# Evaluation of Mechanical and Wear Properties of Aluminium /Al2O3 Composite Material for Brake Rotor

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**Abstract —** The MMC have wide application in all engineering field such as automobile and mechanical industry due to their light weight and high strength parameter. In this paper to study of mechanical and tribological properties of aluminium alloy and effects of reinforcement material such as short fiber alumina. The composite is fabricated by stir casting method and adding reinforcing material as 10%, 15%, 20% respectively. To study wear test and test conduct on pin on disc apparatus as dry sliding condition with ambient temperature for different affecting parameter i.e Normal Load, sliding velocity, sliding distance. And also study of mechanical properties of specimen such as tensile strength, hardness, elongation or chemical composition of material. It was found that tensile strength and hardness increased when alumina is added to 6082 aluminium alloy. Wear rate is decreased when adding alumina to aluminium alloy.

Index Terms—Metal matrix composite, wear test, pin on disc, Al2O3, Composite Material, Tribological properties

## 1. INTRODUCTION

The metal lattice composite (MMC) is by and large a compound, not an unadulterated metal. A metal grid composite is a composite material in which no less than two constituent materials, one being a metal. The other material might be an alternate metal or another material, for example, an earthenware material i.e short fiber alumina. The need of composite materials has expanded, due to the enhanced physical and mechanical properties. A composite material is a material comprising of at least two physically or synthetically unmistakable stages. The composite by and large has great attributes than those of every one of the individual parts. The fortifying segment is circulated in the lattice material. Aluminum grid composites (AMCs) are rising as propel building materials because of their quality, flexibility and sturdiness. The aluminum lattice is getting fortified when it is strengthened with the hard clay particles like Al2O3, and B4C and so forth .Aluminum combinations are as yet the subjects of exceptional examinations, as their low thickness gives extra points of interest in a few applications, for example, break rotor, cylinder, break cushion, break liner and so forth. In this examination, a chronicled foundation on the advancement and utilization of metal framework composite for car brake rotor is displayed. The talk likewise incorporates examination of the item life cycle with mix giving a role as a contextual investigation. The authentic audit examination uncovered that continuous advancement of material and preparing strategy have prompt a lighter weight, bring down cost, and higher execution brake rotor because of the better comprehension of the mechanics of metal network composite. It rose up out of the investigation that mix throwing method gives simplicity of task, manageability and most fundamentally exceptionally focused without giving up quality in respect to different systems and all things considered is the most appealing assembling process in the business. These discoveries can be utilized for future plan and make of a productive and successful aluminum grid composite brake rotor for car and different applications. The wear rate of the surface is additionally subject to sliding pace, temperature, warm, mechanical and substance properties of the materials examined. Tainting on material's surface, for example, flotsam and jetsam or particles between the sliding surfaces additionally increment wear rate and harm to the surfaces.

## 2. LITERATURE REVIEW

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spacing than it was seen that alumina particles were deposited on the aluminium matrix. (7)

## 3. RESEARCH GAP

A lot of work has been done on alloy metal matrix composite with different types of reinforcement, different sizes and manufactured technique. It's generally used automobiles parts such as piston, piston rings, connecting rod, transmission interior part chassis components and body components and then subjected to study the wear behavior. Alloy composition and its condition influence the wear rate. With increase in weight % of reinforcement in the matrix the wear resistance of composite increase. The Mechanical properties will increase with increase in weight % of reinforcement.(9)

A major research work has been done on alloy material by taking different reinforcement such as silicon carbide, Tic, Mg, B4C and Al203Such reinforced composite are likely to overcome the cost barrier for wide spread application in automotive and small engine application and also control environment condition.(4)

In this research to study historical background on the development and study of metal matrix composite for automotive break rotor. is presented. To study mechanical and wear properties aluminum base materials and the effect of varying percentage of alumina on alumina composite are studied by using physical and mechanical properties such as density and hardness. The wear properties are studied by conducting experiment on pin on disc wear test apparatus. The specimens are studied under SEM to get an idea about the distribution patterns of the reinforcement in the matrix alloy.(18)

## 4. PROBLEMS STATEMENT

To improvement of properties of automobiles part such as engine and transmission interior part chassis components and body components and this part made by alloy composite materials and metal for different s type of materials properties. In this project to study automotive break system is responsible for converting kinetics energy into thermal energy which is then dissipated through disc break rotor and other part. Most of the automotive industry use gray cast iron and steel for manufacturer of disc break rotor and break system but it disadvantage its high weight which has impacts on fuel consumption and vehicle emissions and Mechanical properties. Hence in this project break rotor and break made of alloy steel, cast iron replaced by aluminum alloy and reinforcement materials. For this purpose composite will be tested for various combination such as 10%,15%,20% by wt of alumina in aluminum alloy matrix and tested for Mechanical properties such as tensile strength, hardness strengths and wear rate and the result will be compared with existing materials properties .

Objective

- To conduct wear test on aluminum alloy and Al-Al2o3 composite materials off different composition at varying load and sliding distance.
- To study mechanical and tribological properties ofaluminum and there composite materials for different composition to select best composite materials for break system on basis of mechanical and wear properties.

## 5. METHODOLOGY

### 5.1 Fabrication of Metal Matrix Composites

To fabricate the Metal Matrix Composite, different kinds of techniques can be applied. The selection of the suitable process is depended on the distribution and quantity of the reinforcement,(i.e. fiber and particle), the matrix alloy and the application. The convenient and versatile way to fabricate MMC is the mixing of metallic powder and ceramic fibers or particulates, which provide excellent controlling over the ceramic content across the complete range. MMCs can be produced by conventional metalworking equipment. Two common ways to produce magnesium matrix composites are powder metallurgy and casting. (15)

The challenge in the processing of composites is to homogeneously distribute the reinforcement in the matrix alloy to reach a defect-free microstructure. In the powder metallurgy process, the composition of the matrix and reinforcement are independent of one another. It can be difficult to achieve a homogeneous mixture during the process of blending, especially for fibers and fine particles. For squeeze casting, preform is used which is made of fiber or/and particles. The preform is placed in a pre-heated mould, which is later filled with the liquid metal before applying pressure. (20)

### 5.2 Stir casting process

Stir casting of metal matrix composites (MMC) was initiated in 1968, when S. Ray introduced alumina particles into aluminum melt by stirring molten aluminum alloys containing the ceramic powders. In a stir casting process, the reinforcing phases are distributed into molten matrix by mechanical stirrer. The resultant molten alloy, with ceramic particles, can then be used for die casting, permanent mound casting, or sand casting. Stir casting is suitable for manufacturing composites with up to 30% volume fractions of reinforcement. The cast composites are sometimes further

extruded to reduce porosity, refine the microstructure, and homogenize the distribution of the reinforcement. (2)

The final distribution of the particles in the solid depends on material properties and process parameters such as the wet condition of the particles with the melt, strength of mixing, relative density, and rate of solidification. In Fig 1 show that diagram of stir casting and the distribution of the particles in the molten matrix depends on the geometry of the mechanical stirrer, stirring parameters, placement of the mechanical stirrer in the melt, melting temperature, and the characteristics of the particles added. The melt is then cooled down to a temperature between the liquids and solidus points and kept in a semi-solid state.(22)

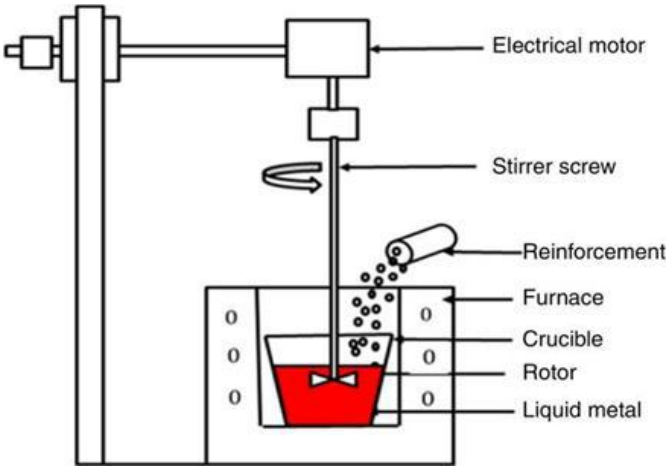



Fig 1: Schematic Diagram of Stir Casting Process.

There are different routes by which MMCs may be manufactured, and among all the liquid-state processes, stir casting technology is considered to have the most potential for engineering applications in terms of production capacity and cost efficiency Casting techniques are economical, easier to apply and more convenient for mass production In preparing metal matrix composites by stir casting method some of the factors that need considerable attention are as follows,

1. To achieve uniform distribution of the reinforcement material
2. To achieve Wet ability between the two main substances
3. To minimize porosity in the cast metal matrix composite (20)

**4.7.3.1 Characterization of stir casting**

Content of dispersed phase are limited (usually not more than 30% by volume)

Distribution of dispersed phase throughout the matrix is not perfectly homogeneous

1. There are local clouds of the dispersed particles
2. There may be gravity segregation of the dispersed phase due to a difference in the densities of the dispersed and matrix phases.
3. The technology is very simple and low cost3.8

## 6. DESIGN OF EXPERIMENTS

### 6.1. Materials Selection

*A. Aluminum Alloy 6082-*

In the present examination, Al-6082 amalgam was picked as the base lattice as it has the incredible erosion obstruction and high quality in 6000 arrangement combinations. As a moderately new amalgam, the higher quality of Aluminum compound 6082 has seen it supplant 6061 in numerous applications. The expansion of a lot of manganese controls the grain structure which thusly brings about a more grounded amalgam. The beneath table gives us the concoction arrangement of Al6082 the rest is aluminum.(11)

**Table -1;** Chemical Composition of Al-6082 alloy

| Element | % |
|---|---|
| Si | 0.7-1.3 |
| Fe | 0.5 |
| Cu | 0.1 |
| Mn | 0.4-1.0 |
| Mg | 0.6-1.2 |
| Zn | 0.2 |
| Ti | 0.1 |
| Cr | 0.2 |
| Re | 95.43 |

*B. Short Fiber Alumina-*

Its high quality mechanical properties, warm security, mechanical similarity, concoction similarity, high youthful's modulus, great monetary productivity. Its intermittent sorts of fiber or particles give great particular firmness and quality. it has beneficial outcome on the hardness, wear obstruction, weakness opposition and pressure obstruction. (4)

**Table -2 ;** Chemical composition of short fiber alumina

| Sr.no | Element | Wt % |
|---|---|---|
| 1 | Al2O3 | 96-97 |
| 2 | SiO2 | 3-4 |
| 3 | Fe | 0.040 |
| 4 | Cr | 0.006 |
| 5 | Ni | 0.014 |
| 6 | Mg | 0.013 |
| 7 | Na | 0.088 |
| 8 | Ca | 0.053 |
| 9 | Chloride | 0.008 |

*A. Fabrication of Composite Material-*

The creation of composites materials by utilizing blend throwing is done in materials research center of Reliable laboratories, Thane. Its fluid metallurgy method process. Since blend throwing process is efficient, large scale manufacturing & required size and state of composite can be delivered. Its appeared in fig 1 mix throwing process has been utilized to created aluminum and alumina composite material with various example of composite materials.(9)

**Table-3** Composition of aluminium with alumina Composite Materials

| Sr.no | Sample | % of alumina |
|---|---|---|
| 1 | Al 6082 | 0 |
| 2 | Al 6082+ alumina | 10 |
| 3 | Al 6082+ alumina | 15 |
| 4 | Al 6082+ alumina | 20 |

Synthetic sythesis of aluminum 6082 and Al2O3 appeared in tables 1 and 2. An electric heater was utilized as first phase of liquefying the aluminum in the cauldrons at the climatic condition. The softening of aluminum take set at 700c which is accomplished in 1 hours. After accomplishing 700c temperature heater kept on consistent temperature of 700c for 30 minutes. Preheated alumina down to earth included liquid metal through pipe. Alumina particles are preheated to a temperature of 300c at the same time. the support are preheated to enhance the wet capacity, evacuate dampness and furthermore to diminish temperature inclination between liquid metal and fortification. Alumina included 10% 15%,20% by weight in dissolved aluminum amalgam for various sythesis. Also, electrical obstruction heater collected with graphite impeller utilized as blended was utilized for stirrings reason. After alumina augmentations fluid , metal – support blend was mixed for30 minutes .at last composite were poured in preheated metal molds at 700c. lastly take up example.(16)

Fig 1. Sample of Composition

The readied example test was prepared for handling; it is to be machined on machine in the wake of cutting on control hack saw. The example turned on machine to get required measurements and wrapping up. The required measurement of Ø10×30 mm is acquired on machine. Along these lines the example of various organizations prepared for wear test.(1)

Fig 2.Specimen Pin For Wear Test.

For the most part the external race split cushion is comprised of treated steel and low steel, semi metallic material. So partner i.e. break cushion material is likewise chosen as made up of same material. Plate material chose as steel with grade EN8.(12)

Fig 3.En8 Disc

Fig 4: Pin on Disc Apparatus

VII. EXPERIMENTAL WORK

*A. Wear Test*

The readied tests were utilized for tribological test on Wear and grinding screen at PG Laboratory, Department of Mechanical Engineering in Dr.Vitthalraovikhepatil College of Engineering, Ahmednagar. The stick on circle is a device used to decide Tribological properties of composite materials. The composite material example stick is put on a spoil acting plate which pivoting at a variable RPM. Dry sliding wear test "stick - on - circle" component appeared in fig 4. The composite examples are readied is as indicated by ASTMG99 Slandered. the breadth of the slider plate made up of solidified steel having distance across 165mm and 8mm thickness. The stick test measurements are 10mm width with 30mm stature. The test is directed in dry sliding conditions. The weight has been estimated in a computerized adjust having slightest tally 0.1mg.after each test the plate is cleaned . To direct the wear analyze 3 levels of load and 3 levels of speed are considered. The heap go is taken to be 20 N to 60 N and sliding speed is taken to be 1.03 to 3.14 m/s. Its appeared in tables(20)

**Table -4** ; Process Parameter Wear Test

| Sr.no | Parameter | Value |
|---|---|---|
| 1 | Sliding velocity m/s | 1.03 to 3.14 |
| 2 | Normal load N | 20 to 60 |
| 3 | Test duration (sec) | 750-900 |
| 4 | Track diameter (mm) | 60-140 |
| 5 | RPM | 1000 to 1400 |

*B. Hardness Test*

Hardness is the resistance of materials to localized deformation. A hard material surface resists indentation or scratching and ability to indent or cut material. Hardness of the four stir casted sample was tested on Brinell hardness tester. In the Brinell hardness test a hardened steel ball is pressed into the flat surface of test pieces using force 500kgf to 1000kgf. The ball is removed the diameter of resulting indentation is measure using a microscope. Reading on three location are taken and average reading of each sample was considered.

The density is the physical property of the material. The density of the material can be defined has mass per unit (15)

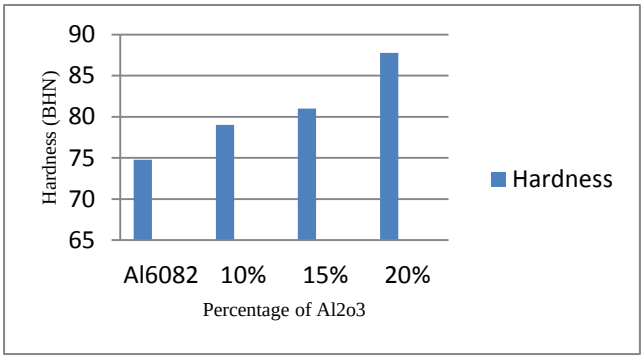
VIII. RESULTS& DISCUSSIONS

*A. Hardness test*

Table show hardness of the composite among the different specimen.Al6082 with 20%alumina has the highest hardness 87.66 BHN. for sample Al6082 with 10% hardness is 81.01 BHN and sample Al6082 with 15% hardness is 79BHN. The hardness between second and thired sample increased only 2%. But sample four is increased hardness 7% as compared to both sample.

**Table -5** Show Hardness of the Composite Specimen

| Properties | Al6082 | 10% | 15% | 20% |
|---|---|---|---|---|
| Hardness (BHN) | 74.77 | 79 | 81 | 87.66 |



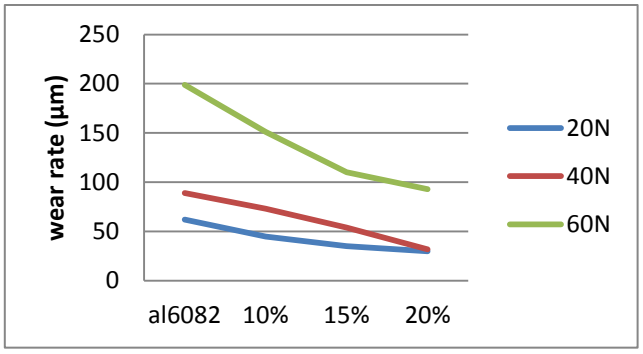

Graph3:Shows Variation of Hardness And Composite

*B. Wear Test*

Sliding wear examination demonstrate the variety of wear rate with sythesis of alumina particles. Its demonstrate the impact of alumina on wear rate for various load condition with rpm. the diagram demonstrates wear rate of composite for various load and track breadth. Al-based composite demonstrates a diminishing in wear rate with expanding substance of Al2O3 support which goes about as hindrance to shear disfigurement.

**Table -6** Show Wear Rate of Composite

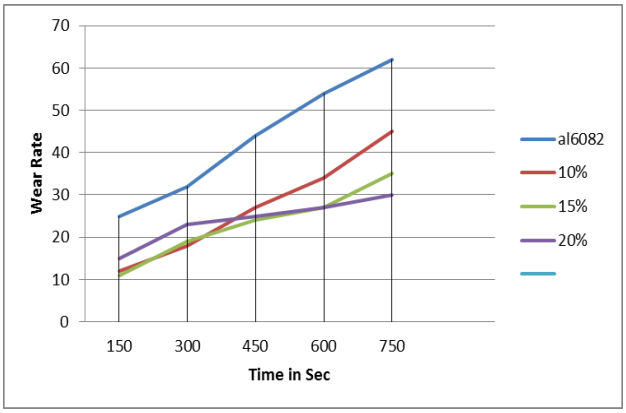
| Sr. no | Material | Load N | Wear rate( $\mu m$) |
|---|---|---|---|
| 1 | Aluminium 6082 | 20 | 62 |
| 2 | | 40 | 89 |
| 3 | | 60 | 199 |
| 4 | Al6082 with10%Al2O3 | 20 | 45 |
| 5 | | 40 | 73 |
| 6 | | 60 | 151 |
| 7 | Al6082with15 %Al2O3 | 20 | 35 |
| 8 | | 40 | 54 |
| 9 | | 60 | 110 |
| 10 | Al6082with20 %Al2O3 | 20 | 30 |
| 11 | | 40 | 32 |
| 12 | | 60 | 93 |



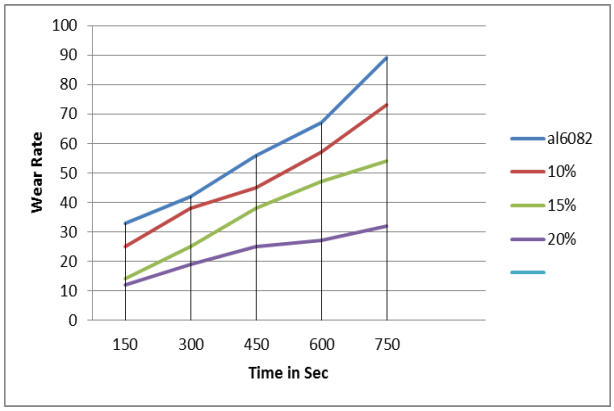

Graph 5. Show Wear Rate Of Composites

The graph show wear rate of Al-based composite with addition of Al2O3.The wear rate of pure aluminum is greater than other composite.the reniforcement particals is increased so wear rate is decreased. The load is increased that wear rate is increased.but rpm is increased so wear rate is decreasd.the adding Al2O3 then reduced wear rate.

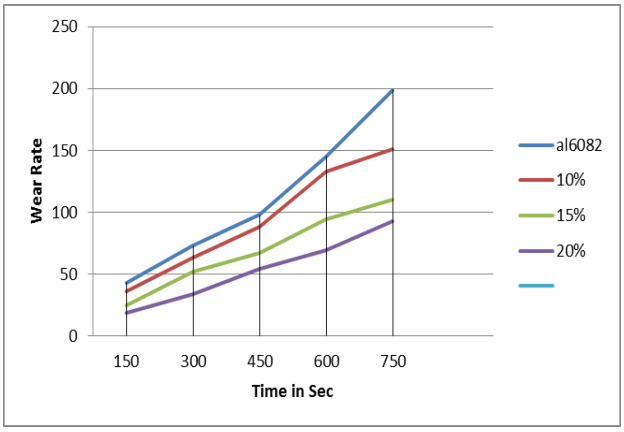
The graph a,b,c shows wear rate vs time of composite.




Graph 6. 20 N




Graph 7.40 N




Graph 8. 60 N

## 7. CONCLUSIONS

1)From the test result the tensile test of the three different wt% of composite sample. The addition of Al2o3 the tensile strength is increased up to 20%.

2) Sample 10% Al2O3 and 20%Al2O3 increased tensile strength as compared sample 15% Al2O3.but yield stress of sample 10% is decreased as compare to other sample.

3) Also elongation is decreased addition of Al2O3. Hardness of composite is increased when addition of reinforcement material.

4)Density variation in different composition for sample 10% Al2O3 is decreased as compare to other both sample and also porosity is decreased.

5) After conduct wear test so find out wear properties of materials. When load is increased that wear rate is increased but adding reinforcement so decreased wear rate of composite. The rpm is increased so wear rate of material is reduced.

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