Proceedings of the 72nd World Foundry Congress
21-25th May 2016, Nagoya, Japan

Effect of Si content and Melt superheat on the liquid aluminum viscosity

Young Ki LEE[1], Jeong IL YOUN[1], Seok Min HWANG[1], Young Jig KIM[1*],
Kyu Chul HWANG[2], Hwi Jun KIM[2]
[1] School of advanced materials science and engineering, Sungkyunkwan University,
2066 Seobu-ro, Jangan-gu, Suwon, Gyeonggi-do 16419, Korea.
[2] Region Advanced Manufacturing Technology Agency, Korea Institute of Industrial Technology,
156 Getpearl-ro, Yeonsu-gu, Incheon 21999, Korea

In the casting processes, fluidity is defined as the maximum length which liquid metal will flow before it is stopped by solidification. The main factor determining the fluidity of liquid metal is the viscosity because which affect in many rheological properties such as surface tension, thermal conductivity and diffusivity. Viscosity is affected mainly on alloy composition and temperature, especially in Al-Si alloy casting alloy, evaluation of viscosity for Si content and pouring temperature is very important because which are affected directly on fluidity. However the researches on the effect of Si content and temperature on viscosity are not sufficient, because methods for measurement of viscosity have limitations such as liquid metal's low viscosity, high temperature and error of measurement. So in this study, the effect of Si contents and melt superheat on the liquid aluminum viscosity is studied.

Keywords: *Aluminum, Silicon, Viscosity, Fluidity, Solidificiation*

1. Introduction

In the casting processes, fluidity is defined as the maximum length which liquid metal will flow before it is stopped by solidification. Fluidity of liquid metals is significantly important property in producing sound castings. The fluidity is affected by many factors that can be divided into metallurgical variables, such as composition, superheat, latent heat, viscosity, surface tension and mould/castings variables, such as part configuration, cooling rate, degree of super heat, mould material and its surface characteristcs [1]. Especially viscosity is an important rheological parameter for understanding the hydrodynamics and kinetics of reactions in metal casting [2]. Viscosity directly influence many metallurgical variables such as surface tension, thermal conductivity and diffusivity, and moreover indirectly influence the mould/castings variables such as mould material and its surface characteristics. Viscosity is affected mainly on alloy composition and temperature, and especially in Al-Si alloy casting alloy, evaluation of viscosity for Si content and pouring temperature is very important because which are affected directly on fluidity. Nevertheless the viscosity is indispensable parameter to predict important transport phenomena of Al-Si casting alloy, only a few researches have paid attention to the viscosity of Al-Si alloys because methods suitable for liquid metals are limited by metal's low viscosities (of the order of 1 mPa·s), their chemical reactivity and generally high melting points [3]. So in the present study, we tried to evaluate the effect of Si contents and melt superheat on the liquid aluminum viscosity.

2. Experimental Procedure

2.1 Viscometer set up

Generally Capillary, oscillating vessel, rotational bob or crucible, oscillating plate have been developed or modified for this purpose [4]. These methods generate the thixotrophic microstructure during measurement of viscosity because these are torque type viscometer. So in this study, we proposed non-torque viscometer which was based on conventional falling ball viscometer and Stokes' law. In this method, a body (normally a sphere) was either allowed to drop due to gravity or drag upwards through the liquid [5].

2.2 Viscosity Measurement

The melt was prepared in a cylindrical crucible with the inner diameter of 60 mm and length of 350 mm. To evaluate of the Si content on viscosity of aluminum, different content of Si (0, 3, 7, 12, 17 wt%) were added in aluminum melts. And to evaluate of the superheat of melts on viscosity of aluminum, degree of superheat are established 45, 80 ºC at liquidus temperature of Al-Si alloys. Measurement of velocity of the falling object was performed to infer viscosity of the liquid.

3. Result and Discussion

Fig. 1 shows a schematic view of the falling ball viscometer. The falling ball made of steel with parting agent because of suppress of chemical react with melts. And to minimize the fraction of device, block and rail are used with pulley.

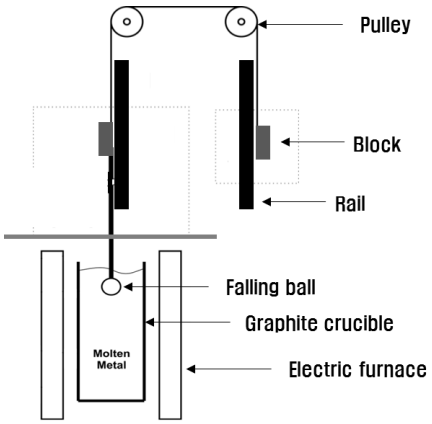

Fig. 1 Schematic view of the falling ball viscometer

The experimental values for the viscosity of the Al–Si alloy at different temperature are shown as Fig. 2. Si plays an important role in lowering the viscosity of Al melt. The viscosity of Al-Si alloy decreases as the Si concentration increases [6], and especially in Al-12Si, viscosity change irregularly with temperature varies. The work by Persion reports complex behaviour especially near the eutectic composition, which they associate with changes in the structure of the liquid [7]. And in the case of Al-7Si, temperature dependence of viscosity is larger than other Al-Si alloys.

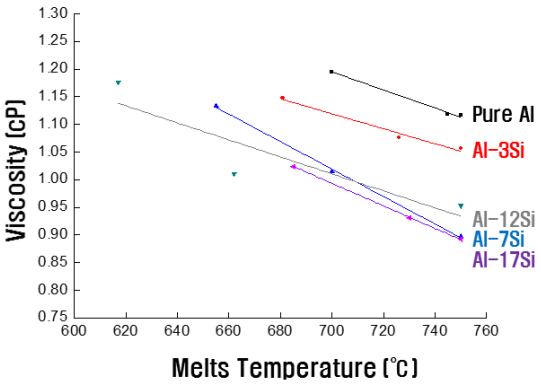

Fig. 2 Temperature dependence of the experimental viscosity data of Al–Si alloy with different Si content.

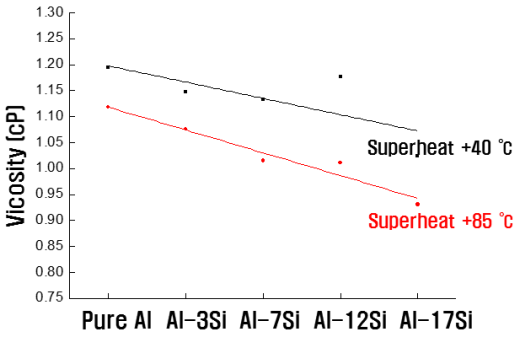

Fig. 3 The experimental viscosity data of Al–Si alloy with different superheat at liquidus temperature.

Fig. 3 shows the experimental viscosity data of Al-Si alloy with different superheat at liquidus temperature. Generally the viscosity decreases as the temperature of liquid metal increases, so when superheat of liquid metal increases, the viscosity of Al-Si alloy decreases. Especially, the degree of superheat increases, the rate of change of viscosity increases.

4. Conclusion

In this study, we evaluate the effect of Si contents and melt superheat on the liquid aluminum viscosity. The viscosity of Al-Si alloy decreases as the Si concentration increases generally. And when superheat of liquid metal increases, the viscosity of Al-Si alloy decreases.

References

[1] K. R. Ravi, R. M. Pillai, K. R. Amaranatha, B. C. Pai and M. Chakraborty: J. Alloy. Compd. 456 (2008) 201-210

[2] S. I. Bakhtiyarov and R. A. Overfelt: Acta Mater. Vol. 47, No. 17 (1999) 4311-4319

[3] A. T. Dinsdale and P. N. Quested: J. Mater. Sci 39 (2004) 7221-7228

[4] R. F. Brooks, A. T. Dinsadale and P. N. Quested: Meas. Sci. Technol. 16 (2005) 354

[5] S. Hossein Elahi, Hadi Abdi and H. R. Shahverdi: Rev. Sci. Instrum. 85, 015115 (2014) 1-4

[6] J. M. Vignau, P. Azou and P. Bastein, Compte Rendu Acad.Sci. 264 (1967) 174

[7] A. T. Dinsdale, P. N. Quested: J. Mater. Sci. 39 (2004) 7221-7228