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Wear analysis of aluminium metal matrix composites

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ABSTRACT

In this study, the effect of sliding distance on the wear rate is studied on the hybrid metal matrix composites. SiC and B4C with varying weight percentage used. Composites are produced using liquid metallurgy route. Using pin on disc apparatus the wear analysis experiment. As the volume fraction of SiC and B4C reinforcement increases, the wear rate decreases.

Keywords: *Wear, Stir-cast, Hybrid composite, Particulate Reinforcement*

1. INTRODUCTION

Yoshiro Iwai et. al. [1] reported that the initial sliding distance requires to achieve mild wear decreased with increasing volume fraction and also severe wear rate decrease linearly with volume fraction. AP Sannino [2] recommended that the increasing particle size of SiC from 4 to 29 micron increased the coefficient of friction. Ali Mazahery and Mohsen Ostacl Shabani [3] emphasized that higher hardness of composite could be achieved by ceramic reinforced particulate (B4C) because B4C particle acts as an obstacle to the motion of dislocation. Alpas and Zhang [4] while investigating the wear of particle reinforced Metal Matrix Composites (MMC) under different applied load conditions identified three different wear regimes. At low load, the particles support the applied load in which the wear resistance of MMCs is in the order of magnitude better than Al-alloy. According to J.Hashim [5], proper selection and controlling of processing variables could achieve a good quality of composites. S.M.Seyed Reihani [6] reported the effect of SiC particles on the aging behavior, mechanical properties and wear resistance of Al (6061) alloy made by squeeze casting method. D.P.Mondal [7] opinion was that the applied load affects the wear rate of alloy and composites significantly and is the most dominating factor in controlling the wear behavior. The cumulative volume loss increases with increasing applied normal load and the contact surface temperature increases as the applied load increases. Kowk and Lim [8] suggested that massive wear occurs if the particles are smaller than the threshold value at higher speeds. A. Daoud et.al [9] reported that addition of magnesium alloy to composite during production ensures good bonding between the matrix and the reinforcement. A. Wang and H.J.Rack [10] reported that the steady-state wear rate of 7091Al matrix composite is generally independent of reinforcement geometry (particulate versus whisker) and orientation (perpendicular versus parallel) with the exception of wear at 3.6m/s where the parallelly oriented SiC composite was found to be superior.

2. EXPERIMENTAL SET UP

Figures 1 shows pin-on-disc wear test experimental setup. The slider disc has been made up of 0.95 to 1.2% carbon (EN31) hardened steel disc with a hardness of 62 HRC having a diameter of 165 mm. A track diameter of 100 mm has been used in all the experiments. The initial surface finish of the steel disc has been 1μm. The Hybrid Aluminium Metal Matrix Composites test samples have been prepared as pins of dimensions 12 mm in diameter and 32 mm in height as shown in Figure 2. Four specimens were made.

It is important to ensure that the test sample's end surfaces have been flat and are polished by using metallographic techniques prior to wearing testing. Conventional aluminum alloy polishing techniques have been used to make the contact surfaces of the monolithic composite aluminum specimen ready for the wear test.

Fig. 1: Pin-on-disc sliding wear testing machine with integrated system

Fig. 2: Wear test Specimens

The procedure involves grinding of composite aluminum surface manually by using 240, 320, 400 and 600 grit silicon carbide papers followed by polishing with 5, 1 and 0.5μm alumina using the low-speed polishing machine. This preparation technique has enabled to create considerable surface relief between hard and soft aluminum matrix. The polished specimens have been then cleaned ultrasonically with acetone and methanol solutions. Similarly, the counterface materials have been polished and cleaned ultrasonically with acetone and methanol solutions before each wear test. The steel slider has been polished by the above-described procedure and all the tests have been conducted at room temperature.

The tests have been carried out by applying normal loads such as 10, 20 and 30N at a maximum sliding distance of 4500m at different velocities such as 1.5, 3.0 and 4.5 m/s. The wear rates of test samples have been measured in weight units by weighing the specimen before and after the test and have finally been converted into volumetric wear loss. The wear losses of the specimens have been measured using a high precision (accuracy 0.001g) electronic balance. The difference in weight loss of the entire test samples has been measured before and after the wear test under dry condition. Using this weight loss data, the composite's volume loss has been calculated. The microstructural investigation and semi-quantitative chemical analysis on the worn surfaces have been performed with the aid of SEM.

Table 1: Parameters considered during the sliding wear test

Applied load (L)	15, 20 and 25 N
Sliding velocity (S)	2, 3 and 4 m/s
Sliding time (t)	10, 15 and 20 min
Volume fraction (R)	2, 4 and 6%

3. RESULTS AND DISCUSSION

Effect of Sliding Distance on Wear Rate

The wear factor, defined as the ratio of wear volume (m^3) to the product of applied load (N) and sliding distance (m) has been an important parameter, which quantifies the wear resistance.

Figures 3 (a-c) clearly enlighten the correlation between wear rate and sliding distance at different applied load. The wear rate decreases and attains a lower steady value with the increase in sliding distance, perpetually for all the samples.

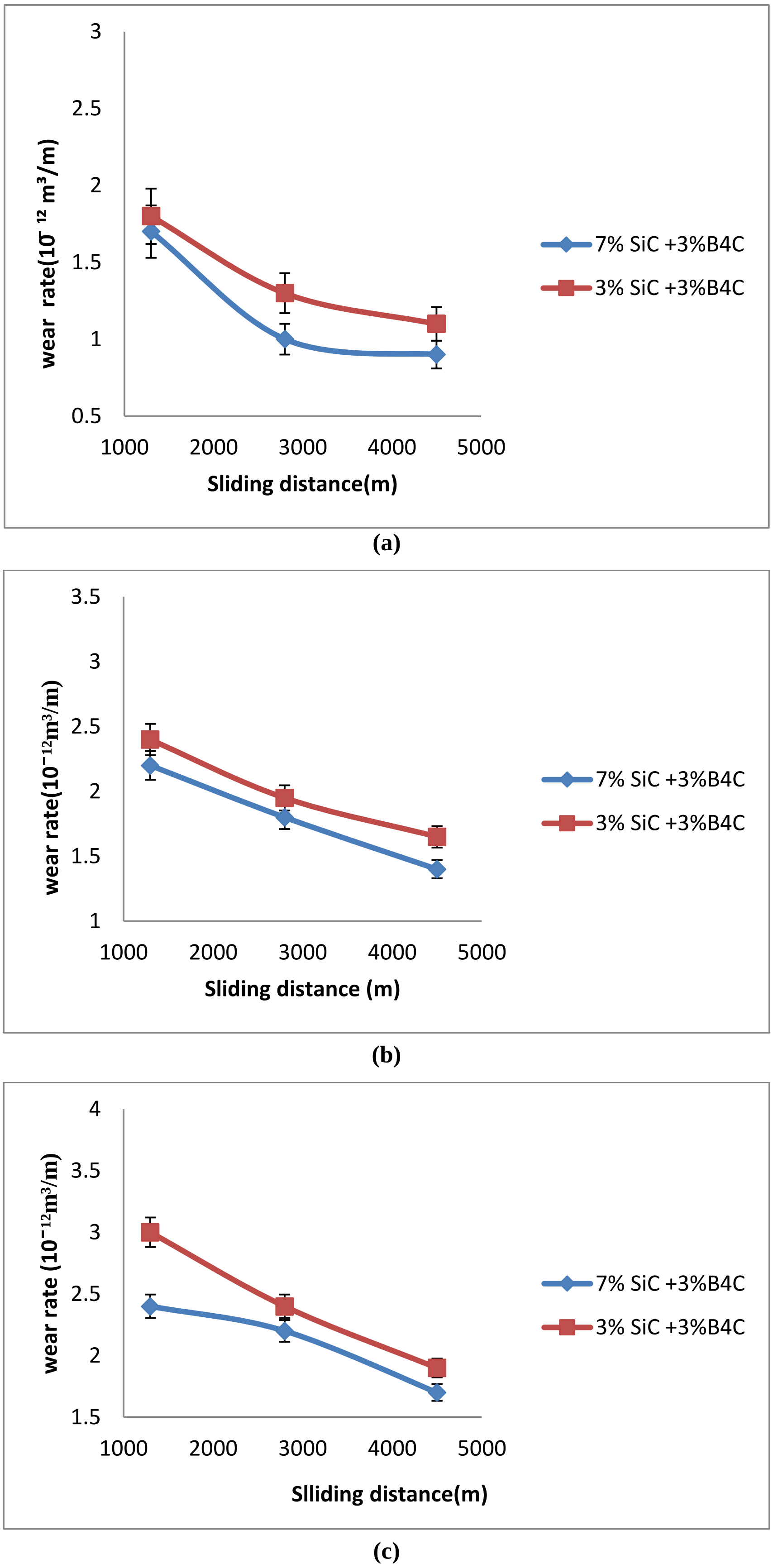

Fig 3: Variation of wear rate with sliding distance at a sliding velocity of 4 m/s for Al7075 HAMMCs under applied loads of (a) 15N, (b) 20N and (c) 25N

Test specimen's wear rate has been obtained from the ratio between volume loss and sliding distance. The variation of wear rate against sliding distance has been calculated for three different applied loads viz., 15, 20 and 25 N for all the samples and shows a reasonable decrease of the wear rate and wear factor as indicated in Figures 3(a-c)

In common at any load, the wear rate of unreinforced material decreases as the sliding distance increases and the wear rate of all composites increases with sliding distance. Nevertheless, beyond the value around 2500m, the wear rate begins to decreases in the case of the test specimens. This is for the reason that, when the sliding distance is lower, because of asperities the contact between the pin and disc remains less, leading to less wear. As the sliding distance increases the same increases which lead to more wear. Alternatively, the smoothness of the contact surface becomes improved after around 3100m and wear rate attains a decreasing mode. Normally when the sliding distance and the load increases, interface temperature will be increased. This results in frictional heating which causes the formation of the thin molten layer at the contacts. This lead to the fall in friction coefficient and reduction in shear strength. Hence in these tests, low speed has been applied to minimize the frictional heating between the contact surfaces. The hard particles assist the retention of oxide transfer layer on sliding surfaces, which prevent metal-metal contact and thus decreases wear resistance at low sliding velocity range.

4. CONCLUSION

The following interpretation has been made during the wear analysis of HAMMCs. The wear rate for the unreinforced alloy has been found to be larger than that of the reinforced HAMMCs at a constant applied load. The HAMMCs reinforced with a higher concentration of SiC and B_4C, i.e. 7%SiC 3% possesses lower wear rate. At the maximum load of 25N, wear rate has been high as compared to other load conditions. The wear rate has been low at low applied loads. Hence it leads to a conclusion that the reinforced HAMMCs at a higher percentage of reinforcements have been found to be better than the unreinforced alloys at all loads and sliding distances.

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