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

Effect of reinforcement particles on the viscosity of the molten SiC_P/Al alloy composites

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To investigate the effect of reinforcement particles on the viscosity of the molten PRMMCs, the viscosity was evaluated by measuring the torque required to stir the molten PRMMCs. The torque increased with increasing the volume fraction and particle size of SiC particles. The torque changed with stirring time and the changing behavior of the torque was different in SiC particle size. However, the torque of molten PRMMCs with large SiC particles was high and decreased with stirring time, the torque of molten PRMMCs with small ones was low and almost constant. This difference is considered to be resulted from the difference of the settling behavior of SiC particles. The microstructures of the PRMMCs quenched after holding for various periods, showed that the larger the SiC particles size was, the faster the particles settled down. The result was in agreement with the settling behavior expected by the settling velocities of the SiC particles estimated using Stokes' law.

Keywords: *Metal matrix composite, Casting, Viscosity, Settling*

1. Introduction

Recently, the demands on the fabrication of particle reinforced metal matrix composite (PRMMC) components are increased due to their high mechanical and physical properties. The casting process is desirable to fabricate the PRMMC components because of its high productivity and formability. In the PRMMC casting process, it is known that the viscosity of the molten PRMMCs and the settling of the reinforcement particles will influence the castability and the characteristics of the PRMMC castings [1]. Some researchers have reported that the effect of reinforcement particles on the viscosity of molten PRMMCs in the stir casting process [2, 3], though there are few reports concerning the relationship between the viscosity of molten PRMMCs and the settling behavior of reinforcement particles.

In the present work, the viscosity of the molten PRMMCs was evaluated by measuring the torque required to stir the molten PRMMCs. In addition, the changing behavior of the torque was investigated associated with settling behavior of reinforcement particles in the molten PRMMCs.

2. Experimental procedure

The SiC_P/Al-Si alloy (AC3A) composites fabricated by Lanxide process were prepared for the experiments. The SiC particle size was varied from 15 to 75μm and the volume fraction of the SiC particles was varied from 10 to 30vol%. The experimental setup for the measurement of the torque was shown in Fig. 1. The torque of molten PRMMCs was measured

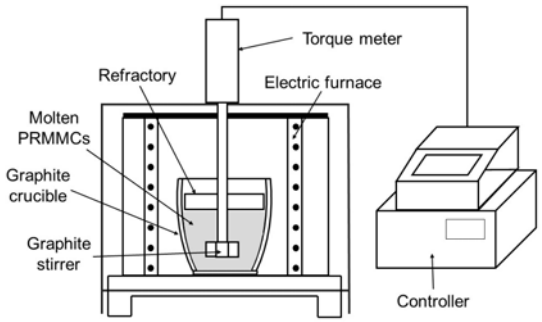

Fig. 1 Experimental setup for the measurement of the torque required to stir the molten PRMMCs.

by torque meter. The temperature of the molten PRMMCs was varied from 923 to 1023K. The rotational speed was fixed to 200rpm. To investigate the settling behavior of the SiC particles in the molten PRMMCs, the microstructure of the PRMMCs, which were quenched after holding at 973K for 1-5min, was observed. The volume fraction of SiC particles in the quenched specimens were evaluated by microstructure observation and image analysis.

3. Results and discussion

Fig. 2 shows the relationship between stirring time and stirring torque of molten PRMMCs containing 30vol% SiC particles with 15, 27 and 63μm diameter.

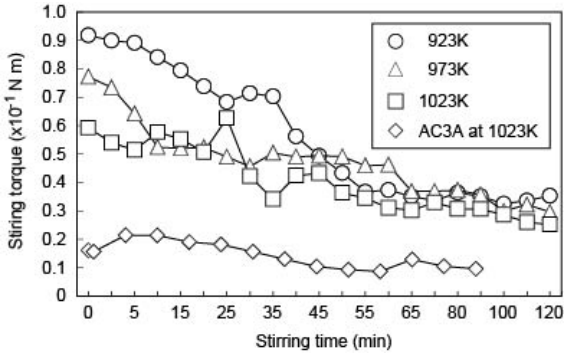

Fig. 2 Relationship between stirring time and stirring torque of 30vol% SiC_P/AC3A composites.

The stirring torque of all molten PRMMCs was higher than that of AC3A alloy melt and was increased with decreasing the temperature of molten PRMMCs. This increase in the stirring torque is considered to be caused by the decrease in the viscosity of AC3A alloy melt resulting from the temperature decrease. The effect of volume fraction and particle size of SiC particles on the stirring torque is shown in Fig.3. The

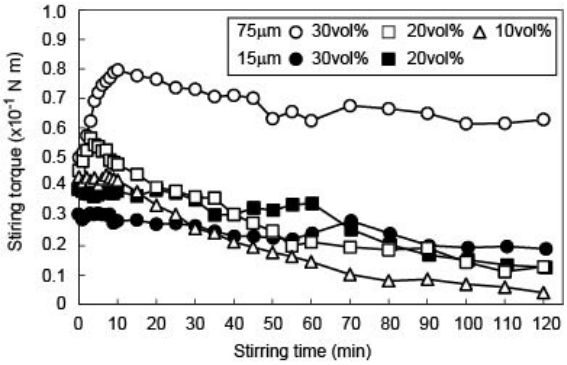

Fig. 3 Effect of volume fraction and particle size of SiC particles on stirring torque of SiC_P/AC3A composites at 973K.

stirring torque increased with increasing the volume fraction and particle size. The stirring torque changed with stirring time and the changing behavior of the stirring torque was different in particle size. However, the stirring torque of molten PRMMCs with large SiC particles was decreased with stirring time, the stirring torque of molten PRMMCs with small ones was almost constant. In addition, the peak of the stirring torque of molten PRMMCs with large SiC particles seems to shift to longer stirring time with increasing the volume fraction of SiC particles. These differences is considered to be resulted from the difference of the settling behavior of SiC particles. In order to investigate the dependence of the settling behavior of the SiC particles on particle size, the volume fraction of the SiC particles at the bottom and upper part of the quenched specimens was measured by image analysis. The results of image analysis are shown in Fig. 4. The

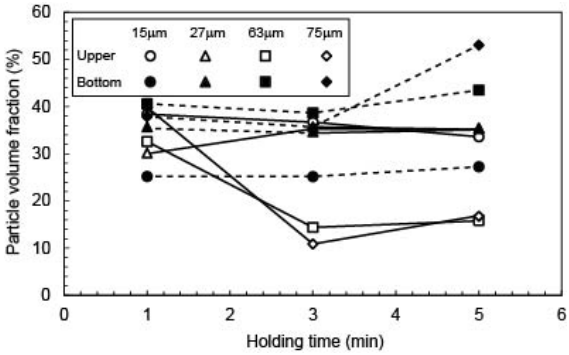

Fig. 4 Particle volume fraction in upper and bottom part of PRMMCs quenched after holding at 973K.

larger the reinforcement particles size was, the faster the particles settled down to the bottom. Then, the particle settling time was expected by the settling velocities of SiC particles using Stoke's law. The estimated particle settling time was 1.6, 2.3, 12.4 and 40min for 15, 27, 63 and 75μm diameter, respectively. These results were in roughly agreement with the settling behavior shown in Fig. 4. It is indicated that the changing behavior of the torque depends on the settling behavior of the SiC particles.

4. Conclusion

The stirring torque of molten PRMMCs is changed depending on the volume fraction and particle size of reinforcement particles. The changing behavior of the stirring torque of molten PRMMCs depends on the settling behavior of the reinforcement particles.

Acknowledgements

This work was supported by JSPS KAKENHI Grant-in-Aid for Scientific Research (C), 26420752.

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