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Evaluation of Mechanical Behaviour Aluminium Metal Matrix Composites

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Abstract - **Technology is advancing, demand of the hour is increasing and to face that engineers are also ready. Maintaining the economic production with optimal use of resources is of prime concern for the engineers. Aluminum alloy materials or simply composites are combinations of materials. They are made up of combining two or more materials in such a way that the resulting materials have certain design properties on improved properties .The Aluminum alloy composite materials consist of high specific strength, high specific stiffness, more thermal stability, more corrosion and wear resistance, high fatigue life. Conventional materials like Steel, Brass, and Aluminum etc will fail without any indication. Cracks initiation, propagation will takes place within a short span. Now a day to overcome this problem, conventional materials are replaced by Aluminum alloy materials. Aluminum alloy materials found to the best alternative with its unique capacity of designing the materials to give required properties. In this project tensile strength experiments have been conducted by varying mass fraction of SiC and fly ash magnesium with Aluminum. To attain maximum tensile strength various mechanical properties alloys are also to be investigated.**
Keywords: **Aluminum, SiC, magnesium, Fly ash and Composite materials.**

I.INTRODUCTION

Composite materials are important engineering materials due to their outstanding mechanical properties. Composites are materials in which the desirable properties of separate materials are combined by mechanically or metallurgic ally binding them together. Each of the components retains its structure and characteristic, but the composite generally possesses better properties. Composite materials offer superior properties to conventional alloys for various applications as they have high stiffness, strength and wear resistance. The development of these materials started with the production of continuous-fiber-reinforced composites. The high cost and difficulty of processing these composites restricted their application and led to the development of discontinuously reinforced composites (Ozdemir et. al.1999).

Aluminum (Al) is a silvery white and ductile member of the poor metal group of chemical elements. Al is an abundant, light and strong metal which has found many uses. Like all composites, aluminum-matrix composites are not a single material but a family of materials whose stiffness, strength, density, and thermal and electrical properties can be tailored. The matrix alloy, the reinforcement material, the volume and shape of the reinforcement, the location of the reinforcement, and the fabrication method can all be varied to achieve required properties. Regardless of the variations, however, Al composites offer excellent thermal conductivity, high shear strength, excellent abrasion resistance, high temperature operation, non flammability, minimal attack by fuels and solvents, and the ability to be formed and treated on conventional equipment.

Silicon carbide (SiC) is composed of tetrahedral of carbon and silicon atomswith strong bonds in the crystal lattice. This produces a very hard and strong material. SiC is not attacked by any acids or alkalis or molten salts up to 800oC. In air, SiC forms a protective silicon oxide coating at 1200oC and is able to be used upto 1600oC. The high thermal conductivity coupled with low thermal expansion and high strength gives this material exceptional thermal shock resistant qualities. SiC ceramics with little or no grain boundary impurities maintain their strength to very high temperatures, approaching 1600oC with no strength loss. Chemical purity, resistance to chemical attack at temperatures, and strength retention at high temperatures has made this material very popular as wafer tray supports and paddles in semiconductor furnaces. Properties of silicon carbide are low density, high strength, low thermal expansion, high hardness, and high elastic modulus. Particle reinforced composites have relatively isotropic properties compared to short fiber or whisker reinforced composites. The properties of the composites can be tailored by manipulating parameters such as reinforcement particle distribution, size, volume fraction, orientation, and matrix microstructure (Ayyar et. al, 2006). Metal matrix composites (MMCs), such as SiC particle reinforced Al, are one of the widely known composites because of their superior properties such as high strength, hardness, stiffness, wear and corrosion resistance. SiC particle reinforced Al based MMCs are among the most common MMC and available ones due to their economical production. They can be widely used in the aerospace, automobiles industry such as electronic heat sinks, automotive drive shafts, or explosion engine components. The physical and chemical compatibility between SiC particles and Al matrix is the main concern in the preparation of SiC/Al composites. Therefore, the particle reinforced metal matrix composites can be synthesized by such methods as powder metallurgy (PM), standard ingot metallurgy (IM), disintegrated melt deposition (DMD) technique, spray atomization, and code position approach. Different method results in different properties.

In this study, the casting method is carried out to prepare SiC particle reinforced Al MMC. The effect of weight percentage of the reinforced particles on mechanical behavior such as hardness and corrosion of the composites can be investigated.

II. RELATED WORK

There have been tremendous strides in engineering materials since 1950s. Several superalloys and heat resistance materials have been developed for various industrial applications, especially aerospace/aircraft and defense. Automotive, medical and sport equipment industries pushed advances in materials particularly having low density and very light weight with high strength, hardness and stiffness. One of these important advanced material is composites (Ozben,T. 2007).

A composite material is a nonuniform solid consisting of two or more different materials that are mechanically or metallurgically bonded together. Each of the various composites retains its identity in the composite and maintains its characteristic properties such as stiffness, strength, weight, high temperature, corrosion resistance, hardness, and conductivity, which are not possible with the individual components by themselves (Black, 2007). Example of the traditional composite is brick which consists of clay that mix up with grass and concrete that have mixture of cement and sand. In this example, clay and cement are matrix component while grass and sand are the reinforcement (Hashim,J. 2003).

Generally, one component acts as a matrix in which the reinforcing phase is distributed. The matrix component is, thus the continuous phase. When the matrix component is metal, we call such a composite a metal matrix composite (MMC). The reinforcement can be in the form of particles, whiskers, short fibers, or continuous fiber. There are three entities that determine the characteristics of a composite which are reinforcement, matrix and interface. The role of matrix was considered to be that of a medium or binder to hold the strong and stiff fibers or other types of reinforcement. Over the years, however, it has been realized that the matrix microstructure and consequently its mechanical properties have a considerable influence on the overall performance of a composite. This is particularly true of the MMCs because the very act of incorporating a reinforcement can result in change(s) in the microstructure of the metallic matrix and, consequently in their structure-sensitive properties such as a strength and toughness (Cahn, et.al. 2005).

III. PROPOSED METHOD

Aluminum alloy materials or simply composites are combinations of materials. They are made up of combining two or more materials in such a way that the resulting materials have certain design properties on improved properties .The Aluminum alloy composite materials consist of high specific strength, high specific stiffness, more thermal stability, more Corrosion and wear resistance, high fatigue life. AlSiC, pronounced ‘alsick’ is a metal matrix composite consisting of aluminum matrix with silicon carbide particles. It has high thermal conductivity (180–200 W/m K) and it is chiefly used in microelectronics as substrate for power semiconductor devices and high density multi chip modules, where it aids with removal of waste heat. The mechanical properties of aluminum alloys reinforced with ceramic particulates are known to be influenced by the particle size and the volume fraction. Arsenault, 1984 has concluded from the series of experiments that 0.2% proof stress and ultimate tensile strength tend to increase, and toughness and ductility decrease with increasing volume fraction of particulate or decreasing particle size.

Hashim et al., 1999 have made this type of processing in commercial use for particulate Albased composites. Casting is a probably one of the most ancient processes of manufacturing metallic components. First melting the Aluminum metal with 5%, 10%, 15%, and 20% on mass fraction basis. Pouring it into a previously made mould or cavity which conforms to the shape of the desired component. Allowing the molten metal to cool and solidify in the mould.

Removing the solidified component from the mould, cleaning it. The solidified piece of metal, which is taken out the mould, is called as casting. Finishing casted object by using lathe machine for required shape and size.

A. Metal Matrix Composite

Metal matrix composite (MMC) is composite material with at least two constituent parts, one being a metal. The other material may be a different metal or another material, such as a ceramic or organic compound. MMCs are nearly always more expensive than the more conventional materials they are replacing. As a result, they are found where improved properties and performance can justify the added cost. Today these applications are found most often in aircraft components, space systems and high-end or “boutique” sports equipment. The scope of applications will certainly increase as manufacturing costs are reduced.

In comparison with conventional polymer matrix composites, MMCs are resistant to fire, can operate in wider range of temperatures, do not absorb moisture, have better electrical and thermal conductivity, are resistant to radiation, and do not display out gassing. On the other hand, MMCs tend to be more expensive, the fiber-reinforced materials may be difficult to fabricate, and the available experience in use is limited.

B.Material requirement finding method

Specimen size-25 mm dia-
Length-250 mm
Volume-3.14/4*25^2*300*percentage of composite*density*percentage of excess of material
Sample 1: 90%$AL_2 0_3$, 2.5%Flyash, 2.5%Megnisium, 5%Sic Excess for Runner, Riser& Slag
Aluminium-562gm, Fly ash-13.5gm, Megnisium-9.62, Silicon crbide-36.3gm
Sample 2: 84%$AL_2 0_3$, 10%Flyash,3%Megnisium,3 %Sic Excess for Runner, Riser & Slag
Aluminium-525gm, Fly ash-49gm, Megnisium-12.5gm, Silicon crbide-21gm
Sample 3: 75%$AL_2 0_3$, 10%Flyash,5%Megnisium, 10%Sic Excess for Runner, Riser & Slag
Aluminium-438gm, Fly ash-49gm, Megnisium-39.4gm, Silicon crbide-71.69gm
Sample 4: 90%$AL_2 0_3$, 10%Sic Excess for Runner, Riser & Slag
Aluminium-562gm, Silicon crbide-72gm

C. Casting

In this project we have used sand mold casting for produce the requirement size. Sand casting, also known as sand molded casting, is a metal casting process characterized by using sand as the mold material. It is relatively cheap and sufficiently refractory even for steel foundry use. A suitable bonding agent (usually clay) is mixed or occurs with the sand. The mixture is moistened with water to develop strength and plasticity of the clay and to make the aggregate suitable for molding. The term "sand casting" can also refer to a casting produced via the sand casting process. Sand castings are produced in specialized factories called foundries. Over 70% of all metal castings are produced via a sand casting process.

D.Destructive Test

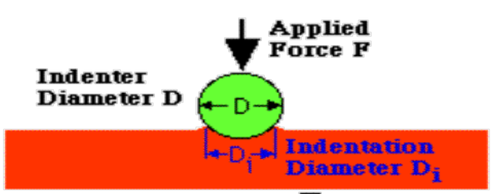
1. Hardness

There are three types of tests used with accuracy by the metals industry; they are the Brinell hardness test, the Rockwell hardness test, and the Vickers hardness test. Since the definitions of metallurgic ultimate strength and hardness are rather similar, it can generally be assumed that a strong metal is also a hard metal. The way the three of these hardness tests measure a metal's hardness is to determine the metal's resistance to the penetration of a non-deformable ball or cone. The tests determine the depth which such a ball or cone will sink into the metal, under a given load, within a specific period of time. The followings are the most common hardness test methods used in today`s technology:

2.Brinell hardness Test

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. The Brinell 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. 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 by 2). 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 tin carbide ball is substituted for the steel ball. The Brinell hardness test was one of the most widely used hardness tests during World War. For measuring armour plate hardness the test is usually conducted by pressing a tin 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:



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

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

ASTM E-10 is a standard test for determining the Brinell hardness of metallic materials. The load applied in this test is usually 3,000, 1,500, or 500 kgf, so that the diameter of the indentation is in the range 2.5 to 6.0 mm. The load is applied steadily without a jerk. The full test load is applied for 10 to 15 seconds. Two diameters of impression at right angles are measured, and the mean diameter is used as a basis for calculating the Brinell hardness number (BHN), which is done using the conversion table given in the standard.

TABLE I BRINELL HARDNESS NUMBER (BHN)

S.No.	Material	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean dia	Avg BHN
1	90%$AL_2 0_3$, 2.5%Flyash, 2.5%Megnisium, 5%Sic	4.2	4.36	4.02	4.0	4.25	4.17	28.42
2	84%$AL_2 0_3$, 2.5%Flyash, 2.5%Megnisium, 5%Sic	4.1	4,19	4,18	4.16	4,11	4.15	28.80
3	75%$AL_2 0_3$, 10%Flyash, 5%Megnisium, 10%Sic	3.6	3.7	3.5	3.7	3.8	3.67	39.70
4	90%$AL_2 0_3$, 10%Sic	4.0	4.1	4.16	4.28	4.28	4.2	27.84

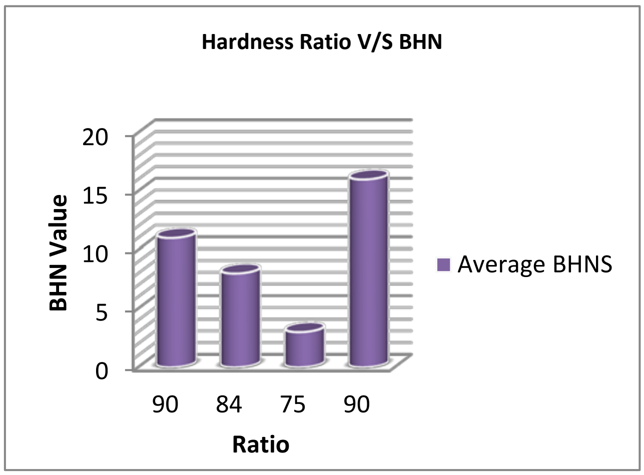


Fig.1 Graphs for Hardness

IV. CONCLUSION

Composite materials especially aluminum and silicon, flyash megnisium composites having good mechanical properties compared with the conventional materials. It is used in various industrial application these materials having light weight along with high hardness .It with stand high load compare with the existing materials are most applicable in the engineering products instead of existing materials. Finally I conclude that the percentage of megnisium increases automatically the toughness, machining timing decreases.

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