

# Dry Slidingwear Characterization Of Al-SiC Composite By Stir Casting Technique

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**ABSTRACT:** In this work attempt has been made to evaluate the wear characteristics of Al-SiC composites prepared by using stir casting technique. Using pin on disc type wear testing machine wear characteristics under dry sliding condition under the influence of applied load, frictional coefficient, sliding speed were examined. Worn out surface of pins were examined under optical microscope. Wear results indicates that there was increase in wear rate with the applied load and sliding speed.

**KEYWORDS:** Aluminium; metal matrix composite; stir casting; Silicon carbide;

## I. INTRODUCTION

Stir casting is a technique in which the reinforcing materials are distributed into molten metal by means of mechanical stirring. MMC's have the better wear resistance over the unreinforced alloy, Abrasive wear resistance of particle reinforced MMC's increases with volume fraction of particles, under both high and low stress abrasive wear conditions [1]. MMC's have been designed with aim of combining the desirable attributes of metals and ceramics. The addition of refractory particles with high strength, high modulus to a ductile metal matrix produces a material whose mechanical properties are intermediate between matrix alloy and ceramic reinforcement [2]. Development of MMC's with improved wear property has been one of the major requirements in the field of materials science and technology [3]. Aluminium alloy materials or composites are the combination of materials they are produced by combination of two or more materials such that the resulting materials have improved properties, AMC's have high specific strength, thermal stability, corrosion and wear resistance [4]. MMC's are emerging the focus of researchers due to their ability to alter physical properties like tensile, wear, creep and compressive behaviour by varying the filler phase and also due to the requirement of advance materials in areas of automobile, aerospace and marine field has led to development of MMC [5]. Many examinations have been done to study wear behaviour of composites.

### 1.1 Classification of Composites

Based upon the matrix material used, the classification of composites is given in three categories

**Polymer matrix composites (PMC's):** Polymer matrix composites are also known as fiber reinforced polymers, In these materials polymer based resin is used as matrix and various fibers like glass, aramid and carbon as the reinforcement.

**Metal matrix composites (MMC's):** Metal matrix composites have found wide range of applications in aerospace and automobile industries these materials use metal as matrix and organic compounds as reinforcement.

**Ceramic matrix composites (CMC's):** Ceramic matrix composites can be used in very high temperature environments. These materials use matrix as ceramic and reinforcement as short fibers.

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## 1.2 Types of Aluminium alloys

Pure aluminium is a soft material hence in order to overcome this, the metal can be alloyed with other alloying elements. Aluminium alloys are identified according to the international standards. The first digit in the code indicates the major alloying element. Based on the alloying element aluminium alloys are divided into 8 groups.

1xxx series: Contains no alloying elements. Major constituent is aluminium 99.3-99.9% and remaining with tiny impurities.

2xxx series: Contains copper as alloying elements, these are high strength alloys. Strength is increased by heat treatment process. The tensile strength is about 400 mpa on completion of hardening.

3xxx series: Contains manganese as alloying elements.

4xxx series: Contains silicon as alloying elements.

5xxx series: Magnesium is used as alloying elements.

6xxx series: Magnesium and silicon alloying elements.

7xxx series: Among all series this series have high strength contains zn as alloying element [6].

## 1.3 Wear

Wear is defined as the loss of the material on the solid surface due to the rubbing action of hard surface, measure of difference between initial and final weight of the rubbed material.

### Types of Wear

1. Adhesive wear: when two smooth bodies are sliding over each other this type of wear. Relative motion can be reciprocating or unidirectional, due to this fragments from one of the surfaces are pulled off and adhere to other, later fragments may come off the surface on which they are formed and transferred to original surface or may form loose wear particles.
2. Abrasive wear: when rough surface or soft surface containing hard particles slide on a surface which is soft and ploughs grooves in a series and usually occurs in high loads.
3. Corrosive wear: This type of wear occurs when sliding occurs in a corrosive environment. During absence of sliding products of corrosion form a film on a surface tends to arrest corrosion.
4. Surface fatigue wear: Surface fatigue is occurred by repeated rolling or sliding over a track.

## 1.4 Mechanism of Wear

Mild wear: Delamination and oxidation.

Severe: Adhesive, diffusive and abrasive.

Scuffing: Adhesive and diffusive.

Scoring: Abrasive

Pitting: Fatigue and external crack

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## II. RELATED WORK

A B. Gurcan et al [1] studied wear resistance of Al 6061 MMC's along with monolithic materials using pin on disc and proposed that with addition of SiC there was improvement in wear resistance.

J. Hashim et al [2] studied the production of MMC's by low cost stir casting technique and difficulties involved in obtaining a even mixture of SiC.

J P Pathak et al [3] examined the wear behaviour of AMC's under the dry sliding conditions and found improved wear resistance in presence of SiC.

## III. EXPERIMENTAL DETAILS

### 3.1 Material Selection

Al 6061 was chosen as matrix material and SiC powder of 10µm and 20µm was chosen as reinforcement material. The chemical composition of Al 6061 is given below

**TABLE 1: CHEMICAL COMPOSITION OF AL6061**

Element	Al	Cr	Cu	Fe	Mg	Mn	Si	Tn	Zn	Other
Wt%	Balance	0.04	0.15	0.2	0.8	0.15	0.4	0.15	0.25	0.15

### 3.2 Material composition

Experiment was carried out on four varying compositions of SiC reinforced with aluminium alloy. Composition details are mentioned in the table

**Table 2: ADDITION OF SiC TO AL 6061 ALLOY**

Sl. No	Composition	Al 6061 (gm)	SiC (gm)
1	Aluminium 6061	2000	
2	Aluminium 6061 + 3% SiC	1940	60
3	Aluminium 6061 + 6% SiC	1880	120
4	Aluminium 6061 + 9% SiC	1820	180

### 3.3 Manufacturing of Al-SiC AMC by Stir Casting Process

Al-SiC composites were manufactured by using stir casting route. A known quantity of Al 6061 was taken into graphite crucible and placed into aging bath furnace and temperature of furnace was set to 700°C from indicator and furnace is closed till the temperature reaches to 800°C and mold die is assembled by clamp and was kept ready for pouring. Once temperature was attained crucible is taken out and degasser is introduced into melt to prevent oxidation, according to the compositions and mixture was stirred by using power driven portable stirring unit at 150 rpm slag is removed from the melt, mixture was poured at room temperature gradually and uniformly and allowed to cool at room temperature. Solidified Al-SiC is obtained according to composition, Similar process is carried out for different composition.



Fig.1.Aging bath furnace



Fig.2.Portable stirring unit

#### IV. WEAR CHARACTERIZATION OF MMC

##### 4.1 wear studies

Wear is defined as the material loss on the surface of solid due to rubbing action of another hard surface. It is the measure of difference between initial and final weight of the rubbed material, some factors which influence wear are relative hardness between disc and sample, sliding velocity and normal load on the specimen. Samples were prepared on lathe using single point cutting tool with specification of 30 mm length and 8 mm diameter. Initially the rotating disc is thoroughly cleaned to remove worn out and dust particles. Machine is turned on without any load to check correctness of the equipment, initial weight of the specimen is measured and specimen is fixed on the pin holder using allen key, track diameter was set to 80mm. Required speed, time and load was set and once the specimen was brought in contact with disc, motor was turned on after the preset time motor is set to cease and final weight of the specimen is measured using digital balance. Tests were carried out for different load and velocity keeping sliding distance as constant and worn out surface of the pin's were taken for optical microscopy



Fig.1. wear specimen



Fig.2.Pin on disc apparatus

#### V. RESULTS AND DISCUSSIONS

##### 5.1 Wear studies

The variation of wear behaviour of Al/SiC composites was observed by conducting a pin on disc dry sliding wear testing for different loads, different sliding speed and constant sliding distance. The result graph have been plotted between wear rate and applied loads for different speeds. From the graphs (fig.1.a, b, c) we can observe wear rate is high in case of as cast condition wear rate was decreased with reinforcement of SiC with different wt%.

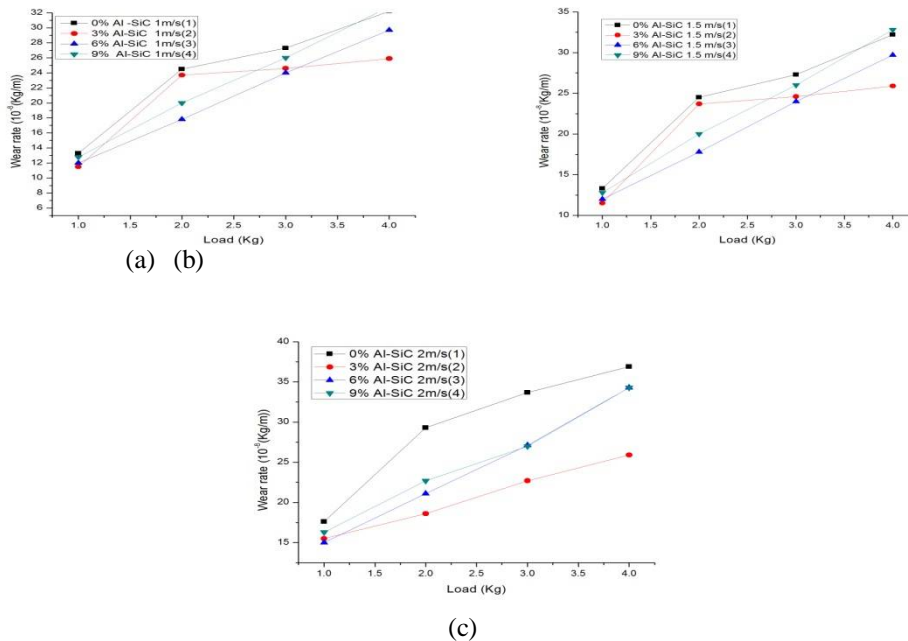


Fig.1.Effect of applied load on wear rate in all wt% at velocities (a) 1 m/s (b) 1.5 m/s (c) 2 m/s

Nature of worn out surface of pins

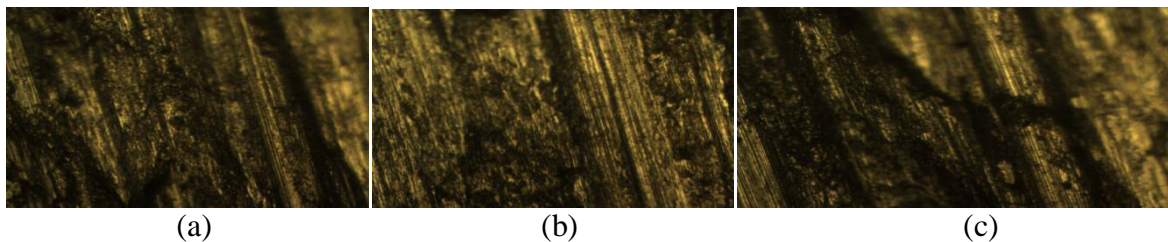


Fig.2. optical micrographs of worn out surface of pin (a) 0% Al-SiC 1m/s 2kg (b) 0% Al-SiC 1.5m/s 2kg (c) 0% Al-SiC 2m/s 2kg

The above image (2) indicates nature of worn out surface for as cast Al 6061 alloy under different velocities of 1, 1.5, 2 m/s under 2kg.

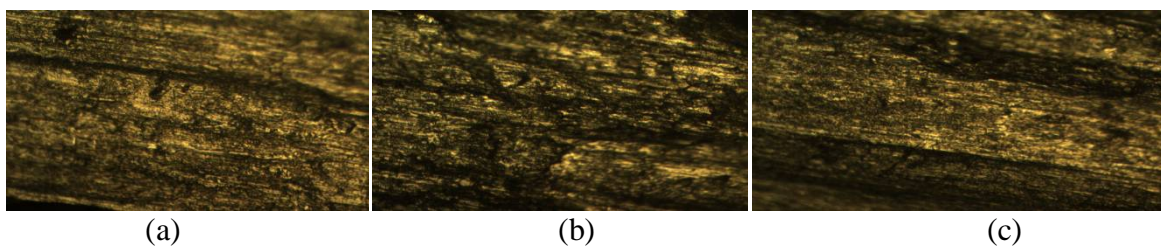


Fig.3.optical micrographs of worn out surface of pin (a) 0% Al-SiC 1m/s 4kg (b) 0% Al-SiC 1.5m/s 4kg (c) 0% Al-SiC 2m/s 4kg

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The above image (3) indicates nature of worn out surface for as cast Al 6061 alloy under different velocities of 1, 1.5, 2 m/s under 4kg.

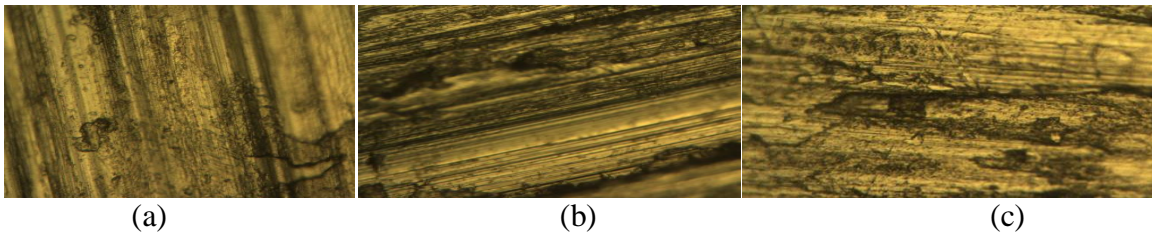


Fig.4. Optical micrographs of worn out surface of pin (a) 3% Al-SiC 1m/s 2kg (b) 3% Al-SiC 1.5m/s 2kg (c) 3% Al-SiC 2m/s 2kg

The above image (4) indicates nature of worn out surface for 3% Al-SiC alloy under different velocities of 1, 1.5, 2 m/s under 2kg.

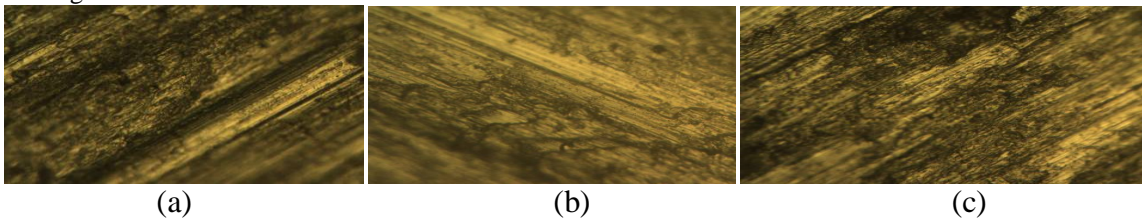


Fig.5. Optical micrographs of worn out surface of pin (a) 3% Al-SiC 1m/s 4kg (b) 3% Al-SiC 1.5m/s 4kg (c) 3% Al-SiC 2m/s 4kg

The above image (5) indicates nature of worn out surface for 3% Al-SiC alloy under different velocities of 1, 1.5, 2 m/s under 4kg

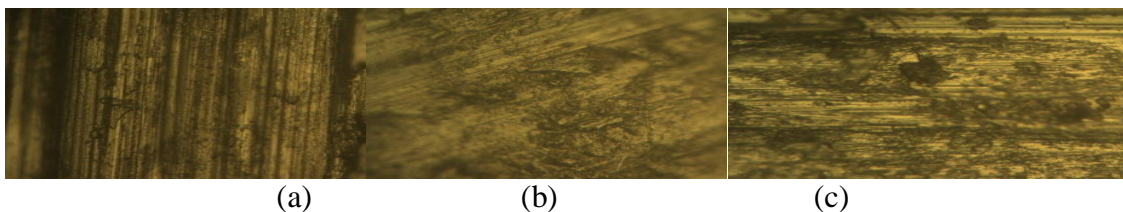


Fig.6. Optical micrographs of worn out surface of pin (a) 6% Al-SiC 1m/s 2kg (b) 6% Al-SiC 1.5m/s 2kg (c) 6% Al-SiC 2m/s 2kg

The above image (6) indicates nature of worn out surface for 6% Al-SiC alloy under different velocities of 1, 1.5, 2 m/s under 2kg

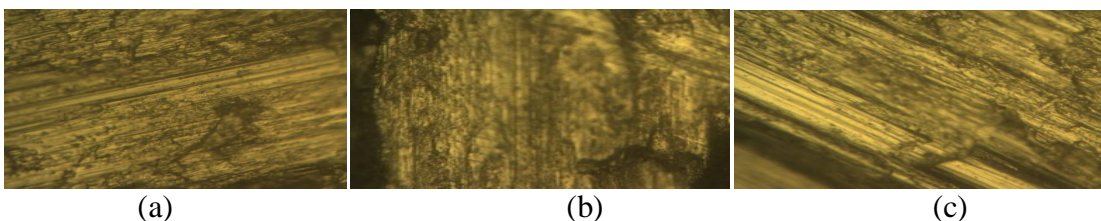


Fig.7. Optical micrographs of worn out surface of pin (a) 6% Al-SiC 1m/s 4kg (b) 6% Al-SiC 1.5m/s 4kg (c) 6% Al-SiC 2m/s 4kg

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The above image (7) indicates nature of worn out surface for 6% Al-SiC alloy under different velocities of 1, 1.5, 2 m/s under 4kg

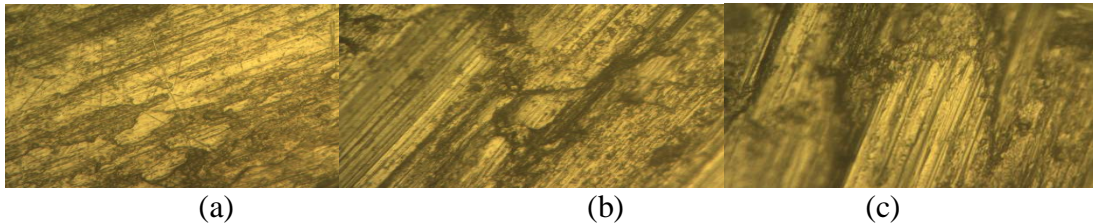


Fig.8. Optical micrographs of worn out surface of pin (a) 9% Al-SiC 1m/s 2kg (b) 9% Al-SiC 1.5m/s 2kg (c) 9% Al-SiC 2m/s 2kg

The above image (8) indicates nature of worn out surface for 9% Al-SiC alloy under different velocities of 1, 1.5, 2 m/s under 2kg

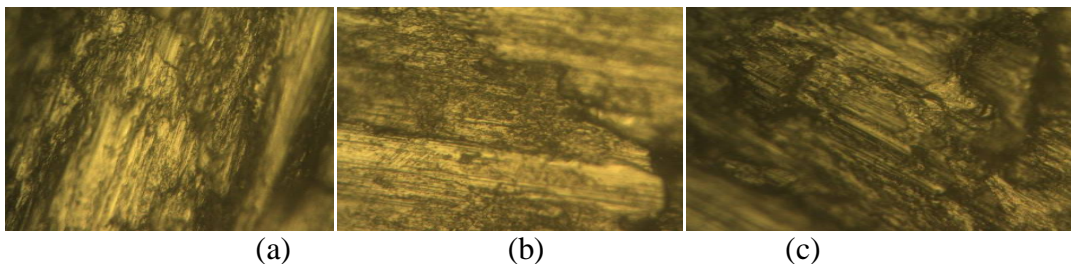


Fig.9. Optical micrographs of worn out surface of pin (a) 9% Al-SiC 1m/s 4kg (b) 9% Al-SiC 1.5m/s 4kg (c) 9% Al-SiC 2m/s 4kg

The above image (9) indicates nature of worn out surface for 9% Al-SiC alloy under different velocities of 1, 1.5, 2 m/s under 4kg

Fig 2, 3, 4, 5, 6, 7, 8, 9 indicate wear for 0%, 3%, 6% and 9% Al-SiC under 2 and 4 kg loads respectively. From the observation of graph its clear that wear rate increased with increase in load and incase of reinforced alloy wear was less compared to unreinforced alloy and type of wear occurred was abrasive wear form the graph we can clearly see the formation of grooves, ridges running to the direction of sliding and ploughing marks.

### VI. CONCLUSION

- Wear test was carried out on pin on disc TR-20 Ducom machine for different wt % (0% ,3%, 6%, 9%) of SiC reinforced with Al6061, maximum wear was observed in as cast material as compared to other percentages of AMC's.
- Wear test results shown increase in wear rate with the application of load.
- All micrographs show the formation of grooves, ridge running parallel to the direction of sliding and ploughing marks in alloys hence it is abrasive type of wear.

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