FLUIDITY ASSESSMENT OF 6XXX ALLOYS IN MAGNESIA INVESTMENT SHELL MOULDS

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Abstract

The present work was intended to judge the influence of superheat and mould preheat temperature on the fluidity of 6xxx Al-alloys. The fluidity spirals were made using magnesia filler materials and the colloidal silica binder. The fluid increases with the increase of super heat and shell mould preheat temperature. The fluidity was higher for 6061 Al-alloy than that of 6013 Al-alloy.

Keywords: *6xxx Al- alloys, fluidity spiral, super heat, mould preheat temperature, magnesia.*

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1. INTRODUCTION

The 6xxx commercial alloys ranges all the way from 6002 to 6951. The main components of the alloys are magnesium and silicon to form Mg_2Si. Iron may also present as $FeAl_3$, $FeAl_6$, Fe_2SiAl_8 or $FeMg_3Si_6Al_8$. Most alloys have either magnesium or silicon excess. Magnesium excess leads to better corrosion resistance but lower strength and formability; silicon excess produces higher strength without loss of formability and weldability. 6xxx alloys have been very important in aerospace manufacturing since the introduction of metal-skinned aircraft. Fluidity is a widely accepted measure of the alloy's ability to fill the mold cavity. Because of its importance in casting, the fluidity of casting alloys has been studied extensively over decades [1-3]. Generally, whether a mold cavity can be filled completely or its details can be replicated depends not only on the alloy's characteristics but also on the mold properties, such as its dimensions, geometry, material, temperature, etc, and casting process parameters, such as temperature and pressure.

The objective of the present work was to study the influence of superheat of liquid metal and preheat temperature of magnesia investment shell mould on the fluidity of 6xxx alloys.

2. MATERIAL AND METHODS

6013, 6061 and 6063 Al-alloys were gravity cast in the investment shell moulds. Magnesia was used as the filler materials to make investment shell moulds. The investment slurry was prepared by adding the filler materials to the colloidal silica binder. The silicon radicals in the colloidal silica binder were 30%. The primary coats (first two coats) were stuccoed with fine silica grains of AFS fineness number 120 and the remaining backup coats with sand grains of AFS fineness number 50. All the investment shell moulds were preheated as per the design of experiments before pouring the liquid metal. The 6xxx alloys were melt in an induction furnace. They were modified with sodium. They were super heated before pouring into the moulds [6-8]. The fluidity spiral made from the alumina filler material is shown in figure 1. The length of fluidity spiral was 500 mm.

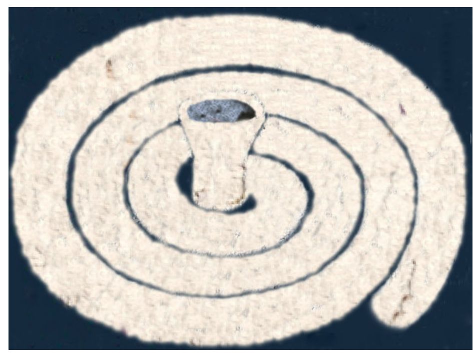

Figure 1: Fluidity spiral.

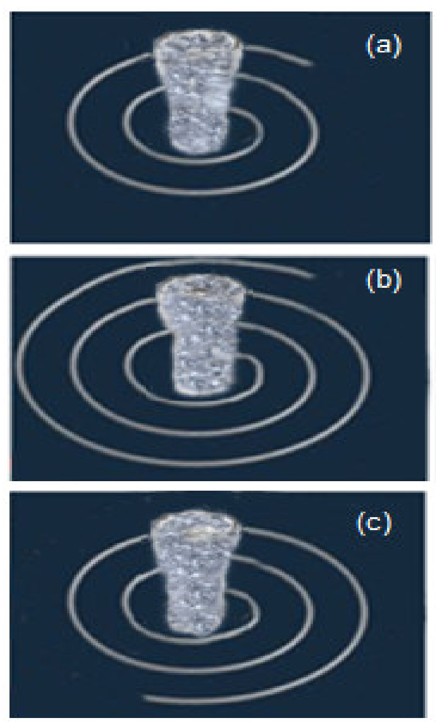

Figure 2: Fluidity spirals of (a) 6013 (b) 6061 and (c) 6063 Al-alloys.

3. RESULTS AND DISCUSSION

In the present investigation three 6xxx Al-alloys (figure 3) were considered. Alloy-1 was the 6013 Al-alloy; Alloy-2 was 6061 Al-alloy; Alloy-3 was 6063 Al-alloy. The alloy-1 consists of 1.0%Mg and 0.8%Si; the alloy-2 consists of 1.0%Mg and 0.6%Si; the alloy-3 consists of 0.7%mg and 0.4%Si. The optical microstructures of 6013, 6061 and 6063 Al-alloys are shown in figure 2. Formation of Mg_2Si and $FeAl_6$ were observed in the microstructures. The fluidity spirals of 6013, 6061 and 6063 Al-alloys cast in preheated (400^{o}C) magnesia investment shell moulds poured at 800^{o}C of liquid melt.

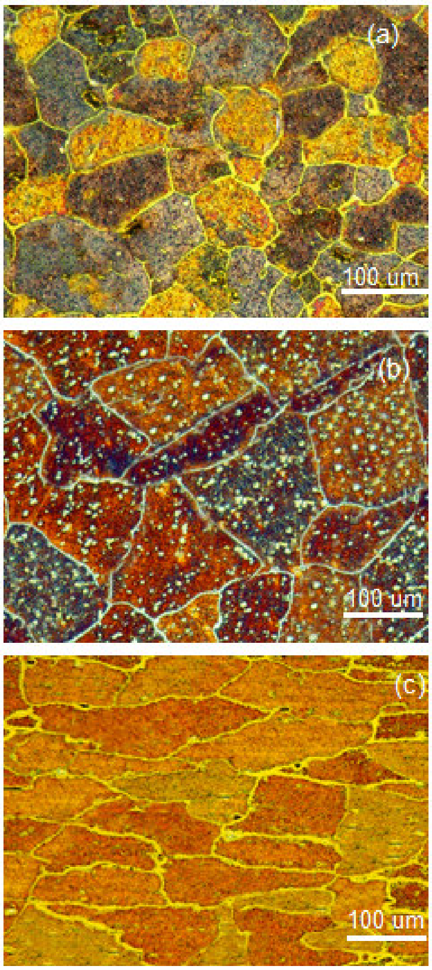

Figure 2: Microstructure of (a) 6013 alloy, (b) 6061 and (c) 6063 alloy.

3.1 Effect of alloy type on fluidity

The effect alloy type on the fluidity is shown in figure 3. The fluidity was measured at constant pouring temperature of 800^{o}C and mould-preheat temperature of 400^{o}C. The fluidity was high for 6061 Al-alloy and it was least for 6013 Al-alloy. The fluidity of 6063 Al-alloy was intermediate between 6013 and 6061 Al-alloys.

3.2 Effect of superheat on fluidity

The effect of superheat of liquid metal on the fluidity is shown in figure 4. The mould-preheat temperature was 400^{o}C. The fluidity of eutectic 6xxx alloy increases with the increase of superheat. If the melt was at a higher temperature relative to its freezing point, it would remain in the liquid state longer throughout the metal casting operation, and hence its fluidity would increase. The influence of superheating on the crystallographic characteristics of alloys revealed that superheating shifts its eutectic reaction toward higher level of silicon accompanying with the appearance of Al-dendrite in the hypo eutectic and eutectic Al-Si alloys [9]. Kolsgaard [10] has reported that the fluidity length, measured with a spiral test in sand mould, increases linearly by increasing superheat.

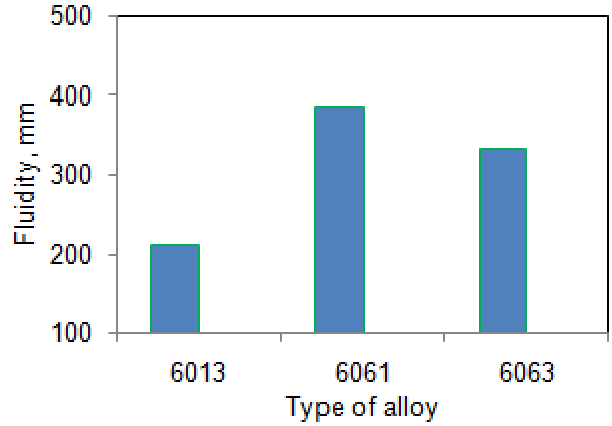

Figure 3: Effect of alloy type on fluidity.

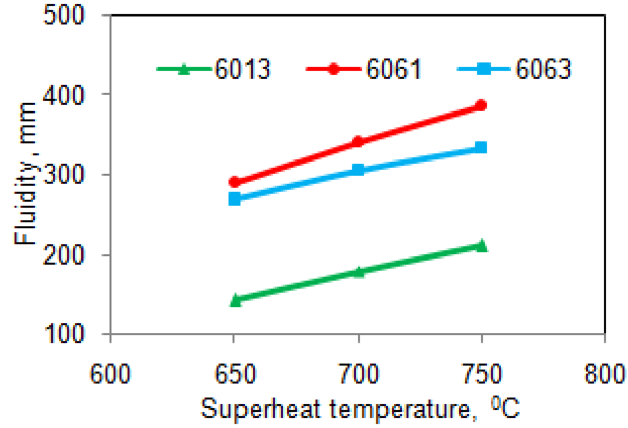

Figure 4: Effect of superheat temperature on fluidity.

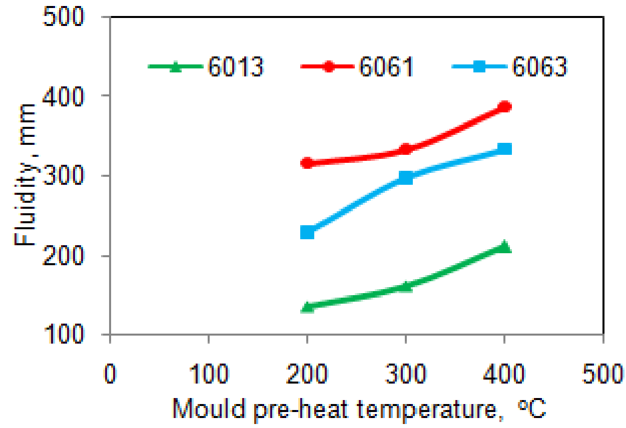

Figure 5: Effect of mould preheat on fluidity.

3.3 Effect of mould preheat on fluidity

The effect of mould reheat of liquid metal on the fluidity is shown in figure 4. The fluidity was measured at constant pouring temperature of 800°C for eutectic alloy. The fluidity increases with the increase of mould pre-heat temperature. This was due to reduced temperature gradient which would prolong solidification process.

5. CONCLUSIONS

The fluidity increases with the increase of super heat and shell mould preheat temperature. The fluidity was low for 6012 Al-alloy and it was high for 6061 Al-alloy.

REFERENCES

[1. J. Campbell, Review of Fluidity Concepts in Casting, Cast Metals, vol.7, no. 4, pp.227-237, 1995.

[4]. S. Floreen and D. V. Ragone, The Fluidity of Some Aluminum Alloys, AFS Transactions, vol. 65, pp. 391-393, 1995.

[4]. M. R. Sheshradri and A. Ramachandran, Casting Fluidity and Fluidity of Aluminum and its Alloy, AFS Transactions, vol. 73, pp. 292-304, 1965.

[5]. M. Sumanth, A. Chennakesava Reddy, V.S.R. Murti, Fluidity testing of Al-Si-Mg alloys, CEMILAC Conference, Ministry of Defence, India, August 1999, 1 (I), pp. 1-4.

[6]. A. Chennakesava Reddy, K.M. Babu, P.M. Jebaraj and M.P. Chowdaiah, Accelerator for faster investment shell making and its effect on the properties of investment moulds, Indian Foundry Journal, ISSN: 0379-5446, vol. 41, no.10, pp.03-08, 1995.

[7]. A. Chennakesava Reddy, and V.S.R. Murti, Studies on Lost-Wax Process Using Silox Binder, X-ISME Conference on Mechanical Engineering, New Delhi, 09-11th December, 1996, pp.82 – 86.

[8]. S. Madhav Reddy and A. Chennakesava Reddy, Interfacial Reaction between Magnesium Alloy and magnesia Ceramic Shell Mold, National Conference on Advanced Materials and Manufacturing Technologies, Hyderabad, 18-20 March 2000, pp. 218-222.

[9]. J.B. Friauf, The crystal structure of two intermetallic compounds, Journal of the American Chemical Society, vol. 49, pp. 3107–3114, 1927.

[10]. A. Kolsgaard, Casting characteristics of SiC particulate reinforced AlSi7Mg aluminium matrix composites, PhD thesis, NTNU Univ. of Science and Technology, 1993 .

[11] A.K. Dahle, L. Bæckerund and L. Arnberg, Castability of Aluminum foundry alloys, Final report for AFS, 1997.

[12] B. Kotte, Strontium modification gives critical melt control, Modern Casting, pp.33-35, 1985.