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Fabrication and Study of Wear Properties of AA8090 Composite Reinforced with SiC Particles after Precipitation Hardening with Directional Quenching

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1- Introduction

Lithium is the lightest metal element, the addition of 1wt% of this element to these alloys causes the density to decrease by 3% and the elastic modulus to increase by 6%.

Al-matrix composites, owing to their high specific strength and good wear resistance, have attracted great attentions in the last three decades. Most Al-Li matrix composites like SiC_w/Al-Li or SiC_p/Al-Li are produced with melt stirring, powder metallurgy, squeeze casting or spray deposition methods. The melt stirring method or in other words stir casting is currently one of the simplest and most economical methods of manufacturing dispersion-strengthened materials.

2- Experimental Procedure

Fig.1 shows the equipment used for the production of the cast Al8090 composite. To produce Al8090 composite, pure aluminum billets were used along with Al_3Zr, pre-cast Al50%Cu and Al50%Mg, and pure lithium. Having prepared the molten Al8090 with stoichiometric copper and magnesium contents and preformed the slag removal process, the graphite agitator was inserted into the melt such that 30% of the molten volume lies beneath it. Then, the SiC particles with the mesh size of 380, which were previously subjected to an inactive oxidation treatment at 900°C for 2 hours, were fed into the melt during agitating operation through the powder injection system. At this point, the automated agitating operation was carried out at 600 rpm for 15 min. Immediately after the agitating operation, the stopper was raised and the melt was cast into the mold.

To improve the microstructure of the castings, small samples of 3cm diameter and height, were cut out of the final cast composites and extruded at 500°C with a reduction ratio of 12:1. Wear pins of square cross-section (5×5×15mm) were prepared from the final extruded samples. For each composite material, three samples were precipitation hardened after directional quenching. The wear test was then performed on heat treated and non-heat treated samples using pin-on-disk method at 10, 20 and 30N loads. Each sample was rinsed with acetone prior to a wear test of 1000m distance at a linear velocity of 0.25m/s. The weight of samples was accurately measured before and after the test using a digital scale of 0.0001g accuracy. Scanning electron microscopy (SEM) was used to study the microstructure and distribution of SiC particles in the extruded samples and also to observe the surface of the samples after the wear test.

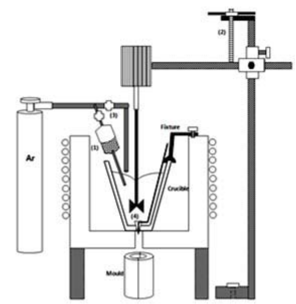

Fig. 1 Schematic diagram of the modified stir casting equipment used for fabricating the composites

3- Results and Discussion

According to the microhardness results (Fig. 2), the time to reach the peak hardness is approximately 6.5-7 hours which is significantly shorter than the reported period of 12-15 hours for Al8090/SiC_p composites at 190 ^{0}C. This reduction of the aging time for the peak hardness is attributed to the effect of the directional quenching.

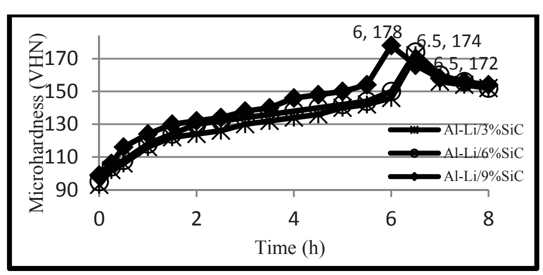

Fig. 2 Aging curves of the wear samples aged at 190°C after directional quenching

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All samples exhibited a mild wear at 10 and 20N wear loads, which turned into a sever wear at 30N. It was shown that increasing the SiC content in the composite samples reduces the wear rate (Fig. 3). Also, the wear results after precipitation hardening indicated a decrease in the wear rate only at the wear loads of 10 and 20N. This is indicative of improvement of wear resistance caused by the formation of strengthening precipitates and increased hardness in the matrix. At the wear load of 30N, the wear rate increased after precipitation hardening (Fig. 4). This behaviour was attributed to a transition in the wear mechanism from abrasive to adhesive by increasing the load (Fig. 5).

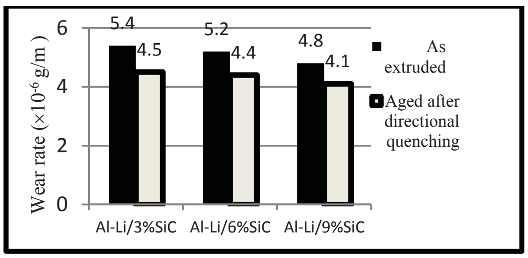

Fig. 3 Wear results of Al8090 composites reinforced with different volume fraction of SiC after heat treatment at 10N load

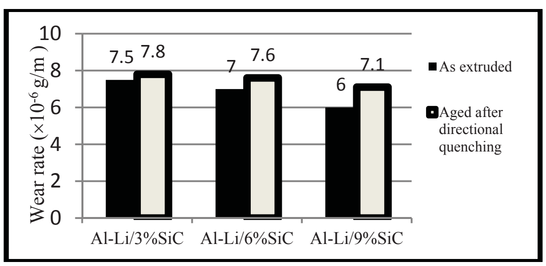

Fig. 4 Wear results of Al8090 composites reinforced with different volume fraction of SiC after heat treatment at 30N load

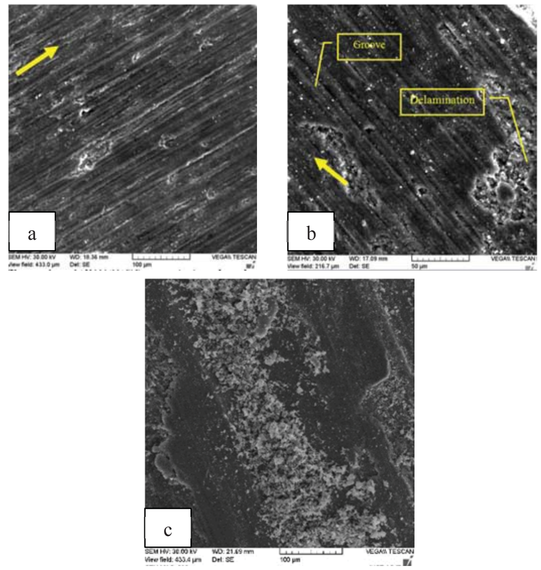

Fig. 5 Worn surface of Al8090/9%SiC$_p$ composite in peak aged at a)10N; b) 20N; c) 30N load

4- Conclusions

The wear rate decreases at all testing conditions with increasing the content of reinforcing SiC particles from 3 to 6 and then 9 vol.%. Also, at wear loads of 10 and 20N, all composite samples exhibited a lower wear rate after performing the precipitation hardening treatment. However, the effect of precipitation hardening was reversed at the wear load of 30N.