Int. J. of Applied Mechanics and Engineering, 2022, vol.27, No.4, pp.205-210
DOI: 10.2478/ijame-2022-0060

Tech note

FABRICATION OF A HIGH WEAR RESISTANCE AA7075/AL2O3 COMPOSITES VIA LIQUID METALLURGY PROCESS

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In the present study, AA7075/Al2O3 composites have been fabricated via liquid metallurgy process. AA7075 alloy and Al2O3 particles were taken as the base matrix and reinforcements, respectively. Then, contents of 3 and 6 wt. % of Al2O3 subdivisions were added into the AA7075 matrix. To improve wettability and distribution, reinforcement particles were pre-heated to a temperature of *550°C* for each composite sample. A hardened EN32 steel disc as the counter face was used to evaluate the wear rate pin-on-disc. The results showed that the wear rate of the AA/Al2O3 composites was smaller than that of the monolithic AA7075 samples. Finally, the worn surfaces of samples were investigated by SEM.

Key words: AA7075, Al2O3, wear, composites, stir casting.

1. Introduction

In many industries such as automobile, aerospace, vessels and electrical, nowadays there has been a considerable attention in the use of metal matrix composites (MMCs) with high wear resistance in other several industries such as aerospace, automobile, vessels and etc. due to their desirable properties such as high coefficient of thermal expansion, high strength and high Young's modulus [1, 2]. Many times in industries the

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need for a high performance tribological applications with a high wear-resistance is one of the major inducements for the technological development of aluminum matrix composites (ALMCs) [3, 4].

Aluminum base matrix composites usually have an ideal structure for wear resistant materials due to being reinforced with hard particles dispersed through a relatively ductile matrix [5-11]. Significant progress in the development of light ALMCs has been made in recent years and as mentioned before, the composites have been introduced in many needed applications such as in the aerospace and automotive industry [8-11]. So, these kinds of composites have led to fabrication of tailorable engineering materials with durable and enhanced properties [12-15].

In the present study, AA7075/ Al2O3 composites have been fabricated using liquid casting technique. The wettability of the molten aluminum alloys was increased by using the degassing process to improve the bonding between metallic matrix and Al2O3 reinforcements. Then, the effect of Al2O3 particles on the wear rate and wear morphology of these composite samples under different wear loads and velocities has been investigated.

2. Experimental procedure

In the present study, using the stir casting process, AA7075/Al2O3 composites containing 3 and 6 Wt.% of Al2O3 particles have been fabricated. First of all, the required amount of materials was placed in an electrical resistance furnace at *770°C*. After that, degassing was done using Solid Hexa-Chloro ethane to remove the absorbed gasses from the melt.

The next step after degassing the melt was adding Al2O3 as reinforcement particles, with average size *7μm* into the matrix during the melt stirring. The wettability of the Al matrix and ceramic Al2O3 particles increases and generates a good bonding between the particles and Al matrix with a better distribution of Al2O3 particles through the Al matrix.

During the addition of particles into the Al matrix, a stirring process was carried out at a rotary speed of *400rpm* for twenty minutes. The fabricated composites were machined and tested, to examine the tribological properties after pouring the produced melt into the cast iron dies. To investigate the wear behavior of composites on the composite samples and in order to study the tribological properties, the wear test was carried out using the pin on disk equipment. The test samples were cylindrical specimens of *7mm* in diameter and *20mm* height and prepared from the composite samples fabricated with 3 and 6 Wt.% of Al2O3 particles. Al2O3 is the hardest material after the natural diamond based on the Mohr hardness criteria. Then, wear investigations were performed under varying conditions of sliding velocities and load. The mass loss of the pin was used to calculate the volumetric loss. During the wear test, the applied load varied between *3–5kg* while the disc speed varied from *170* to *5000rpm* at the ambient temperature. So, the volumetric loss during the wear test is measured as:

$$V_l = \frac{Initial\ weight - final\ weight}{Density\ of\ the\ composite} \tag{2.1}$$

where L is the sliding distance V , N is the normal load and V_l is the volumetric loss.

3. Results and discussion

3.1. Microstructure investigation

Figure 1 shows the surface morphology of the sample fabricated with 6 Wt.% of Al2O3 particles using a scanning electron microscope. As can be seen in Fig.1, the microstructure of as cast AA7075 with 6wt% Al2O3 particulates reveals that there is a fairly uniform distribution of Al2O3 particles through the Al matrix containing an excellent bonding between Al2O3 particulates and Al matrix. In other words, it can be concluded from Fig.1 that increasing the wettability of the molten Al matrix improves the bonding between the Al matrix and Al2O3 particles.

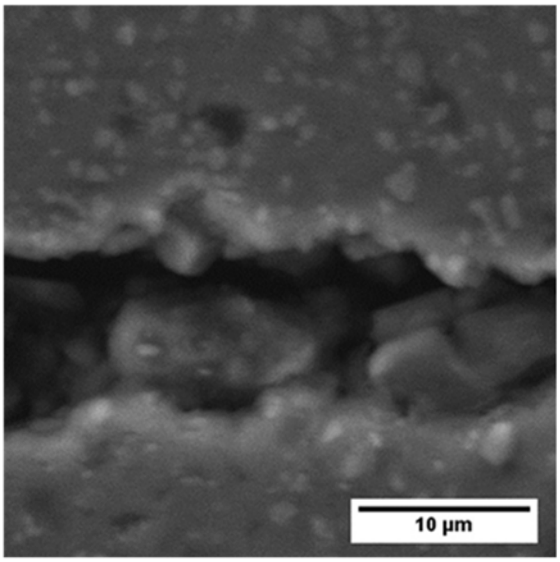

Fig.1. SEM microphotographs of Al/5Wt.% Al2O3 composite.

The effect of applied load and Al2O3 Wt.% on the wear rate and Vol. wear loss of composite samples is shown in Figs 2 and 3, respectively. The pin rotary speed during the wear test was *350rpm* at the ambient temperature. As can be seen in Figs 2 and 3, the wear resistance of composite samples increases while these particles resist the cutting action of the rotating wear pin by increasing the Al2O3 content in low material removal from the pin surface. So, Al2O3 particles have an enhancement role on the wear resistance for all the applied loads in all experimental conditions and act as lubricant agents [12-14].

Figures 4 and 5 show the wear resistance of composite samples vs the wear disc speed. The test was conducted at a varying disc speed of *150rpm*, *300rpm* and *450rpm* at a constant load of *4kg*. According to Fig.5, increasing the sliding speed, increases the wear rate of composites. Also, the differences between monolithic and composite samples are more considerable due to the enhancing effect of Al2O3 particles on the wear resistance.

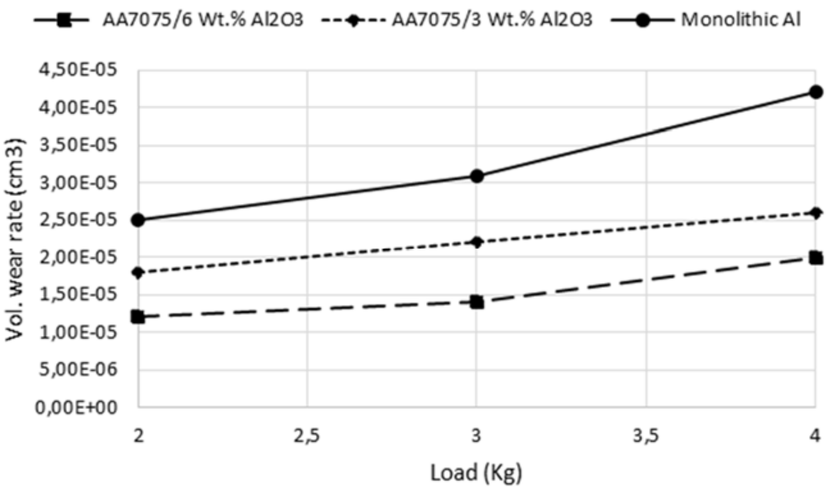

Fig.2. The Vol. wear rate vs the applied load.

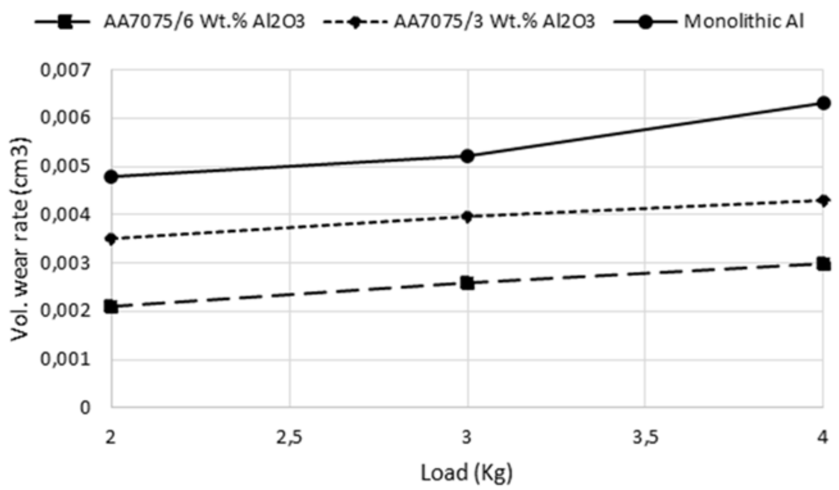

Fig.3. The Vol. wear rate vs the applied load at *300rpm*.

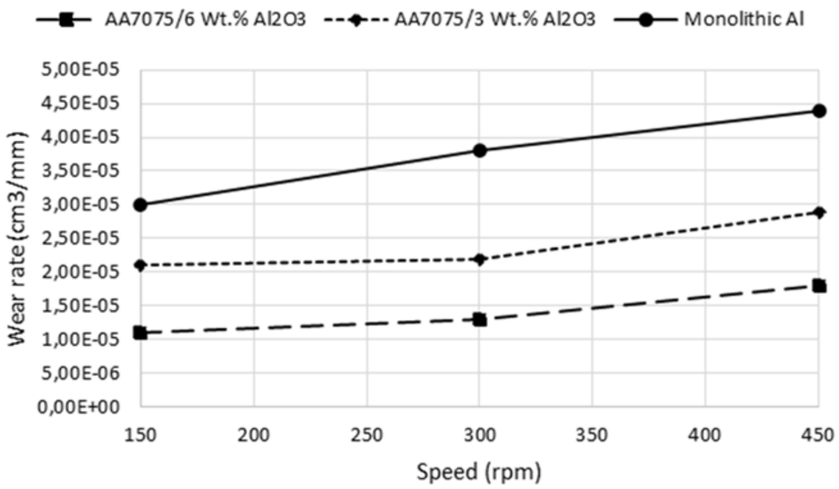

Fig.4. Effect of rotating wear pin speed on the wear rate at *3kg* load.

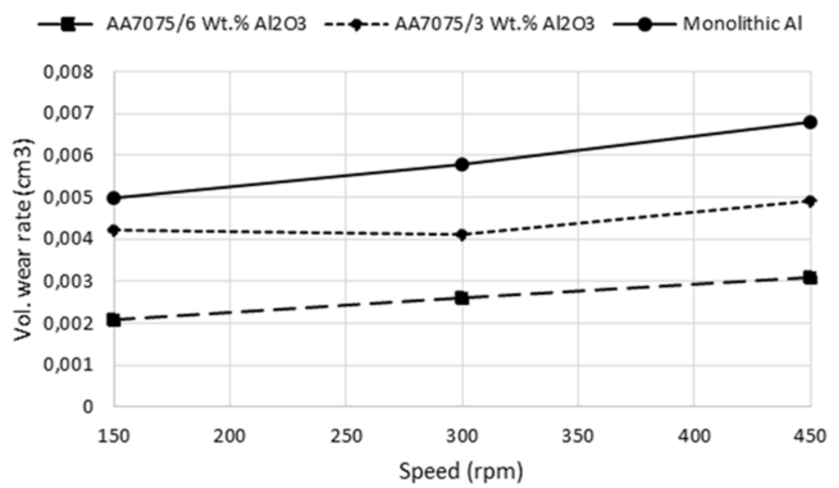

Fig.5. Effect of rotating wear pin speed on the Vol. wear rate at *3kg* load.

Figure 6 shows the worn surfaces of monolithic and Al/6 Wt.% Al2O3 composite samples at *4kg* load and *350rpm* using the scanning electron microscopy. As illustrated in Fig.6, Al2O3 particles have a considerable effect on the wear resistance enhancement. The surface delamination and wear tracks are evident in Fig.6. As mentioned before, Al2O3 also acts as a lubricant and decreases the friction between the composite surface and the rotating wear test pin. Based on Fig.6, it is observed that the width of wear channels decreases due to the enhancing effect of Al2O3 particles as lubricant. So, Al/ Al2O3 composites have a better wear resistance than monolithic samples [10].

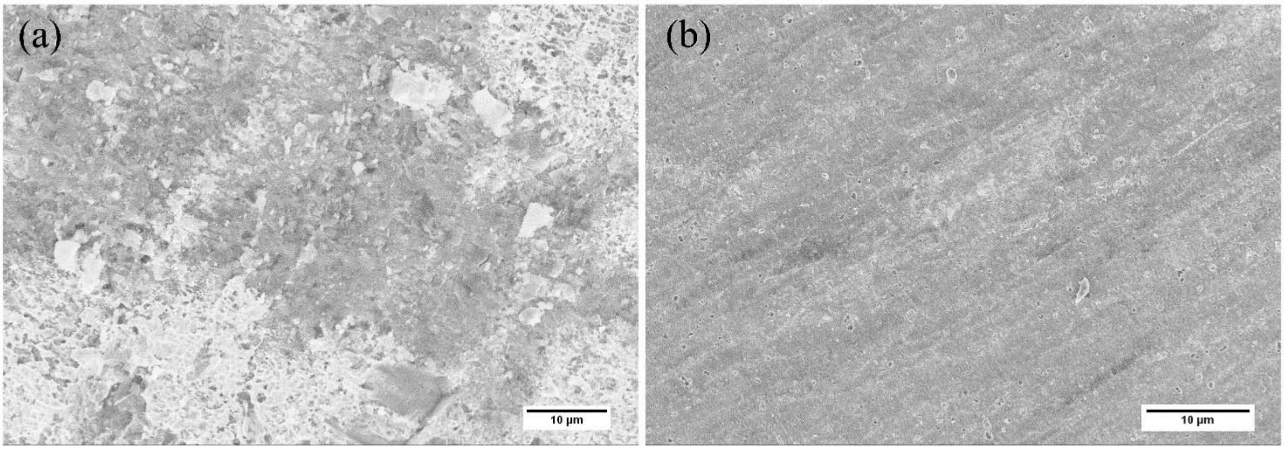

Fig.6. SEM morphology of worn surfaces of (a) monolithic sample and (b) Al/ 6 % Al2O3 composite.

4. Conclusion

The Al/ Al2O3 metal matrix composites have been fabricated with melt stirring. The following conclusions can be made:

- AA7075/ Al2O3 composites have been successfully fabricated via melt stirring process.
- The wear resistance of the composite samples improved by addition of Al2O3 particulates to the aluminum matrix.
- The SEM results revealed a uniform scattering of Al2O3 particulates through the AA7075 matrix.
- A significant increase was achieved in the wear and volumetric wear loss at higher values of sliding speeds due to the improving effect of Al2O3 as compared to cast monolithic AA7075.

Acknowledgement:

The support of the research center of the Islamic Azad University of Mobarakeh is appreciated.

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Received: May 5, 2022
Revised: August 16, 2022