ABRASIVE WEAR OF LM-13 ALUMINIUM ALLOY AND DUAL REINFORCEMENT (6%TiB2 + 6%SiC) COMPOSITE MATERIAL

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Abstract - *This thesis report shows the result of abrasive wear test of LM-13 Alloy and composite (6%silicon carbide and 6%titanium diboride) material parallel to the sliding distance of 500 meter with abrasive paper with grit size of mesh 180, 220, 320 and 400 at the sliding speeds of 2.61 m/s, 5.23 m/s and 7.85 m/s and applied load ranging 10N, 20N, 30N and 40N. Wear experiments on specimens are conducted with a pin-on-disk type wear testing apparatus. In this experiment two material are consider one is LM-13 alloy and other is composite material with contain 6% silicon carbide and 6% titaniun diboride and compare these sample after wear test, composite material found more reliable than LM-13 alloy.*

Key Words: Wear, pin on disc wear machine, Titanium diboride and silicon carbide

1. INTRODUCTION

Aluminium is light weight, recyclable, strong, corrosion unaffected, and an important part of daily life. The occurrence of wear is not only responsible for material removal and also lead to precipitate failure of engineering components. Abrasive wear is an important degradation mechanism for structural materials which occurs Abrasive wear happens when slides across a softer surface to hard rough surface. When the components are entrained in such surroundings, the design life of constituent is greatly reduced, subsequent in huge economic losses.

1.1 STIR CASTING ROUTE

Stir casting set-up mainly consists a furnace and a stirring assembly.

1. Uniform distribution of the reinforcement materials.
2. Porosity in the cast metal matrix composites.
3. Established Chemical reactions between the reinforcement particles and the metal matrix alloy.

The LM-13 alloy ingots were charged into a muffle furnace and heated to a temperature of 8000C (above the liquid us temperature of the alloy) and the liquid alloy was then allowed to cool in the furnace to a semi solid state at a temperature of about 7500C. The stirring operation was performed at a speed of 630 rpm for 10minutes to help improve the distribution of the zircon sand and silicon carbide particles in the molten LM-13 alloy.

Table: 1 Properties of the ceramic particulates reinforcements

Particulate type	Density (g/cm3)	Melting point	Modulus (GPa)	Coeff. Of thermal expansion
BORIDES				
CrB	5.10	2100	-	7.5
TiB2	4.50	2800	515-574	7.8
ZrB2	6.20	3200	-	5.9
CARBIDES				
CrC	7.00	3660	370	11
SiC	3.21	2690	450	4.5
TiC	4.95	3000	460	7.6

2. REINFORCEMENT

2.1 TITANIUM DIBORIDE AS REINFORCEMENT

Titanium diboride is chemical compound. It is most volatile transition consists of mostly titanium and diboride (TiB2) and some hafnium in addition to some rare earth elements, titanium minerals (Rutile, Limonite), monazite, etc. titanium is used chiefly for facing on foundry moulds to increase the resistance against metal penetration.

Advantages of titanium diboride as reinforcement
1. High hardness.
2. High modulus of elasticity,
3. High temperature resistance (MP of 25000C),
4. Acid corrosion resistance, thermal stability excellent.

Table: 2 Properties of Titanium diboride

Properties	Titanium diboride
M.P.(0C)	2800
Molecular weight	207.68
Density(g/cm3)	4.31
Appearance	Black solid

2.2 SILICA CARBIDE AS REINFORCEMENT

This research work entails producing copper matrix using silicon carbides (Sic) as reinforcement. Copper silicon carbide composites were produced in 80 % Cu-20 % Sic, 70 % Cu-30 % Sic, 60 % Cu-40 % SiC, 50 % Cu-50 % SiC, 40 % Cu-60 % SiC ratios with an average grain size of 212 μ m, 425 μ m and 710 μ m respectively via liquid metallurgy method. The result revealed that increasing volume fraction and particle sizes of the particulate had significant effect on the thermal and electrical conductivity of the composites.

Table: 3 Properties of Silicon Carbide

Properties	Silicon carbide
M.P. (0c)	2200-2700
Linear coeff. of expansion (10-6k)	4.1-7.7
Density g/cm3	3.2
Fracture toughness(MPa-m1/2)	4.6
Crystal structure	Hexagonal

3. EXPERIMENTAL WORK

3.1 DETAILS OF RAW MATERIALS

Raw materials and synthesizing process of composite are discussed below:

3.2 MARTIX MATERIAL

Al-Si alloy (LM-13 alloy) master alloy was prepared in a muffle furnace. Commercially pure aluminium was cut from its circular size into smaller pieces by an electric power saw in order to feed the crucible properly. Aluminium was first melted at 750°C and then 11.8 wt% pure silicon and other metal in wires form was dipped completely inside the aluminium melt. The melt was then covered by a flux to minimize loss due to oxidation.

Composition of master alloy was analysed and the chemical composition of the master alloy is given in table.

Table: 4 Chemical composition of Al-Si alloy (LM-13 alloy)

LM13 alloy	Si	Fe	Cu	Mn	Mg	Zn
Wt%	11.8	0.3	1.2	0.4	0.9	0.2

Ti	Ni	Pb	Sn	Al
0.02	0.9	0.02	0.005	Balance

LM-13 alloy was then prepared from the master alloy (Al-11.8wt%Si + other metal) by adding the calculated amount of aluminium to the master alloy that is required to make it LM-13 alloy. This alloy is used as matrix material for the synthesized hybrid composites.

3.3 MATERIAL SYNTHESIS

Titanium diboride and silicon carbide is used as reinforcement material. Particle size of as received titanium diboride in the range between 30-32μm and for Silicon carbide it was also 30-32μm.

Table: 5 Particle size range of Titanium diboride and Silicon Carbide

Reinforcement	Particle size range (μm)	Volume %
Titanium diboride (TiB2)	30-32	6%
Silicon carbide (SiC)	30-32	6%

4. WEAR TEST

The dry sliding wear of the as sintered and heat treated composite was conducted using pin on disc type wear machine. The sintered samples to be tested were used as a pin and the disc was made of the EN 32 steel of hardness 65 HRC. The samples were weighed before and after wear testing (sliding distance of 500 m) to calculate the wear rate as a function of load and speed. The wear track radius was fixed at 40 mm and constant sliding velocity of 2.61m/s, 5.23m/s, 7.85m/s was maintained for all samples. Correspondingly, the disc rotated at 500 rpm, 1000 rpm, and 1500 rpm at testing load levels (10 N, 20N, 30N and 40 N). Grit 180 size of the small loose particles of stone is medium. In grit 220 the small loose particle of stone are small. Grit 320 the small loose particles are to small and 400 grit the size of small loose particles of stone are too much small all particle size in µm.

5. RESULT AND DISCUSSION

The result of abrasive wear test conducted on SiC and TiB2 reinforced matrix. During the experiment varies the temperature and wear loss which are show in graph. In the graph LM-13 alloy is denoted by A and composite material LM-13 (6%TiB2 + 6% SiC) is denoted by C at the load of 10, 20, 30 and 40 N.

5.1 Graph for Weight loss rate vs load (for different speed and material)

Fig 1: Weight loss (N) between material A and C at 500 rpm at 180 grit.

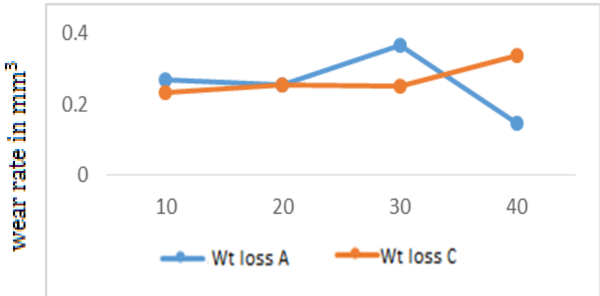

Fig 2: Weight loss (N) between material A and C at 500 rpm and 220 grit.

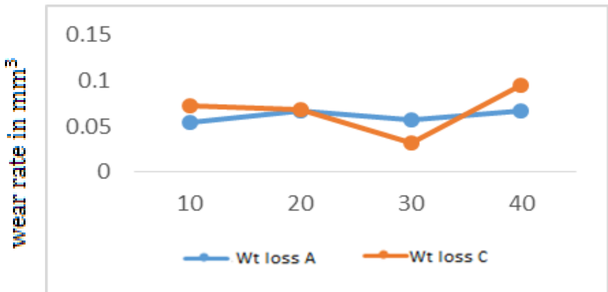

Fig 3: Weight loss (N) between material A and C at 500 rpm and 320 grit.

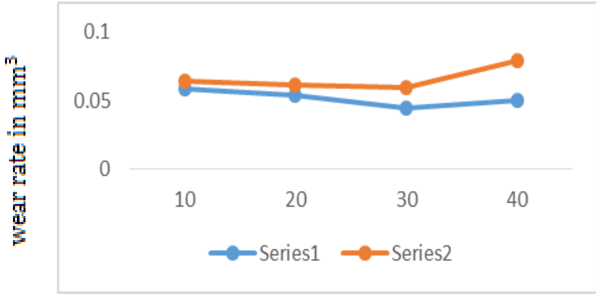

Fig 4: Weight loss (N) between material A and at 500 rpm and 400 grit.

Fig.1, Fig.2, Fig.3 and Fig.4 are graph between A and C which comparison of weight loss with speed 500 rpm at different grit of paper 180, 220, 320 and 400 µm. Figure 1, alloy and composite (6%TiB_2 + 6%SiC) at low speed 2.61 m/s in both wear rate increase as load increase to 30 N then wear rate is less in composite at 40 N. figure 2, paper grit is 220 speed is same wear rate increase with increase load. Similar behavior is observed paper grit is 320 in figure 3. Now in figure 4 composite material less wear at high load as compare to Al alloy in paper grit 400. Paper grit 220 wear is 0.28660 g from material. At 400 grit wear is 0.2442 g.

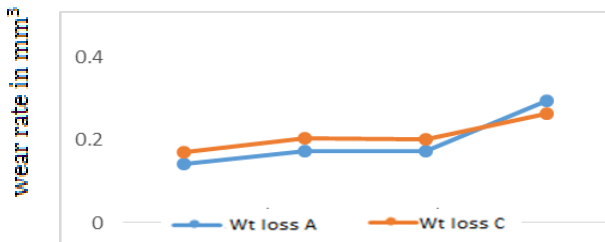

Fig 5: Weight loss (N) between material A and C at 1000 rpm and 180 grit.

Fig.6: Weight loss (N) between material A and C at 1000 rpm and 220 grit.

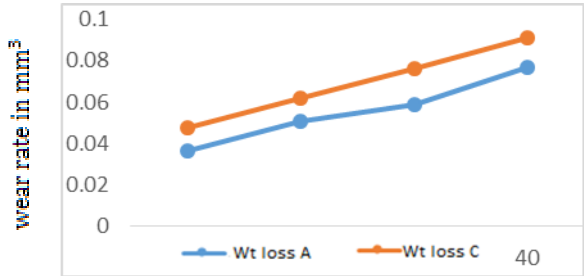

Fig7: Weight loss (N) between material A and C at 1000 rpm and 320 grit.

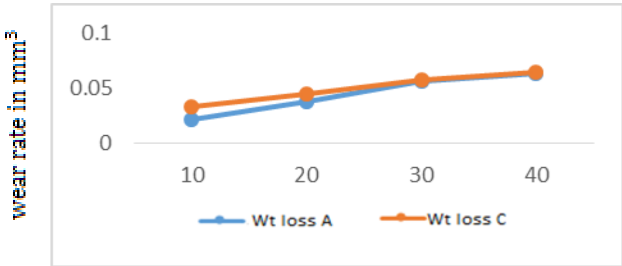

Fig 8: Weight loss (N) between material A and C at 1000 rpm and 400 grit.

Fig.5, Fig.6, Fig.7 and Fig.8 load and grit is same but speed is 1000 rpm for grit 180 load 10N to 30N both wear rate is increase with increase in load at 40N alloy is more wear as composite are less. Similar load initially wear is decrease in alloy but in composite initially it increase then decrease in grit 220. For 320 grit wear rate increase with increase in load. In graph 8 both material wear rate increase with increase load up to 30N.

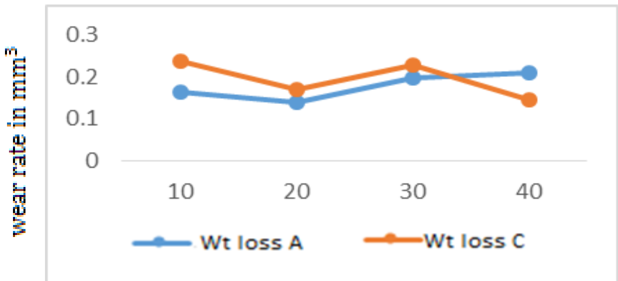

Fig.9: Weight loss (N) between material A and C at 1500 rpm and 180 grit.

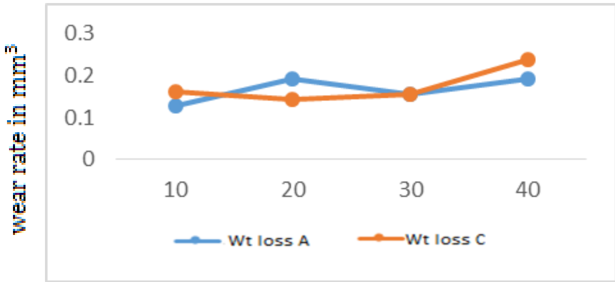

Fig.10: Weight loss (N) between material A and at 1500 rpm and 220 grit

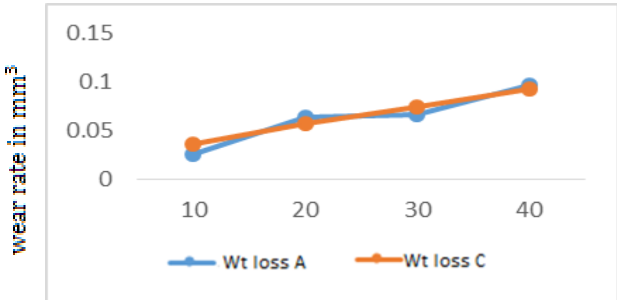

Fig11: Weight loss (N) between material A and C at 1500 rpm and 320 grit.

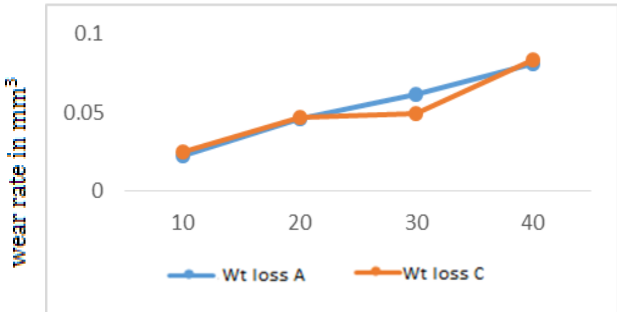

Fig 12: Weight loss (N) between material A and at 1500 rpm and 400 grit.

Fig.9, Fig.10, Fig.11 and Fig.12 speed are 1500 rpm, grit and load is similar time is taken 1.3 min. grit 180 wear rate is decrease then increase then decrease when load is varies similar condition for alloy. Grit 220 wear rate initially decrease then increase and again increase in composite alloy are varies first decrease then increase then decrease. In grit 320 composite material linearly increase but in alloy are differ. For grit 400 alloy material is linearly increase but in composite similar increase then slow increase then rapid increase.

5.2 Graph for temperature vs load (for different speed and material)

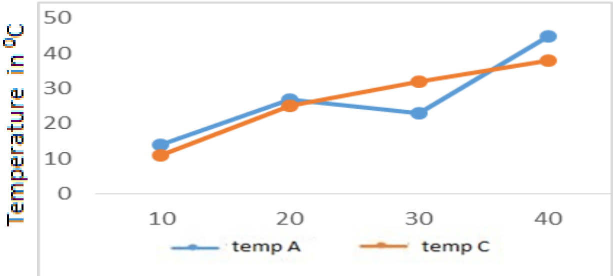

Fig 13: Graph between temperature and load (N) for 500 rpm at 180 grit.

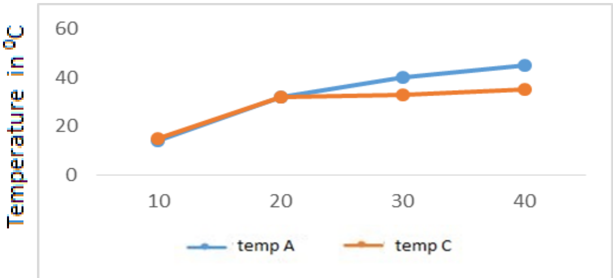

Fig14: Graph between temperature and load (N) for 500 rpm at 220 grit.

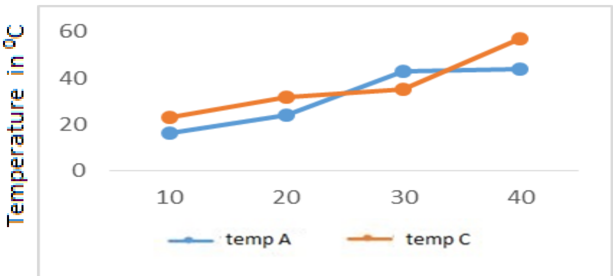

Fig 15: Graph between temperature and load (N) for 500 rpm at 320 grit

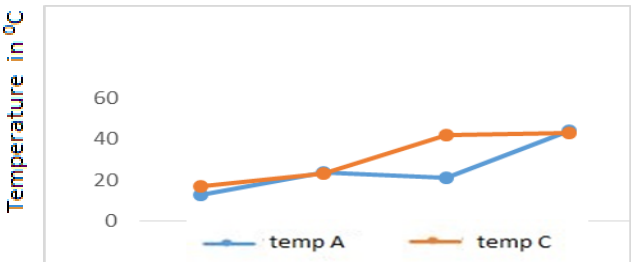

Fig 16: Graph between temperature and load (N) for 500 rpm at 400 grit.

Fig.13, Fig.14, Fig.15 and Fig.16 graph between temperature vs load graph 13 for grit 180 at 500 rpm time taken 3.11 min load are 10N, 20N, 30N and 40N show that when load increase the temperature also increase as load increase. Alloy temperature more than composite. Figure 14 temperature increase 10N to 20N then constant and for alloy tem increase as load increase. Grit 320 and 400 temperature of composite is more than alloy material.

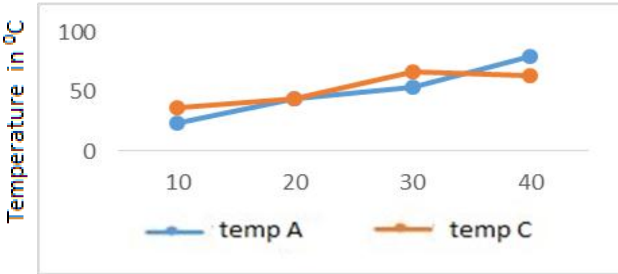

Fig 17: Graph between temperature and load (N) for 1000 rpm at 180 grit.

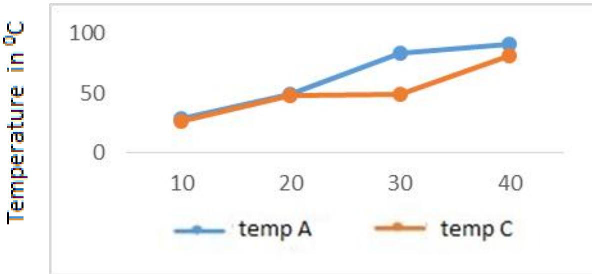

Fig 18: Graph between temperature and load (N) for 1000 rpm at 220 grit.

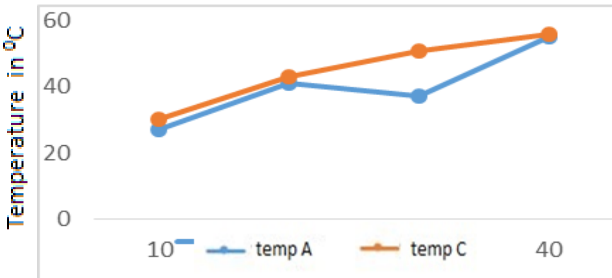

Fig 19: Graph between temperature and load (N) for 1000 rpm at 320 grit.

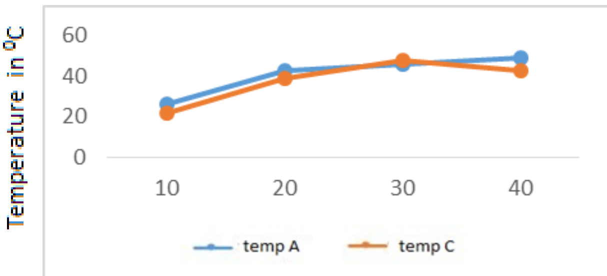

Fig .20: Graph between temperature and load (N) for 1000 rpm at 400 grit

Fig.17, Fig.18, Fig.19 and Fig.20 for 1000 rpm grit are same and load is 10N, 20N, 30N and 40N time are 2.35 min. these graph show that in composite material temperature less than alloy material in grit 400. We can conclude from the above graphs the maximum temperature rise increases with the load irrespective of sliding velocity but the temp difference increases with the speed. At very high speed maximum temperature rise is same for higher load. In this case at higher speed temp rises to the maximum value in very short time and then remains constant.

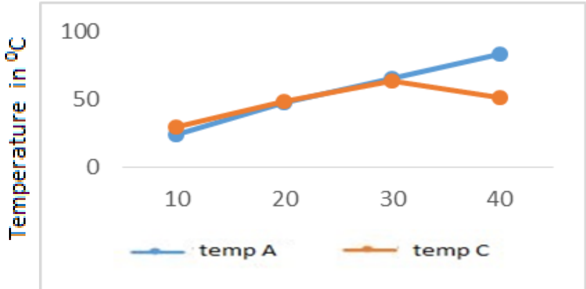

Fig 21: Graph between temperature and load (N) for 1500 rpm at 180 grit.

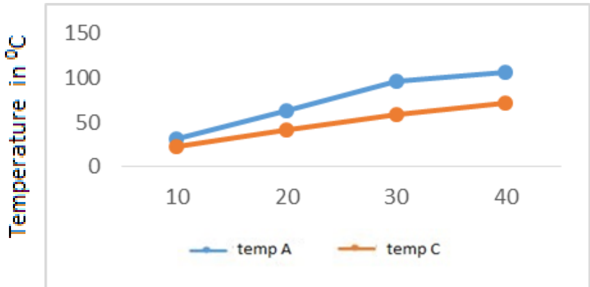

Fig 22: Graph between temperature and load (N) for 1500 rpm at 220 grit.

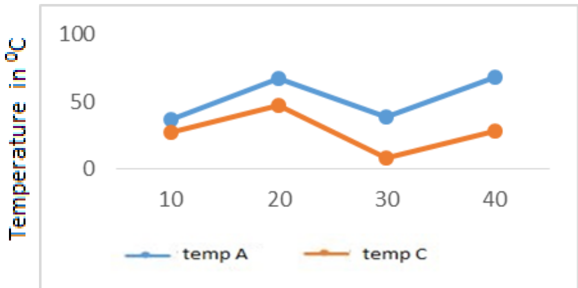

Fig 23: Graph between temperature and load (N) for 1500 rpm at 320 grit

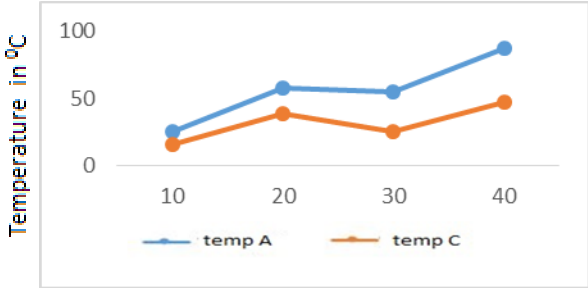

Fig 24: Graph between temperature and load (N) for 1500 rpm at 400 grit.

Fig.21, Fig.22, Fig.23 and Fig.24 show at high speed 1500 rpm grit are same 180,220, 320 and 400 load varies 10N, 20N, 30N and 40N time is 1.03 min shows Graph for Temp Vs Time for Al alloy composite 6% SiC + TiB_2 at 2.61 m/sec, 5.23 m/sec, 7.85 m/sec respectively and same 10N, 20N, 30N, 40N load condition. The temp trend observed in these two composite in different condition is similar to that of alloy. However In this case at higher speed temp rises continuously with time and become constant after longer time duration compared to alloy. This is due to higher thermal conductivity (due to higher porosity).

6. CONCLUSION AND FUTURE SCOPE

Improvement of abrasive wear properties of LM-13 Aluminium alloy, composite synthesized with 6%TiB_2 + 6%SiC as a dual reinforcement and tested with abrasive grit size 180, 220, 320 and 400 and applied load of 10n 20N 30N and 40N. Compression between LM-13 alloy and its composite material (6wt%TiB_2+6wt%SiC) show that wear rate of alloy is more than composite. Calculation of wear loss taking in four type of abrasive grit 180, 220, 320 and 400 at the load of 10, 20, 30 and 40 N for each abrasive paper. At 500 rpm average wt loss in alloy is 6.58% and 4.68% loss in composite. At 1000 rpm average wt loss in alloy is 6.05% and 5.24% in composite and speed of 1500 rpm loss in alloy is 5.23% where as in composite is 2.68%. Silica carbide refines the eutectic silicon where as TiB_2 provide good interface bonding. SiC and TiB_2 particles also provide effective nucleation site for eutectic silicon. The combination of SiC and TiB_2 particles in a proportion of 6wt% and 6wt% respectively better wear resistance at all temperature at low and high load both. Temperature increase with time in alloy and composite respective of speed and load. However the temperature remains constant in high speed with grit 400 for 1500 rpm and wear loss is also less.

In future much more studies are required to develop a reliable correlation which can include. The effect the various parameter effecting wear, including heat treatment, microstructural. Analysis and mechanical properties. These studies provide the base for selection and development of proper material necessary for the component working under simple abrasive wear as well as mechanical properties.

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