EXPERIMENTAL ANALYSIS ON ALUMINUM ALLOY (6063) WITH SILICON CARBIDE: AN EXPERIMENTAL INVESTIGATION

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Abstract - *The objective of the research is to a comparison and experimental analysis on Aluminum (6063) with Silicon Carbide. The comparison is with steel, the aluminum and its components have terrific characteristics like light weight, wear resistance to the corrosion that make acceptable in domestic as well as industries. As we know, steel is the most common material used in industries and automobiles and the price is also increasing day by day, which have an effect in manufacturing expense in automobile and domestic industries. That is why it is necessary to substitute steel with material having light weight and high strength which suit to weight proportion. So here we use Al(6063) since* ***it has good corrosion resistance**, **excellent ductility, high tensile properties and good toughness, medium strength, weldability and good finishing characteristic**.This study is aimed at evaluating the microstructure, mechanical properties such as (hardness, tensile, wear)and also the comparison with steel and Aluminium (6063) with silicon carbide at different weight percentages of silicon carbide (2%, 4%, 6%, 8%, 10%).*

Key Words: *Weldability, ductility, toughness, weight proportion, weight percentage.*

1. INTRODUCTION

The importance of composites as engineering materials was reflected by the facr that out of over 2000 engineering materials available in the market, today more than 500 are composites.

The aluminum composite materials consists of high specific strength, high specific stiffness, more thermal stability, more corrosion, high fatigue life and wear resistances. Aluminum alloy with Silicon Carbide is a metal matrix composite consisting of Aluminum matrix with Silicon Carbide. It has high thermal conductivity.

In the present work, a modest attempt have been made that, to compare Steel and Aluminum(6063)Alloy with Silicon Carbide. There is a comparison between their properties, strength and their uses also mentioned in the comparison. The objective of the study is to estimate the microstructure, mechanical properties, and the comparison with steel at different weight percentage of Silicon Carbide (2%,4%,6%,8%,10%).

2. LITERATURE REVIEW

Experimental analysis have done by using the Aluminum (6061) Alloy and Silicion Carbide in this experiment we use Al(6063) with Silicon Carbide at different percentage.

Singh S [1] investigated and performed an experiment on primary and secondary processing of metal matrix composites. The factors embrace the constant allocation of SiC reinforcement, wettability of SiC and aluminum alloy, defect free casting of mmc's and the reaction takes place among SiC reinforcement and aluminum matrix composite at superior temp.

J. Jebeen Moses, T Dinaharan, S. Joseph Sekhar [2] investigated an experiment based on the characterization of Silicon Carbide particulate reinforced AA6061 aluminum alloy composites produced via stir casting in this experiment it was done by the process of stir casting. The reinforcement of SiC particles improved the microhardness and ultimate tensile strength of AMC's. The details of fracture morphology.

Manoj Kumar Yadav, Bijender Saini, Ashu Yadav [3] investigated and performed an experimental analysis of mechanical properties of Al and SiC composite. In this the weight of different weight percentage of Silicon Carbide in composite on tensile strength, hardness, microstructure, was studied.

Md. Habibur Rahman, H. M. Mamun Al Rashed [4] investigated and performed as experiment on the characterization of Silicon Carbide reinforced Aluminum matrix composites. In this the purpose of this work is to study about the microstructures, mechanical properties and wear characteristics of as caste Silicon Carbide reinforced aluminum matrix composite. The porosities were observed in reinforcing Al matrix with SiC particles increased wear resistances.

Rabindra Rehera, D. Chaterjee, G . Sutradhar [5] investigated and performed an experiment based on the effect of reinforcement particles on the fluidity and solidification behavior of the stir cast aluminum alloy metal matrix composites. In this experiment results indicated that on increasing the weight percentage of reinforcement particles SiC in cast aluminum alloy. MMCs the fluidity of cast composite metal decrease and the rate of solidification decreased due to which the total solidification time enhanced.

2. MATERIAL DESCRIPTION

Aluminum 6063 is a medium strength alloy. It has good surface finish, high corrosion resistance is rarely suited to welding. It is also called architecture alloy. It is normally used in extractions. It has generally good mechanical properties and is heat treatable and weldable. Most commonly available as T6 temp 6063 has a ultimate tensile strength of at least 190 MPa, and yield strength of at least 160 MPa in the thickness of 3.05 millimeters or less. It has elongation of 8% or more in thickness section. It has a elongation of 10%. It has wide spread application especially in the building, aircraft and automotive industry due to their excellent properties.

Silicon Carbide is the only chemical compound of Carbon and Silicon. It is originally produced by a high temperature electrochemical reaction of sand and carbon. Today the material has been developed into high quality technical grade ceramic with very good mechanical properties. Today SiC is still produced via solid state reaction between sand (silicon dioxide) and petroleum coke (carbon) at very high temperature in an electric furnace.

3. THEORY

3.1 STIR CASTING

Stir casting is an economic process for the fabrication of aluminum matrix composites in stir casting process, reinforcing phases are distrusted into molten matrix by mechanical stirring. Stir casting of metal matrix composites was initialed in 1968. When S Roy introduced aluminum particles into aluminum melt by stirring molten aluminum alloys containing the ceramic particles powders. Mechanical stirring in the furnace is a elements of the process. The resultant molten alloy with ceramic particles can be used for the casting, permenant mold casting or sand casting, stir casting is suitable for manufacturing composites with upto 30% volume fraction of reinforcement. The cast composites are sometimes further extrude to reduce porosity, refines the microstructure and homogenize the distribution of the reinforcement. A major concern associated with the stir casting process is the segregation of reinforcing particles which is caused by the surfacing or setting of the reinforcement particles during the melting and casting process. The final distribution of the particles in the solid depends in material properties and process parameters such as the wetting condition. If the particles with the melt strengthen mixing, relives density and rate of solidification. The distribution of the particles in the molten depends in the geometry of the mechanical stirrer in the melts, melting temperature and the characteristics' of the particles.

Fig 1 – Stir casting machine

3.2 STIR CASTING APPARATUS

In stir casting it consists of cylindrical shaped graphite crucible is used for fabrication of AMC's as it is withstand high temperature which is much more than required temperature (680˚C). Along that graphite will not react with aluminum at these temperature. This crucible is placed in multiple which is made up of high ceramic aluminum.

Stir casting process starts with placing empty crucible in the muffle. At first heater temperature is set to 500˚C and then it is gradually increased up to 900˚C. High temperature of the muffle helps to melt aluminum alloy quickly reduces oxidization level, enhance the weldability of the reinforcement particles in the matrix metal. Aluminum alloy is used as matrix material. Required quantity of aluminum alloy is cut from the raw materials which is in the forma of rectangular pieces. Aluminum alloy is cleaned to remove the dust particles weightened and then poured in the crucible for melting powder of and titanium oxide used as reinforcement.

Fig – 2 stir casting apparatus

4. METHODOLOGY

First of all stirring system has been developed by coupling motor with gear box and a mild steel stirrer. All the melting was carried out in a graphite crucible in an oil fired furnace scraps of aluminium were preheated at 450˚C for 3 to 4 hours before melting and mixing the SiC particles were preheated at 1100˚C for 1 to 3 hour to make there surface oxidized.

The furnace temperature was first raised above the liquids to melt the alloy scraps completely and was then cooled down just before the liquids to keep the slurry in the semi solid state. At this stage the preheated SiC particles were added and mixed manually. Manual mixing was used because it was very difficult to mis using automatic device when the alloy was in a semi solid state.

After sufficient manual mixing was done, the composite slurry was reheated to a fully liquid state and then automatic mechanical mixing was carried out for about 10 min at a normal stirring rate of 600 rpm.

In the final mixing process, the furnace temperature was controlled within 760±10˚C. Pouring of the composite slurry has been carried out to the sand mould prepared according to the specified shapes for, microstructure, hardening, tensile, and wear test.

4. EXPERIMENTAL TESTING

4.1 MICROSTRUCTURE

For microstructure testing, the fabricated MMC's were polished in such a fine way that there should be mirror like image in upper surface of samples. The mirror like surface finishes the samples were achieved by rubbing the sample on emery papers (100 to 1000 microns) and velvet cloth with the help of polishing machine. Then surface of sample were washed by Keller etch and Kroll's reagent. In this fabrication metal matrix composites, there is a difference of distribution of SiC particles to be seen by optical microstructure tests.

Fig – 3 microstructure testing equipment

4.2 MECHANICAL PROPERTIES

4.2.1 HARDNESS TEST

Hardness testing was performed on Rockwell hardness testing machine at room temperature. Hardness is a property of a material that enables to resist plastic deformation usually by penetration. However the term hardness may also refer to resistance to bending , scratching, abrasion or cutting.

In the testing the sample were mounted with Bakelite so that samples could not move when the load is applied. A diameter

Indenter was compressed on the material at a load of 5 kg for 5 seconds to avoid the segregation effect the reinforcement in the matrix.

Fig – 5 Hardness testing machine

4.2.2 TENSILE TESTING

The tensile test was conducted at room temperature on four volume (UTM) Universal testing machine. The specimen were prepared of Al/SiC metal matrix composite for various weight fraction (2%,4%,6%,8%,10%). in this test the diameter is measured and use the gauge mark punch fracture. Mark a 2 inch gauge length in each specimen install the specimen in the testing machine. Apply load to the specimen at a very slow rate record load and elongation for constant increments of elongation. At the yield point remove the extensometer from this point the elongation, at the ultimate strength, stop recording the elongation strain continuous loading specimen to fracture.

Fig – 6 Universal testing machine

4.2.3 WEAR TEST

Wear test was conducted using pin on disc method at 100m temperature and dry sliding condition. Cast iron dices of diameter 9 cm and Rockwell hardness HRC-47 were used as counter discs. The diameter of heat and tail were 8mm and 5mm respectively and length of head and tail were 4 mm and 8 mm respectively of wear and tesr samples.

All the wear test were conducted at 300 rpm of rotating counter disc and applying a fixed load of 10N in test samples. During wear test, weight looses from the worn surface were increased at one hour external with total times direction of 5 hours for each samples.

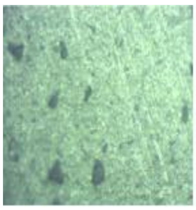
All the wear test were conducted at 300rpm of rotating counter disc and applying a fixed load of 10N in test samples. During wear test, weight looses from the worm surface were increased at one hour interval with total time duration of 5 hours for each samples.

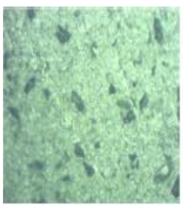
Fig – 7 Wear testing machine (pin on disc)

5. RESULT AND GRAPH

5.1 MICROSTRUCTURE

Microstructure analysis clustering and non homogenous distribution of SiC particles in Al matrix were observed this is due to the variation of contact between SiC particles and molten Al during composites processing high surface tension and poor wearing behavior of SiC particles were observged. This is due to SiC particles were added in the melt during casting, it introduced air in the melt entrapped between the particles. Therefore increasing the weight percentage of the SiC particles increased entrapped air resulted in higher amount of porosity.





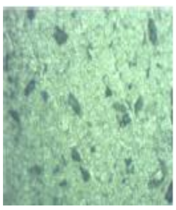
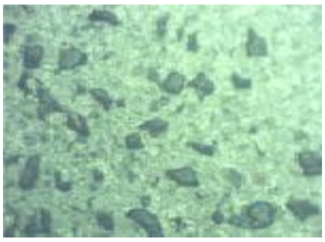


Fig – 8. 2% SiC **Fig – 9.** 4% SiC **Fig – 10.** 6% SiC



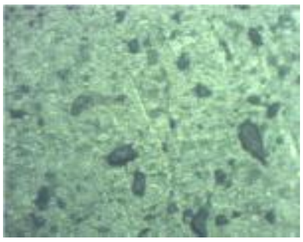


Fig – 11. 8% of SiC **Fig – 12.** 10% of SiC

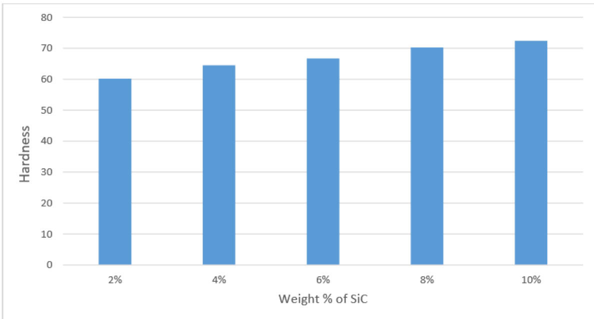
5.2 HARDNESS TESTING

The table shows the addition of SiC particles in Al matrix composite enhances the hardness of AMC's when compared with reinforced Al.

The presence of harder and f well bonded SiC particles in Al matrix that impede the movement of dislocations increases the hardness of AMC's.

Table 1: Hardness weight % in SiC

Weight % of SiC	Hardness
2%	60.20
4%	64.5
6%	66.7
8%	70.25
10%	72.4



Graph – 1: Hardness vs Weight % of SiC

5.3 TENSILE STRENGHT

It is observed that the result of tensile strength of AMC's is greater than unreinforced aluminum. Increase of tensile strength in AMC's can be attributed due to the applied tensile load transfer to the strongly bonded SiC reinforcement in Al matrix. Increased dislocation density near matrix reinforcement interferes and grain refining strengthening effect. In a composite containing strong matrix with strong interference, the crack has to propagate across both matrix and reinforcements, with the increased wt% SiC particles the porosity increases but increase of strength to strong interfacial bong contributes to enmhance3s the tensile strength of AMC'S.

Table 2: Ultimate tensile in MPa and weight % of SiC

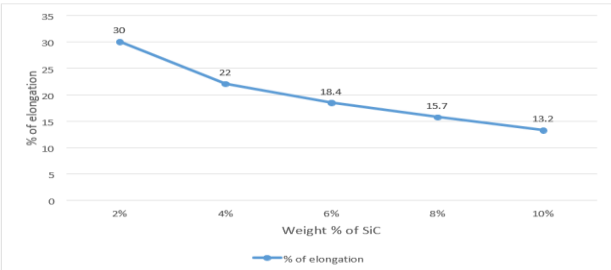
Weight % of SiC	Ultimate strength
2%	100
4%	107
6%	117
8%	129
10%	151

Table 3: Yield strength in MPa and weight % in SiC

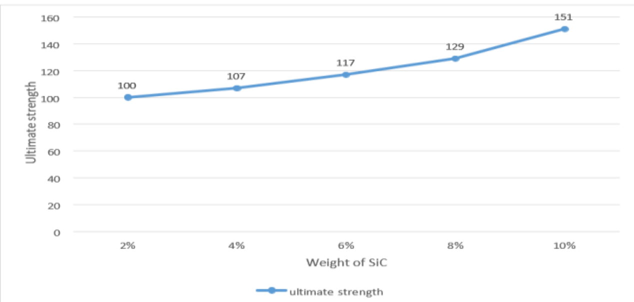
Weight % of SiC	Yield Strength
2%	75.5
4%	95.4
6%	104.6
8%	115.4
10%	120.3

Table 4: % Elongation and Weight % of SiC

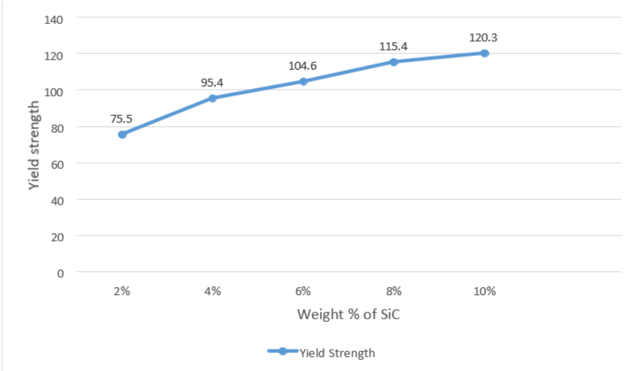
Weight % of SiC	% of Elongation
2%	30
4%	22
6%	18.4
8%	15.7
10%	13.2



Graph 2 : % Elongation vs Weight% of SiC



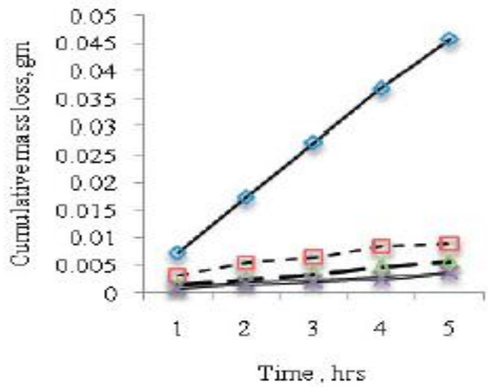
Graph 3: Ultimate strength vs Weight% of SiC



Graph 3: Yield strength vs Weight% of SiC

5.3 WEAR TEST:

It is seen in the graph that the heat mass losses for unreinforced Al is grater than SiC reinforced AMC's. This is because the softer Al matrix is worm away first from sample surface during wear test leaving the hard SiC particles on worm surface. Then exposed SiC particles protect the Al matrix from further wear. As the weight % of SiC in the AMC's increases, the resistance to wear weight containing surface is increased . At 10 wt % SiC reinforced AMC showed lowest amount of mass loss and hence maximum wear resistance.



Graph 5: Wear Resistance

6. COMPARISON BETWEEN STEEL AND AL(6063) ALLOY WITH SILICON CARBIDE

Table 5: comparison between steel and Al(6063) alloy with Silicon carbide.

Steel	Al (6063) with SiC
1. As compared with Aluminium the price of the steel is cheaper.	1. The cost of Al is high due to the raw materials

2. Steel is very tough and resilient metal but cannot be generally be pushed to the same extreme dimensional limits as Al without cracking or ripping during the spinning process, steel can't be modified in to the desired shape and size easily.	2. Al is very desired metal because it is more meltable and elastic to desired shape, Al can go places and create shapes that steel cannot often forming deeper or more intricate spinning. Especially for the parts with deeper and straight walls Al is the material of choice.
3. Steel or carbon steel is the metal usually needs painted or treated after spinning to protect it from rust and corrosion. Especially the steel part will be at work in a moist damp or abrasive environment.	3. Al does not rust and it does not need any protection in any environment conditions. There is no paint or coating to wear or scratch off.
4. Welding capacity is more but less life duration.	4. Welding capacity is more and the life capacity is more as compared with steel.
5. The replacement of steel is not possible easily as the same material steel should be replaced.	5. The replacement of Al can be taken place easily without much effort.

7. CONCLUSIONS

The experiment investigation provides the following conclusions:

a) Microstructure:

Optical microscope showed homogenous dispersion of SiC in Al(6063) Alloy with Silicon MMC's in increasing trend in sample testing.

b)**Tensile strength**:

In this test, the tensile strength (MPa), yield strength (MPa), increasing with increasing in reinforcement particulate size and weight fraction of SiC particles(2%, 4%, 6%, 8%, 10%). The increase in reinforcement particles and weight fraction (2%, 4%, 6%, 8%, 10%) the % Elongation and % Reduction in area decrease gradually.

c)Hardness:

During the hardness testing of Al/SiC MMC's samples, hardness increases with increase in reinforcement particulate and weight fraction (2%, 4%, 6%, 8%, 10%) of SiC particles.

d)Wear:

Wear resistance of SiC reinforcement AMC's showed an increase with increasing SiC content in Al matrix.10 wt.% SiC reinforcement AMC showed maximum wear resistance.

From the above results above, SiC reinforcement AMC's showed better hardness, tensile, and wear resistance than unreinforced Al.

Comparison with steel and Al (6063) alloy with Silicon Carbide, as showed a few comparison above, the steel can be replaced with Aluminum up to a level for better designing and different purposes.

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