# EVALUTION OF MECHANICAL PROPERTIES OF ALUMINIUM/ SILICON CARBIDE /FLY ASH BRAKE ROTOR

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**Abstract** -*Gray cast iron is the most commonly used material in automobile brake rotors. It generates heat easily during braking which affects its mechanical properties and the Coefficient of friction varies depending on the type of material used for the brake rotor. Aluminium (Al) based metal matrix composite gives good braking material compared to cast iron and matrix alloy. In present project, Al composites were fabricated by stir casting method by varying weight percentage of reinforcements for Sample1 (Al 95% + SiC 5%),Sample 2 (Al 90% + SiC 10%), Sample 3(Al 95% + Fly ash 5%), Sample 4(Al 90% + Fly ash 10% ), Sample 5 (Al 90% + SiC 5% + fly ash 5%). The hardness, wear test and tensile test were performed to study the mechanical behavior of all the test specimens. Composites containing hard oxides (like SiC) are preferred for high wear resistance along with increased hardness and high temperature oxidation resistance. The result reveals that wear rates of the composite materials is lower than that of the matrix alloy and friction coefficient was minimum. Also, it improves the micro hardness and tensile strength.*

***Key Words***: Aluminum, silicon carbide, Fly Ash, sand casting technique.

## I. INTRODUCTION

Current engineering applications require materials that are stronger, lighter and less expensive. A good example is the current interest in the development of materials that have good strength to weight ratio suitable for automobile applications where fuel economy with improved engine performance are becoming more critical [1]. In-service performance demands for many modern engineering systems require materials with broad spectrum of properties, which are quite difficult to meet using monolithic material systems [2]. Metal matrix composites (MMCs) have been noted to offer such tailored property combinations required in a wide range of engineering applications [1,2]. Some of these property combinations include high specific strength, low coefficient thermal expansion and high thermal resistance, good damping capacities, superior wear resistance, high specific stiffness and satisfactory levels of corrosion resistance [3–5]. MMCs are fast replacing conventional metallic alloys in so many applications as their use have been extended from predominantly aerospace and automobile to defense , marine, sports and recreation industries.

## 2. Problem Identified

All the engineering applications require materials that should have good strength to weight ratio, wear resistance. Most researchers studied Al–SiC with varying reinforcement material SiC volume fraction from 1% to 20%. It is found that wear resistance of Al–SiC increases with increase in volume fraction 5-15% SiC reinforcement and Coefficient of friction value was found to decrease with increase in volume fraction 5- 15% SiC reinforcement beyond 15% SiC there is slight increase in the wear resistance and slight decrease in coefficient of friction but hardness material is increased. Therefore the relatively poor seizure resistance of aluminium alloy restricted to uses in some engineering applications. Need for improved mechanical properties of metal matrix composites.

## 3. Objectives

- To fabricate the samples of Al+SiC,Al+ Fly Ash , Al+ SiC+ Fly ash combination by varying the percentage of SiC and Fly ash using sand Casting Technique.
- To find theTensile strength, hardnessand wear rate using various testing equipments.

## 4. Materials and methods

### 4.1Materials

The matrix material used in the present investigation was pure aluminium. Aluminium was purchased from sai shradha marketing services, pune, India. Silicon carbide, fly ash were commercially available.

### 4.2Experimental Work

The casting method (also called liquid state method) is used for the hybrid composite materials fabrication, in which a dispersed phase is mixed with a molten matrix metal by means of mechanical stirring. The liquid composite molten material is then cast by casting methods and processed by metal forming technologies. The aluminium-SiC, aluminum-fly ash, aluminium-SiC-fly ash metal matrix hybrid composite was prepared by casting route with Manual stirring For this we have chosen aluminum 6061 has base material and desired amount of SiC, fly ash, SiC-fly ash mixtures in powder form. The fly ash and SiC and their mixture were preheated to 300°C to remove moisture. Aluminum was melted in a resistance furnace (Fig. 1). The melt temperature was raised up to 720°C and then the melt was stirred with the help of a mild steel stirrer. The stirring was proceed for 5 to 7 min and raised the temperature upto 700°C that is the melting point of aluminium, and then addition of SiC, fly ash, SiC-fly ash mixture particles was done. The dispersion of fly ash and other particles were achieved by the vortex method. The melt with reinforced particulates were poured into the preheated sand mold. The pouring temperature was maintained at 680ºC. Then the molten mass was allowed to solidify in the mould (Fig. 2). The metal matrix hybrid composites that we obtained are shown in the Fig. 3.

**Fig -1**: Electric Resistance furnace

**Fig -2**: Mould

**Fig -3**: Composite material specimen obtained from mould

## 5. Material Properties

### 5.1 Fly Ash

Density = **0**.542 gm/cc

**Fig -4**: **Fly Ash**

**Table-1**: **Chemical composition of Fly ash (Weight Percentage)**

| $Al_2O_3$ | $SiO_2$ | $Fe_2O_3$ | $TiO_2$ | Loss of Ignition |
|---|---|---|---|---|
| **28.44** | **59.96** | **8.85** | **2.75** | **1.43** |

### 5.2 Silicon carbide

SiC = 88.2%
Si content in SiC (69% SiC) = 58.45%
Carbon content in SiC (29% SiC) = 24.25%
Density = 1.39gm/cc

### 5.3 Al 6061 (Base Material)

Density = 1.39gm/cc

**Table-2**: **combinations of metal matrix composites fabricated from sand casting technique**

| Sr.no. | Combination | |
|---|---|---|
| 1 | Al 95% + SiC 5% |  |
| 2 | Al 90% + SiC 10% |  |

| | | |
|---|---|---|
| 3 | Al 95% + Fly ash 5% |  |
| 4 | Al 90% + Fly ash 10% |  |
| 5 | Al 90% + SiC 5% + fly ash 5% |  |

## 6. Testing Machines

### 6.1 Universal Testing Machine

**Fig -5**: **Universal Testing Machine**

**Table-3**: **Tensile Testing Machine**

| Sr.no. | Combination | Micro structure |
|---|---|---|
| 1 | Al 95% + SiC 5% |  |
| 2 | Al 90% + SiC 10% |  |
| 3 | Al 95% + Fly ash 5% AND Al 90% + Fly ash 10% |  |
| 4 | Al 90% + SiC 5% + fly ash 5% |  |

### 6.2 Brinnel Hardness testing machine


**Fig -6**: **Brinnel Hardness Testing Machine**

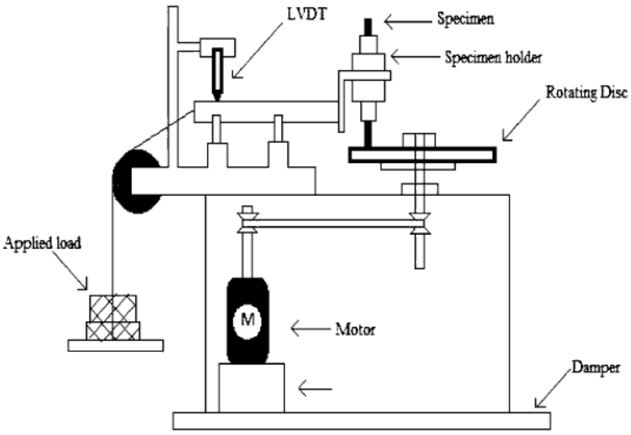
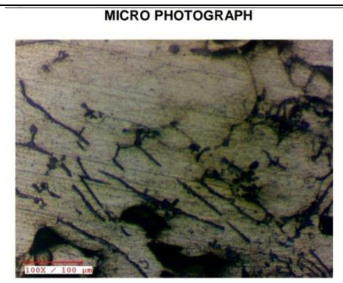


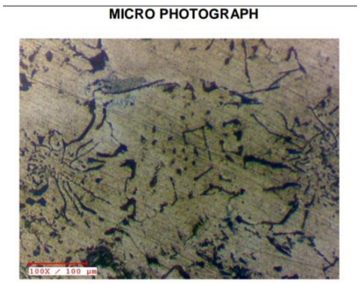
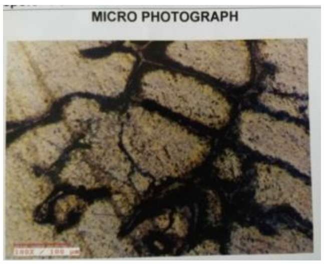
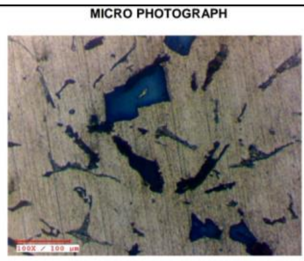

**Fig -7**: **Wear testing machine**

**Table-4**: **Pin and disk samples**

| **Sr.no.** | **Combination** | **DISC** |
|---|---|---|
| 1 | Al 95% + SiC 5% |  |
| 2 | Al 90% + SiC 10% |  |
| 3 | Al 95% + Fly ash 5% |  |
| 4 | Al 90% + Fly ash 10% |  |
| 5 | Al 90% + SiC 5% + fly ash 5% |  |

**Table-5**: **All the samples were micro examined for microstructure. The test method was ASM Vol.9:2004 , magnified at 100x**

| **Sr.no.** | **Combination** | **Mircostructure** |
|---|---|---|
| 1 | Al 95% + SiC 5% |   |

| | | |
|---|---|---|
| 2 | Al 90% + SiC 10% |   |
| 3 | Al 95% + Fly ash 5% |   |
| 4 | Al 90% + Fly ash 10% |   |
| 5 | Al 90% + SiC 5% + fly ash 5% |   |

## 7. Experimental Results

**Table-6: Tensile Strength**

| Sr.no. | Combination | N/mm² |
|---|---|---|
| 1 | Al 95% + SiC 5% | 107 |
| 2 | Al 90% + SiC 10% | 112 |
| 3 | Al 95% + Fly ash 5% | 125 |
| 4 | Al 90% + Fly ash 10% | 128 |
| 5 | Al 90% + SiC 5% + fly ash 5% | 137 |

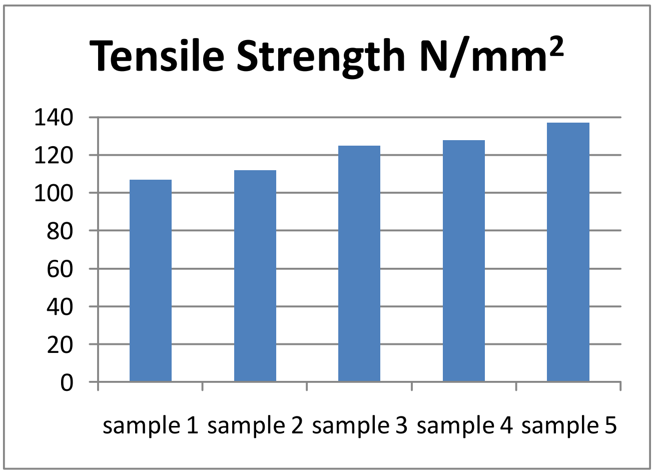



**Fig -8: Graph showing the results of tensile strength**

**Table-7: Hardness**

| Sr.no. | Combination | BHN |
|---|---|---|
| 1 | Al 95% + SiC 5% | 39 |
| 2 | Al 90% + SiC 10% | 40 |
| 3 | Al 95% + Fly ash 5% | 55 |
| 4 | Al 90% + Fly ash 10% | 61 |
| 5 | Al 90% + SiC 5% + fly ash 5% | 59 |

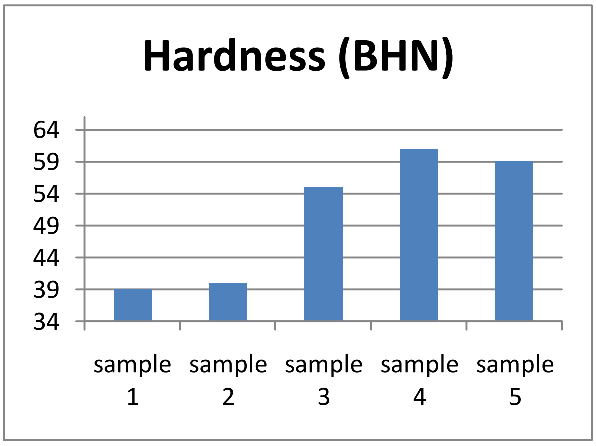



**Fig -9: Graph showing the results of Hardness.**

**Table-8: Wear test**

| Parameters | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 |
|---|---|---|---|---|---|
| Speed in (RPM) | 500 | 500 | 500 | 500 | 500 |
| Time in | 5 | 5 | 5 | 5 | 5 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (Min) | | | | | | | | | | | |
| Track Radius (mm) | | 40 | | 40 | | 40 | | 40 | | 40 | |
| Load in (Kg) | | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| Weight in gms | Before | 9.07 | 9.12 | 9.11 | 9.08 | 9.03 | 9.07 | 9.08 | 9.11 | 9.17 | 9.16 |
| | After | 9.06 | 9.10 | 9.08 | 9.06 | 8.67 | 8.85 | 9.02 | 9.03 | 9.164 | 9.131 |
| Coefficient of friction | | 0.48 | 0.51 | 0.50 | 0.54 | 0.41 | 0.43 | 0.44 | 0.47 | 0.36 | 0.42 |
| Frictional Force in (N) | | 4 | 8 | 5 | 11 | 4.5 | 10 | 5 | 10 | 4 | 9 |
| Wear (micrometers) | | 28 | 136 | 32 | 140 | 46 | 156 | 54 | 163 | 63 | 172 |

## 8. CONCLUSION

From the test result the tensile strength of the five different wt.% composite sample is increased gradually and addition of 5%SiC+5% fly ash sample is to get higher tensile strength 137 N/mm$^2$compared with other Samples. Al alloy 6061 with SiC + fly ash composite material is less in weight than the Al of the same dimensions. For all applied loads, AMMC show a stable friction coefficient (0.30-0.60) which is essential for brake rotor applications. This indicates that the AMMCs having low weight and high strength, it is very much useful in practical automobile applications.

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