Experimental Investigation on Aluminum Metal Matrix Composite

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***Abstract*:- Metal matrix composites (MMCs) have become attractive for engineering structural applications due to their excellent specific strength property and are increasingly seen as alternative to the conventional materials particularly in the automotive, aerospace and defence industries. Al/SiC/Al_2O_3MMC has aluminium matrix and the silicon carbide particles as reinforcements and exhibits many desirable mechanical properties. In the present study, an attempt has been made to fabricate Al/SiC/Al_2O_3composite by stire casting method route as it homogenously distributes the reinforcement in the matrix with no interfacial chemical reaction and high localized residual porosity. SiC particles containing different weight fractions (10 and 15%) and mesh size (300 and 400) is used as reinforcement. The paper presents the processing of Al/SiC/Al_2O_3 by powder metallurgy method to achieve desired properties and also the results of an experimental investigation on the mechanical properties of Al/SiC/Al_2O_3 are determined.**

Key Words - MMC; Al/SiC/Al_2O_3; Stir Casting; Mechanical properties; Hardness; Tensile Strength Microstructure.

1. INTRODUCTION

MMC (Metal matrix composites) are metals reinforced with other metal, ceramic or organic com- pounds. They are made by dispersing the reinforcements in the metal matrix. Reinforcements are usually done to improve the properties of the base metal like strength, stiffness, conductivity, etc. Aluminium and its alloys have attracted most attention as base metal in metal matrix composites. Aluminium MMCs are widely used in aircraft, aerospace, auto- mobiles and various other fields. The reinforcements should be stable in the given working temperature and non-reactive too. The most commonly used reinforcements are Silicon Carbide (SiC) and Aluminium Oxide (Al_2O_3). SiC reinforcement in- creases the tensile strength, hardness, density and wear resistance of Al and its alloys. The particle distribution plays a very vital role in the properties of theAl MMC and is improved by intensive shearing. Al_2O_3 reinforcement has good compressive strength and wear resistance.

2. EXPERIMENTAL METHOD

2.1. MATERIALS

It is indispensable to select pure metal powder and optimal processing parameters for the preparation of specimens. The specifications composition obtained is presented below. The aluminium contains Al(6061)-78%, Al_2O_3 -15%,SiC-7%.

2.2. PRE-TREATMENT OF SIC PARTICULATES

The pre-treatment of SiC particulates is heated in presence of air at a temperature of 700°C in a muffle furnace (TEXCARETM, max.temp. 1000° C) as shown in Fig.1 and kept at the temperature for 1hour preceding to using it for fabrication of MMC samples.

Fig.1. Muffle furnace, Heating of SiCat 700° C

As it is done to shape a thin layer of SiO2 on the surface of SiC particulate to aluminium so that immediate reaction between aluminium and SiC particulates is prevented. [3-7]. Fig.1.Muffle furnace Heating of SiC at 700° C.

2.3. STIR CASTING METHOD

Stir casting is a unique and prominent technique for the development of reinforced aluminium matrix composite materials. This technique is utilized as a result of its simple process and ability to overcome the problem of expensive processing methodwhich has restricted the widespread application of metal matrix composite which are considered potential material candidate for various structural and non structural applications in the field of aerospace, automotive, biomedical, military defence and sports industries. The development of this promising technique evolved as a result of modern technological advancement in material application and the demand for lightweight materials with improved mechanical and thermal properties. This process involves a liquid state fabrication technique which requires the incorporation of reinforcing phase (discontinuous form) into a molten matrix metal (continuous form) to bet a uniform distribution through stirring as shown in Figure.

Fig.2. Melting Material's

3. FABRICATION

Sand casting is a process that uses a mold made from either rmetal, wood, or wax to create a negative impression in a special sand that will be the mold for the molten metal. This mold is then filled with a molten metal that is left to cool and solidify. Once the metal has solidified the mold can be hit with a hammer, pipe, or any hard object to crack the sand.

Fig.3. Outcome Job

4. MACHINING

Machining is any of various processes in which a piece of raw material is cut into a desired final shape and size by a controlled material-removal process.

Much of modern-day machining is carried out by Computer Numerical Control (CNC), in which computers are used to control the movement and operation of the mills, lathes, and other cutting machines.

Fig.4. Machining Outcome Job

5.MECHANICAL PROPERTIES OBSERVATION

5.1.TENSILE TEST RESULTS

Tensile test is conducted on WDW-50/100 series computer control electronic universal testing machine. Four specimens were prepared for tensile test of which two are T6 heat treated specimens.
The ash cast and heat treated samples were machined to get specimens for tensile test. The shape and dimensions of the tensile specimen are shown in figure. The universal testing machine was used for the tensile test.
The specimens were loaded hydraulically. The loads at which the specimen has reached the yield point and broken were noted down. The extensometer was used to measure the elongation.

Fig.5. Tensile Result

In this project we added reinforcement material silicon and aluminum oxide in the ration of 7% and 15% we getting ultimate tensile strength 116.65MPa and Yield Strength 103.92MPa.

5.2. HARDNESS TEST

Fig.6. Hardness Result

Brinell hardness is determined by forcing a hard steel or carbide sphere of a specified diameter under a specified load into the surface of a material and measuring the diameter of the indentation left after the test.TheBrinell hardness number, or simply the Brinell number, is obtained by dividing the load used, in kilograms, by the actual surface area of the indentation, in square millimeters.The result is a pressure measurement, but the units are rarely stated.

The Brinell hardness test uses a desk top machine to press a 10mm diameter, hardened steel ball into the surface of the test specimen. The machine applies a load of 500 kilograms for soft metals such as copper, brass and thin stock. A 1500 kilogram load is used for aluminum castings, and a 3000 kilogram load is used for materials such as iron and steel. The load is usually applied for 10 to 15 seconds. After the impression is made, a measurement of the diameter of the resulting round impression is taken.

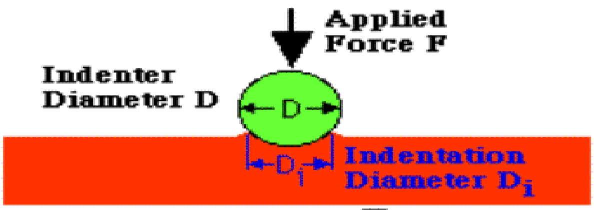
It is measured to plus or minus .05mm using a low-magnification portable microscope. The hardness is calculated by dividing the load by the area of the curved surface of the indention, (the area of a hemispherical surface is arrived at by multiplying the square of the diameter by 3.14159 and then dividing . To make it easier, a calibrated chart is provided, so with the diameter of the indentation the corresponding hardness number can be referenced.

A well structured Brinell hardness number reveals the test conditions, and looks like this, "75 HB 10/500/30" which means that a Brinell Hardness of 75 was obtained using a 10mm diameter hardened steel with a 500 kilogram load applied for a period of 30 seconds. On tests of extremely hard metals a tungsten carbide ball is substituted for the steel ball.

Among the three hardness tests discussed, the Brinell ball makes the deepest and widest indentation, so the test averages the hardness over a wider amount of material, which will more accurately account for multiple grain structures, and any irregularities in the uniformity of the alloy.

The Brinell hardness test was one of the most widely used hardness tests during World War II . For measuring armour plate hardness the test is usually conducted by pressing a tungsten carbide sphere 10mm in diameter into the test surface for 10 seconds with a load of 3,000kg, then measuring the diameter of the resulting depression.

The BHN is calculated according to the following formula:



$$BHN = \frac{F}{\frac{\pi}{2} D \cdot (D - \sqrt{D^2 - D_i^2})}$$

where ,
BHN= the Brinell hardness number
F = the imposed load in kg
D = the diameter of the spherical indenter in mm
D_i = diameter of the resulting indenter impression in mm

HV = Constant x test force / indent diagonal squared

Location	**Observed Values In HBW(10mmBall/500kgLaod)**
Cross section	**48.6,50.3,50.0**

5.3. MICROSTRUCTURAL CHARACTERIZATION

The composites produced were examined by optical microscope to analyze the microstructure. A section was cut from the castings, which is first belt grinded followed by polishing with different grade of emery papers.

Fig.7. Microstructural Result

After that they were washed and again clothpolishing of the sample was done. After etching they were examined for microstructure under optical microscope at different magnifications.

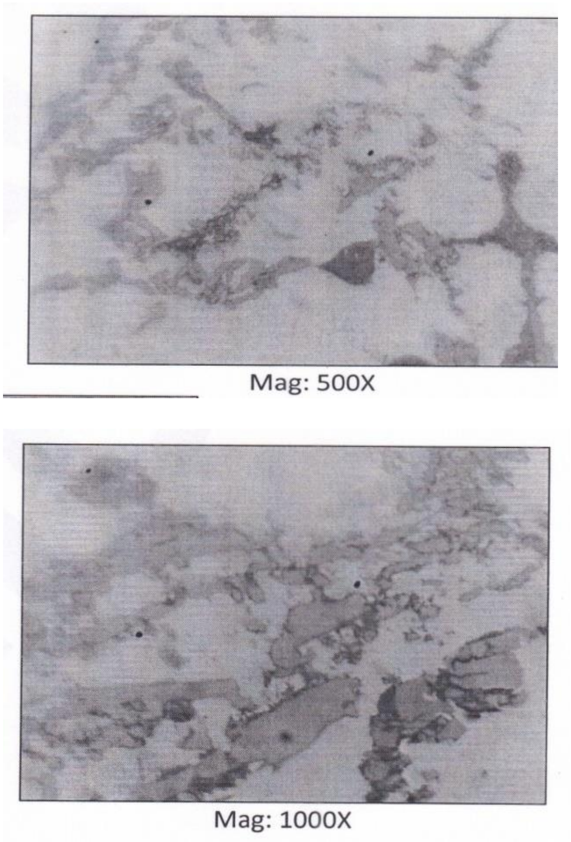


Fig.8. Bonding Structure

6. CONCLUSION

Al – SiC-Al_2O_3 composites were produced by modified stir cast route with different weight percentage of reinforcement and the mechanical properties such as hardness, tensile.Micro Structure property phase segmentation were evaluated.

From this study, the following conclusions are derived.

- The tensile Properties which is with stand connecting road maximum stress factor.
- The aim of this project is to improve the hardness factor and tensile Properties with adding reinforcement material SiC and Al_2O_3.
- The micro hardness of the composites was computed 49.63 for 10mm Ball/500kg Loadfrom adding reinforcement material of weight percentage of Silicon carbide 7% and Al_2O_3 15%. Hardness is an important property of a component which is subjected to heavy load. The reinforcement of particles has enhanced the hardness of aluminum matrix and composites. Al6061with SiC and Al_2O_3which having maximum yield Point is 103MPa and Ultimate tensile Strength is 116.65 MPa.
- Lack of porosity exhibited in the microstructure of Al-Si matrix composite indicates there is a rather good particulate – matrix interface bonding.
- Thus the phase and the volume fraction of Al – SiC-$Al_2O_3$are viewed by using the Metallurgical Image Analysis System. The volume of SiC is increase by increasing the wt.% of SiC.

6. REFERENCES

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