A STUDY ON THE TRIBOLOGICAL CHARACTERISTICS OF FeCrSi/A366.0 ALLOY COMPOSITES

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Abstract

In this paper, we study about wear properties for the metal matrix composites fabricated by low pressure infiltration process. Metal fiber preform reinforced aluminum alloy composite were fabricated by low pressure casting process under 0.4MPa. Infiltration condition was changed the pressure infiltration time of 1 s, 2 s and 5 s under a constant pressure of 0.4MPa. The molten alloy completely infiltrated the FeCrSi metal perform regardless of the increase in the pressure acceleration time. However, the infiltration time at the pressure acceleration time of 1s was shorter than at the pressure acceleration time of 2s or 5s. The FeCrSi/A366.0 composite was investigated the porosity. The porosity is reducing as the pressure acceleration time compared with the pressure acceleration time of 2s and 5s. The FeCrSi/A366.0 composites were investigated the wear resistance. FeCrSi/A366.0 composite at pressure acceleration time of 1s has excellent wear resistance.

INTRODUCTION

Recently, as the industry technique grows rapidly, the design and manufacture are required that high precision and high strength about the machine component. And have to research for enhance the performance of the existing material and development new material. Especially, the engine inside of the automobile is composite environment as corrosion, wear and high temperature. Therefore, Using the Material Matrix Composite(MMC) at the piston part in the engine is enhance the

life extension and the saving fuel[1-3]. Producing aluminum alloy casting with a low pressure casting process has the advantage of being semi-automatic and thus saving labor cost as well as obtaining better casting quality and higher yield. It is believed that the cost of low-pressure casting is lower than that of squeeze casting and that the process provides better quality than gravity casting. In the previous study was investigated the infiltration behavior of filling pattern and the velocity profile with low pressure casting process.[4-5] In this study, the cause of pore generation inside the composite is discussed And it was investigated relationship between the porosity and wear resistance.

MATERIALS AND EXPERIMENTAL METHODS

Materials and Production FeCrSi/A3666.0 Alloy Composites

Table 1 show the Chemical composition of A3666.0 alloy, which corresponds to the AC8A aluminum alloy of the JIS standard in Japan. It was used as a molten metal to infiltrate of inside preform. Table 2 shows property of FeCrSi metal fiber. [NHK SPRING Co., Ltd]

Figure 1 shows schematic diagram of a typical low-pressure casting. Figure 1(a) was low-pressure casting machine includes usually a pressurized mould, compressor, vacuum pump and air vent that is removing the air in the preform before applying pressure. Figure 1(b) was process diagram of low pressure casting. For removing the air in the preform, it was carried to reduce pressure about –0.09MPa at the air vent for 5s after pouring molten aluminum alloy. Then the pressure of 0.4MPa was applied from the top. The preheating temperature of the preform was 400℃. The preform was set in the metal mould. The temperature of this mould was about 200℃. The molten aluminum with 750℃ was poured into the mould.

Table 1 Chemical composition of A366.0 alloy

Cu	Si	Mg	Zn	Fe	Mn	Ni	Ti	Pb	Sn	Cr	Al
0.8~1.3	11.0~13.0	0.7~1.3	0.00.15	0.8	0.15	0.8~1.5	0.2	0.05	0.05	0.10	Bal.

Table 2 Property of FeCrSi metal fiber

Diameter (㎛)	Density (Mg/m^3)	Thermal conductivity (W/m·K)	Thermal expansion (K-1)
40	7.32	11.8	11.5×10-4

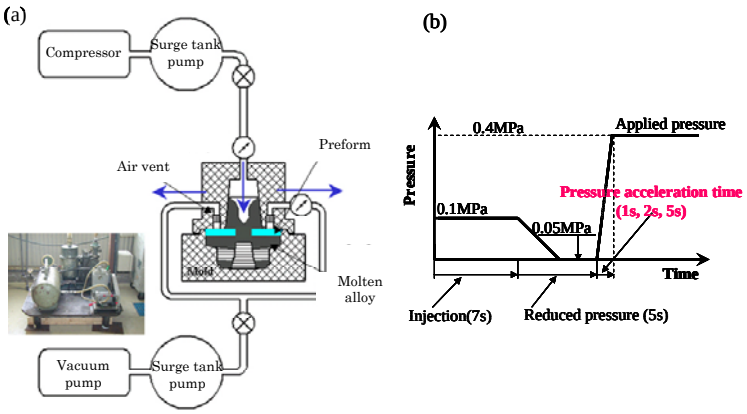

Figure 1 (a) Equipment of low pressure casting (b) Schematic of a typical low- pressure casting

Experimental Method

Each test piece for wear test was measured 10 times under a hardness measuring condition, and the average of the measurements excluding the highest and lowest ones was obtained as the hardness. Also, wear test equipment used was a ball-on-disk type dry wear tester. A SUJ2 ball 5.0mm in diameter was used as the ball test. The size of specimen for wear test was 11×11×6.0mm^3. It was precisely polished with #1500 abrasive papers surface roughness was evenly set to 0.2㎛. The specimen was tested with dry verticality abrasion for 30minute by pressing a test piece at a load of 10 N and rotating it at 50 RPM and 70 RPM.

RESULTS

Porosity

The porosity of piston head part composite is entrained imperfect infiltration. The relationships between the porosity and the pressure infiltration time of 1s, 2 and 5s can be seen in Figure 2. This figure numerous of porosities were seen at the side of mould compared to the beginning of infiltration inside preform. That was expected increase of porosity by the fast decreasing a temperature of molten alloy because of mould with 200^{o}C and not to be enough the applied pressure. The porosity of the composites produced at the pressure acceleration time of 1 sec, 2 sec and 5 sec under the applied pressure of 0.4 MPa was estimated to be 0.36%, 0.48% and 0.78%, respectively. The porosity decreased as fast the pressure acceleration time. Therefore, the porosity depended on the pressure acceleration time.

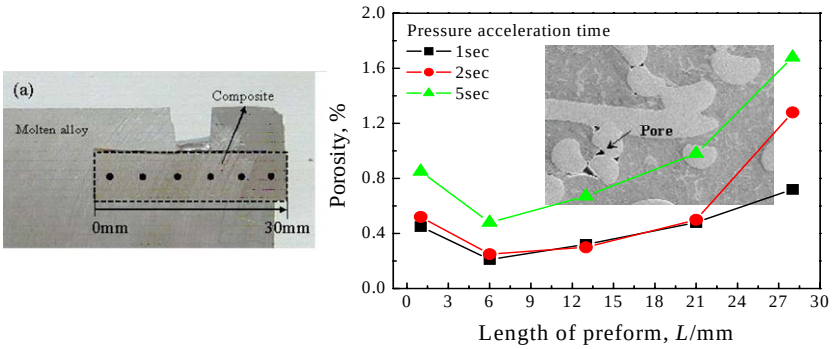

Figure 2 Influence of pressure acceleration times 1sec, 2sec and 5sec on porosity cau sed by imperfect infiltration.

Micro-Vickers Hardness of FeCrSi/A3666.0 composite

Figure 3 shows the Micro-Vickers hardness as a function of the pressure acceleration time of 1s, 2s and 5s Micro-Vickers hardness of FeCrSi/A366.0 composite at the pressure infiltration time of 1s, 2s and 5s were 389Hv, 345Hv and 378Hv respectively. Micro-Vickers Hardness of FeCrSi/A366.0 composite increased with increasing the pressure infiltration time. An increase of Micro-Vickers Hardness at the pressure infiltration time of 1s due to decrease in the porosity.

Wear properties of FeCrSi/A366.0 Alloy composite

Figure 4 and Figure 5 shows the relationship between the frictional coefficients of FeCrSi/A366.0 composite at different pressure acceleration times and wear test times. Frictional coefficient of FeCrSi/A366.0 composite at the pressure acceleration times of 1s, 2s and 5s almost no change. However, frictional coefficient of composite at the

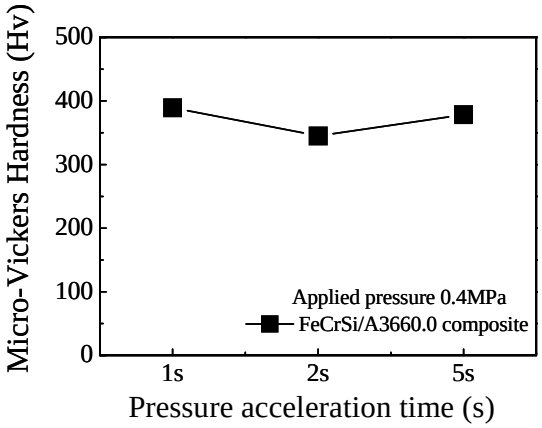

Figure 3 Relation between Vickers hardness and infiltration times (FeCrSi/A366.0)

pressure infiltration time of 5s was slight unstable initially. It was supposed that the unstable part of frictional coefficient increased porosity of composite with the pressure infiltration time, 5s compared with the pressure infiltration time of 1s and 2s. The average frictional coefficient of FeCrSi/A366.0 composite at the pressure infiltration time of 1s, 2s and 5s was 0.140, 0.145 and 0.168 in the case of 50 RPM while 0.11, 0.092 and 0.099 respectively in case of 70RPM. It was confirmed that the frictional coefficient of FeCrSi/A366.0 composite depended on the porosity inside composite. Figure 6,7 show the relationship between the wear depth of FeCrSi/A366.0 at different pressure acceleration times and test times. In case of 50RPM, show much wear loss quantity at 5s and show little wear loss quantity 1sec relatively and In case of 70RPM, show much wear loss quantity at 5s and little wear loss quantity is 2sec. the average wear depth of FeCrSi/A366 composite at the pressure infiltration time of 1s, 2s and 5s was 0.011, 0.025 and 0.069 at 50RPM while 0.009, 0.028 and 0.035 at 70RPM. Therefore, FeCrSi/A366.0 composites at pressure acceleration time of 1s and 2s have excellent wear resistance.

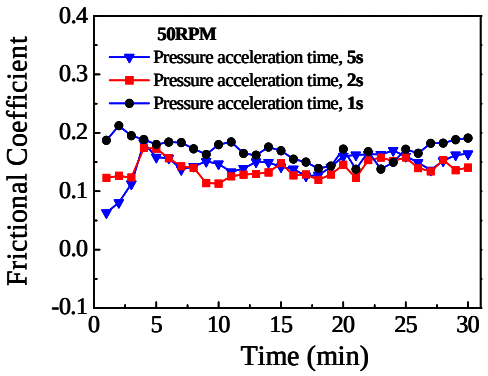

Figure 4 Relation between Frictional Coefficient and Times(50RPM)

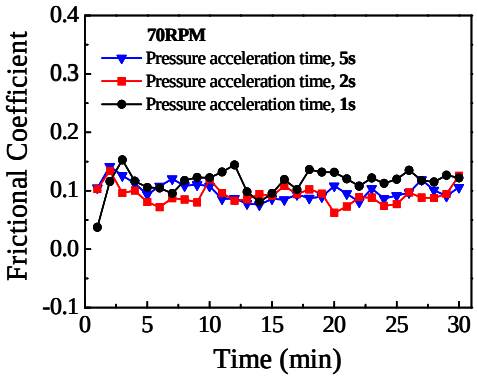

Figure 5 Relation between Frictional Coefficient and Times(70RPM)

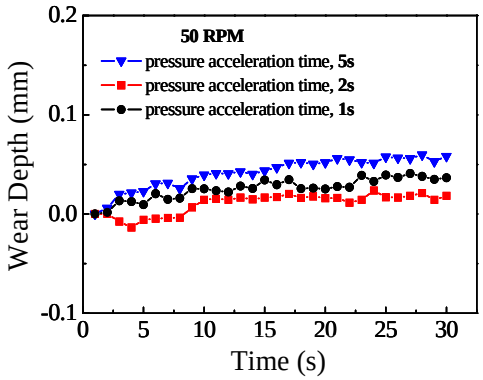

Figure 6 Relation between Wear Loss and Times(50RPM)

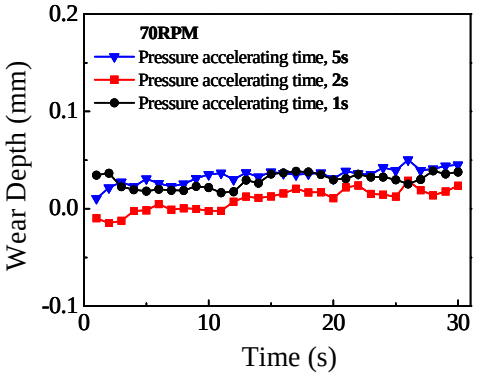

Figure 7 Relation between Wear Loss and Times(70RPM)

CONCLUSION

Low-pressure infiltration process is very effective for FeCrSi reinforced aluminum alloy composite fabrication. Infiltration of velocity at applied pressure time 1s, 2s and 5s is completely filled. In these conditions, FeCrSi fiber preform has successfully infiltrated by low-pressure casting. Further for reliability of composites, the porosity of composite was observed and the automobile piston with FeCrSi reinforced aluminum alloy is developed. The porosity is reduced as the pressure acceleration time fast. Likewise show similar tendency at wear test. When the pressure acceleration time is 1sec at 50RPM, the least porosity appeared In result the wear depth(1s) is less then other acceleration time(2s,5s). It is showed similar at 70Rpm. According to hardness test, 5s is hard than 2s nevertheless the wear loss of 2s less than 5s. The reason is porosity effect higher than hardness.

ACKNOWLEDGEMENT

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