FLUIDITY TESTING ON Al-Si-Mg CAST ALLOYS

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ABSTRACT

An investigation has been carried out to study the influence of pouring temperature, degasification, mould pre-heat temperature and alloy composition on the casting fluidity. The results include that higher the pouring and mould pre-heat temperature greater the casting fluidity. The fluidity was found to be directly proportional to the silica content in the alloy composition. 1.2% tetra - chlorethane treatment promoted maximum fluidity.

INTRODUCTION

The pouring of molten metal into the mould and its afterwards filling are important steps in metal casting. It has been observed in foundry practice that in filling moulds of intricate design, distinctly those which include thin sections, some alloys fill the mould cavity fully and reproduce its details in the finished casting better than others. The testing of mould filling capability is therefore, essential as it not only helps the selection of alloy composition for a particular application, but also assists in quality control and thereby minimizing casting rejections.

Inadequate fluidity may be a factor in production of misrun castings or missing of surface features. Both metal and mould characteristics are involved in determining fluidity [1].

The factors related to mould are :
- Permeability
- Surface roughness
- Mould temperature
- Thermal conductivity of mould
- Gating ratio
- Sprue height

The factors related to metal are:
- Metal composition
- Super heat
- Density
- Viscosity
- Surface tension
- Surface oxide films
- Suspended inclusions
- Inclusions precipitating during freezing.
- Heat fusion

Since about 1915, a combination of two circumstances - gradually decreasing cost, the expansion of air transportation, development of specific casting alloys, improved properties, and the impetus provided by the two world wars has resulted in an ever increased demand for aluminum castings. Aluminum - silicon - magnesium castings, the light metals, are making rapid strides toward more extensive engineering use. Because magnesium oxidizes so rapidly, there is more chance to result dressy and gassed castings [2]. Magnesium and aluminum have low heat content per unit volume of metal and therefore loses temperature rapidly as heat is extracted [3]. For this reason it is not possible to run metal over long distances in thin castings. Feeding solidification shrinkage is largely accomplished on account of low pressure (i.e. low metallostatic pressure of the metal) feeding [4-5].

Casting characteristics of Al-si-Mg alloys are generally poor and this requires careful melting, degasifying and pouring. Certain problems are directly related to failure to exercise adequate control during the melting and casting processes. An ease or a difficulty of producing acceptable thin castings in chilled moulds is of interest to the designer or user of the casting and particularly with respect to the field of aerospace applications.

An investigation has been carried out to study effects of pouring temperature, degasification, mould pre-heat temperature and alloy composition on casting fluidity of Al-Si-Mg alloys used for gravity die casting.

EXPERIMENTAL PROCEDURE

The Composition of Al-Si-Mg alloys used in the present investigations are given in Table - 1. A strip fluidity testing mould (a cast iron strip type mould) whose design and dimensions are shown in Fig.1 was used for determining the casting fluidity of alloys. The strip fluidity test measures the ability of alloy to fill a mould of different cross sections and thus provides a wider specification of actual casting conditions.

Alloy	Composition (% Weight)			
	Al	Si	M_g	Fe
1	94	2.0	4.0	-
2	92	6.0	2,0	-
3	88	9.0	2.0	1.0

Table - 1 : Compositions of Al-Si-Mg Alloy

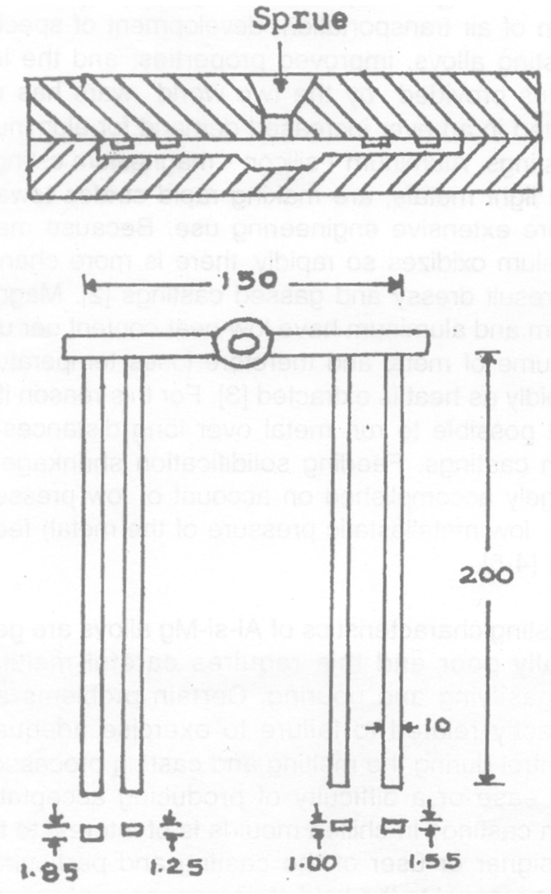

Fig. 1 Strip fluidity test mould.

The various alloys selected were method in an oil fired crucible furnace. The melting losses of the various alloys selected were melted in an oil fired crucible furnace, the melting losses of aluminum and magnesium were taken into account while preparing the charge. The crucibles were made of graphite. During melting the charge was fluxed with coveral-11 (a Foseco company product) to prevent dressing. The amount of coveral -11 was 1% total charge. The molten metal was then degasified by tetrachlorethane fin solid form) using a plunger ending in a small inverted crucible. The melt was also grain refined with 0.25% of titanium in the crucible before pouring.

The charge was reheated to the required pouring temperature in a muffle furnace. The temperature of the melt was measured using a dip type thermocouple. The dross removed melt was finally poured into the preheated mould.

Before starting the actual fluidity test experiments, the strip fluidity test mould was given a graphite coating each time at parting so that the alloy after solidification did not stick to the metal mould. The metal mould was preheated in the muffle furnace and the temperature of mould was measured using thermocouple just before pouring the liquid metal.

RESULTS AND DISCUSSION

The surface roughness of metal mould was 90 microns. The average size of graphite coating particles was 5 pm. Temperature and relative humidity of foundry atmosphere were 38°C and 45.

EFFECTS OF POURING TEMPERATURE

The liquid metal which was degassed with 1% of tetracholrethane was poured into the moulds at foundry temperature. The effect of pouring temperature on the strip length obtained in each mould channel of three alloys is shown in Fig 2-a, b and c. It can be seen that in all the cases, the casting fluidity in the thin channel is the least and is highest in thick channel. This is owing to the dissipation of heat at faster rate in the thin channels and their resistance to the flow of metal than the thick channels. The degree of super heat of the alloy increases with increase in pouring temperature and consequently the retaining time of alloy in the liquid form is prolonged. The super heating of alloy decreases the viscosity of the fluid. Therefore, the liquid melt is able to flow over a longer distance due to increase in fluid life.

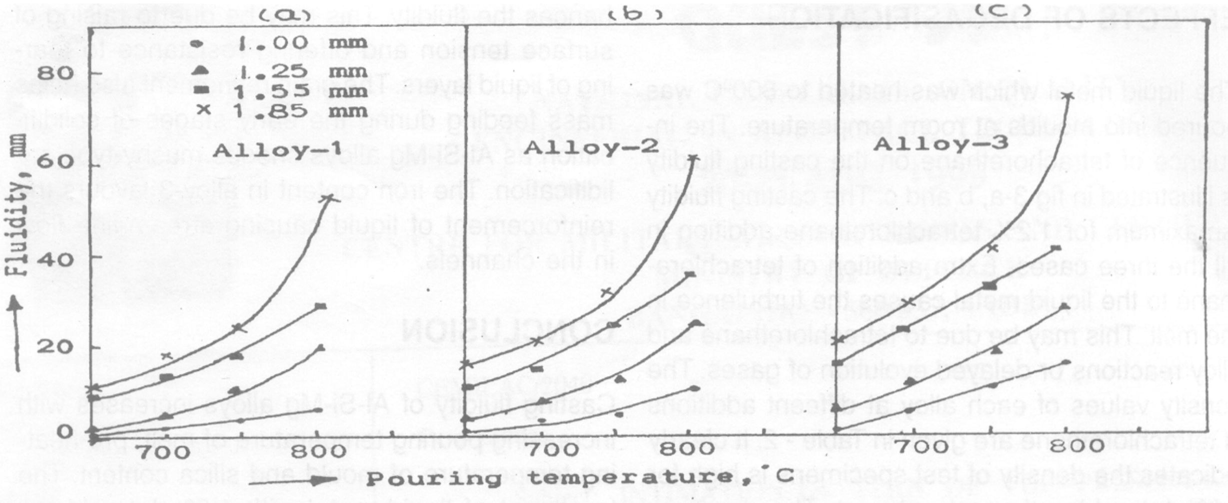

Fig.2 Effect of pouring temperature on casting fluidity

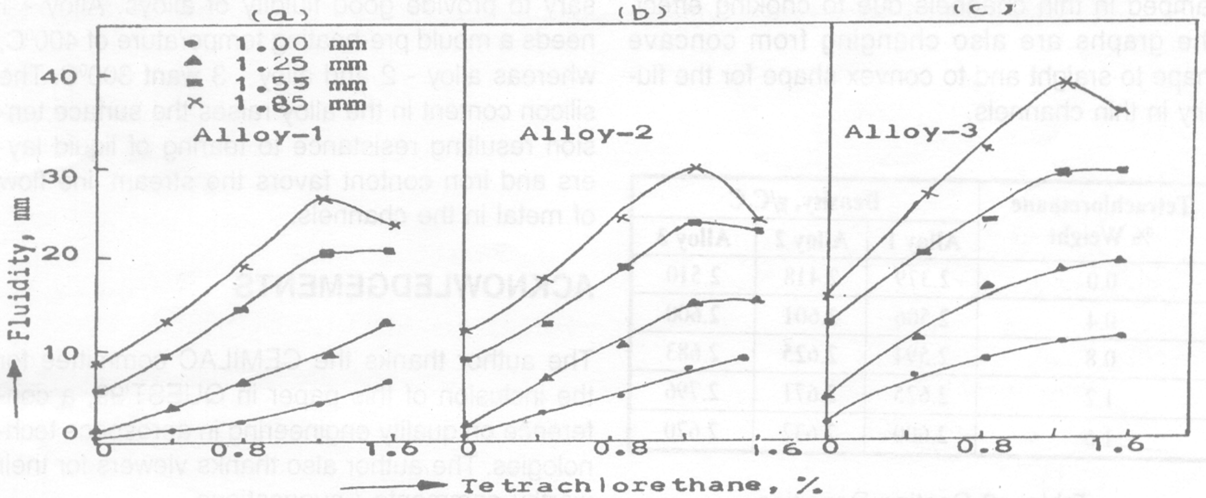

Fig.3 Effect of degasing on the casting fluidity

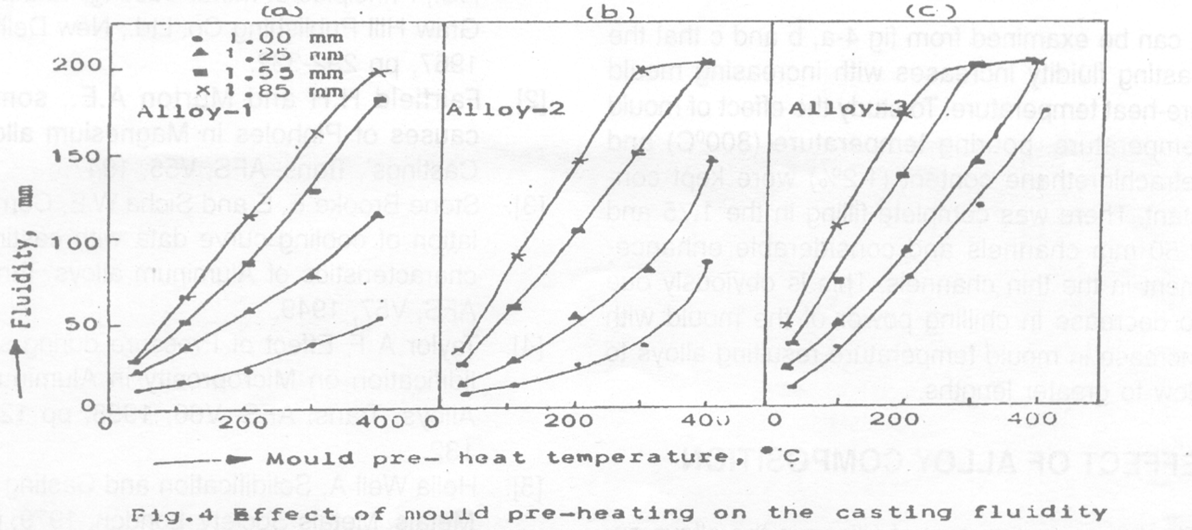

Fig.4 Effect of mould pre-heating on the casting fluidity

EFFECTS OF DEGASIFICATION

The liquid metal which was heated to 800°C was poured into moulds at room temperature. The influence of tetrachlorethane on the casting fluidity is illustrated in fig 3-a, b and c. The casting fluidity is maximurn for 1.2% tetrachlorethane addition in all the three cases. Extra addition of tetrachlorethane to the liquid metal causes the turbulence in the melt. This may be due to tetrachlorethane and alloy reactions or delayed evolution of gases. The density values of each alloy at different additions of tetrachlorethane are given in Table - 2. It clearly indicates the density of test specimens is high for 1.2% tetrachlorethane treatment. The decreasing of density is due to the entrapped porosity in the castings. It can also be revealed from the figures that the intensity of turbulence may be damped in thin channels due to choking effect. The graphs are also changing from concave shape to straight and to convex shape for the fluidity in thin channels.

Tetrachlorethane % Weight	Density, g/C.C		
	Alloy 1	Alloy 2	Alloy 3
0.0	2.379	2.418	2.510
0.4	2,506	2.6(7[	2.600
0.8	2,5>4	2.625	2.68.1
1.2	2.625	2.671	2.796
1.6	2.600	2.632	2.670

Table - 2 Casting Densities

EFFECT OF MOULD PRE-HEAT TEMPERATURE

It can be examined from fig 4-a, b and c that the casting fluidity increases with increasing mould pre-heat temperature. To study the effect of mould temperature, pouring temperature (800°C) and tetrachlorethane content (1.2%) were kept constant. There was complete filling in the 1.75 and 1.50 mm channels and considerable enhancement in the thin channels. This is obviously due to decrease in chilling power of the mould with increase in mould temperature resulting alloys to flow to greater lengths.

EFFECT OF ALLOY COMPOSITION

The increasing content of silicon in the alloys enhances the fluidity. This may be due to raising of surface tension and offering resistance to tearing of liquid layers. The grain refinement also helps mass feeding during the early stages of solidification as Al-Si-Mg alloys choose mushy-type solidification. The iron content in alloy-3 favours the reinforcement of liquid causing stream-line flow in the channels.

CONCLUSION

Casting fluidity of Al-Si-Mg alloys increases with increasing pouring temperature of melt, preheating temperature of mould and silica content. The treatment of liquid metal with 1.2% tetrachlorethane gives maximum fluidity.

A pouring temperature of 800 - 850°C is necessary to provide good fluidity of alloys. Alloy - 1 needs a mould pre-heating temperature of 400°C, whereas alloy - 2 and alloy - 3 want 300°C. The silicon content in the alloy raises the surface tension resulting resistance to tearing of liquid layers and iron content favors the stream line flow of metal in the channels.

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