Influence of Alumina on LM24 Alloy Composite Under Dry Sliding Condition

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Abstract:- Metal Matrix Composites (MMCs) offer designers benefits, and are particularly suited for applications requiring good strength at high temperature, good structural rigidity, dimensional stability and light weight. The trend is towards safe usage of the MMC parts in the automobile engine, which work particularly at high temperature and pressure environments. Particle reinforced MMCs have been the most popular over the last two decades. The modern trend for potential applications, is to optimize the mechanical properties and heat treatment of MMCs. Aluminium–base alloys are characterized by low initial cost, excellent foundry castability and fluidity, good mechanical properties, good machining properties, compared to many ferrous and nonferrous casting alloys. However, many attempts were made in the past to synthesize Aluminium matrix composites reinforced with particles by using the stir casting method and also few studies were devoted to the heat treatment of Al alloy MMCs. In view of the above, an attempt has been made to evaluate the dry sliding wear behaviour of garnet particle reinforced MMCs over a range of loads and sliding speeds. The unreinforced LM 24 alloy is the reference material. The operating wear mechanism causing material removal in all the cases has been examined. Proper setting of process parameters is essential to produce good quality product. The process of identification of suitable combination of input process parameters so as to produce the desired output parameters necessitates the conduct of several experiments which consumes significant time and cost. Researchers have concentrated on understanding and studying the effect of process parameters on material flow behaviour, microstructure formation and mechanical properties of reinforced composite. Researchers have applied conventional experimental techniques in which single parameter will be varied, keeping other parameters constant. Dry sliding wear behavior of LM24 cast alloy reinforced with particulate composite against EN32 steel disc was investigated, using a pin-on-disc tribometer. Experiments were carried out with sliding velocity ranging from 1.0 to 3.0 m/s, different load conditions from 20 to 80 N, and with a constant sliding distance of 3000 m. Samples were prepared with different weight percentage of in the alloy varying from 3% to 15% in a step of 3 wt% prepared. Scanning electron microscopy was used to realize the distribution of reinforcement in the matrix material and mechanism of wear. Experiments showed that the 15% composite exhibited lower wear rate at all applied loads. The wear resistance was better at low loads and mild to severe wear was exhibited when load/sliding velocity was increased.

Keywords: Dry sliding wear, LM24, metal matrix composite, scanning electron microscopy

I. INTRODUCTION

Composite materials have important progress and advances in our understanding of these materials and their metallurgical behavior. The greatest advantage is in the fact that we can inherit properties of both, the metal matrix and the reinforcements, providing a material with properties which can meet specific and difficult requirements in many applications (Sharma et al. 1988, Sharma, et al 1999). Metal matrix composites (MMCs) are engineering materials in which a hard ceramic component is dispersed in a ductile metal matrix in order to obtain characteristics that are superior to those of the conventional monolithic metallic alloys. The primary support for these composites has come from the aerospace industry for airframe and spacecraft structures. Metal matrix composites are their capability to be designed to provide needed types of material behavior, such as their improved strength and stiffness, outstanding corrosion resistance, friction resistance and wear resistance, high electrical and thermal conductivity, and high temperature mechanical behavior (Chawla, 2006, Hashim et al 1999) . Hence they are suitably used in automotive and tribological applications.

Aluminium metal matrix composites are commonly used MMCs in automotive components such as cylinder piston, brake drum and cylinder block because of their light weight, better corrosion resistance and wear resistance. The wear properties of MMC are important as they influence the performance of the product when used in tribological and wear resistant applications. Recent years, the research community is interested to develop hybrid metal matrix composites (HMMC) having two or more reinforcements and the combination of reinforcements enhances the physical, mechanical and tribological properties. In this path, research ventures have been made in developing new aluminium based HMMCs.

II. LITERATURE REVIEW

There are two main practical problems that engineers face in a manufacturing process. The first is to determine the values of the process parameters that yield the desired product quality and the second is to maximize manufacturing system performance using the available resources. The modern industries focus mainly on the achievement of high quality, in terms of work piece dimensional accuracy, surface finish, high production rate, tool life, economy of machining in terms of cost saving and increase the performance of the product with reduced environmental impact.

Renjie et al (2012) expressed their view that Al-SiC composite is one of the advance composite material that posses superior physical and mechanical properties in compare to other conventional material.

Kumar et al (2006) evaluated the unlubricated sliding wear behavior of zinc-aluminum ZA-27 alloy composites reinforced with garnet particles. In the former, the content of garnet was varied from 2 to 6 wt% in steps of 2 wt% and in the latter it was varied between 0 and 20 wt% in steps of 5%. The results showed that with the increase in garnet content, the wear resistance increased. The wear rates increased with the increase in load and the sliding speed. The wear mechanism changed from abrasion to particle cracking when the applied load was increased.

Sharma (2001) investigated the tribological behavior of aluminum–magnesium–silicon Al6061–garnet particulate reinforced composites prepared by liquid metallurgical technique. The wear tests were carried out on both composites and matrix alloy over a load range of 10–50 N and sliding velocities of 1.25–3.05 m/s for various sliding distances of 0.5–3 km.

Kathiresan and Sornakumar (2010) studied the effects of normal load and sliding speed on tribological properties of the MMC containing LM24 alloy matrix reinforced with Al2O3. The results revealed that the wear and friction coefficient of the aluminum alloy–aluminum oxide MMC are lower than the plain aluminum alloy. The wear rate increased and coefficient of friction decreased with increasing normal load and sliding speed.

Patel et al. (2009) studied about machining characteristics, surface integrity and material removal mechanism of Al_2O_3–SiCw–TiC ceramic composite and found that surface roughness increases with discharge current and pulse on time as well as it provides the key information on the mechanisms of formation of recast layer.

Kohli et al (2012) have applied fuzzy logic analysis to compare the experimental results with the result generated by fuzzy model during die sinking EDM process using copper as electrode and Medium Carbon Steel as work-piece to evaluate the material removal rate.

OBJECTIVES

The objective of this research is to investigate the influence of EDM machining parameter and tribological studies of aluminium alloy garnet and flyash hybrid composite under different conditions has the following objectives:

- To fabricate the aluminium alloy with MMC and aluminium alloy- and aluminium alloy-garnet flyash hybrid MMC using stir casting method.
- To study the mechanical properties of the aluminium alloy-garnet and aluminium alloy-composite.
- To study the tribological characteristics of aluminium alloy-garnet and aluminium alloy-composite.

III. EXPERIMENTAL DETAIL

The objective of this study is to analyze the mechanical properties and tribological studies of aluminium alloy garnet and aluminium alloy garnet and flyash hybrid composite. The experiments have been conducted by varying percentage of garnet (3wt%, 6wt%, 9wt%,). The vortex method was adopted to prepare the composite specimens and the melting was carried out in an electrical resistance furnace. The temperature of the furnace was precisely measured and controlled in order to achieve sound quality composite. Two thermocouples and one proportional integral derivative controller were used for this purpose. The melt was maintained at a temperature between 1023 and 1073K for one hour. Garnet particles of 120 mesh size varying from 3 to 15 wt% in steps of 3 wt% were used to prepare the composites. The vortex was created using an aluminite coated mechanical stirrer. The coating of aluminite was necessary in order to prevent the migration of ferrous ions from the stirrer into the matrix alloy melt.

The garnet particles were preheated to a temperature of 713K and then introduced into the slurry. The stirring was continued until particle and matrix wetting occurred. Chemical analysis was carried out which showedthatsignificant part of the particles were retained in the melt. Finally, the melt was degassed and deslagged and the refined metal was poured into cylindrical mold (0.02 m diameter and 0.2 m length). After the mold was cooled down to the room temperature, the specimens were taken out and cut to required dimension. The chemical composition of LM 24 aluminium alloy used in the present investigation is given in the Table1. Alumina, abundantly available and having hardness values of 981–1161 HV, which is nearly equal to that of SiC. It is composed of silicates of calcium, which is chemically inert even at higher temperatures. Fly-ash which mainly consists of refractory oxides like silica, , and iron oxides is used as reinforcing phase. Composite was produced with 50 gm fly-ash as reinforcing phase.

Table 1 Chemical composition of Aluminium LM24

Mg	Si	Fe	Cu	Ti	Cr	Zn	Mn	Ni	Pb	Al
0.3	9.5	1.3	3	0.2	-	3	0.5	0.5	3	Bal

The mechanical properties such as hardness and tensile strength of composites were measured using standard testing procedures. Dry sliding wear test was carried out using pin-on-disc machine. Cylindrical pins of dimensions 10 mm diameter and 30 mm height were machined from LM 24/alumina particulate composite castings for tribology tests, based on the ASTM G99-05(2010). Pins were tested against on EN32 steel disc having the hardness 62 HRC, ground to a surface finish pins were polished with a SiC-1200 grit polishing paper and cleaned with acetone. Specific gravity measurements were conducted according to ASTM Standard C127-88. The volume loss of the pin was calculated before and after each wear test using an electronic digital weight balance with an accuracy of 0.1 mg. The temperature rise of pin during wear testing was measured using ‘‘K’’ type thermocouple. The thermocouple was embedded in the pin at a distance of 0.002 m from the contact surface. All these tests were conducted at room temperature 300 K and relative humidity of 48%.

The worn surface of the specimen with 6% reinforcement, 1 m/s, and 80N load. At lower velocities two body wear occurs. As the sliding velocity an increase, the particle is pulled out of the matrix and three bodies wear occurs. During the three body wear, the average loose abrasive particle abraded the surface for approximately 10% of the time and this lead to lesser wear rate when compared to two body abrasive wear.

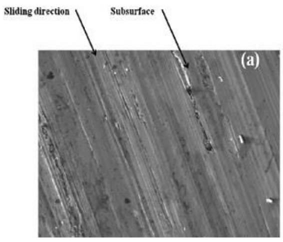
Thus, under high load, the protective layer of reinforcing particles can no longer remain stable under the plouging action and the wear strips are formed. During the sliding process, the material is removed in the form of small pieces resulting in the formation of flake type debris. The shear strains induced in the process are transmitted to matrix alloy and the wear mechanism proceeds by subsurface crack propagation that caused the delaminating wear. These observations suggest that the main wear mechanism at high loads is delaminating wear causing excessive fracture of reinforcement and the matrix, resulting in determination of the wear resistance of the composite. When the relative slide between the disc and the pin occurred, the wear surface temperature of the specimen gets increased and the surface layer softened because of frictional heat and operating temperature. These resulted in the plastic deformations and dislocations in the inner surface of the alloy. With the rise in temperature, the cracks were initiated in the surface layer, and then expanded to the subsurface layer. The wear surface layer was torn up and then desquamated.

IV. RESULT AND DISCUSSION

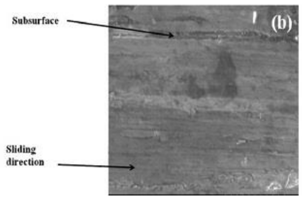
In this experimental of composite material was made by using Aluminium LM 24 and Aluminium oxide (Al_2O_3). The composites made was analysed by means of Wear Study and Microstructure tests

4.1 MICROSTRUCTURE TEST:

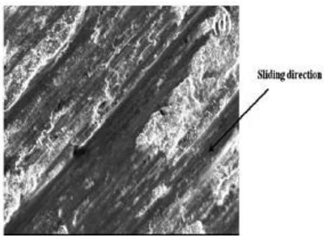
Microstructure is the very small scale structure of a material, defined as the structure of a prepared surface of material as revealed by a microscope above 25× magnification.



(a)



(b)



(c)

4.2 WEAR TEST:

The wear mechanism was adhesion wear. The dislocation accumulation because of the garnet particles in the aluminum matrix resulted in the stress concentration and the crack initiation. The expansions and junctions of the crack contributed to the generation of the desquamation fragments and particles performed relative moving on the wear surface, where the apparent plough cutting traces were observed. The wear mechanism was mainly abrasive wear. With the increase, the amounts of the garnet reinforcement particles in the aluminum matrix resulted in bulging on the wear surface and stayed bearing the applied force. The soft aluminum matrix could not establish direct contact with the counter wear pin.

The adhesive wear occurs when two surfaces are moving relatively one over the other, and this relative movement is in one direction or a successive movement under the effect of the load so that the pressure on the adjacent projections is big enough to make a load plastic deformation and adhesion. This adhesion will be at a high grade of efficiency and capability in relative to the clean surfaces, and adhesion will take place between a number of these projections whose sizes will be bigger and the area will be increased during movement.

Table 4.2 Tribological behaviour LM24

Sl.No.	%ALUMINA	Distance (m)	Load (N)	Wear rate(μm)	Coefficient of friction
1	4	500	29.4	25.01	0.42
2	4	1000	39.2	45.18	0.43
3	4	1500	49.0	208.26	0.49
4.	8	500	29.4	316.16	0.3
5.	8	1000	39.2	114.44	0.37
6.	8	1500	49.0	155.93	0.39
7.	12	500	29.4	143.83	0.35
8	12	1000	39.2	181.65	0.36
9	12	1500	49.0	283.18	0.49

V. CONCLUSION

Thus the composite material was made by using Aluminium LM 24 and Aluminium oxide (Al2O3). The composites made was analysed by means of Wear Study and Microstructure tests.Through this test wear rate and coefficient of friction was found out.

- Wear test is carried out to predict the wear performance and to investigate the wear mechanism.Wear testing will give the data to compare materials or coatings and can help to predict the lifetime of a material or coating.
- Microstructure is the very small scale structure of a material, defined as the structure of a prepared surface of material as revealed by a microscope above 25× magnification.

Thus the composite study of LM 24 and Aluminium oxide (Al2O3) was successfully manufactured and the experimental is tested successfully.

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