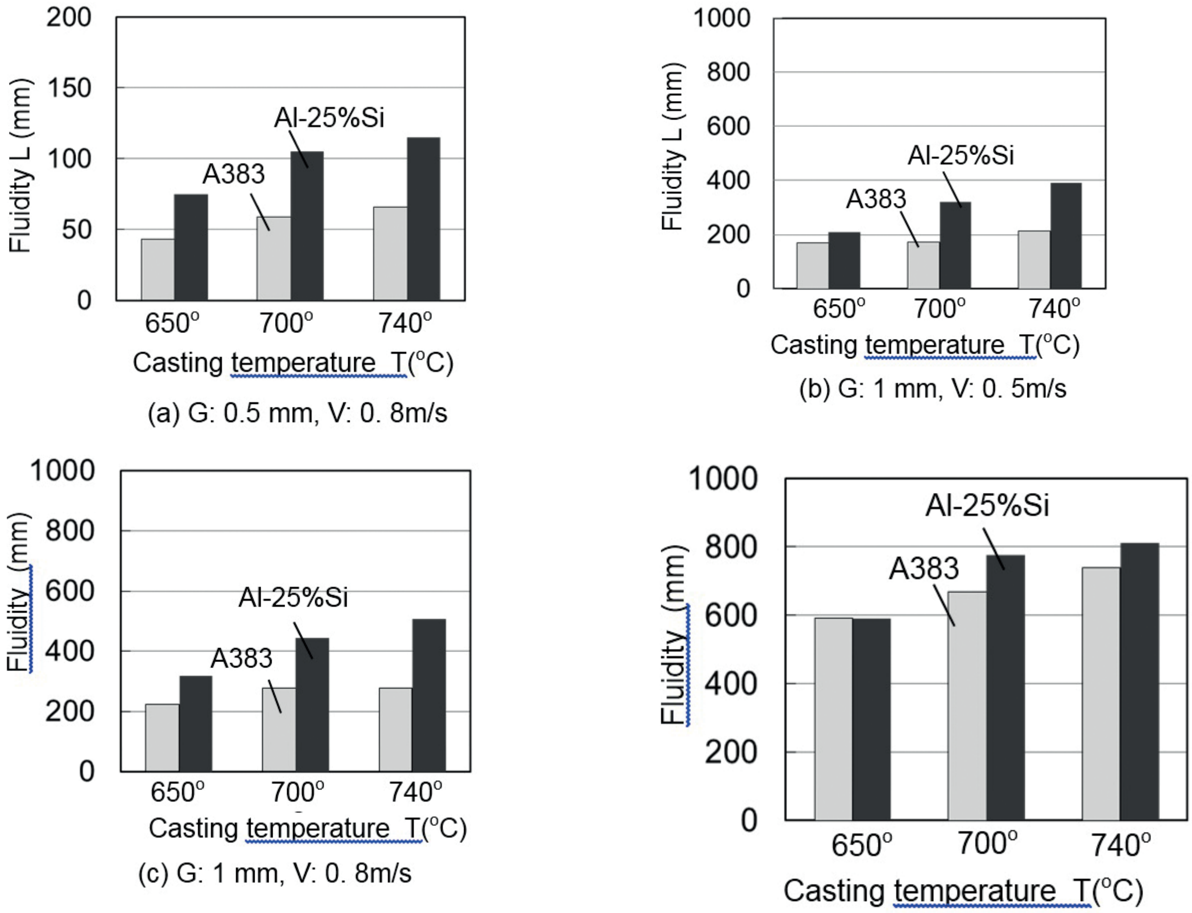

Fig.3 - caption Result of the fluidity test of A383 and Al-25%Si using a spiral die by a die-cast machine
G: gap of the die cavity, V: plunger speed

The result of casting the model of the heat sink is shown in Fig. 4. The thickness of the tip of the fine was 0.5 mm, the draft angle of the fin was 0.5 degree and fin height was 50 mm. The casting temperature was 740°C. Plunger speed was 1.6 m/s. The model of the heat sink cast from the Al-25%Si had fins with no defect.

The microstructure of die-cast Al-25%Si is shown in Fig. 5. The microstructure consisted of primary Si, Al and eutectic. The primary Si was globular. It is estimated that most of the primary Si was small enough to not interrupt the metal flow in the thin gap. The existence of Al might be evidence of the super cooling.

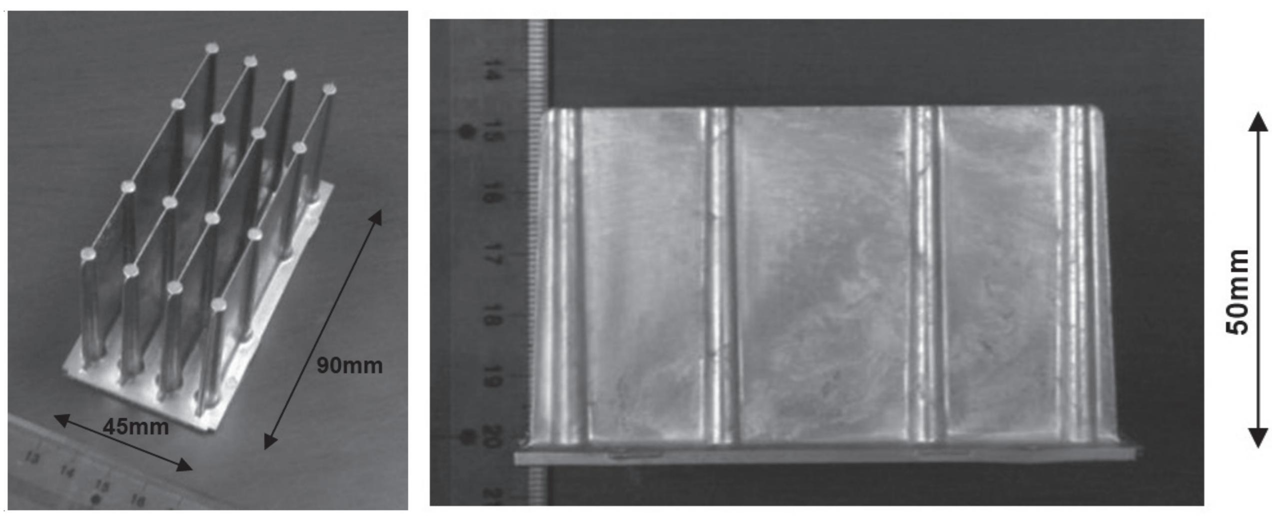

Fig.4 - Model of the heat sink cast from Al-25%Si. The height of the fin was 50 mm. The thickness of the tip of the fine was 0.5 mm, and the draft angle of the fin was 0.5 degree.

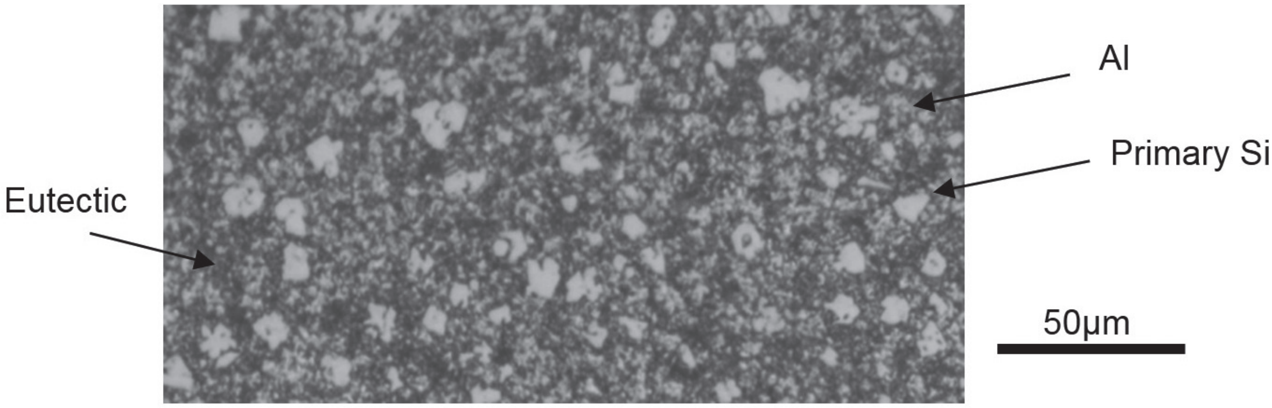

Fig.5 - Microstructure of die-cast Al-25%Si

CONCLUSION

Fluidity of Al-25%Si was investigated to cast a product with thin fins. It became clear that the Al-25%Si had excellent flow ability in comparison with that of A383, which is popular aluminum alloy for die-casting. The fluidity of the semisolid Al-25%Si was better than that of the liquid A383 under the condition that the thickness of the die-cavity was thinner than 1mm. The crystallization of primary Si in the Al-25%Si poured into the sleeve decreased to approximately 700°C by the effect of super cooling. In the condition that the casting temperature of Al-25%Si is lower than 700°C, this die-casting is simple rheocasting. The model of the heat sink with thin fins of 50 mm height could be cast by this simple rheocasting of Al-25%Si.

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