

TRIBOLOGICAL BEHAVIOR OF METAL MATRIX COMPOSITE MATERIAL

Santhosh.T.U¹ and Siddesh Kumar N.G.²

¹Department. of Mechanical I Engineering, and Shridevi Institute of Engineering and technology, Tumkur. Karnataka. India.

², Research scholar, Department of Mechanical Engineering, Siddaganga Institute of Technology Tumkur. Karnataka. India.

ABSTRACT

For structural application of moving components, the tribological properties are considered to be one of the major factors controlling the performance. In the present study, Al-Cu-Mg alloy was used as a matrix material. Particulate Titanium dioxide was used as a reinforcing material. This investigation is carried out to understand tribological properties of as cast Al alloy and TiO₂ reinforced Al alloy metal matrix composite. Dry sliding wear test was conducted to understand the tribological behaviors of the test samples. A pin-on-disc type test rig was used to evaluate the wear behavior of the composite. Addition of hard Titanium dioxide to Aluminum alloy results in enhancement in the hardness of the composites. Increased hardness leads to lowering of wear loss and seizing.

Key words: Titanium Dioxide; Dry sliding wear; Deformation; Protruding.

1. INTRODUCTION

Metal matrix composites (MMCs) are engineering materials that refer to a metal based materials reinforced with particulates, whisker or fiber which can produce considerable alteration in the physical and mechanical properties of the base alloy. According to Pradeep Rhotagi, metal matrix composites have proved to be an important class of materials with the potential to replace a number of conventional materials being used in automotive, aerospace, defense and leisure industries where the demand for lightweight and higher strength components is increasing. M.K. Surappa (2003) reported that, Aluminum matrix composites (AMCs) are the promising materials in high technology fields owing to their excellent

specific mechanical properties. The key benefits of Aluminum matrix composites in transportation sector are lower fuel consumption, less noise and lower airborne emissions.

Ceramic whisker, fibers and particulate reinforced AMCs have been used as a tribo material, for e.g., piston and cylinder liners in automotive engines are typical applications. MMCs generally possess superior wear resistance compared with unreinforced Aluminum alloy. A lot of research on the dry sliding wear behavior of MMCs have been reported by W. Ames and A.T. Alapas (1995) and P.H. Shipway, A.R. Kennedy, A.J. Wilkas (1998) and also reviewed by T.A.P. Sannino, H.J. Rack (1995), C.S. Ramesh, S.K. Seshadri and K.J.L. Iyer (1991) and G.Ranganath, S.C. Sharma and M. Krishna (2001).

Tribological behavior of materials depends on many factors such as properties of material combinations, experimental condition and type of wear tester. In order to understand tribological behavior of composites researcher has carried out many investigations. Important research has been listed. T. Miyajima et al. [3] carried out dry sliding wear tests using pin-on-disc wear tester where the pins were of 0.45% carbon steel and disc were made of Aluminum alloy composites reinforced with SiC-whisker, Al₂O₃-fibers and SiC particles. The result analysis shows that, the wear rate of MMCs decreased with increasing volume fraction of reinforcing material. Basavarajappa et al., (2006) investigated the dry sliding wear behavior of Aluminum alloy reinforced with SiC particles and reported that the wear rate of the MMCs reduces with increasing reinforcement content. Shipway et al. [1998] produced TiC reinforced AMCs using novel casting technique. The sliding wear behavior of the extruded composites has been studied as a function of load and volume fraction. The result reveals that, particle addition of TiC has reduced the wear rates of the composites. Ranganath et al. [2001] studied the dry sliding wear of garnet reinforced Zinc-AMCs and reported that wear resistance of the MMCs increases as the content of the Garnet increases. S.K. Acharya et al. [2006] investigated the wear behavior of Al / red mud composites and

reported that coefficient of friction decreases as the load increases. Presence of red mud particles improve the hardness and wear resistance of the composites.

2. EXPERIMENTAL PROCEDURE

2.1 Material

Aluminum 2618 alloy, which contains Copper and Magnesium as major constituent, was used as matrix material and its composition is shown in the Table 1. Titanium dioxide of laboratory grade was used as a reinforcing material. TiO₂ reinforced Al2618 alloy composite were produced using stir casting technique, which was used by researcher K.V. Mahindra. K. Radhakrishna. [2007]. Both the base alloy and the composite specimen were subjected to T-6 heat treatment standards.

Table: 1 Composition of Al 2618 alloy.

Cu	Mg	Ni	Fe	Si	Ti	Mn	Al
2.1	1.4	1.1	0.9	0.1	0.0	0.02	Bal
8	3		3	6	4	8	

2.2 Experimental set –up

In order to characterize the dry-sliding wear behavior of the test specimens, wear tests were performed using a Pin-on-disc machine, which is shown in figure 1. Circular pins of diameter 8 mm and height 30 mm was used as a test specimen. The test specimen was gripped in the wear testing machine to avoid rolling during the test. The wear parameters chosen for the experiment were: Sliding speed in m/s, Load in N and Sliding distance in m. The wear test was conducted by keeping speed constant at 350 rpm for the total time duration of 30 minutes. The wear rate and the coefficient of friction of the test samples was studied as a function of the sliding velocity, applied load and sliding distance. Wear test were conducted as per procedure reported in the paper R.K. Uyyuru et. Al., (2006). Each experiment was repeated twice and mean response values were considered for the result analysis.



Figure 1. Dry sliding wear test rig.

3. RESULT DISCUSSION

3.1 Wear mechanism

The mechanism of material removal during the wear process of the unreinforced alloy is by plastic deformation and gouging. The improvement in wear resistance of the composite material is attributed to the changes in the wear mechanism induced by the presence of the reinforcing particles. In composite material the wear mechanism is by plastic deformation, gouging and fracture of reinforcing material (TiO_2) leading to the formation of a thin layer at the interface, there by providing protection to the matrix material. The layer formed at the surface of the specimen may have high hardness reported by S. Chung (1994), but at the expense of low fracture toughness. The sub surface deformed layer beneath the worn surface of MMC pins is composed of a number of distinct layer like mechanically mixed surface (Mms). The Mms layer withstands high stresses without plastic deformation or fracture and is very effective in reducing the wear rate in the case of composite. This phenomenon will drastically reduce the wear loss of the composites.

3.2 Effect of applied load on wear rate

Figure 2 shows the effect of applied load on wear rate of Aluminum alloy and its composite material, at sliding speed of 1.099 m/s and for sliding distance 2000 m. Figure 2, which indicate that the wear rate of the matrix alloy as well as the composite specimen increases with increase in applied load. The wear rate of the composite material decreases with increasing percentage of reinforcement from 0 % to 6 % by weight ratio.

When load applied is low, the wear loss is quite small, which increases with increase in applied load. It can be considered that, it is quite natural for the weight loss to increase with load. Further, the cause of the lower wear rate of the composite materials is a phenomenon of “Protruding” of the reinforcing particles over the friction surface. This graph also depicts the role of reinforcing material – TiO₂ particles in reducing the wear rate of Aluminum alloy composite. Figure 3 depicts the effect of Sliding distance on wear rate Aluminum alloy & composite material. The wear rate of the composite material increase with increase in the sliding distance. The least wear rate was observed for highest reinforcement content of composite.

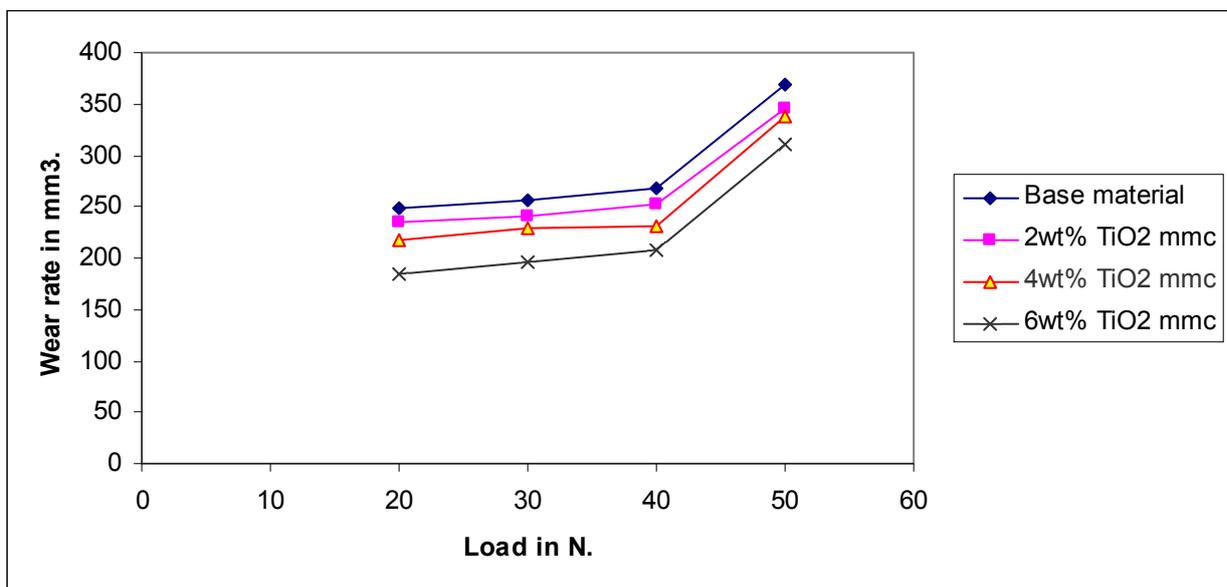


Figure 2. Effect of applied load on wear rate of Aluminum alloy & composite material.

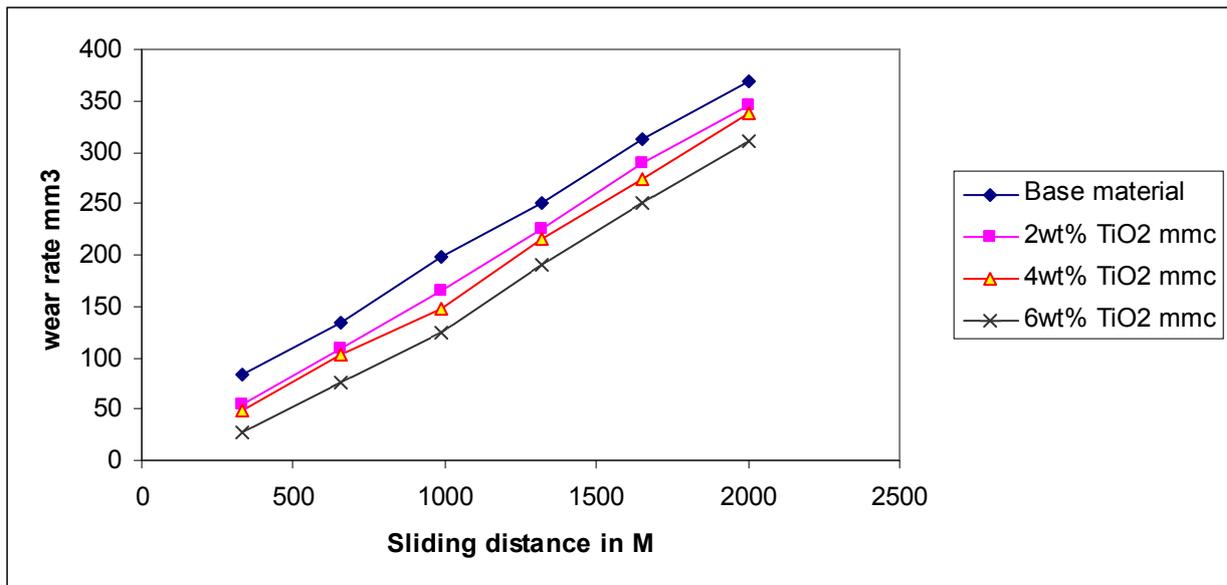


Figure 3. Effect of Sliding distance on wear rate Aluminum alloy & composite material.

3.3 Effect of applied load on coefficient of friction

Figure 4 shows the variation of coefficient of friction with applied load for both matrix alloy and its composites at applied loads of 20 to 50 N with sliding speed of 1.099m/s for a sliding distance of 2000 m. It is observed that increased sliding distance results in higher coefficient of friction for the both matrix and the composite material. Increased content of TiO₂ in the composite material results in decreased coefficient of friction. The mechanically mixed layer, which is formed below the contact surface, is attributed to reduction in coefficient of friction.

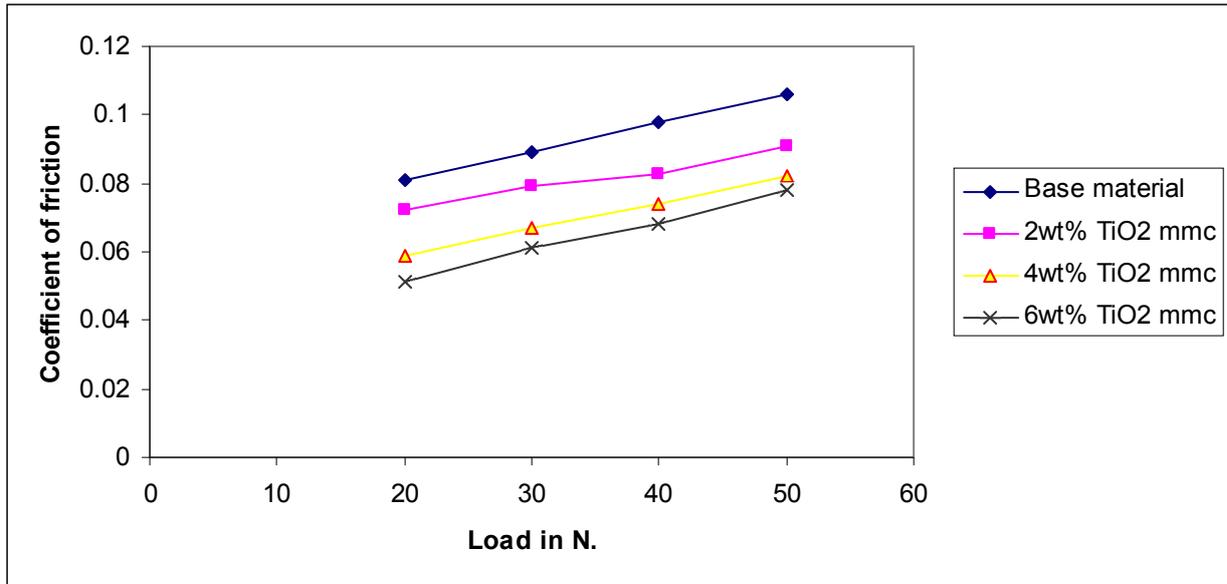


Figure 4. Effect of load on Coefficient of friction on Aluminum alloy & composite material

4. CONCLUSIONS

Particulate reinforced Al –Cu- Mg alloy / TiO₂ metal matrix composite was successfully fabricated by the stir casting technique. Dry sliding wear behavior study was conducted to understand the Tribological properties of Aluminum alloy and it's composite. The final conclusions obtained were listed below.

1. The dry sliding wear rate of composites and the matrix material alloy increased with the load applied.
2. The coefficient of friction of composite material decreases with increase in percentage of reinforcement from 0 to 6 % by weight.
3. Titanium dioxide particle reinforced composite exhibited reduced wear rate than the unreinforced alloy specimens.

5. REFERENCE.

- Acharya S.K, N. Prasad and Uma – Shankar. IE (I) Journal –MM. Vol.87. Oct. 2006.
- Ames W. and A.T. Alapas. Metallurgical and materials transaction. A. Vol. 26 A. Jan 95. PP. 85 – 98.
- Basavarajappa S, G. Chandramohan. R. Subramanian. chandrasekar.. Materials science Poland. Vol. 24. No. 2 /1. 2006.
- Chung S, B.H. Hwang. Tribological international. 27 (1994) 307 -314.
- Mahindra K.V, K. Radhakrishna. Material Science – Poland. Vol/ 25. No. 1. 2007. PP. 57– 67.
- Miyajima T. and Y. Iwai. Wear. 255 (2003) 606 – 616.
- Pradeep Rhotagi. University of Wisconsin, Milwaukee, Wisconsin. Silver anniversary paper, Div.2. 2001, 01 -25.
- Ramesh C.S, S.K. Seshadri and K.J.L. Iyer. Indian Journal of Technology. Vol. 29. Apr.1991. PP. 179 -185.
- Ranganath G, S.C. Sharma and M. Krishna.. Wear. 251 (2001) 1408 – 1413.
- Sannino A. P, H.J. Rack. Wear 189 (1995) 1-19.
- Shipway P.H, A.R. Kennedy. A.J. Wilkas. Wear. 216 (1998) 160 – 171.
- Surappa. M.K, Sadhana. Vol.28. Part 1 & 2. Feb/Apr. 2003. PP 319-334.
- Uyyuru R.K, M.K. Surappa. S. Brusethaug. Wear. 260 (2006) 1248 – 1255.