FRICTION AND WEAR BEHAVIOUR OF AA 6063/SiC-Gr HYBRID MMC FOR BRAKE APPLICATIONS

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ABSTRACT:

This paper is investigated the friction and wear behaviour of aluminium matrix composites reinforced with silicon carbide and graphite hybrid metal matrix composites (MMC) for brake applications. A pin on disc type apparatus is used for measure the sliding wear rate, the friction force and the coefficient of friction. Friction and wear behaviour of aluminium MMC have been investigated at various load and sliding velocity and constant sliding distance. The applied loads are 20N, 40N, 60Nand 80 N, sliding speeds are 1.5 m/sec and 3 m/sec and sliding distance is 1500 m. The aluminium based MMC pin has been produced by stir casting technique using AA 6063 with 12SiC-5Gr and machined to the required size. Optical microscope is used for investigated the microstructure and surface properties of MMC specimen. The addition of graphite and silicon carbide particles reinforcement to AA 6063 alloy increases the wear resistance and hardness of the composites.

Key words: Metal matrix composites; Stir casting; Optical microscope; Rockwell hardness; Wear rate.

1. INTRODUCTION

Aluminium alloys are used in the various applications like automobile and aerospace industries because of their high strength, low weight, and excellent corrosive resistance. Aluminium alloys have poor tribological properties and low wear resistance. Aluminium metal MMC required for improve wear resistance and better tribological properties. The addition of graphite and SiC reinforcement to aluminium alloy reduced the wear rate of the composites [1].

Fehmi Nair et al. have investigated AA6063 reinforced with SiC_p and the results indicate extrusion ratio is increased, the fiber alignment is improved, but fracture is more severe [2]. The investigation on machining of 0-8.2 wt.% for Al-Gr composites by suresh et al. has indicate reduced wear rate with increase in particulate content [3]. Baki Karamis et al. have observed that the effect of finer particles on the die wear is more effective than those of coarser one [4].Suresh et al. have discussed that the squeeze cast matrix is improve hardness and also minimize porosity and it have lower weight losses [5].

MMC has less wear rate and stable friction coefficient as noticed by Natarajan et al. [6]. The investigation carried out by Daud et al.[7] on pin on disc machine using aluminium alloy has shown that the wear rate has been increased with applied load and sliding velocity. Wang [8] used statistical approach to investigate that the coefficient of friction is decreased with increase of load.

2. EXPERIMENTAL PROCEDURES

2.1 FABRICATION OF MMC

AA6063 aluminium alloy is used as a matrix material and 12% of SiC particles and also % of graphite were used as reinforcement. The chemical composition of the AA6063 matrix is given in the Table 1.

Table 1: Chemical composition of AA6063 matrix material (wt. %)

Elt	Si	Fe	Mn	Mg	Ti	Al
Wt%	0.41	0.15	0.023	0.38	0.016	Bal

The Al/SiC-Gr metal matrix composite is manufactured by stir casting process. First, the Al matrix material is melted in resistance heated furnace in a graphite crucible and liquid metal heated to 800ºC. Next, SiC and graphite pre-heated to 400^{o}C are added into molten aluminium material by means of argon gas flow with rate of 20 g/min. During the processes, the molten matrix and SiC_p-Gr are stirred by a mixture with 750rev/min. When the temperature of the matrix material decreased to near the melting point, which makes the stirring process hard, the process is stopped, but the matrix material is heated again up to 800^{o}C to ensure the homogeneity of the mixture.

After the completion of stirring process, the mixed material at 700-800^{o}C is cast into a metallic mould and it is quenched in atmosphere air together with mould.

2.2. MICROSCOPIC INVESTIGATION AND HARDNESS TEST

After machined MMC parts are cut with suitable dimensions by hack saw. A freshly mixed etchant consisting of 95 ml distilled water, 1.5 ml HCl, 1 ml HF,and 2.5 ml HNO_3 are used to reveal the shape of deformation zone. The longitudinal section of the composites is ground on SiC paper (grit 80-1200), immersed at room temperature into etching solution for a few seconds. The particle orientation anddeformation zone is investigated through optical microscope. The micro hardnesstest is evaluated by using Rockwell hardness tester as per the IS: 1586-2000.

2.3. WEAR TEST

Wear experiments are carried out using pin-on-disc wear testing apparatus shown in Fig.1.The test parameters used for the present work are listed in Table 2.

Fig.1. Pin on disc apparatus

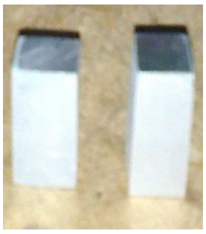

Fig.2. MMC specimen for wear test

The measurement of wear loss of the pin is used to evaluate the volumetric loss, which in turn is used to compute the wear rate of the composites using the following formula: W_R=V/LP

Where, W_R is the wear rate in mm^3/N-m, V the volumetric wear loss in mm^3, P the normal load in N and L is the sliding distance in m.

Table 2: Details of wear testing parameters

Pin material	Al 6063/12SiC_p-5Gr
Disc material	EN 36 steel with a hardness of 65 HRC
Pin dimensions	10x10x30
Sliding speed (m/sec)	1.5 &3
Sliding distance (m)	1500
Track diameter (mm)	100
Disc speed (rpm)	287 &573

3. RESULTS AND DISCUSSION

3.1. MICROSTRUCTURAL STUDIES

Fig.3. shows the microstructure of aluminium MMC in cast conditions. The microstructure clearly indicates the particles in the distribution of reinforcement in the matrix alloys.

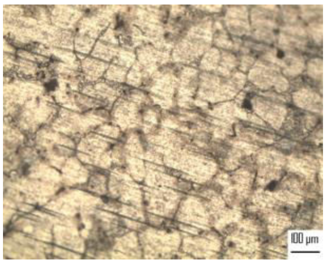

Fig.3. Microstructure of Al6063 cast composites

3.2. HARDNESS TEST

Microhardness improvement is calculated using the equation 2. The effect of reinforcement was studied by comparing the hardness of stir casted composite material with the base material. The hardness value of composite material is taken from five different points because it is non-homogeneousproperty. The hardness of matrix and composite is varied from each point shown in Fig.4.

$$\text{RH improvement (\%)} = \frac{\text{HRCc} - \text{HRCmx}}{\text{HRCmx}} \text{ X } 100$$

where, HRC_c and HRC_{mx} are the Rockwell hardness of composite and matrix material. The average hardness of metal matrix composite is 56HRC and hardness of matrix material AA6063 is 40 HRC.

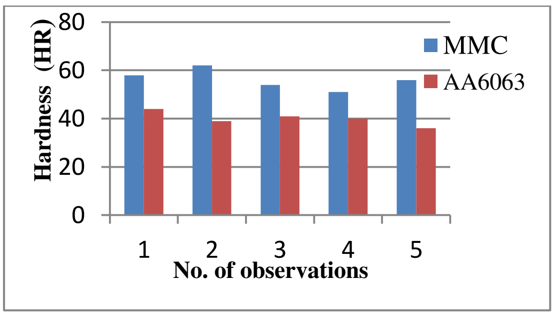

Fig.4.Rockwell hardness of composite and AA6063

3.3. WEAR STUDIES

3.3.1. WEAR OF MMC

The wear of composite pin material has been determined from several tests conducted at different loads and speeds. The wear in terms of volume losses will be useful in order to determine the geometrical changes in the components. The variation of wear with load for composite pin is shown in Fig. 5.

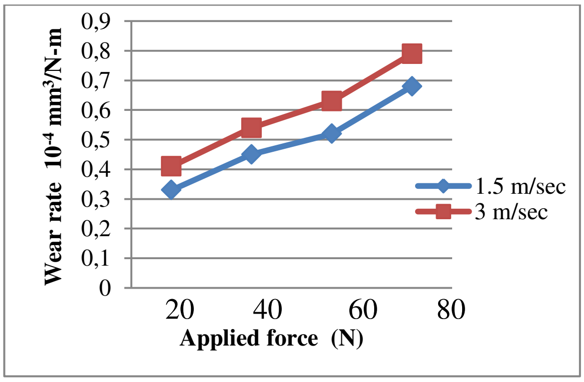

Fig.5. Wear rate of MMC at different velocity and applied load

The wear is low at lower value of applied loads. So at lower loads and reduced wear are observed. As the applied load is increased, the wear loss is also increased. Higher wear is observed for the maximum load.

3.3.2. FRICTIONAL FORCE

The variation of frictional force with applied load for composite material is shown in Fig.6. More variations are observed with applied load then with the sliding velocity. At higher loads, the frictional force is higher because of more contact area at the friction material surface. Here, higher variations are observed for the maximum load.

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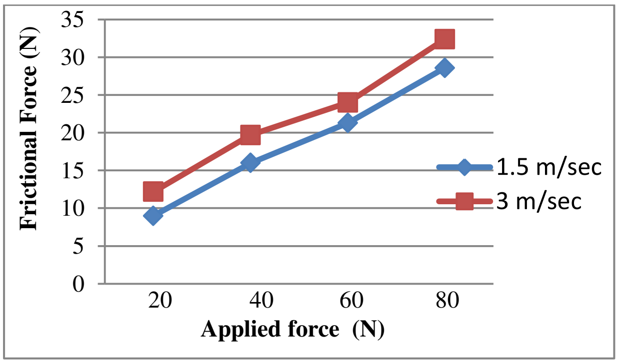

Fig.6. Frictional force of MMC at different velocity and applied load

3.3.3. COEFFICIENT OF FRICTION

The coefficient of friction is a definite ratio between the developed and the applied force, it is called the friction coefficient. The friction coefficient is observed high for lower loads and reduced for increase of applied loads shown in Fig.7.

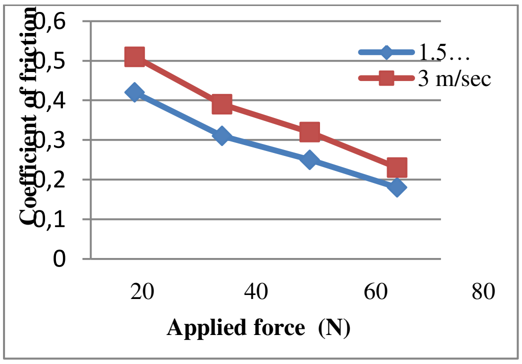

Fig.7. Coefficient of friction of MMC at different velocity and applied load

3.4. CONCLUSION

The hardness of composites was 40% improved compare to the matrix material (AA6063).The wear of composites has been found to increase with increase applied load and sliding velocity. The friction coefficient is decrease with increase applied load.MMC has more wear resistance and stable friction coefficient; it can be a better material for brake drum applications. The frictional force and friction coefficient of the MMC is found to be variations with the applied force are determined at different speeds. It was found that the frictional force increased with applied load and sliding velocity. It can be also concluded that the frictional force and friction coefficient in the MMC is improved.

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