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Mechanical Properties of Al 6061 Alloy Reinforced with Fly Ash Particles

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Abstract – Metal matrix composites possess good mechanical properties such as tensile, hardness. Our present investigation focuses on the fabrication of Aluminium Metal Matrix reinforced with various weight fractions of fly ash of 0% to 8% of 75µm. Stir casting method is a simplest process of fabrication method. Fly ash is a by-product of the thermal power plant and it is used as reinforcement material. Fly ash improves the strength and hardness of the material. Microstructure study indicates the distribution of fly ash in metal matrix.

Keywords—Al6061, MMCs, Fly Ash, Stir Casting, Tensile, Hardness.

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INTRODUCTION

Composite is a material which is made up of two or more materials chemically distinct and insoluble phases which is called as composite materials. Composite materials are composed of two phases one is termed as matrix which is continuous and surrounds the other phase which is called as dispersed phase. [1] The progress of material science and modern technology has given birth to these compelling and wonderful materials. We can find wide varieties of applications in the field of many engineering fields like marine, aerospace, sports etc. Composite materials are used for structural properties and it is also used for tribological, electrical, and in the field of thermal engineering, and environmental application. Aluminum is considered as one of the most popular matrix for the metal matrix composites (MMCs). [5]

Aluminium alloy exhibits excellent mechanical properties like mach inability and good bearing and wear properties [2].The main aim is involved in designing the metal composite materials as matrix in order to incorporate the desirable qualities of metals and ceramics [4].

Aluminum 6061 alloy is one of the most frequently available materials which are heat treatable aluminum alloys for the purpose of commercial use. Aluminum 6061 has a less sensitive factor to the solution of heat treatment [3].

Table 1: Chemical composition of Al 6061 alloy

Material	Percentage %
Iron	0.0 - 0.7
Silicon	0.4 - 0.8
Magnesium	0.8 - 1.2
Zinc	0.0 - 0.25
Manganese	0.0 - 0.15
Copper	0.15 - 0.40
Titanium	0.0 - 0.15
Chromium	0.04 - 0.35
Other elements	0.05 - 0.15

2. METHODOLOGY

Selection of the material to prepare the required specimen

Fly ash is used as reinforcement material with aluminium alloy (Al6061) processed by stir casting method to prepare the required specimen. Fly ash of 0%, 2%, 4%, 6%, 8% were taken in the form of fine powder to prepare the specimen.

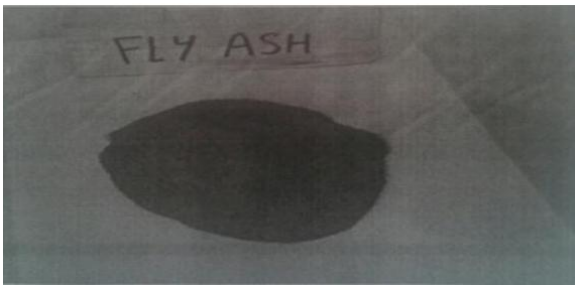

Fig1. Fly Ash Particles

Table 2: Composition of fly ash

Sl. No.	Composition of Composite
1	Al6061 + 0% Fly ash
2	Al6061 + 2% Fly ash
3	Al6061 + 4% Fly ash
4	Al6061 + 6% Fly ash
5	Al6061 + 8% Fly ash

Experimental method to test Mechanical properties

i. Tensile Test

ii. Hardness Test

3.3 Tensile Test and specimen dimension

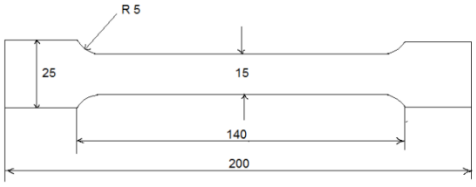

Fig 2 Outline of tensile specimen in mm

The specimen is turned into 12 mm diameter in lathe machine. The material is then turned to 12-9-12 for a length of 25-54-25 respectively. Again the material is turned to a gauge diameter of 9 mm and gauge length of 54mm and the fillet radius of 4 mm are given as inner radius.

Fig 3 Tensile test specimen before testing

The test is conducted in UTM. As the weight of fly ash increases the UTS also increases it is due to dispersion that creates hindrance to disposition of motion. The specimen is subjected to uni-axial tension until the specimen fail. Properties which are directly measures tensile test which is used to perform to evaluate the mechanical properties like yield strength, ultimate strength and elongation.

Fig. 4 Tensile test specimen after testing

Hardness Test

Hardness test is conducted by using Vickers hardness test in order to measure the composite material and 1N of load with the time of 10 seconds was applied on the required load. The uniform increase in hardness and indentation can be seen, it is due to resistance to deformation which is increased by adding fly ash as reinforcement in aluminium 6061 alloy. The specimen is machined to the diameter of 12mm and a length of 12.5 mm.

- The test method consists of indenting the test material and which has a diamond indenter in the shape of a right pyramid and with a square base with an angle of 136^0 within opposite faces and it is subjected to a load of 1kgf to100 kgf.
- The load is applied for 10 -15 seconds normally. The indentation of the two diagonals has left on the surface of the sample.

- After the removal of the load are measured by using an optical microscope.
- The major advantages of this test are accurate readings can be obtained and also only one type of indenter is used for all kind of metals and for surface treatments.

Optical Microstructure

Aluminium is reinforced with fly ash particulate composites are used for fabrication by stir casting process. With different size of fly ash particles and different weight % of reinforcement are tested in optical micrometer in order to see whether the particles are well dispersed with aluminium. The below fig shows the clear picture particle size of fly ash particles which is uniformly dispersed in the matrix of aluminium. Microstructure helps to reveal the micro porosities in the casting.

3. RESULTS OF TENSILE TEST

Table 3 Observation and calculation

Composition	Ultimate Tensile Strength		
	S1	S2	Average
Al6061	153.57	99.18	126.38
Al6061+2%Fly Ash	151.84	198.68	175.26
Al6061+4%Fly Ash	181.55	180.76	181.15
Al6061+6%Fly Ash	206.38	214.71	210.55
Al6061+8%Fly Ash	221.53	229.15	225.34

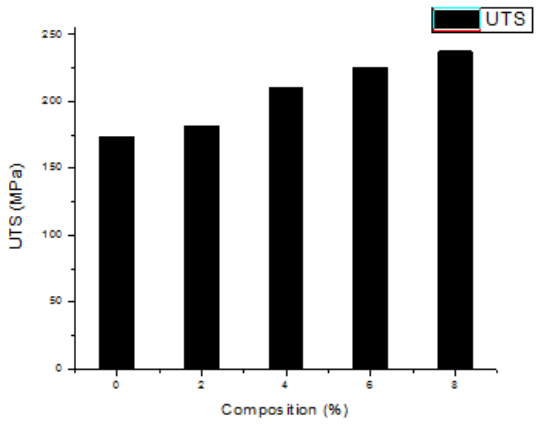

Fig 5 UTS versus Fly Ash

From the experiment, the above graph clearly shows the increase of ultimate tensile strength as the percentage of fly ash is increased. It is because of good bonding strength between fly ash and matrix. The matrix of Aluminum 6061 is improved by mechanical properties on fly ash incorporation. The tensile strength of matrix was found up to the particle size of 75µ.

Table 4 Observation and calculation

Composition	% Elongation			
Pure Al6061	S1	S2	Average	% of Elongation
Al6061+2%Fly Ash	108.75	110.35	109.55	5.33
Al6061+4%Fly Ash	111	109	110	5.77
Al6061+6%Fly Ash	112	109	110.5	6.25
Al6061+8%Fly Ash	115	109	112	7.69

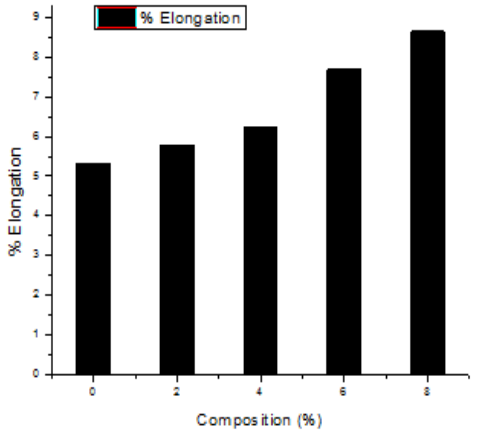

Fig 6 Composition Vs % Elongation

From the above graph it is clear that, as the % of fly ash particles increases in Aluminium 6061 alloy % of elongation increases as shown in the above fig. Increase in ductility can be attributed to the presence of fly ash particles that are prone to localized crack initiation and increased embrittlement effect due to local stress concentration factor at the reinforcement matrix interface.

Results of Hardness Test

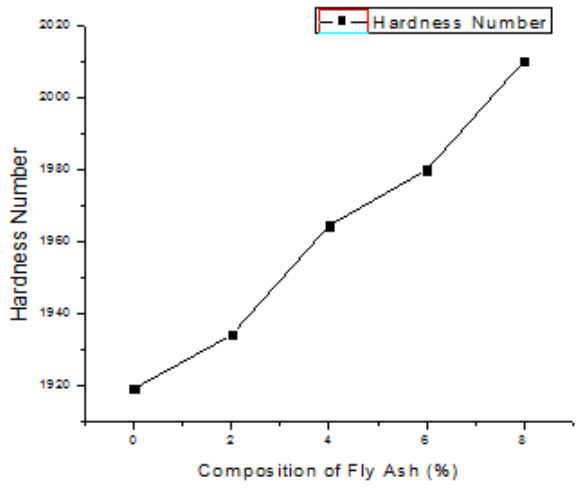

Fig 7 Variation of VHN with increases % fly ash in Al6061 alloy

From the observation of above fig, it states that hardness of Al 6061 increased with the increase in composition of fly ash of different weight fractions and it is plotted in the above graph. Particle size and reinforcement weight of micro hardness of AMMs are increased. Hardness of composites increased with different wt ratios of fly ash particles it is due to the strength of Al 6061 alloy matrix.

Microstructure Results

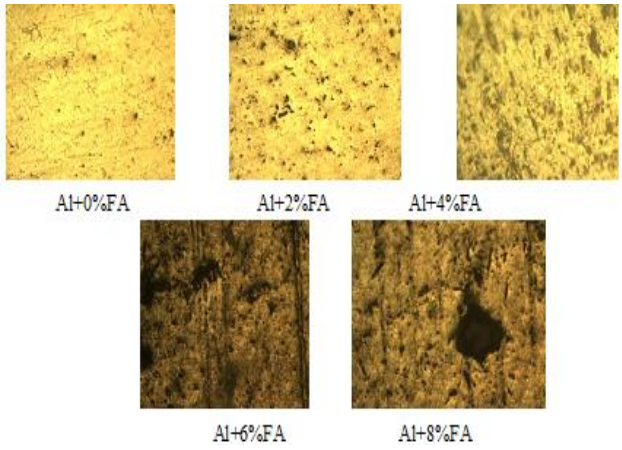

Fig 8 Microstructure study of Al 6061 and Fly ash of different weight fraction

The above experimental results show the microstructure results of various weight fraction of fly ash in metal matrix composites. Microstructure shows the absence of the micro porosity, and grain refinement interfacial bond between matrix and reinforcement. It is clear from the above fig that the distribution of fly ash is uniform in aluminum alloy matrix.

4. CONCLUSION

As the Fly Ash percentage increases ultimate strength increases.

Hardness will increase with increase in the load for 8% of weight fraction which gives better hardness number.

The microstructure study shows the distribution of fly ash particles is uniform and random.

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