

# A Study on Mechanical Properties of Aluminium Alloy 7075 with Sic and Flyash

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**Abstract**— Two phases namely a matrix and reinforcement phases constitute composite materials. Most of studies shows that the material used for components should possess better mechanical properties. In this paper four samples were prepared by using stir casting. First sample is Al7075 with 2% SiC and 8% Fly Ash, second sample consist of Al7075 with 4% SiC and 6% Fly Ash, third sample consist of Al7075 with 6% SiC and 4% Fly Ash, and the fourth sample is of Al7075 with 8% SiC and 2% Fly Ash. Tensile strength and yield stress and hardness increased when Silicon Carbide and Fly Ash is added to Al7075. Microstructure is also studied to understand the wear. Al7075 with Silicon Carbide and Fly Ash finds application in automobile industries.

**Key words:** Sic; Flyash; Al7075; Metal Matrix Composite; Reinforcements; Mechanical Properties and Stir Casting

## I. INTRODUCTION

Aluminium is the most abundant metal and the third most abundant chemical element in the earth's crust comprising over 8% of its weight. Only oxygen and silicon are more prevalent. Yet until about 150 years ago aluminium in its metallic form was unknown to man, the reason for this is that aluminium, unlike iron or copper, does not exist as a metal in nature. Because of its affinity for oxygen, aluminium is always found combined with other elements mainly as aluminium oxide.

Composite materials are defined as "a material systems consisting of mixture of or combination of two or more micro constituents insoluble in each other and differing in form and or material composition". In aluminium 7075 alloy, zinc is the primary alloying element. It is strong, with a strength comparable to many steels, and has good fatigue strength and average machinability, but has less resistance to corrosion than many other Al alloys. Silicon carbide(SiC),also known as carborundum is the only chemical compound of carbon and silicon. It was originally produced by a high temperature electro-chemical reaction of sand and carbon. Fly Ash is a material separated from exhaust gases of power plants with suspension – fired furnace in which pulverized coal is used as fuel. Aluminium have useful properties such as high strength, ductility, high thermal and electrical conductivity but have low stiffness. Methods available for the production of Hybrid composites are powder metallurgy, spray deposition, liquid metal in filtration, squeeze-casting, stir casting. Hence stir casting method is used in this study .The objective of present work is to produce hybrid composites of Al7075/ Sic/Fly ash by stir casting method and determine the effect of addition of Fly ash on mechanical properties of Al7075-Silicon carbide MMCs.

## II. LITERATURE REVIEW

[1]Kanthavel et al. 2016, Vol.55., pp.13-17, 2016, explains the aluminium matrix composite reinforced with ceramic material of alumina (Al<sub>2</sub>O<sub>3</sub>) has good tribological properties. However, aluminium based ceramic composites require improvements in their lubrication properties. In this study an attempt is made in the development of a new material through powder metallurgy technique by the addition of molybdenum disulphide (MoS<sub>2</sub>), which acts as a solid lubricant.

[2]Zhang et al. 2016 Vol.95, pp. 39-47, 2016., says that composites are prepared by hot pressing, and the microstructures, thermal conductivity, and coefficient of thermal expansion (CTE) are characterized considering the tungsten coating and the volume fraction of diamond. The results show that the diamond particles distribute quite uniform in Al matrix without formation of Al<sub>4</sub>C<sub>3</sub> phase at the interface. Although the tungsten coating effectively improves the interface bonding between the diamond and matrix, relative densities decrease with increasing diamond fraction.

[3]Selvam et al 2013 vol.34, pp.637-646, 2013, the author in this paper said that the mechanical properties of matrix alloy AA6061 is improved upon with the incorporation of SiC and Fly ash.

During solidification of AA6061-Flyash and Sic composites, Fly ash and SiC are rejected in the direction of refined AL grains. Refinement of a-AL grains may be due to Fly ash and SiC themselves, which act as nucleus on which the aluminium grains solidify and Fly ash and SiC offer resistance to the growing a-Al phase during the solidification process. The sources formation of Mg<sub>2</sub>Si are addition of Mg in the molten aluminium alloy matrix and Mg and Si are already present in AA6061 alloy as a major constituent.

[4]Ganesh, R, Subbiah, R. & Chandrasekaran K (2015) et al vol.2 (4), pp.1441-1449, 2015., the author in this paper aims to study the effect of sintering temperature on physical, mechanical and wear properties of Al 2219 alloy matrix reinforced with SiC particulates of average particle size 23 µm for different weight fractions 10%, 15% and 20% fabricated by powder metallurgy (PM) method.

[5]Muruganandan et al. (2015) Int. J. Eng. Res., vol. 3, pp.78-83, 2015., used Aluminium 7075 as a matrix material with fly ash and titanium carbide as reinforcement materials. A comparison has been made between the reinforced and unreinforced alloys such as Al6061, Al7075 and concluded that the tensile strength and hardness of the proposed composite is increased by increasing the weight percentage of fly ash and titanium carbide.

[6]Sachin Malhotra et al.(2013) vol. 3, pp.1717-1719, 2013., investigated the effect of reinforcement of

Zirconia and Fly Ash on mechanical properties of Al 6061 aluminium alloy composites samples, processed by stir casting method. Two sets of composites were prepared with fixed percentage of fly ash (10%) and varying percentage of Zirconia (5% and 10%) by weight fraction. The author has revealed that increase in percentage increases the properties such as tensile strength and hardness.

[7]Sreenivasa Reddy et al. (2012) Int. J. Appl. Sci. Eng. Res., vol. 1, pp.176-183, 2012., investigated on formation of a hybrid composite by using industrial waste fly ash and E glass short fibers by dispersing them into Al7075 alloy by Stir casting method. The MMC was obtained for the different compositions of Eglass and Fly ash particulates. The specimens were tested for tensile test at different loads by using Universal Test Machine. The results are plotted and it is concluded that the MMC obtained has got better tensile strength compared to Al7075 alloy alone. Further, tensile strength slightly increased with 1 hour aging heat treatment. For 3 hour and 5 hour aging tensile strength decreases.

[8]Jebeen Moses et al.(2014) Proc. Mat. Sci., vol. 5, pp.106 – 112, 2014., investigated the effect of Al6061 reinforced with various amounts (0, 5, 10 and 15 wt. %) of SiC.

The microstructures of the AMCs were studied using optical and scanning electron microscopy. It was observed that the distribution of SiC particles in the matrix was uniform and SiC particle clusters were also seen in a few places. SiC particles were properly bonded to the aluminium matrix. Micro-hardness and ultimate tensile strength was tested and it was found that reinforcement of SiC particles improved the micro-hardness and ultimate tensile strength (UTS) of the AMCs.

### III. RAW MATERIAL

#### A. Al7075

Aluminium 7075 (Al7075) is chosen as the matrix material since, it is low cost and has better properties like good thermal conductivity, high shear strength, abrasion resistance, high-temperature operation, non flammability, minimal attack by fuels and solvents, and the ability to be formed and treated on conventional equipment. It possesses excellent casting properties and reasonable strength. This alloy is best suited for mass production of lightweight metal castings. Fig. 1 shows Al7075.



Fig. 3.1: Al7075

#### B. Fly Ash

Fly ash particles (usually of size 0.5-100 micron) which are extracted from residues generated in the combustion of coal. Fly ash has low density having good wettability between fly ash & matrix Al alloy. It has low cost with advantages like isotropic properties and the possibility of secondary processing. It has high electrical resistivity and low thermal conductivity.



Fig. 3.2: Fly Ash

#### C. Silicon carbide

Silicon carbide has the density close to aluminium and is best for making composite having good strength and good heat conductivity. It occurs in nature as the extremely rare mineral moissanite. Silicon carbide powder has been mass-produced since 1893 for use as an abrasive. Grains of silicon carbide, can be bonded tighter by sintering to form very hard ceramics that are widely used in applications requiring high endurance, such as car brakes, car clutches and ceramic plate in bullet proof vests.



Fig. 3.3: silicon carbide

### IV. EXPERIMENTAL SETUP

#### A. Material selection

The powders selected are as follows

- 1) Aluminium powder (Al 7075)
- 2) Silicon carbide powder (commercial pure)
- 3) Fly Ash

B. Powder mixture:

Specimen	Percentage (%)			Grams (gm)		
	Al	SiC	Fly Ash	Al	SiC	Fly Ash
1	90	8	2	225	20	05
2	90	6	4	225	15	10
3	90	4	6	225	10	15
4	90	2	8	225	05	20

Table 4.2.1:

	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Others-Each	Others Total	Al
7075	0.40	0.50	1.2-2.0	0.30	2.1-2.9	0.18-0.28	5.1-6.1	0.20	0.05	0.15	Remainder

Table 4.2.2: chemical composition of Al7075

C. Stir Casting Procedure

Al7075 was melted by raising its temperature to 800°C and degassed using a solid dry hexa-chloro-ethane compound. The silicon carbide and fly ash particles were preheated for 30 min at 600°C for improving the wettability and added to the molten metal, and stirred continuously with an impeller at a speed of 600 rpm for 5 min. The melt with reinforcement particles was poured into a cylindrical permanent metallic mold with a diameter of 20 mm and 100 mm length. The cast rods were rapidly cooled to room temperature by knocking them out, 5mins after casting. Fig.4. shows the Stir Casting Machine.



Fig. 4.1: stirr casting machine

V. RESULT & DISCUSSION

A. Testing of specimens

- Tensile test
- Hardness test ( brinell hardness )
- Microstructure test

1) Tensile test

Tensile strength is a measurement of the force required to pull something to the point before it breaks. Tensile test was done using Universal Testing Machine (UTM). The Specimen used is of ASTM B 557:2010 standard.



Fig. 5.1.1 : specimens before testing



Fig. 5.1.2 : specimens after testing

Below table shows the tensile strength and yield stress of the composites. For (Al7075 + 4%SiC + 6% Fly Ash) has the higher tensile strength and yield stress than other specimens. It is clear that tensile strength and yield stress of AL7075+ 4% SiC + 6% Fly Ash is increased due to bonding of AL7075, SiC and Fly Ash.

Specimen type	Tensile strength (Mpa )	Yield Stress ( Mpa )
AL+8%SiC+2%FLY ASH	115.568	106.164
AL+6%SiC+4%FLY ASH	98.255	94.8751
AL+4%SiC+6%FLY ASH	115.867	111.831
AL+2%SiC+8%FLY ASH	102.993	99.763

Table 5.1.1: tensile strength and yield stress

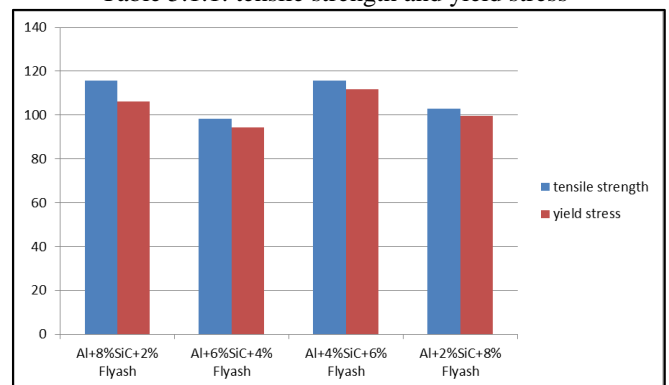


Fig. 5.1.3: tensile strength and yield stress of the composites

2) Brinell hardness test

Hardness is the resistance of a material to localized deformation. A hard material surface resists indentation or scratching and has the ability to indent or cut other materials. Hardness of the four stir casted samples was

tested on Brinell Hardness Tester. In the Brinell hardness test, a hardened steel ball is pressed into the flat surface of a test piece using a specified force. The ball is then removed and the diameter of the resulting indentation is measured using a microscope. The Specimen used is of IS 1500-2005 standard. Readings on 3 locations were taken and average reading of each sample was considered.

$$H = \frac{2P}{\pi D(D - \sqrt{D^2 - d^2})}$$

Brinell hardness number is given by

Where, P-----load in Kg

D-----diameter of indenter in mm

d-----diameter of indentation in mm

Indenter diameter: 5mm

Load applied : 250 kgs

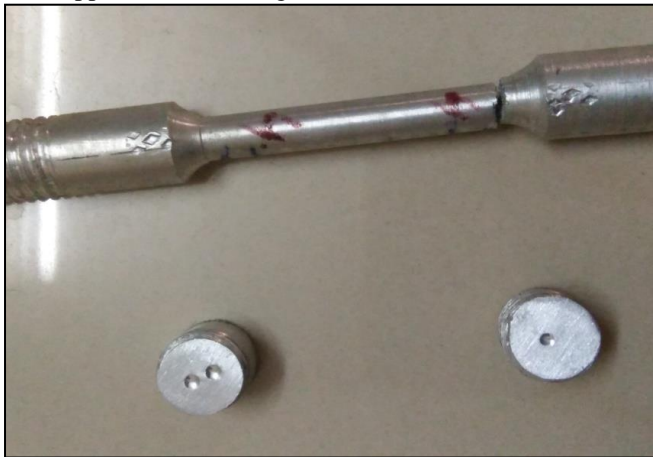


Fig. 5.2.1: specimen after brinell hardness test

Sample No.	Identification	Location	Observed values in HBW 5mm/250			
			Impression 1	Impression 2	Impression 3	Average
1	AL+8%SiC+2%FLY ASH	ON SURFACE	84	84.9	84.9	84.6
2	AL+6%SiC+4%FLY ASH	ON SURFACE	90.7	90.7	89.7	90.37
3	AL+4%SiC+6%FLY ASH	ON SURFACE	89.7	90.7	90.7	90.37
4	AL+2%SiC+8%FLY ASH	ON SURFACE	83	84	84	83.67

Table 5:2:1: BHN number

Above table 5.2.1 shows the hardness of the composites. Among the different specimen, (Al+6% SiC+4% Fly ash) and (Al+4%SiC+6% Fly Ash) has the highest hardness of 90.37 BHN

Sample	Identification	Location	Observed values in HBW 5mm/250			
			Impre	Impre	Impre	Ave
1	AL+8%SiC+2%FLY ASH	ON SURFACE	84	84.9	84.9	84.6
2	AL+6%SiC+4%FLY ASH	ON SURFACE	90.7	90.7	89.7	90.37
3	AL+4%SiC+6%FLY ASH	ON SURFACE	89.7	90.7	90.7	90.37
4	AL+2%SiC+8%FLY ASH	ON SURFACE	83	84	84	83.67

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2	AL+6%SiC+4%FLY ASH	ON SURFACE	90.7	90.7	89.7	90.37
3	AL+4%SiC+6%FLY ASH	ON SURFACE	89.7	90.7	90.7	90.37
4	AL+2%SiC+8%FLY ASH	ON SURFACE	83	84	84	83.67



Fig. 5.2.2: specimen after brinell hardness test

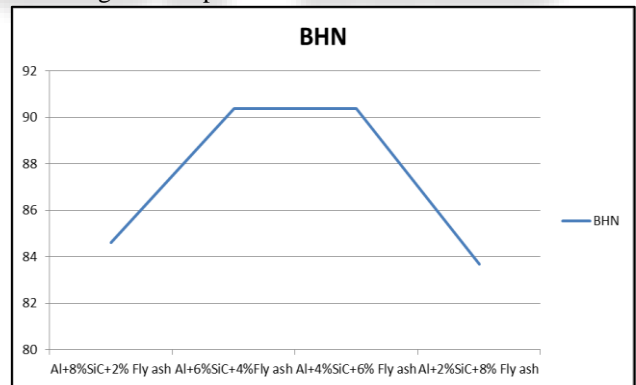


Fig. 5.2.3: BHN for different composites

### 3) Microstructure

Microstructure is the small scale structure of a material, defined as the structure of a prepared surface of material as revealed by a microscope above 100x magnification. The microstructure of a material (such as metals, polymers, ceramics or composites) can strongly influence physical properties such as strength, toughness, ductility, hardness, corrosion resistance, high/low temperature behavior or wear resistance.

- Equipment used: Metascope, metallurgical microscope/ ASTM E 407
- Etchant used: kellers reagent
- Magnification: 100x

1) Specimen 1

Al+8%SiC+2% Fly Ash

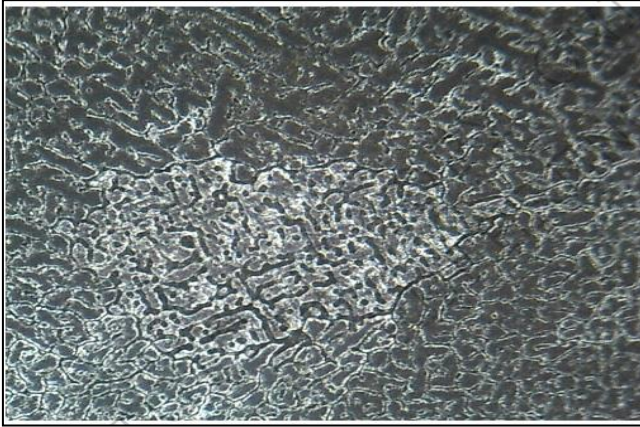


Fig. 5.3.1: microstructural view of MMC

The microstructure consist of fine interdenritic network with uniform distribution of SiC and Fly Ash particles and agglomeration of particles in the matrix of Al solid solution.

2) Specimen 2

Al+6%SiC+4% Fly Ash

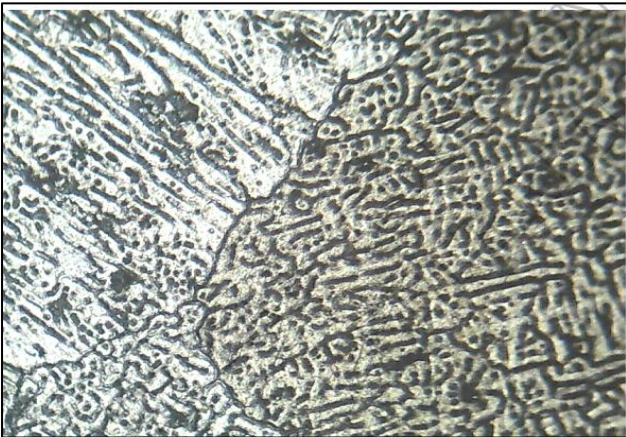


Fig. 5.3.2 : microstructural view of MMC

The microstructure consist of small broken interdenritic network with uniform distribution of SiC and Fly Ash particles and agglomeration of particles in the matrix of Al solid solution.

3) Specimen 3

Al+4%SiC+6% Fly Ash

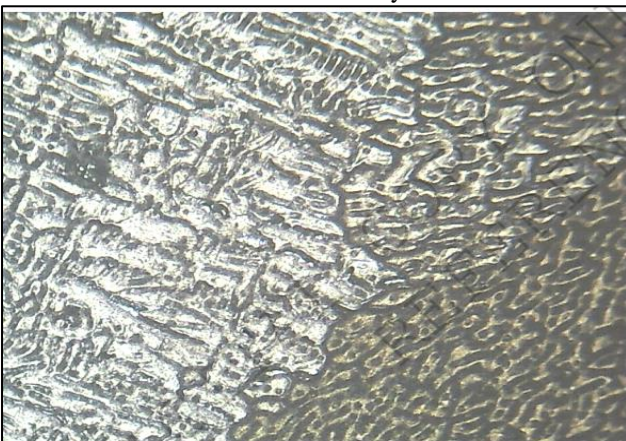


Fig. 5.3.3 : microstructure view of MMC

The microstructure consist of large broken interdenritic network with uniform distribution of SiC and Fly Ash

particles and agglomeration of particles in the matrix of Al solid solution.

4) Specimen 4

Al+2%SiC+8% Fly Ash

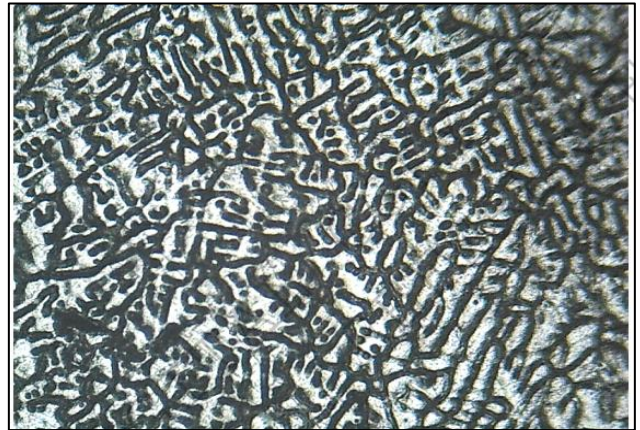


Fig. 5.3.4 : microstructure view of MMC

The microstructure consist of coarse interdenritic network with uniform distribution of SiC and Fly Ash particles and agglomeration of particles in the matrix of Al solid solution.

## VI. CONCLUSION

From the experiments on Al7075/SiC/Fly Ash hybrid metal matrix composites, the following conclusions are obtained.

- Tensile strength and yield stress increases when 4%SiC and 6% Fly Ash is added to AL7075.
- Hardness is more for (AL7075+ 4%SiC + 6% Fly Ash) than composition of other specimen used.
- Micro-structural view is observed for all the composites.
- Among the four composition, (AL7075+ 4%SiC+ 6% Fly Ash) is better than others when comparing its tensile strength, hardness and yield stress.
- In (Al+8%SiC + 2% Fly Ash) specimen, the scratches and depth of grooves were smaller than the other three specimens.
- As the % of silicon carbide increases and % of Fly Ash decreases, the Scratches and depth of grooves decreases

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