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Investigations on the Tribological Properties of AA6063-TiC Metal Matrix Composites with and without heat treatment

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Abstract: This study has been undertaken to investigate the wear behaviour of AA60633-TiC Metal matrix composite, in this investigation aluminium alloy MMC is prepared by varying percentage of 2%, 4%, 6% TiC(ceramic material) in the powder form is stir casted through liquid metal aluminium alloy 6063 by liquid metallurgical process. The wear behaviour the sample specimens are analyzed under heat treatment and without heat treatment process, the results shows that improved results in heat treated material samples compared to without heat treatment samples.

***Index Terms* – AA6063 (Aluminium Alloy6063), TiC (Titanium Carbide), Heat treatment, Wear Analysis.**

I. INTRODUCTION

Aluminium MMCs, Recent years have seen a growth in the use of aluminium metal matrix composites because of their increased demand in high-performance areas of science and engineering like aerospace, structural, automotive, and sports. An effective combination of reinforcing materials and fabrication techniques significantly impacts the performance of these materials. With a high strength-to-weight ratio and favourable mechanical and tribological qualities, aluminium is a desirable metal. The need for new wear-resistant materials for high performance tribological applications has been one of the major incentives for the technological development of ceramic particulate reinforced aluminium alloys during the last decade. [1-5]

AA6063 – Matrix material: AA6063 is a type of aluminium alloy that also contains magnesium and silicon. The most popular aluminium alloy for extrusion is AA6063. It's commonly used for structural applications in aerospace and automobile sectors because it allows complicated shapes to be created with very smooth surfaces suitable for anodizing. [6-8]

TiC – Reinforcement: Titanium carbide (TiC) is a refractory ceramic with a high hardness, Crystals of this substance found in nature are typically between 0.1 and 0.3 millimetres in size. Cermets, which are typically prepared using titanium carbide, are used to mill steel materials at high cutting speeds. [9-10]

Fig 1: Aluminium alloy sample and TiC power

Fig.1, Represent the Aluminium alloy 6063 made in foundry with chemical composition of Si- 0.2%, Mg-0.8% small traces of Fe, Cu, Zn, Cr total about 0.2%, remaining core material Aluminium. The fig 1 also contains sample of Titanium Carbide of mesh size 100-300 ASTM standards. The properties of Tic are mentioned below table.

Table 1: Properties of TiC

Density	Melting Point	Hardness Vickers(VH)	Elastic Modulus	Shear Modulus
4.93 g/cm^3	3160°C	2850 VH	440 GPa	188 GPa

II. FABRICATION TECHNIQUE:

Liquid metallurgy process, Stir casting, powder metallurgy, squeeze casting, and die casting are a few fabrication methods that can be used to manufacture a metal matrix composite. The easiest and most cost-effective way to make a metal matrix composite is through the process of stir casting. The work employs a stir casting technique to produce AA 6063-TiC MMCs. The percentage of TiC varied by 2%, 4%, 6%, and 8% in MMCs. The below ***figure 2*** shows the liquid metallurgical process using muffle furnace and dies for casting the cylindrical rod, test specimen are made by using cylindrical rod as per the ASTM standards.

(a)

Fig 2.a Muffle furnace used for heating aluminium alloy

(b)

(c)

Fig 2b & 2c: Dies for making cylindrical rod

2.1 Optimization of stirring parameters

Due to the high density of reinforcements, achieving particle uniformity via the liquid metallurgical approach is extremely difficult. The optimisation of stirring parameters and the subsequent discussion of their impact on the characteristics of AA 6063 TiC MMCs are studied in detail. Below ***table 2*** shows the optimized values of the aluminium alloy in the experiments.

Table 2: The optimized values of the stir casting

Stirring parameters	**Range of values**	**Optimized value**
Stirring Temperature	750ºC - 850ºC	800ºC
Stirring Time	2 - 5 minutes	3 minutes
Stirring Speed	150 – 500 rpm	350 rpm

2.2 Density measurements

Density of AA 6063 is 2.69g/cc and density of TiC is 4.93 g/cc. The Archimedes method was used to calculate density of MMCs, while the theoretical density of AA 6063 TiC MMCs was determined using the rule of mixtures. The result shows that the density of the composite increased by increasing the percentage of reinforcement. Adding more dense reinforcement makes the composite denser, with better mechanical and tribological properties.

2.1 Wear Studies

The wear behaviour of AA 6063 - TiC MMCs is analysed in conformity with the ASTM G99 standards. The cast composites wear rate was analyzed using the TR20-LE Ducom wear testing model. Sliding distances between 500 and 1000 m were used, and the load was varied from 5 N to 25 N against a 60 HRC hardened EN 32 steel disc. The wear track analysis and wear mechanism type were both identified using SEM analysis. Figure 3 shows the wear specimen prepared as per the ASTM G99 standards.

0% 2% 4% 6%

Fig 3: Wear specimen of AA 6063 MMC with TiC , 0%, 2%, 5%, 6%.

III. RESULTS & DISCUSSION

3.1 Optical studies

Improved distribution of matrix and reinforcement at optimized fabrication parameters, figure 4, 5, 6 shows the visibilities of the reinforcement of TiC particles in AA 6063 matrix.

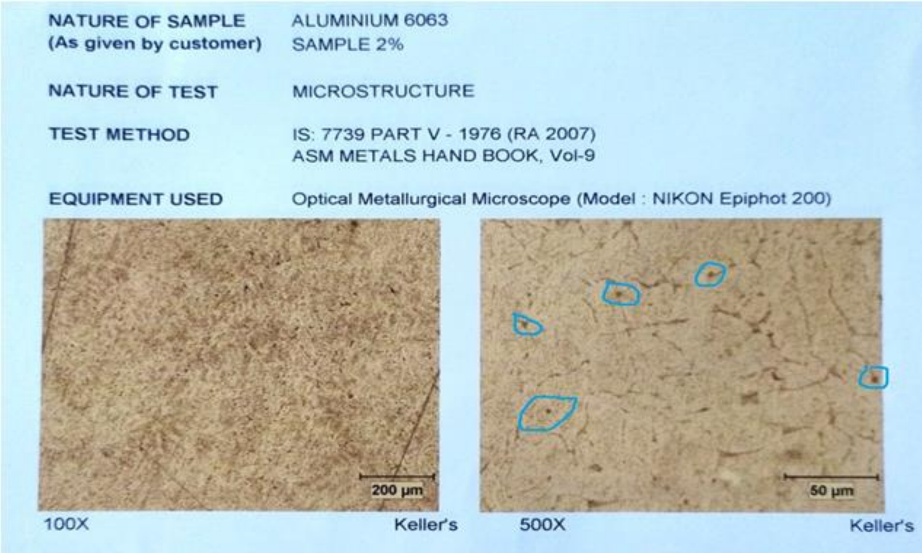


Fig 4: Optical microscope image of 2% TiC with AA6063

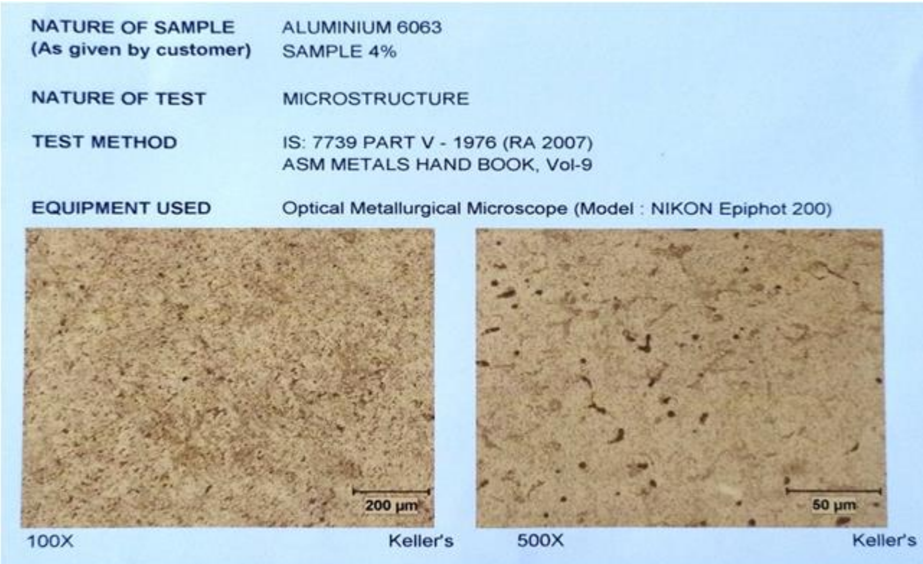


Fig 5: Optical microscope image of 4% TiC with AA6063

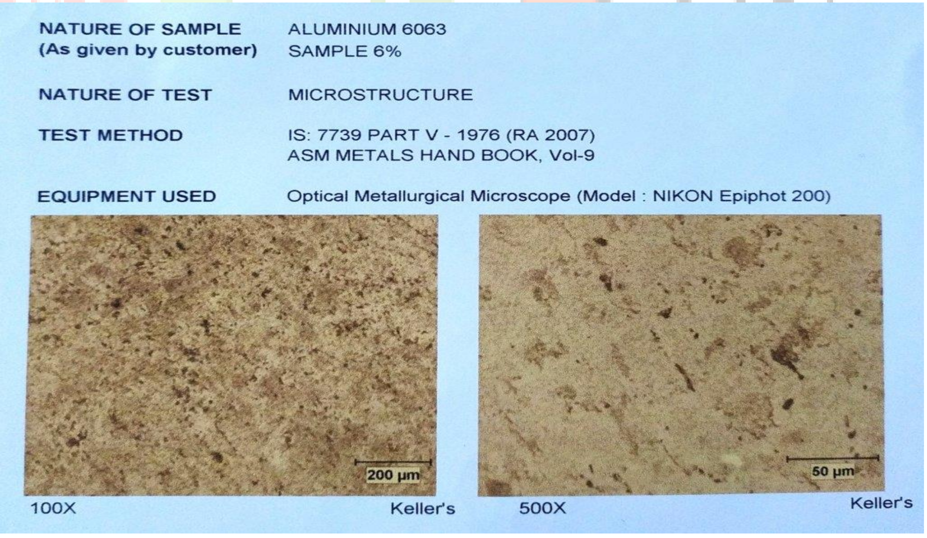


Fig 6: Optical microscope image of 6% TiC with AA6063

3.2 Tribological Studies

Formulae used for calculations

Mass loss, (g) = **Initial Weight – Final weight**

Sliding distance, (m) = $\frac{\pi DN\, t}{60}$

Volume loss, (cm^3) = $\frac{\text{Mass loss (g)}}{\text{Density (g/cm3)}}$

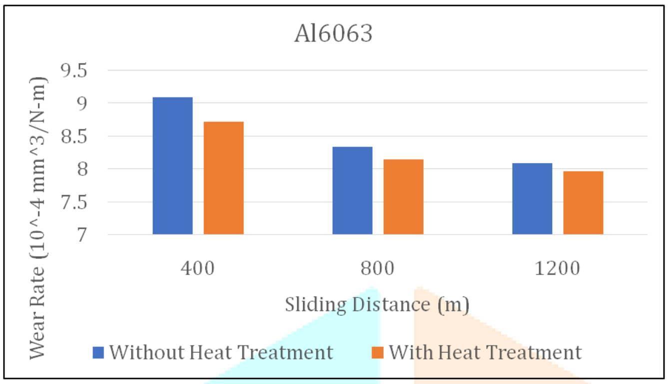
$$\text{Wear rate, (mm/N-m)} = \frac{\textbf{Volume loss}}{\textbf{Force X Sliding distance}}$$

The process parameters for the several experiments are carried out on dry sliding wear test under the 2 load conditions 0.5kg and 0.75kg at varying the sliding distance from 400m to 1200m. The studies of wear behavior of specimen of varying reinforcement from 2 to 6 % are carried with heat treatment and without treatment.

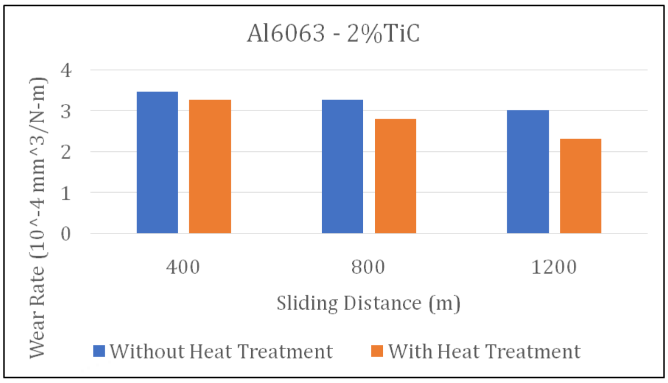
The load on wear test plays an important role in wear. Several experiments are carried out to observe the effect of normal load on wear rate of aluminium. The results of the wear of different specimen are shown in the graphs below

3.21 Sliding distance on wear rate graphs

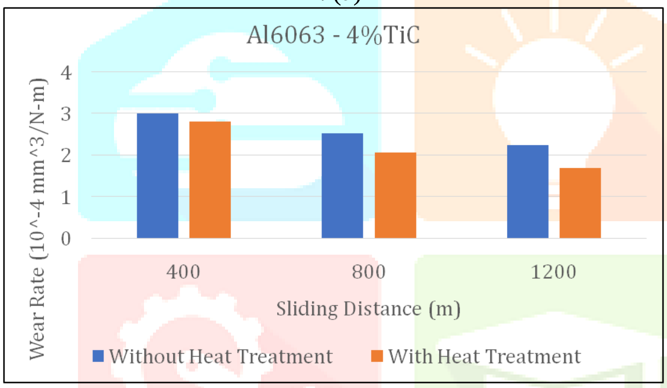
The figure 7 shows the effect of sliding distance on ***wear rate at 0.5 kg*** load for different reinforcement percentage, where the decrease of wear with increasing the percentage of reinforcement TiC.



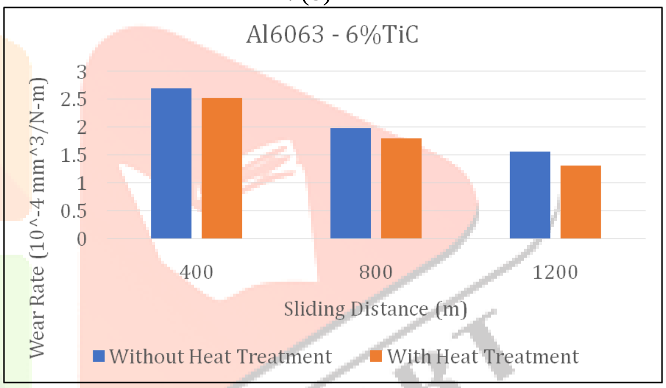
7. (a)



7. (b)



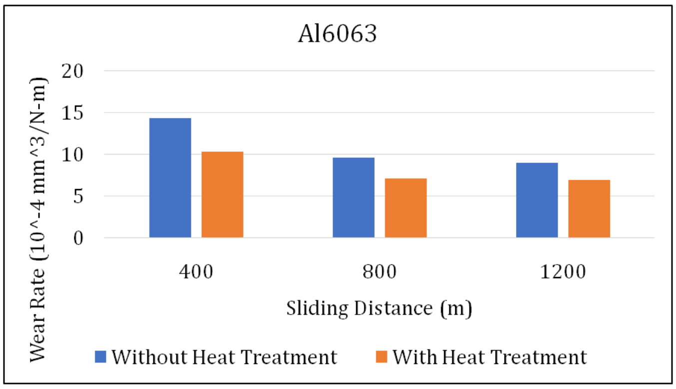
7. (c)



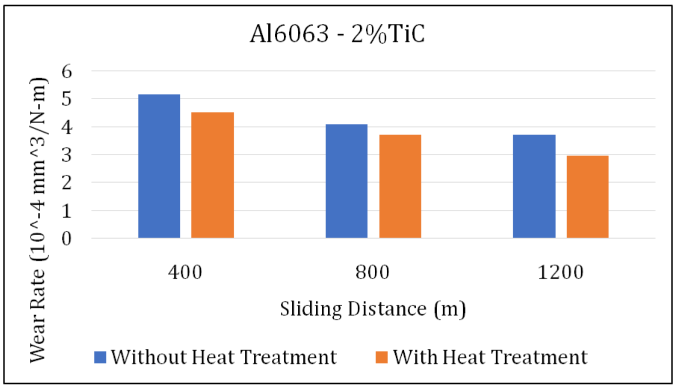
7. (d)

Fig 7: (a), (b), (c), (d) The graph of sliding distance on ***wear rate at 0.5 kg*** load for 0%, 2%, 4%, 6%.

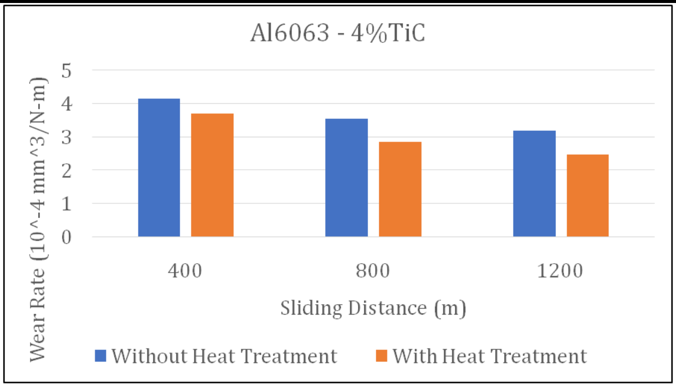
The figure 8 shows the effect of sliding distance on ***wear rate at 0.75 kg*** load for different reinforcement percentage, where the decrease of wear with increasing the percentage of reinforcement TiC.



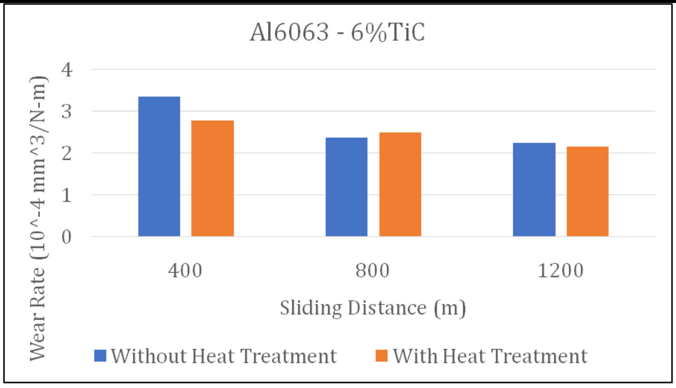
8. (a)



8. (b)



8. (c)



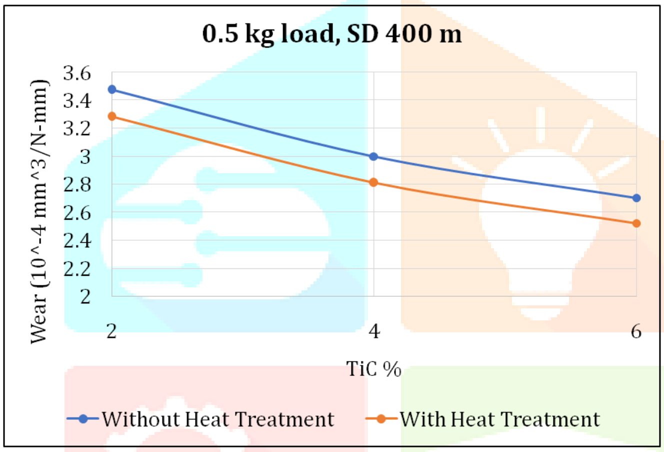
8. (d)

Fig 8: (a), (b), (c), (d) The graph of sliding distance on ***wear rate at 0.75 kg*** load for 0%, 2%, 4%, 6%.

With the increase in sliding distance, wear rate is reduced. This is attributed to the fact that at higher speeds, the temperature at the contact increases resulting in a formation of oxide layer (Al_2O_3). This layer acts as a protective cover which reduces the wear rate.

3.22 Heat treatment on wear rate graphs

The below graphs shows the effect of Heat Treatment on wear rate at sliding distance of 400 m, The heat treatment resulted in increase of wear resistance of Al6063-TiC MMC with increase in strength.



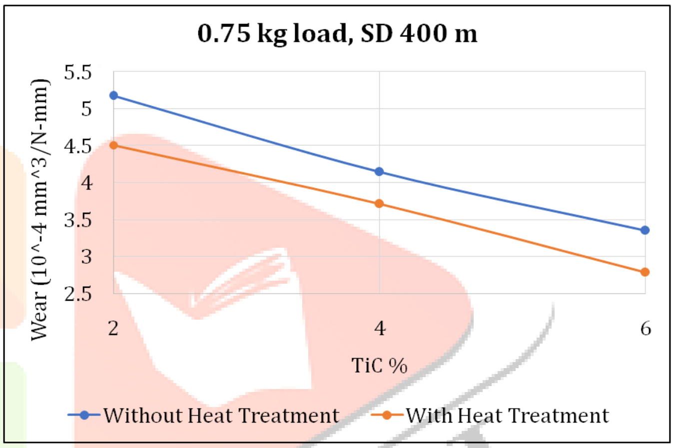
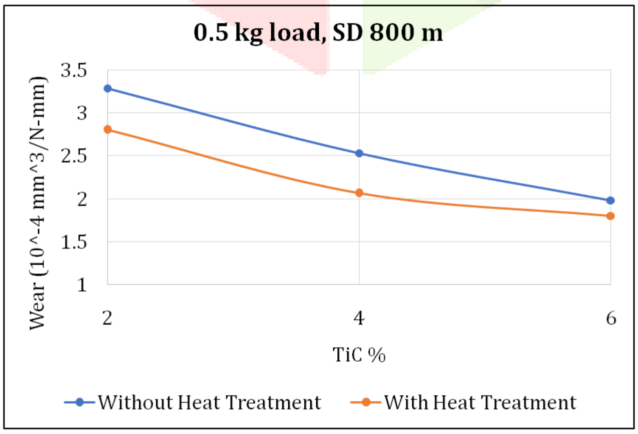


Fig 9: comparison of wear rate with heat treatment and without heat treatment at 400m

The below graphs shows the effect of Heat Treatment on wear rate at sliding distance of 800 m. the wear rate of heat-treated samples are less compared to samples without heat treatment.



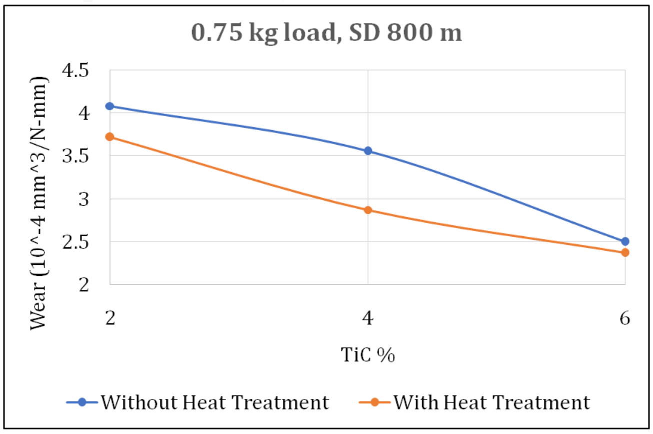


Fig 10: Fig 9: comparison of wear rate with heat treatment and without heat treatment at 800m

The below graphs shows the effect of Heat Treatment on wear rate at sliding distance of 1200 m

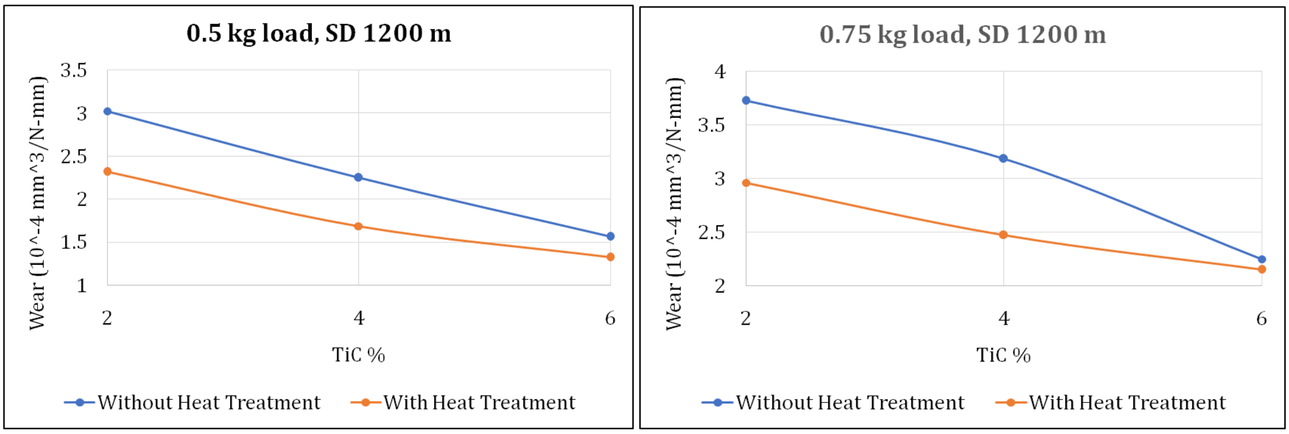


Fig 11: Fig 9: comparison of wear rate with heat treatment and without heat treatment at 1200m

The Wear rate of heat-treated samples are less compared to samples without heat treatment.

Conclusions

1. In engineering, composite materials play significant roles and have been used in the marine, aerospace, and automobile industries.
2. In the present study, the addition of TiC in Al6063 matrix has been explored to investigate further and improve physical, mechanical properties and tribological properties
3. Al6063-TiC MMCs were successfully fabricated using stir casting.
4. Optimization of stirring temperature, stirring time and stirring speed resulted in a uniform distribution of TiC in the matrix
5. Wear rate of Al6063-TiC was determined by varying tribological parameters like the Sliding distance, Load, reinforcement percentage and effect of heat treatment.
6. Because TiC is a tougher ceramic particle, it has produced many grain boundaries, which inhibits the movement of dislocations, and increasing the reinforcing % led to a decrease in wear rate.
7. With the increase in load the wear resistance of Al6063-TiC was reduced.
8. Formation of oxide layer was observed due to the heat generated at larger sliding distances.
9. The oxide layer being harder acted as protective layer and this resulted in reduction of wear rate at larger sliding distance.
10. Quenching of Al6063-TiC resulted in increase in wear resistance compared to Air cooled Al6063-TiC.

References:

[1] Rama Rao, S., Padmanabhan, G., 2012, Fabrication and mechanical properties of aluminium-boron carbide composites, International Journal of Materials and Biomaterials Applications,

[2] Vijaya Ramnath, C., Elanchezhian, M., Jaivignesh, S., Rajesh, C., Parswajinan, Siddique Ahmed Ghias, 2014, Evaluation of mechanical properties of aluminium alloy–alumina–boron carbide metal matrix composites, Materials and Design, 58, 332–338.

[3] Thirumalai, T., Subramanian, R, Kumaran, S., Dharmalingam, S., SRamakrishnan, S., 2014, Production and characterization of hybrid aluminium matrix composites reinforced with boron carbide (B4C) and graphite, Journal of Scientific & Industrial Research, 73, 667-670.

[4] Vijaya Ramnath, C., Elanchezhian, M., Jaivignesh, S., Rajesh, C., Parswajinan, A., Siddique Ahmed Ghias, 2014, Evaluation of mechanical properties of aluminium alloy–alumina–boron carbide metal matrix composites, Materials and Design, 58, 332–338.

[5] G.Shaikshavali, Dr. E.Venugopal good, M.Murali Mohan, "Mechanical Properties of Al6061 BasedMetal Matrix composites Reinforced with Ceramic Particulates and Effect of Age Hardening" International Journal of Engineering Research and General Science Volume 4, Issue 2, March- April 2016 ISSN 2091-2730.

[6] H Abdizadeh and M.A.Baghchesara, Investigation into the mechanical properties and fracture behavior of A356 aluminum alloy-based ZrO2 particle-reinforced metal-matrix composites, Mechanics of Composite Materials, 49(5), 2013.

[7] Ajay Singh, Love Kumar, Mohit Chaudhary, Om Narayan, Pallavi Sharma, Piyush Singh, Bhaskar Chandra Kandpal, and SomAshutosh, Manufacturing of AMMCs using a stir casting process and testing its mechanical properties, Int. J AdvEngg. Tech/IV/III/, 2013, 26-29.

[8] O.Yılmaz and S.Buytoz, Abrasive wears of Al2O3 reinforced aluminum based MMCs, Compos. Sci. Technol.61, 2001, 2381-2392.

[9] Vijay Kumar S. L., Vikranth Kannanth M. S., Vinay D. R, Three Body Abrasive Wear Study on A356 Aluminum Alloy under T6 Heat Treated Conditions, American Journal of Materials Science 2015, 5(3C): 43-47.

[10] Mahesh B. Davanageri1, Narendranath S, Ravikiran Kadoli , Influence of Heat Treatment on Microstructure, Hardness and Wear Behavior of Super Duplex Stainless Steel AISI 2507, American Journal of Materials Science 2015, 5(3C): 48-52.