Analysis of sliding distance over friction coefficient and Characterization of hybrid Aluminium metal matrix composites.

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Abstract:

In this paper the characterization of hybrid metal matrix composites and the effect of sliding distance of friction coefficient is studied.Silcon carbide and Boron carbide are used as reinforcement in the fabrication of hybrid aluminium metal matrix composites.Stir casting process is used to fabricate the specimen. Pin on disc equipment was employed to analyse the wear resistance.

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

1. Introduction

A P Sannino [1] reported that the increasing particle size of Silicon carbide in microns increases the coefficient of friction.. Alpas and Zhang [2]explained that the wear of particle reinforced Metal Matrix Composites under various loads identified three different wear regimes. At low load the particles support the applied load in which the wear resistance of metal matrix composites are in the order of better than Al-alloy. S.M.Seyed Reihani [3] stated the effect of SiC particles on the aging behavior, mechanical properties and wear resistance of Al alloy was high. D.P.Mondal [4] stated that the load affects the wear rate of alloy and composites and is the most important factor of the wear behavior. Kowk and Lim [5] told that the wear occurs if the particles are smaller than the threshold value at higher speeds. A. Daoud et.al [6] explained that inclusion of magnesium alloy to composite during production ensures high bonding between the matrix and the reinforcement. A.Wang and H.J.Rack [7] reported that the steady state wear rate of Al matrix composite is generally independent of reinforcement geometry .

2. Experimental Set up:

The slider disc with hardness 62HRC and diameter 170mm with 1.5% carbon EN31 hardened steel disc was used. A track diameter of 100 mm has been used for the trials.The steel disc surface finish is of 2µm. The Hybrid Aluminium Metal Matrix Composites test samples have been prepared as pins of dimensions 10 mm in diameter and 30 mm in height . TWO specimens were made The test samples are made flat and are polished using metallographic techniques.Normal polishing techniques are used to prepare the specimen and the specimen is made ready for the wear analysis.Specimens are polished using various types of emery sheets using alumina in a disc polishing machine.then the specimens are cleaned using acetone and methonal solutions.

By applying normal loads such as 15, 20 and 25N at a maximum sliding distance of 3000m at different velocities such as 1,2 and 3 m/s ,the tests has been carried out. The wear loss of the test specimen before and after has been calculated by weighing the test specimen.The before and after specimen weight shows the actual weight loss. The difference in weight loss of the entire test samples have been measured before and after the wear test under dry condition.. The micro structural investigation and semi quantitative chemical analysis on the worn surfaces have been performed with the aid of SEM.

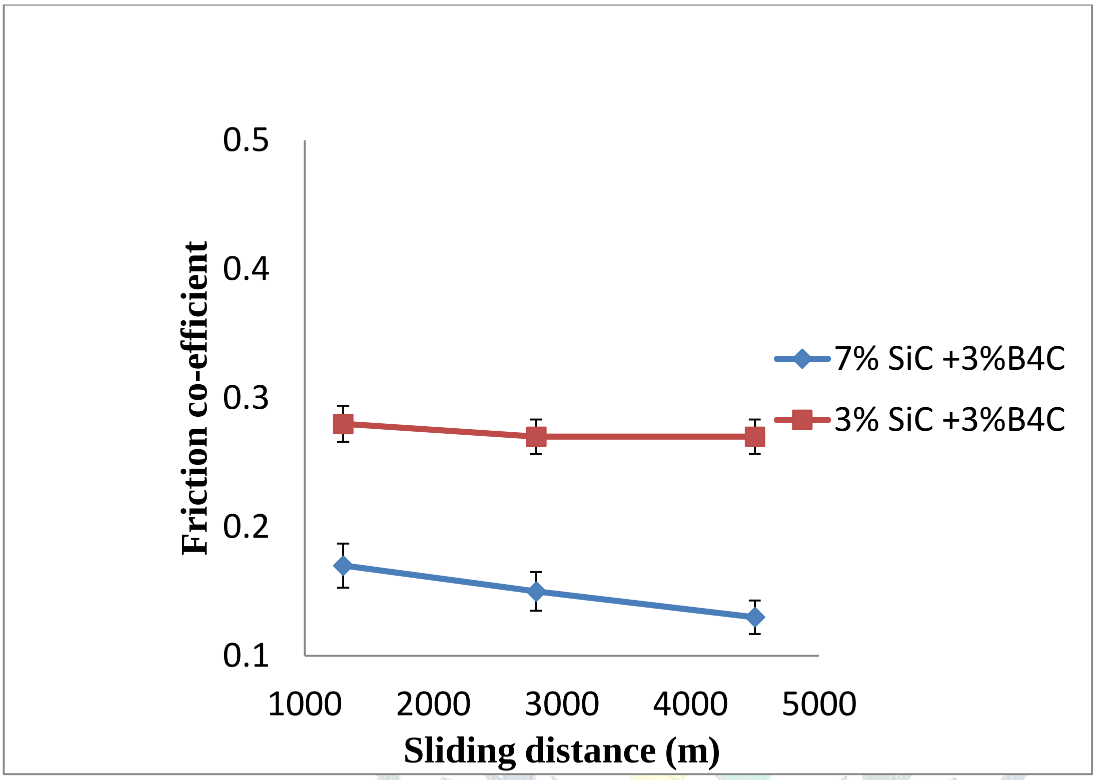
Table 1 Parameters considered during sliding wear test

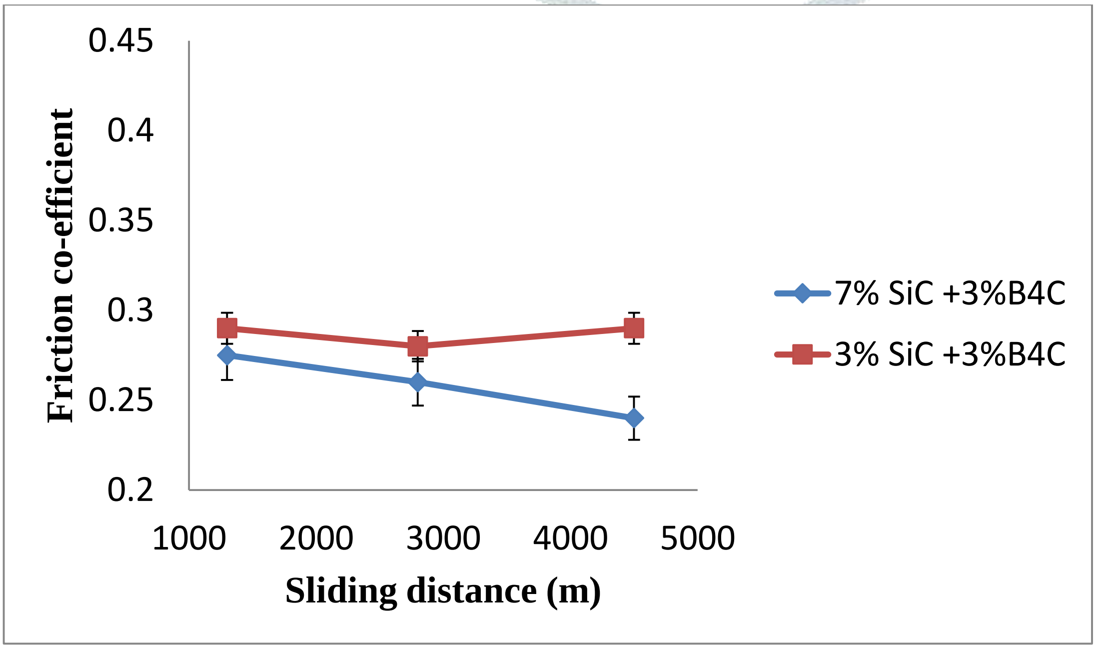
Applied load (L)	15, 20 and 25 N
Sliding velocity (S)	1, 2 and 3 m/s
Sliding time (t)	15, 20 and 25 min
Volume fraction (R)	3, 5 and 7%

3. Results and Discussion:

Effect of Sliding Distance on Friction Co-efficient

Figures 1(a-c) shows the Friction co-efficient of the test specimens obtained from the frictional force of the specimens during sliding against sliding distance for three different loads viz., 15, 20 and 25N. In all the Figures, friction co-efficient of the hybrid composite shows initially high value due to more frictional force and as the sliding distance increases the friction co-efficient decreases because of less frictional force between the disc and the test specimen pin. At higher load of 25 N conditions, the friction co-efficient of the hybrid composite has been reduced compared to that of the unreinforced alloy. It has been established that during the initial stages, the surfaces of both the composite specimens and the unreinforced alloy counterpart have been rough and thus strong locking took place, resulting in high friction coefficient.





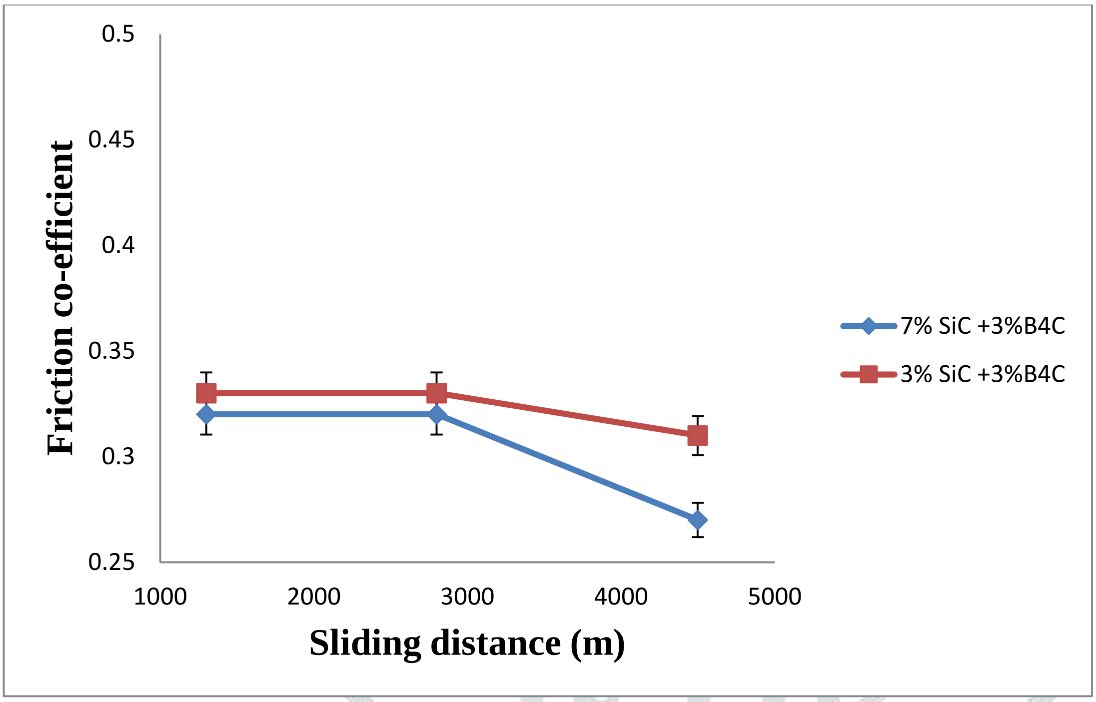


Figure 1 Variation of friction co-efficient with sliding distance at a sliding velocity of 5m/s for Al 7075 HAMMCs under the applied load of (a) 15N, (b) 20N and (c) 25N

When the wear process continued, the rough surface of Al alloy and their composite specimens have been smoothened due to abrasion and a film has been formed on the surface of the composite specimen as well as on its counter part. Therefore, lower friction co-efficients have been achieved when a steady wear stage has reached. A decrease in the friction co-efficient with increased sliding distance can also be attributed to the fact that the brittle particulate reinforcements in the composites crack and have squeezed out onto the mating surfaces forming a thin adherent solid lubricating film.

Effect of Applied Load on Friction Co-efficient

Figures 2 point to that increase in friction co-efficient with increase in load has been attributed for the maximum speeds at different volume fraction of the reinforcement. It has been experiential that, the value of friction co-efficient has been low at initial loads for the matrix alloy and its composites. However, the 7%SiC3%B_4Cwt.% of volume fraction composite possesses the lowest friction co-efficient at any particular load. Thus, friction co-efficient increases with increase in applied load.

From this test, it has been confirmed that the friction co-efficient of the composite with 7%SiC 3%B_4Cwt.% has been low for all loads. On the other hand, considering the different load conditions the wear rate is as intense as the friction co-efficient.

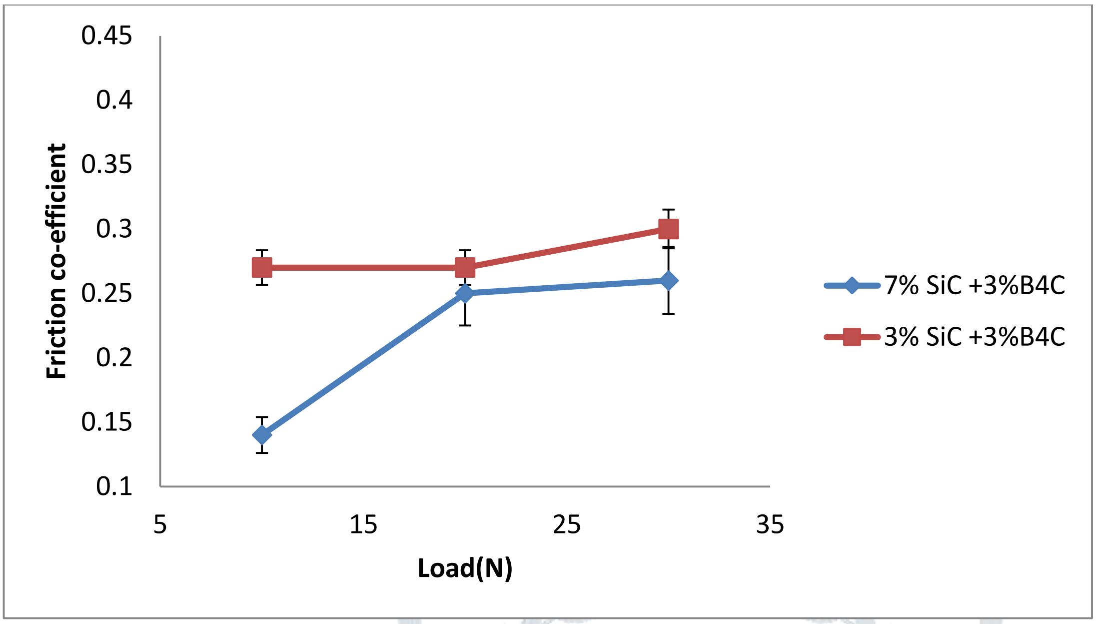


Figure 2 Variation of friction co-efficient with applied load at a sliding velocity of 5m/s of Al 7075 based HAMMCs

Characterization :

Grooves, scratch, micro cutting formed by the reinforcement materials have been observed in the composite materials after wear. This clearly indicates that the wear of the composite has been due to abrasion. Delamination has also been observed on the wear surface of the composite which induces sub surface cracks that gradually grow and eventually shear to the surface forming long thin wear sheets. Figures 3(a-e) show the SEM worn surface micrographs of unreinforced and reinforced Al alloy samples. The pure A1 7075 have a smooth surface nature with more tribolayers formed. Hence, the wear rate has been more in the unreinforced sample. The examination shows that the worn surface of the composite has generally been much rougher than that of the unreinforced alloy.

The Al 7075 based HAMMCs reinforced with 7%SiC+3%B_4C particulate shows more cavities and large grooved regions on the worn surface after wear as shown in Figures 3d. The other weight percentage of reinforcement particles interaction effects have been marginal.

Grooves have been mainly formed by the reinforcing particles in the matrix. As the sliding velocity increases, the number of grooves also increases and the reinforcements have been projecting out from the pin surface due to ploughing action between the counterface pin and the formation of wear debris has also been observed. The hard particles have been found inside the cavities in which some particles have been found broken, where as few other particles have been pulled out from the surface. These indicates an abrasive wear mechanism which has essentially been a result of hard particles and resist the delamination process, so that the wear resistance has been more in the case of HAMMCs.

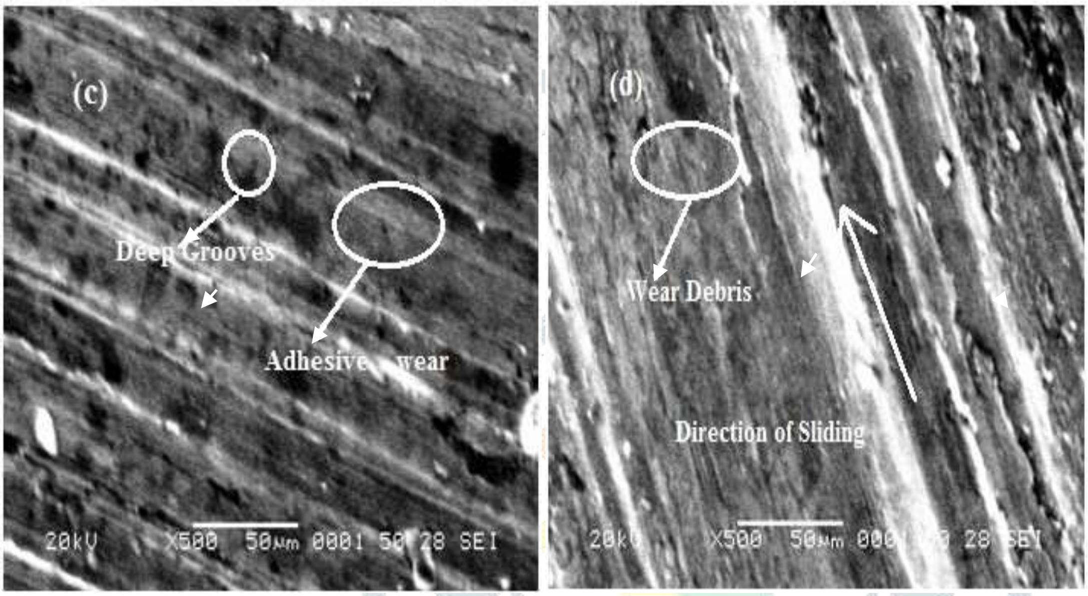


Figure 3 SEM Photographs of the worn surfaces c) 3%SiC 3%B_4C and d) 7%SiC 3% B_4C

Conclusion:

The hybrid aluminium metal matrix composites reinforced with larger reinforcement of SiC and B_4C shows lower wear rate. An additional momentous observation is that at lower applied load and at higher weight fraction of reinforcement and sliding distance the wear rate has been low for Al 7075 based HAMMCs. It has also been apparent that as the sliding distance and weight fraction of reinforcement increases, the friction co-efficient decreases due to less frictional force, whereas it has been the reverse for applied load.

References

[1] Sannino,A.P., Rack,H.J., 1996, “Tribological investigation of 2009 Al-20vol% SiC/17-4PH

Part I: Composite performance", *Wear* 197, pp.151-159.

[2] Alpas,A.T., and Zhang,J., 1994, "Effect Of Microstructure (Particulate Size And Volume Fraction) And Counterface Material On The Sliding Wear Resistance Of Particulate-Reinforced Aluminium Matrix Composites", *Metall. Mater. Trans. A* 25, pp. 969-974.

[3] Seyed Reihani,S.M., 2006, "Processing of Squeeze Cast Al6061-30vol% SiC Composites And Their Characterization",*Materials And Design* 27, pp.216-222.

[4] Mondal,D.P., Das,S., Jha,A.K., Yegneswaran,A.H., 1998, "Abrasive Wear of Al Alloy-Al2O3 Particle Composite: A Study on the Combined Effect of Load and Size of Abrasive", *Wear* 223,pp.131-138.

[5] Kwok,J.K.M., and Lim,S.C., 1999, "High-Speed Tribological Properties Of Some Al/Sic Composites I. Frictional And Wear-Rate Characteristics", *Composite Science and Technology* 59, pp.55-63.

[6] Daoud,A., Abou-Elkhair,M.T., and Rohatgi,P., 2004, "Wear and friction behaviour of near eutectic Al-Si+ZrO2 or WC particle composites", *Compos. Sci. Technol.* 64, pp. 7-8.

[7] Wang,A., and Rack,H.J., 1991, "Abrasive wear of silicon carbide particulate and whisker reinforced 7091 aluminium matrix composites", *Wear* 146, pp. 337-348.