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# External Investigation and Various Behaviour Analysis of LM356 Hybrid Metal Matrix Composites Reinforced with SiC and Flyash

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**ABSTRACT:** Stir casting is an economical process for the fabrication of aluminum matrix composites. There are many parameters in this process which affect the mechanical properties of the composites. In this study, SiC, B<sub>4</sub>C particles were used as reinforcement to fabricate. The different compositions in volume fraction were chosen namely 90%Al 8%SiC 2%B<sub>4</sub>C, 90%Al 5%SiC 5%B<sub>4</sub>C, 90%Al 3%SiC 7%B<sub>4</sub>C. Finally, the mechanical properties of the composites were Evaluate and their relation with the corresponding process parameters of the composites.

**KEYWORDS:** Aluminium;Silicon carbide;Boron carbide; Reinforcement;Metal matrix composite; Stir casting process;Mechanical properties.

## I. INTRODUCTION

The growing need for lightweight, fuel-efficient, and comfortable vehicles in the automotive sector has prompted the advancement of innovative materials and optimized designs. This heightened demand for lightweight materials with specific strength characteristics in both the aerospace and automotive industries has facilitated the development and application of a particular category of composites known as metal-matrix composites (MMCs). MMCs are extensively utilized across various industries due to their remarkable mechanical properties and resistance to wear. Over time, MMCs have gradually supplanted certain traditional lightweight metallic alloys, including various grades of aluminum alloys, in applications where minimizing weight and conserving energy are critical, all while maintaining the strength of the components. A metal matrix composite (MMC) is characterized by a metallic matrix, typically an alloy of aluminum, copper, iron, magnesium, titanium, or lead, which contains three-dimensional inclusions, often in the form of oxides, carbides, or nitrides. In these composites, the desirable ductility of the metallic alloy matrix is preserved, while the modulus and strength are enhanced through the incorporation of reinforcement phases. By carefully selecting the matrix material and reinforcements, MMCs can be engineered to exhibit superior electrical, mechanical, and even chemical properties. This capability is particularly vital in scenarios where traditional metals and alloys fail to meet the increasingly rigorous standards set by designers and engineers in modern engineering applications. Metal-matrix composites (MMCs) are capable of enduring significant tensile and compressive stresses by effectively transferring and distributing the applied load from the ductile matrix to the reinforcement phase. The fabrication of these MMCs involves integrating a reinforcement phase into the matrix using various techniques, including powder metallurgy, liquid metallurgy, and squeeze-casting. The inclusions in MMCs can take the form of continuous fibers, discontinuous particulates, or whiskers, with particulates serving as excellent inclusions due to their predictable performance.

## II. LITERATURE SURVEY

A.ANISH [1]et.al were investigated Tungsten Carbide (WC) particulate and Molybdenum Disulphide (MoS<sub>2</sub>) as reinforcements. The metal matrix composites are fabricated by stir-casting process. The Tungsten Carbide particulate was added in proportions of 2%, 4%, 6%, 8% and 10% and Molybdenum Disulphide was added in constant proportion of 4% on mass fraction basis to the molten metal. The different combination sets of composites were prepared.



Mechanical properties like hardness and tensile strength were studied for both reinforced and unreinforced Al7075 samples. Microstructure examination was carried by using Metallurgical Microscope to obtain the distribution of Tungsten Carbide particulate and Molybdenum Disulphide in base matrix. From the results, it was found that the hardness and tensile strength of the prepared metal matrix composites increases with increasing weight percentage of Tungsten Carbide, however a decreasing trend of hardness is found at 8% and 10% of Tungsten Carbide. This could be attributed to agglomeration of the Tungsten Carbide particles due to insufficient rpm of the stirrer.

**RAJESH PRABHA N [2]** et.al were investigated the mechanical behaviors like hardness, tensile and thermal evaluation have been investigated. In this work revealed that the addition of TiC improves the damage resistance of aluminium composites. The outcomes confirmed that the mechanical residences, along with tensile electricity, spectrum examine expanded with the aid of the proportion of TiC present within the samples when compared with base aluminium alloy. The outcomes of composites have a higher composition in addition with Al7075. The SEM-XRD analysis found out the occurrence of TiC in the metal matrix. The best composition of hybrid composite become found with nine 9wt% TiC composite in comparison to different compositions

**AJITH ARUL DANIELA[3]** et.al were studied the influence of weight percentage of silicon carbide (SiC) (5, 10 %, 15%) and particle size (10, 20, 40 $\mu$ m) of SiC and constant 2% of Molybdenum disulphide(MoS<sub>2</sub>) is reinforced with aluminium matrix. Wear performance of the composite was carried out through pin-on-disc method to calculate friction coefficient and wear resistance of the composites. The experiments were conducted by varying the sliding speed of (1.5, 2.5 & 3.5 m/s), loads (30, 50 & 70N) with sliding distance ranges from (500, 1000 & 1500m) under dry sliding conditions. Taguchi plan of experiments and ANOVA method was carried out to find the outcome of reinforcement ceramic particles, sliding distance, sliding speed, and applied load over the friction coefficient and wear rate. The result reveals that applied load and sliding distance are the most influencing factors for friction coefficient. Load and percentage of SiC indicates the most affecting factor for wear rate. Worn out surface of the composites were studied by optical microscopic image and Gwyddion software. To conclude, it was interfered that 15% weight percentage of SiC at 10 $\mu$ m offers better wear resistance and friction coefficient in AHMMCs.

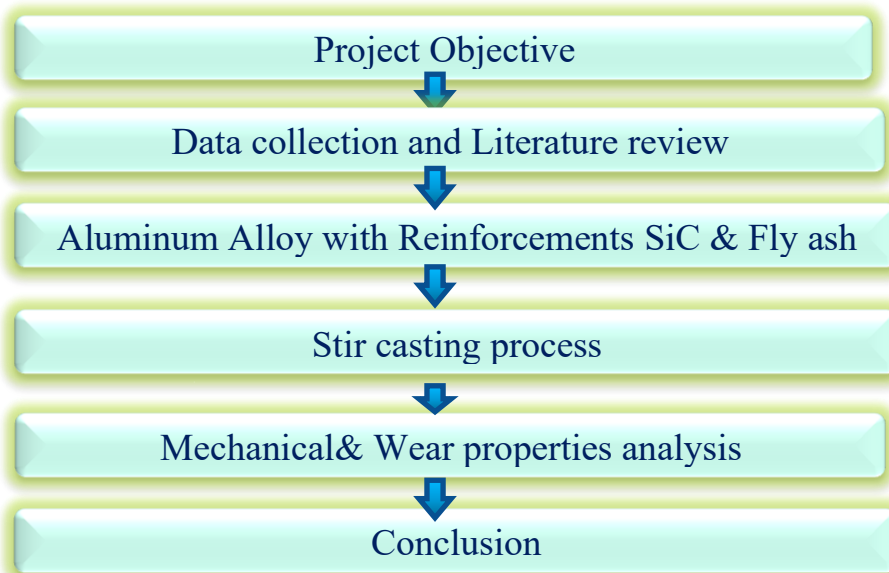
**P. PARANTHAMAN [4]** et.al were developed with Varying percentage of rice husk ash (5, 10, 15 wt. %) and constant wt. % of molybdenum disulphide (MoS<sub>2</sub>) (3 wt. %) was used as reinforcement to improve the wear resistance of base material. Tribological behaviour of hybrid composite was studied with various wear parameter viz. applied load (10, 20, 30N) and sliding velocity (2, 4, 6 m/s). Taguchi approach was adopted for design of experiment. Multi objective optimization of wear parameter has been carried by Grey relation analysis. Results revealed that applied load acts as the major parameter for governing the wear parameter and other parameter exhibits least influence.

**S. SENTHIL MURUGAN [5]** et.al were experimentally studied composites with two different reinforcements (SiC, Al<sub>2</sub>O<sub>3</sub>) were prepared using stir casting setup. The properties of the developed composites were studied and the values were reported. It was noted that reinforcements increased the strength and reduced the weight of the composites. In this work, Fabrication of composite with Al.6061-20% SiC- 7% Al<sub>2</sub>O<sub>3</sub> for IC engine Pushrod and structural analysis were main objectives. ANSYS workbench software package was utilized to study the structural stability of the pushrod.

### **III. METHODOLOGY**

#### **OBJECTIVE**

The objectives of the current study focus on the increasing demand for composite materials, which are favored for their advantageous characteristics such as low density, excellent wear resistance, high tensile strength, and superior surface finish. Silicon carbide (SiC) and fly ash serve as cost-effective and lightweight reinforcements. This study will also consider tensile strength and wear properties. To achieve these goals, an experimental setup has been established to incorporate all necessary inputs. In this research, a composite material is created by incorporating SiC and fly ash into aluminum at varying weight ratios. The composite will be produced using the stir casting technique and will undergo analysis of various mechanical properties.



## 1.MECHANICAL PROPERTIES RESULT

### HARDNESS VALUE

Below mentioned HRB value obtained from hardness inspection by using Shivganga testing machine.

Table: 7.1 Hardness value of hybrid AMMC

S.NO	COMPOSITION	HARDNESS		AVG HARDNESS HRB
R <sub>1</sub>	SiC -2.5% + Flyash-5% & Mg- 1%	36	41	39
R <sub>2</sub>	SiC -5% + Flyash-7.5% & Mg- 1%	42	44	43

Hardness Test Graph

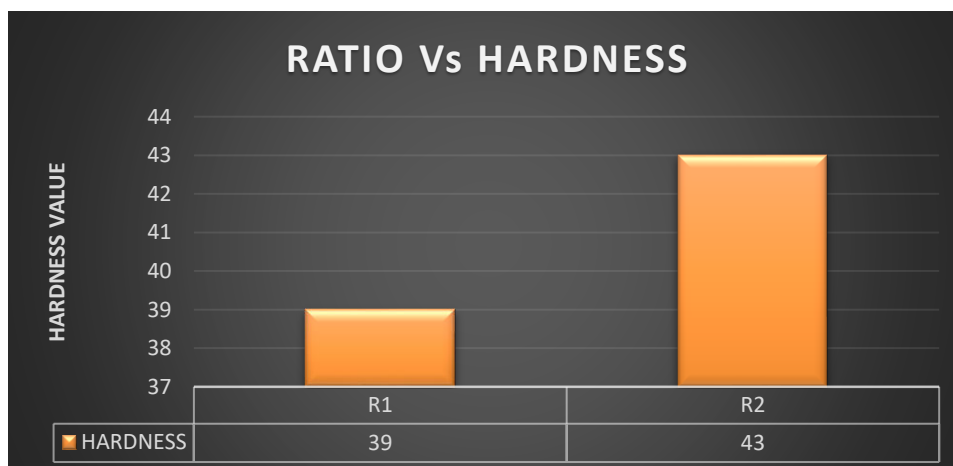


Figure: 7.1 Graphical representation of Hardness value

The higher level percentage of silicon carbide and fly as induces the maximum hardness of the AMMC (43 HRB).

## 2. TENSILE STRENGTH VALUES OF HYBRID AMMC

Table: 2 Tensile Strength values

SAMPLE	Dia mm	CSA mm <sup>2</sup>	TL KN	TS N/mm <sup>2</sup>
R <sub>1</sub>	13	132.73	20.66	155.65
R <sub>2</sub>	13	132.73	19.51	146.99

Graphical representation of Tensile strength

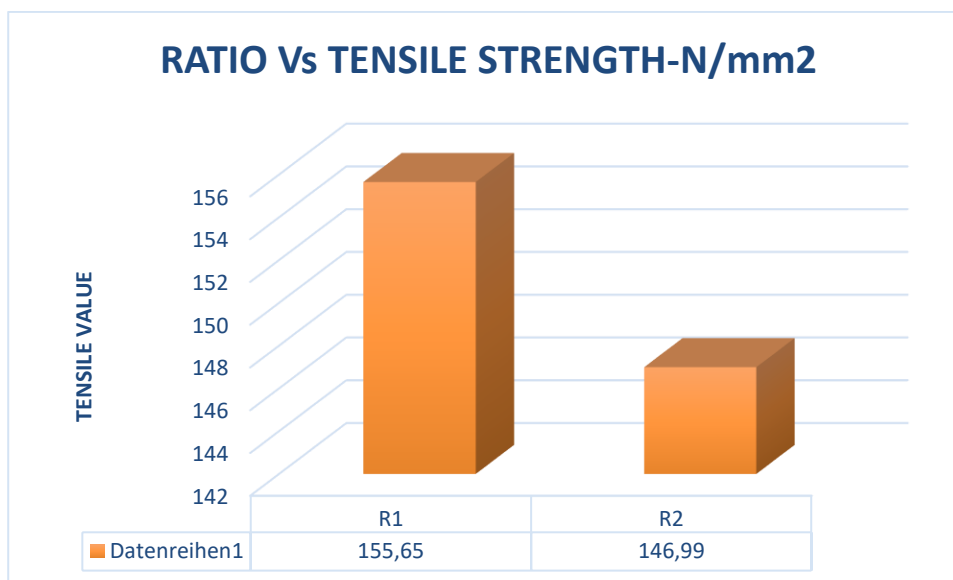


Figure: 7.2 Graphical representation of Tensile strength value

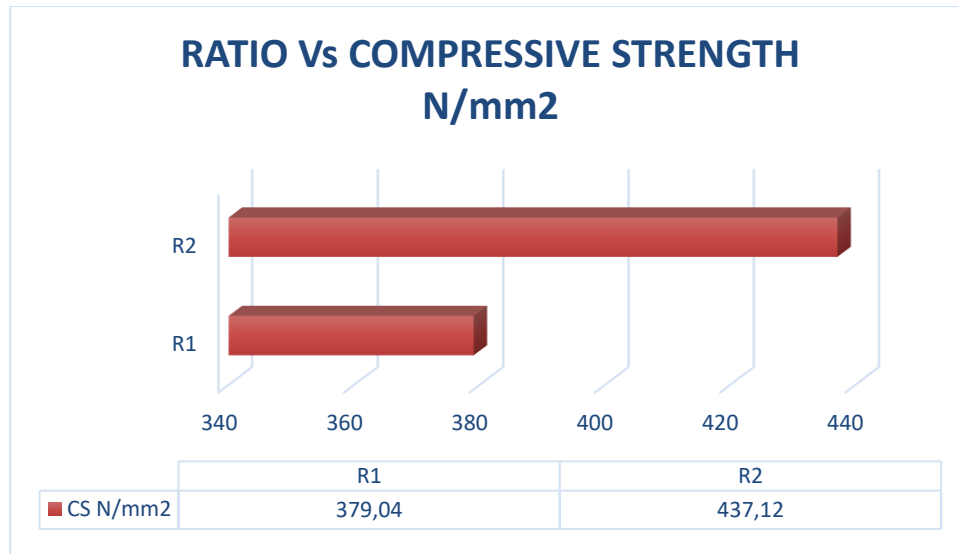
The lower percentage of silicon carbide and Fly ash induces ultimate tensile strength.

## 3 COMPRESSIVE STRENGTH VALUES

Table: 7.3 Compression Strength values

SAMPLE	Dia mm	CSA mm <sup>2</sup>	CL KN	CS N/mm <sup>2</sup>
R <sub>1</sub>	13	132.73	50.31	379.04
R <sub>2</sub>	13	132.73	58.02	437.12

Graphical representation of compressive strength



Graphical representation of compressive strength value

The higher percentage of Silicon carbide and Fly ash induces more compressive strength. Lower level percentages of reinforcements induces of minimum compressive strength.

#### 4. TRIBOLOGICAL ANALYSIS

##### WEAR TEST

A tribometer is an instrument that measures tribological quantities, such as coefficient of friction, friction force, and wear volume, between two surfaces in contact. A tribotester is the general name given to a machine or device used to perform tests and simulations of wear, friction and lubrication which are the subject of the study of tribology. Often tribotesters are extremely specific in their function and are fabricated by manufacturers who desire to test and analyze the long-term performance of their products. An example is that of orthopedic implant manufacturers who have spent considerable sums of money to develop tribotesters that accurately reproduce the motions and forces that occur in human hip joints so that they can perform accelerated wear tests of their products.



**Figure 1 Pin-On Disc setup**

## 5. TEST RESULTS

TECHNICAL SPECIFICATION OF WEAR MACHINE –PIN ON DISC Test Speed: 478 RPM, Normal Load: 20 N, Pin Dia: 40mm, Sliding distance: 500m, Sliding distance-40 mm

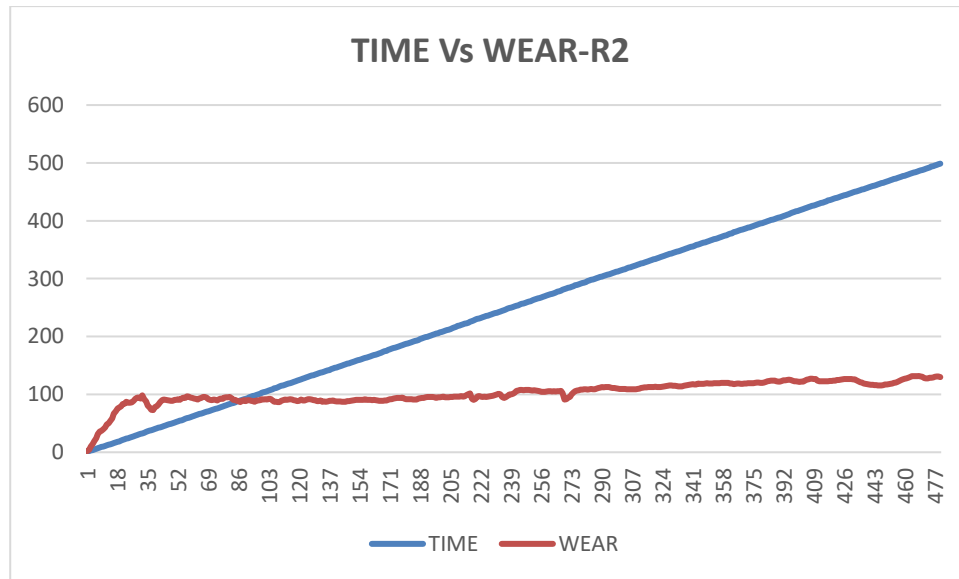


Figure 8.4: Time- Vs Wear rate -R2

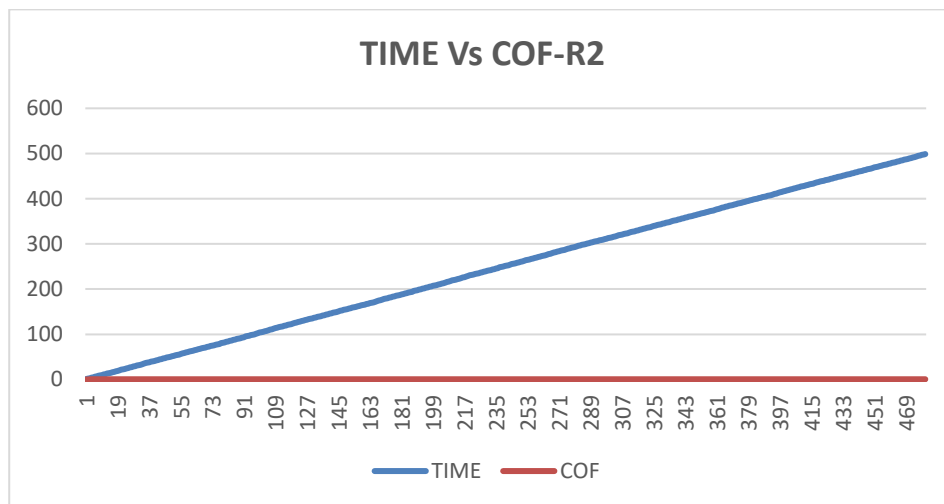


Figure 8.5: Time- Vs COF-R2

### 8.2.3 Weight of testing specimen before and after

Table: 8.1 Wear rate of the different AMMC ratios

1) Samples	2) Initial weight g	3) Final weight g	4) Wear loss in g
5) R1	6) 4.353	7) 4.342	8) 0.011
9) R2	10) 4.386	11) 4.384	12) 0.002

## 6. SPECIFICATION

Table: 8.2 Specification

Test parameters				Machine setting			
Expt . No.	Applied Load (N)	Sliding velocity (m/sec)	Sliding Distance (m)	Sliding dia in mm	R.P.M	Time in secs	Time in min:secs
R1	20	1	500	40	478	500	8.332
R2	20	1	500	40	478	500	8.332

## IV. CONCLUSION

The incorporation of Silicon carbide and Fly ash (SiC & FA) particles into the LM-356 matrix alloy has been successfully achieved using the Stir casting technique. The mechanical and tribological properties of the composite materials, specifically aluminium LM-356 Silicon carbide and Fly ash composites, exhibit a range from minimal to maximal reinforcements in the metal matrix composites (MMCs). These materials are utilized in various industrial applications due to their lightweight and high hardness characteristics. The investigation revealed that the mechanical properties of the LM-356 metal matrix were significantly enhanced by the reinforcement of Silicon carbide and Fly ash. Furthermore, the analysis indicated that the metal matrix demonstrated a variety of mechanical behaviors, with hardness and compressive strength improving at lower levels of reinforcement. A minimal percentage of reinforcement in the matrix resulted in increased tensile strength, while the wear rate was notably low at the highest percentage of reinforcements in the LM-356 AMMCs.

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