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Prepration & Analysis For Some Mechanical Property Of Aluminium Based Metal Matrix Composite Reinforced With Sic & Fly Ash

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ABSTRACT

The paper deals with the fabrication of aluminium based metal matrix composite and then characterized their mechanical properties such as hardness, toughness and tensile strength. In the present study a modest attempt has been made to develop aluminium based silicon carbide particulate MMCs with an objective to develop a conventional low cast method of producing MMCs and to obtain homogeneous dispersion of ceramic material. To achieve this objective stir casting technique has been adopted. Aluminium 6061 (97.06% C.P) and SiC, Fly Ash has been chosen as matrix and reinforcement material respectively. Experiment has been conducted by varying weight fraction of SiC (2.5%, 5%, 7.5%, 10%) while keeping all other parameters constant. The result indicated that the developed method is quite successful and there is an increase in the value of tensile strength, hardness and toughness with increase in weight percentage of SiC.

Keywords – Matrix Composite, Stir Casting Technique, Aluminium 6061, SiC , Fly Ash

1. INTRODUCTION:-

Demand for developing metal matrix composites for use in high performance application have significantly increased in the recent times. Among these composites, aluminium alloy matrix composites attract much attention due to their lightness, high conductivity moderate casting temperature and others. Various kind of ceramic materials, e.g. SiC, Al2O3, MgO and B4C are extensively used to reinforce aluminium alloy matrices. Superior properties of these materials such as refractoriness, high hardness, high tensile strength, wear resistence etc. make them suitable for use as reinforcement in MMCs [1-3].

The objective of developing metal matrix composite materials is to combine the desirable properties of metal and ceramics. The major advantages of aluminium matrix composites compared to unreinforced materials are greater strength, improved stiffness, reduced density, improved temperature properties, controlled thermal expansion and improved wear resistance [3]. Because of these improved properties AMCs are increasingly being utilized in high tech structural and functional applications including aerospace, defense, automobile and thermal management areas.

Based on the literature survey it is evident that though the application scope for AMCs is expanding, the major hindrance is in the production of these AMCs on an industrial scale can be either solid state processing or liquid state processing[3]. The liquid state processing especially, stir casting is a promising route for the synthesis of AMCs because of their simplicity and scalability. However, stir casting has inherent problems such as good wetting between the particulate reinforcement and the liquid aluminium alloy melt. Moreover the problem with finer reinforcement particles especially nano particles would be agglomeration, If these challenges could be overcome then stir casting would be a commercially viable technology for producing AMCs. A few researches [2,4,5] have made attempts to develop stir casting setup that can overcome these problems.

Hashim *et al.*, [2] have identified four technical difficulties in stir casting: difficulty of achieving a uniform distribution of the reinforcement material; wettability between the two main substances; porosity in the cast metal matrix composites; and chemical reactions between the reinforcement material and the matrix alloy. These difficulties need to be overcome in order achieve a MMC with a broad range of mechanical properties. They have also identified the important process variables that affect the mechanical properties of MMC. The holding temperature, stirring speed, size of the impeller and the position of the impeller in the melt are to be considered in the production of cast metal matrix composites.

Sahin [4] has developed a setup for manufacturing MMCs. The setup has a bottom tapping facility. He has evaluated three methods for mixing of the reinforcement and has achieved full and homogenous distribution of the particles in the matrix alloy. However, the setup does not have the facility to change the position of the impeller in the melt. If investigated, this could further enhance the quality of the MMCs produced. The pouring molten mixture is tapped from the bottom of the crucible after mixing process is completed. Hardness of the aluminium alloy improved significantly by addition of SiC particles into it, while density of the composite also increased almost linearly with the weight fraction of particles [4].

A.Chennakesava [5] studied mechanical properties for different metal matrix composites produced from Al 6061, Al 6063 and Al 7072 matrix alloys reinforced with silicon carbide particulates. The ductility of Al/SiC metal matrix composites are in the descending order of Al 6061, Al6063 and Al 7072 matrix alloys. Mg has improved the wettability between Al and SiC particles by reducing the SiO2 layer on the surface of the SiC. The fracture mode is ductile in nature.

2. MATERIALS:-

2.1 Metal Matrix:-

The matrix material used in the experimental investigation is an aluminium alloy (6061-T6) whose chemical composition (in weight %) is listed in Table 1. Al6061 is precipitation hardening aluminium alloy, containing Magnesium and Si as its major alloying elements. It has good mechanical properties. It is one of the most common alloys of Aluminium for general purpose use, Its ha low melting point (710°C). The molten metal has high fluidity and solidifies at constant temperature [6, 7].

Table 1 - Chemical composition of Alluminium6061-t6

Component	Wt. %	Component	Wt. %
Al	**95.8- 98.6**	**Mn**	**Max0.15**
Cr	**0.04- 0.35**	**Other, each**	**Max0.05**
Cu	**0.15- 0.40**	**Other, total**	**Max0.15**
Fe	**Max 0.7**	**Si**	**0.4 - 0.8**
Mg	**0.8 - 1.2**	**Ti**	**Max0.15**
Mn	**Max0.15**		

2.2Reinforcement Material:-

The role of the reinforcement in a composite material is fundamentally one of increasing the mechanical properties of the neat resin system. All of the different particulates/ fibres used in composites have different properties and so affect the properties of the composite in different ways. The reinforcement used in the experimental investigation are:-

Silicon Carbide: Silicon Carbide (SiC) is highly wear resistant and also has good mechanical properties with low density, including high temperature strength and thermal shock resistance. Silicon carbide (SiC), also known as carborundum, is a compound of silicon and carbon with chemical formula SiC. It was originally produced by a high temperature electro-chemical reaction of sand and carbon. Silicon carbide is an excellent abrasive and has been produced and made into grinding wheels and other abrasive products for over one hundred years. Today the material has been developed into a high quality technical grade ceramic with very good mechanical properties. It is used in abrasives, refractories, ceramics, and numerous high-performance applications [6].

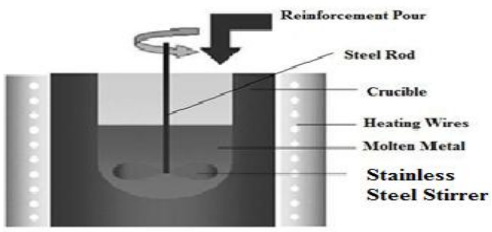
Fly Ash: Fly ash is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. Ash which does not rise is termed bottom ash. In an industrial context, fly ash usually refers to ash produced during combustion of coal. Fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys of coal-fired power plants, and together with bottom ash removed from the bottom of the furnace is in this case jointly known as coal ash [8]. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline) and calcium oxide (CaO), both being endemic ingredients in many coal-bearing rock strata. The chemical composition of fly ash is shown in Table – 2.

Table 2 - Chemical Composition of Fly Ash

Component	Wt. %	Component	Wt. %
SiO_2 (%)	**40-60**	**CaO (%)**	**5-30**
Al_2O_3 (%)	**20-30**	**LOI (%)**	**0-3**
Fe_2O_3 (%)	**4-10**		

3. EXPERIMENTAL METHODOLOGY:

The synthesis of metal matrix composite used in the study was carried out by stir casting method. A stir casting setup, Consisted of a resistance Muffle Furnace and a stainless Steel stirrer assembly, was used to synthesize the composite. The stirrer assembly consisted of a stirrer, which was connected to a variable speed vertical drilling machine with range of 80 to 890 rpm by means of a steel shaft. The stirrer was made by cutting and shaping a Stainless Steel block to desired shape and size manually. The stirrer consisted of three blades at an angle of 120° apart. Clay graphite crucible of 1.5 Kg capacity was placed inside the furnace. The graphical representation of stir casting was shown in Fig.



Approximately 750gm of alloy in solid form (rectangular rod) was melted at 820°C in the resistance furnace. Preheating of reinforcement (Fly Ash at 400°C, silicon carbide at 800°C) was done for one hour to remove moisture and gases from the surface of the particulates. The reinforcement particles were sieved by sieve shaker. The stirrer was then lowered vertically up to 3 cm from the bottom of the crucible (total height of the melt was 8 cm). The speed of the stirrer was gradually raised to 800 rpm and the preheated reinforced particles were added with a spoon at the rate of 10- 20g/min into the melt. The speed controller maintained a constant speed of the stirrer, as the stirrer speed got reduced by 50-60 rpm due to the increase in viscosity of the melt when particulates were added into the melt. After the addition of reinforcement, stirring was continued for 8 to 10 minutes for proper mixing of prepared particles in the matrix. The melt was kept in the crucible for approximate half minute in static condition and then it was poured in the mould. The value of the SiC varies from 2.5% to 10% and four different samples were made whose compositions are given in Table 3.

Table 3 - Composition of Al Composite for various samples

Sample	Total wt. of specimen in gm	Aluminm (6061-T6) In (gm)	% of Silicon Carbide (SiC) Added	% of Fly Ash Added
Sample 1	750	693.75	2.5%	5%
Sample 2	750	675.00	5%	5%
Sample 3	750	656.25	7.5%	5%
Sample 4	750	637.5	10%	5%

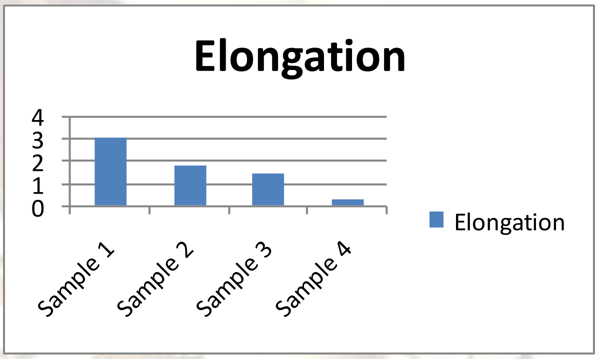
4. RESULT & DISCUSSION:-

4.1 Tensile Test:-

Tensile test was carried out at room temperature using a computerized universal testing machine. In this study it can be noted that the addition of silicon carbide & Fly Ash particles improved the tensile strength of the composites. It is apparent that an increase in the volume fraction of silicon carbide particle results in an increase in the tensile strength. Graph shows the effect of the volume fraction on the tensile strength. The tensile strength of SAMPLE 1 (2.5%SiC & 5% Fly Ash) is 57 N/mm2 and this value increases to a maximum of 115 N/mm2 for SAMPLE 4 (SiC10% & fly ash 5%) which is about 50% improvement on that of SAMPLE 1.

Sample	Tensile Strength(N/mm2)	Elongation (%)
Sample 1	57	3.00
Sample 2	69	1.80
Sample 3	74	1.43
Sample 4	115	0.25

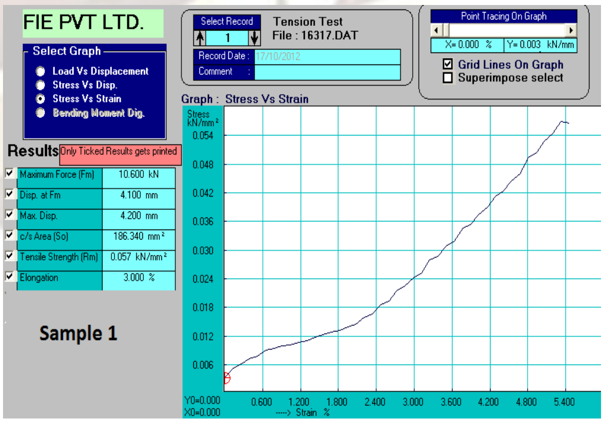
As shown in graph the elongation tend to decrease with increasing particles weight percentage which conforms that Silicon Carbide & Fly Ash addition decreases ductility.

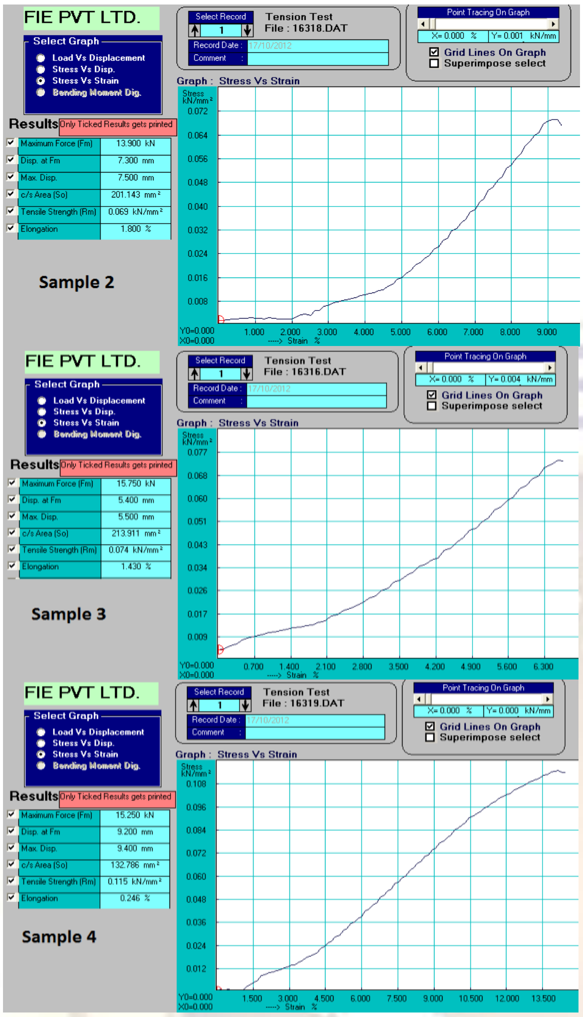


Comparison of Elongation for different samples

4.1.1 Stress Vs Strain Curves:-

During tensile testing the stress strain curve is a graphical representation of the relationship between stress, derived from measuring the load applied on the sample, and strain, derived from measuring the deformation of sample, i.e elongation. The stress strain curves of different samples are shown below:



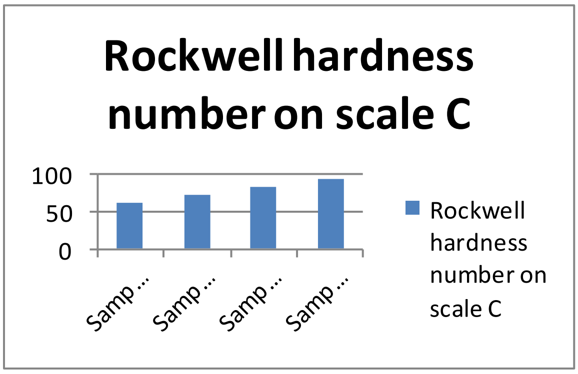


4.2 Hardness Measurement:

Hardness test was carried out at room temperature using Rockwell hardness tester with at least six indentations of each sample and then the average values were utilized to calculate hardness number. Load used on Rockwell's hardness tester 150 Kg at dwell time of 20 sec. for each sample. The hardness of MMCs increases with increase in the volume fraction of particulate in the alloy matrix. The added amount of SiC & fly ash particles enhances hardness, as these particles are harder than Al alloy, which render their inherent property of hardness to soft matrix.

Sample	Rockwell Hardness Number on scale C
Sample 1	61
Sample 2	70
Sample 3	81
Sample 4	93

As shown in table the hardness of sample 1 is 61 RHN, it increase with increase in weight percent of Silicon carbide and it reaches to a maximum value of 93 RHN for sample 4 which has maximum value of SiC (10%) and fly ash (5%).



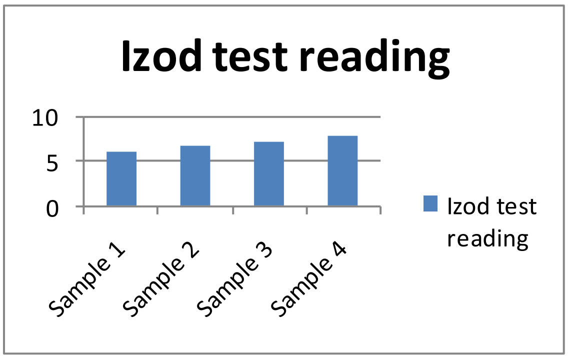
Comparison of hardness for different samples

4.3 Impact Toughness:

Impact test was carried out at room temperature using Impact tester to calculate toughness. The specimen is supported at one end like a cantilever beam in the test and reading was taken by breaking the specimen due to the impact of the pendulum.

Sample	Izod Test Result
Sample 1	6.0
Sample 2	6.6
Sample 3	7.1
Sample 4	7.8

It can be noted that the toughness increased with an increase in the weight percentage of silicon carbide. This is due to proper dispersion of silicon carbide & fly ash into the matrix or strong interfacial bonding between aluminium alloy 6061 and Sic & fly ash interfaces. As shown by the graph the toughness of sample 1 is 6.0 and it increase with increase percent of Silicon carbide and reaches to a maximum value of 7.8 for sample 4 which has maximum value of SiC (10%) and fly ash (5%).



Comparison of Toughness for Different Samples

5. CONCLUSION

- Aluminium based metal matrix composite up to 10% silicon carbide have been successfully fabricated by stir casting technique with fairly uniform distribution of Silicon Carbide & Fly Ash.
- The hardness of Metal Matrix Composite increased with increase in SiC content.
- It appears in this study that Tensile Strength starts increases with increase in weight percentage of SiC. The best result of tensile strength has been obtained at 10% weight percentage of SiC & 5% of Fly Ash .
- It is found that elongation tend to decrease with increasing particles weight percentage which conforms that Silicon Carbide & Fly Ash addition increases brittleness.
- The impact strength of MMC increases with increase in weight percentage of SiC and it is maximum for sample 4 (10% of SiC & 5% of Fly Ash & rest is Aluminium 6061).
- From this study it is concluded that we can use fly ash for the production of composites and can turn industrial waste into industrial wealth. This can also solve the problem of storage and disposal of fly ash.

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