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A study on Mechanical and tribological properties of aluminium alloy (LM24), reinforced with mica, Al_2O_3, and graphite

Mr.Arunkumar[1], Mr.Guruprasad[1], Mr.Satish[1], Mr.veeranagouda.S.Patil[1], Asst.Prof.Sharanabasappa R P[2], Asst.Prof.Ritesh Mulge[3]

Abstract: In this study an experimental investigation on composite materials using aluminium- alloy LM24 as the base metal (matrix) with graphite, mica and Al_2O_3 as the reinforcements. Induction furnace is used to melt the metal matrix. The stir casting method is used which enables the uniform distribution of reinforcements. Seven sets of composites with constant weight fraction of two reinforcements and varying weight fraction of one reinforcement and a base metal specimen. The main mechanical properties studied were the tensile strength, ductility, impact strength &hardness. Tribological property studied was wear test. The results reveal that the incorporation of graphite acts as self-lubricating material and it reduces the wear. Al_2O_3 particles increase the tensile strength of the material and mica increases hardness of the material.

Keywords: LM24, Graphite, Mica, Al_2O_3induction furnace, stir casting, Mechanical and tribological properties.

1) INTRODUCTION

Composite material is the material having two or more distinct phases like matrix phase and reinforcing phase and having bulk properties significantly different from those of any of the constituents present in the matrix material. The matrix holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix. When designed properly, the new combined material exhibits better strength than would each individual material. Composites consist of one or more discontinuous phases embedded in a continuous phase. The discontinuous phase is usually harder and stronger than the continuous phase and is called the 'reinforcement' or 'reinforcing material', whereas the continuous phase is termed as the ' matrix'. Apart from the nature of the constituent materials, the geometry of the reinforcement (shape, size and size distribution) influences the properties composite to a great extent. Concentration, usually measured as volume or weight fraction, determines the contribution of a single constituent to the overall properties of the composites. It is not only the single most important parameter influencing the properties of the composites, but also an easily controllable manufacturing variable used to alter its properties. The orientation of the reinforcement affects the isotropy of the system. The composite materials exhibits better properties compared to the conventional alloy in various applications as they have high specific strength, stiffness and better wear resistance. Because of having good properties and light weight they have vast applications in aerospace, automobile & transportation industry, marine industry and in defence.

2) LITRATURE REVIEW

S.P Deshmukh1, A.C. Rao1, V. R. Gaval1, Seena Joseph2, P.A. Mahan war. In this study, the effect of the mica with different particle size and different filler concentration on the mechanical and electrical properties of the polyvinyl chloride (PVC) was investigated. Mechanical properties such as stiffness, and Young's modulus of the PVC mica composites were found increasing with increase in mica loading, whereas elongation at break and tensile strength was found to be decreasing with the mica loading.

United States Patent, Patent Number: 5,656,563 Date of Patent: *Aug. 12, 1997: This patent says that a dense, self-centred silicon carbide/carbon-graphite composite materials and a process for producing the composite material is disclosed. The density is achieved with minimal micro-cracking at a high graphite loading with large graphite particles. The composite materials exhibit good lubricity and wear characteristics, resulting in improved tribological performance.

Bikramjit Singh*, HarwinderLal, Gurvishal Singh and Parminderjit Singh: In the present paper they studied on sharp show off activities of Aluminum metal matrix composite reinforced with Alumina slag, SiC and Al2O3 has been carried out. There are various production techniques offered where the value fraction of Straighteners could be inflamed and are likely to vary the wear performances of the composite. Composites possess excellent Strength and Stiffness and this describes that these are very light Materials. Our paper also describes the advantages of MMC's as it provides Dimensional stability. Wear and Corrosion resistance, Reduced Weight. It is

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studied that micro hardness and resistance to wear of MMCs is produced by Strengthener and also the wear properties are improved remarkably by introducing hard intermetallic compound into the aluminum matrix.

A. Miranda, N. Alba-Baena, B.J. McKay, D.G. Eskin, S.H. Koand J.S. Shin.:In this study mechanically alloyed Cu-CNTs powders were added to molten LM24. The melt was processed using ultrasonic cavitation and subsequently high pressure die casting to form as-cast tensile specimens. SEM results indicate that CNTs can be successfully introduced into the melt using this method. Compared to the unreinforced alloy, the CNT additions resulted in an increment to both ultimate tensile strength and yield strength, with a corresponding decline (~1 ± 0.5l %) in elongation. This observed increase in strengthening may be attributed to the CNTs pinning and hindering both grain boundary and dislocation migration during applied loading.

3) EXPERIMENTAL PROCEDURE

3.1) SPECIMEN PREPARATION:

The materials used to prepare specimens are LM24, Graphite, Mica and Al_2O_3.Reinforcement materials are preheated by using electrical oven around 300^0C .Reinforcement materials are added with base metal(LM-24) in the induction furnace and are heated by stir casting method with 300RPM speedup to about 600^oC. At 800^0C molten metal undergoes self-stirring due to boiling. This enables the uniform distribution of reinforcements in the matrix. The molten metal is poured to the preheated die (at 100^o) and hence casted products are obtained. Later these products undergo machining operations in lathe, Shaper machine etc. in order to obtain the desired dimensions of the specimens.

Fig:1 Preheating Die

Fig:2 Induction furnace

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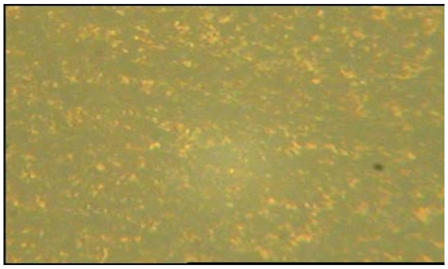
Fig:3 Pouring molten metal

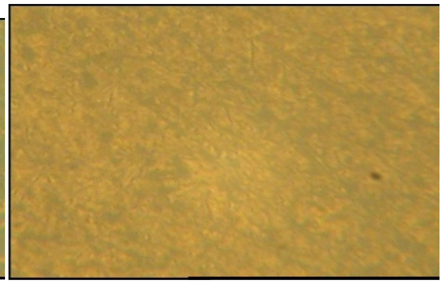
Fig:4 Cast specimens

4) RESULTS AND ANALYSIS

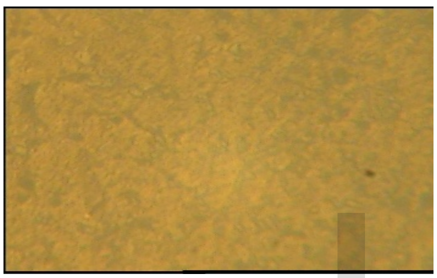
4.1) MICROSTRUCTURE:



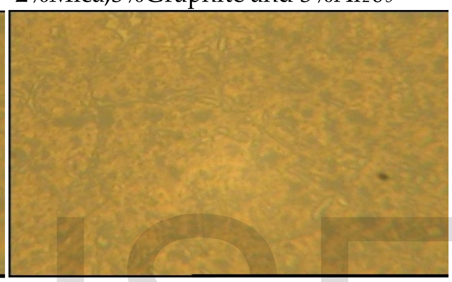
Micro structure of base metal (LM24)



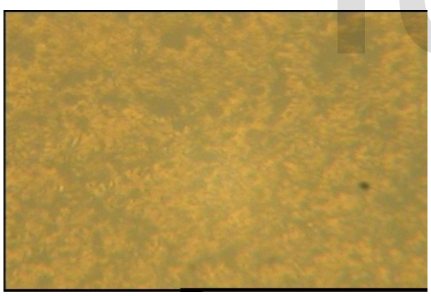
Microstructure for LM24 reinforced with 2%Mica,3%Graphite and 3%Al_20_3



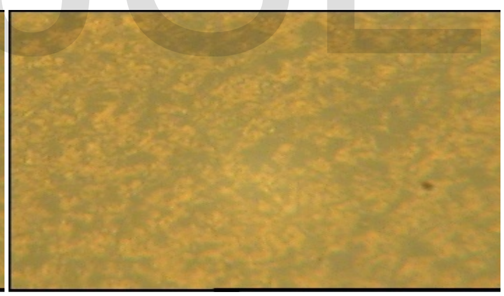
Lm24 reinforced with 2%Mica, 3%Graphite and 6%Al_20_3



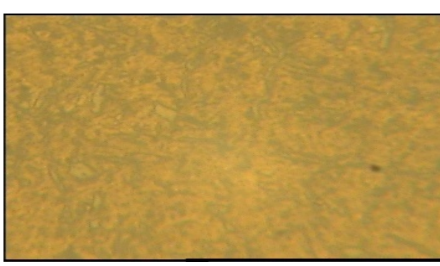
Lm24 reinforced with 2%Mica, 3%Graphite and 6%Al_20_3



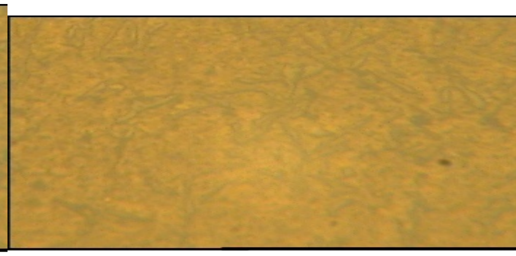
Micro structure of LM24 reinforced with 2%Mica, 6%Graphite and 3%Al_20_3



Microstructure for LM24 reinforced with 2%Mica, 9%Graphite and 3%Al_20_3



Microstructure for LM24 reinforced with 4%Mica,3%Graphite and 3%Al_20_3

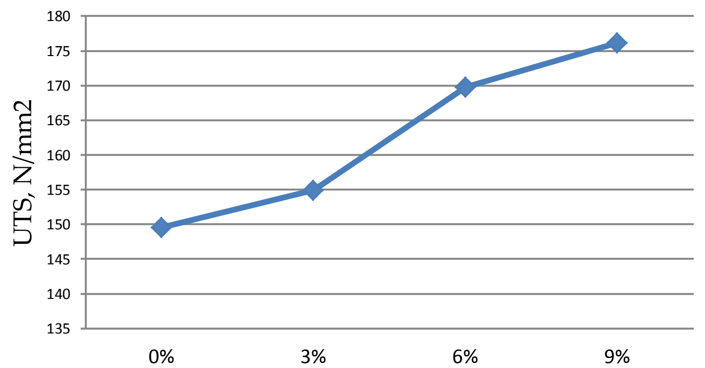


Microstructure for LM24 reinforced with 6%Mica,3%Graphite and 3%Al_20_3

4.2) TENSILE TEST:

Table 1

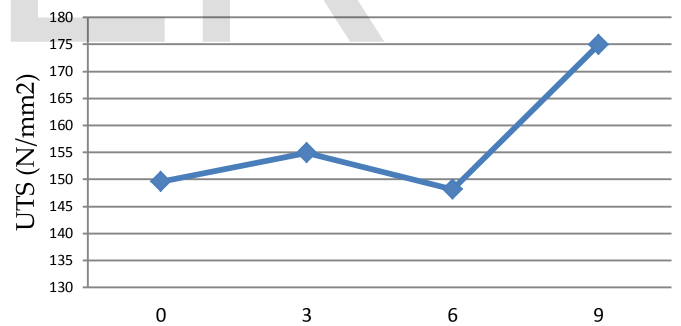
Serial No.	%wt of graphite	%wt of mica	%wt of Al_2O_3	UTS (N/mm2)
1	0%	0%	0%	149.6
2	3%	2%	3%	154.9
3	3%	2%	6%	169.76
4	3%	2%	9%	176.13



Graph 1: % varying wt of Al_2O_3, with const. % wt of Graphite(3%) & Mica(2%)

Table 2

Serial No.	%wt ofAl_2O_3	%wt of mica	%wt of graphite	UTS (N/mm2)
1	0%	0%	0%	149.6
2	3%	2%	3%	154.9
3	3%	2%	6%	148.12
4	3%	2%	9%	176.13



Graph2: % wt varying of graphite with const. %wt of Al2O3(3%) & mica (2%)

Table 3

Serial No.	%wt ofAl_2O_3	%wt of graphite	%wt of mica	UTS (N/mm2)
1	0%	0%	0%	149.6
2	3%	3%	2%	154.9

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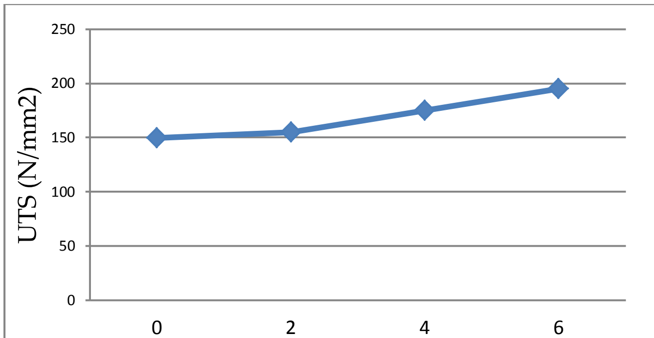
3	3%	3%	4%	148.12
4	3%	3%	6%	176.13

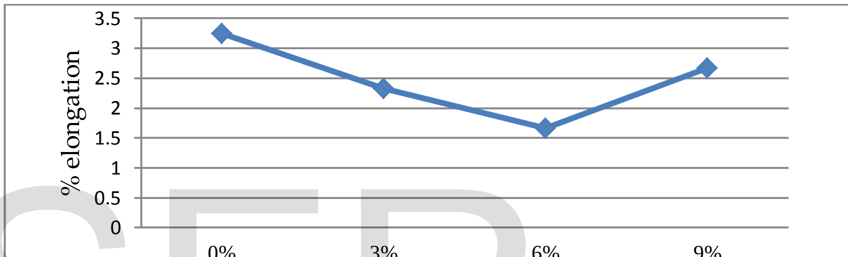


Graph 3: % wt varying of mica with % const. wt of graphite(3%) & Al_2O_3(3%)

4.3) DUCTILITY:

Table 4

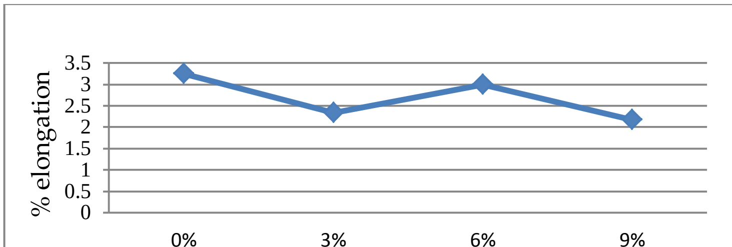
Serial No.	%wt of graphite	%wt of mica	%wt of Al_2O_3	% Elongation
1	0%	0%	0%	3.25
2	3%	2%	3%	2.33
3	3%	2%	6%	1.667



Graph 4: %varying wt of Al2O3, with const. % wt of…

Table 5

Serial No.	%wt. of Al_2O_3	%wt. of mica	%wt. of graphite	% Elongation
1	0%	0%	0%	3.25
2	3%	2%	3%	2.33
3	3%	2%	6%	3
4	3%	2%	9%	2.167

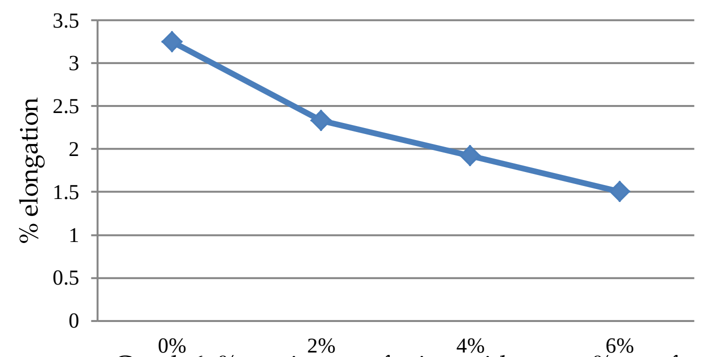


Graph 5: %varying wt of graphite, with const. %…

Table 6

Serial No.	%wt. of Al_2O_3	%wt. of graphite	%wt. of mica	% Elongation
1	0%	0%	0%	3.25
2	3%	3%	2%	2.33

3	3%	3%	4%	1.92
4	3%	3%	6%	1.5

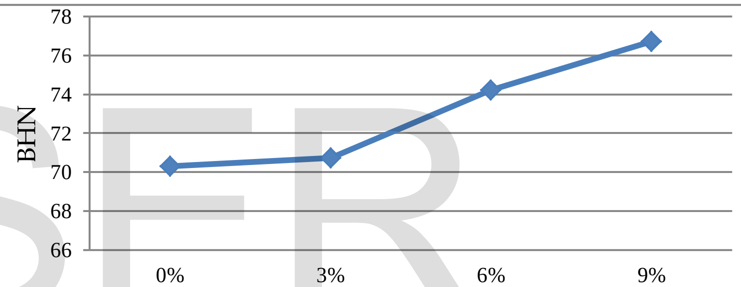


Graph 6: %varying wt of mica, with const. % wt of Al2O3(3%), graphite(3%)

4.4) HARDNESS:

Table 7

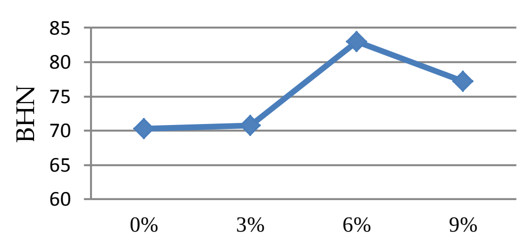
Serial No.	%wt of graphite	%wt of mica	%wt of Al_2O_3	BHN
1	0%	0%	0%	70.3
2	3%	2%	3%	70.742
3	3%	2%	6%	74.227
4	3%	2%	9%	76.73



Graph 7: %varying wt of Al2O3, with const. % wt of…

Table 8

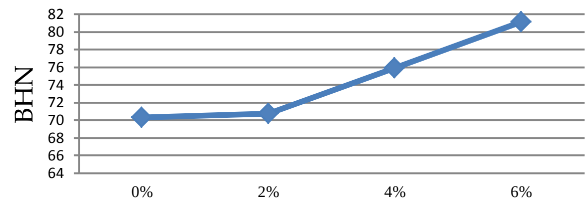
Serial No.	%wt ofAl_2O_3	%wt of mica	%wt of graphite	BHN
1	0%	0%	0%	70.3
2	3%	2%	3%	70.742
3	3%	2%	6%	82.99
4	3%	2%	9%	77.18



Graph 8: %varying wt of graphite, with…

Table 9

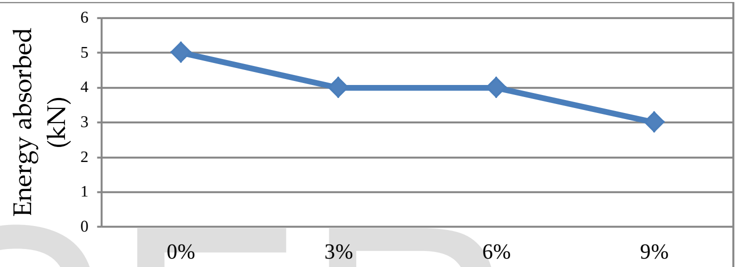
Serial No.	%wt ofAl_2O_3	%wt of graphite	%wt of mica	BHN
1	0%	0%	0%	70.3
2	3%	3%	2%	70.742
3	3%	3%	4%	75.93
4	3%	3%	6%	81.11



Graph 9: %varying wt of mica, with const.…

4.5) IMPACT STRENGTH:
Table 10

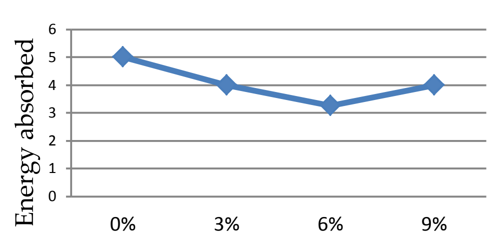
Serial No.	%wt of graphite	%wt of mica	%wt of Al_2O_3	Energy absorbed (kN)
1	0%	0%	0%	5
2	3%	2%	3%	4
3	3%	2%	6%	4
4	3%	2%	9%	3



Graph 10: %varying wt of Al2O3, with const. %…

Table 11

Serial No.	%wt ofAl_2O_3	%wt of mica	%wt of graphite	Energy absorbed (kN)
1	0%	0%	0%	5
2	3%	2%	3%	4
3	3%	2%	6%	3.25
4	3%	2%	9%	4



Graph 11: %varying of graphite wt…

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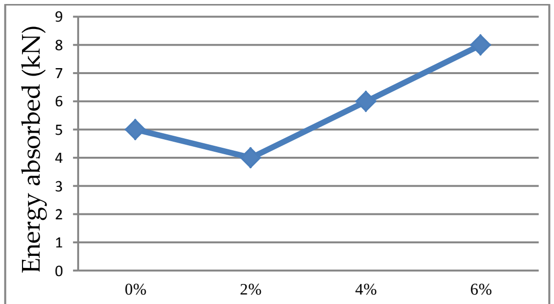
Table 12

Serial No.	%wt of Al_2O_3	%wt of graphite	%wt of mica	Energy absorbed (kN)
1	0%	0%	0%	5
2	3%	3%	2%	4
3	3%	3%	4%	6
4	3%	3%	6%	8



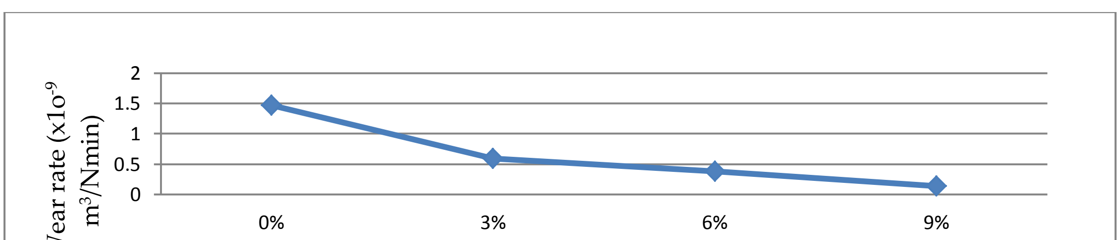
Graph 12: %varying wt of mica,…

4.6) WEAR TEST:

Table 13

Sl No	% Weight Graphite	Load(Kg)	Speed N(RPM)	Time(Min)	Initial Weight(gm)	Final weight(gm)	Change in weight(gm)	Wear rate W_R ($x10^9 m^3/Nmin$)

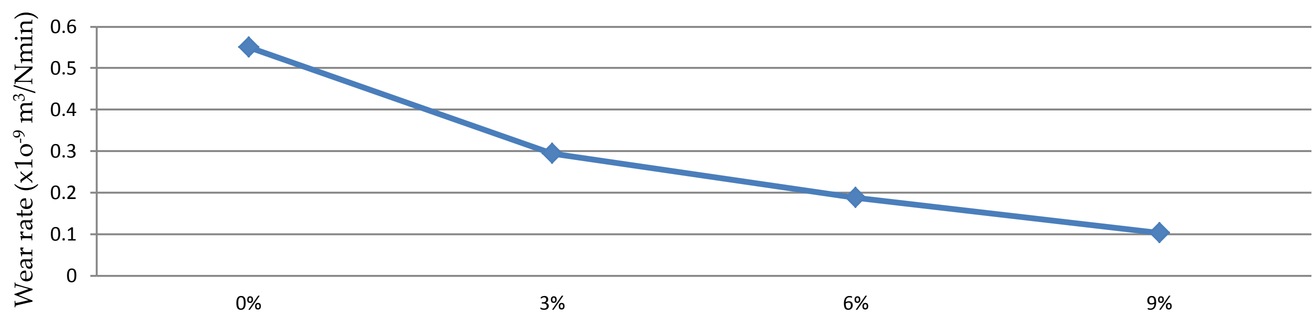
Serial No.	%wt of graphite	Load (kg)	Speed N (rpm)	Time t(min)	Initial wt (gm)	Final wt (gm)	Change in wtdw(gm)	Wear rate W_R ($x10^{-9} m^3/Nmin$)
1	0%	1	300	10	22.9660	22.9395	0.0265	1.4676
2	3%	1	300	10	22.9667	22.9560	0.0107	0.5920
3	6%	1	300	10	22.9675	22.9606	0.0069	0.3821
4	9%	1	300	10	22.980	22.9774	0.0026	0.1439



Graph 13: varying the %wt of graphite at const. load 1kg

Table 14

1	0%	3	300	10	22.9395	22.9097	0.0298	0.5500
2	3%	3	300	10	22.9560	22.9401	0.0159	0.2935
3	6%	3	300	10	22.9606	22.9504	0.0102	0.1883
4	9%	3	300	10	22.9774	22.9718	0.0056	0.1033



Grapgh 14: varying %wt of graphite with const. load 3kg

5) RESULTS

In the present study experimental investigations have been carried out on composite materials containing LM24 as base metal reinforced with mica, graphite and Al_2O_3in different composition. The experimental result is concluded as below.

- Through examining the above provided microstructure images it is evident that the reinforcements are near uniformly distributed in the metal matrix.
- The universal tensile (UTS) strength of the material increase with increase in the percentage weight of mica and Al_2O_3 (shown in graph 1& 3). But for graphite initially it increases at 3%, then it decreases at 6% again it increases for 9% of graphite (shown in graph 2). The decrease may be due to casting defects occurred in specimen.
- The ductility gradually decreases with increase in percentage weight of Al2O3 up to 6%, again increases at 9%(shown in graph 4). It decreases and increases alternatively for increase in the percentage weight of graphite i.e., 0%,3%,6% & 9% (shown in graph 5). It gradually decreases as increase in the percentage weight of mica (shown in graph 6)
- The hardness of the material increases slowly with increase in percentage weight of Al_2O_3 up 3%, again for 6% & 9% it increases rapidly (shown in graph 7). It increases with increase in the percentage weight of graphite up to 6%, again it decreases at 9% due to the presence of graphite in excess quantity (shown in graph 8). It increases slowly with increase in the percentage weight of mica up to 2%, later it increases rapidly rapidly at 4% and 6 %(shown in graph 9).
- The impact strength of the material decreases with increase in the percentage weight of the Al_2O_3, it is constant from 3% to 6% (shown in graph 10). It decreases with increase in in the percentage of graphite up to 6%, again increase up to 9 %(shown in graph 11). It decreases with increase in the percentage weight of mica up to 2%, later increases gradually up to 6 %(shown in graph 12). Wear rate decreases with increase in the percentage weight of graphite in metal matrix (shown in graph 13 & 14).

6) CONCLUSION

From the above results and analysis it can be concluded that %wt. of increase of Al_2O_3 and mica increases the tensile strength and hardness of the material. Ductility and Impact strength decreases with %wt. of increase of Al_2o_3 and % wt. of increase of mica decreases the ductility but impact strength increases. Tribological property (Wear rate) decreases with excess quantity of graphite.

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ABOUT AUTHOR (S)

1) [1]B.E in mechanical engineering, Department of Mechanical Engineering, AIET Gulbarga.

2) [2]Asst.Professor, Mechanical department, Appa Institute of engineering & Technology Gulbarga

3) [3]Asst.Professor, Mechanical department, Appa Institute of engineering & Technology Gulbarga