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RESEARCH ARTICLE

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ANALYSIS AND TESTING OF ALUMINIUM SILICON CARBIDE METAL MATRIX COMPOSITES

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ABSTRACT

Metal Matrix Composites (MMCs) have shown great interest in recent times due to its potential of applications in aerospace and automotive industries because of having superior strength to weight ratio. The wide use of particular metal matrix composites for engineering applications has been obstructed by the exact use of silicon carbide (SiC) by weight %, hence high cost of components. Although there are several technical used for casting technology rather it can be used to overcome this problem. Materials are frequently chosen for structural applications because they have desirable combinations of mechanical characteristics. Development of hybrid metal matrix composites has become an important area of research interest in Materials Science. In view of this, the present study focuses on the behavior of aluminium silicon carbide (AlSiC) hybrid metal matrix composites. The present study was aimed at evaluating the mechanical properties of Aluminium in the presence of silicon carbide with different weight percentages of silicon carbide (5%, 10%, 15% & 20%) combinations. Consequently aluminium metal matrix composite combines and exhibit huge strength of the reinforcement with the toughness of the matrix to achieve a combination of desirable properties not available in any single conventional material. The compositions were added up to the ultimate level and stir casting method was used for the fabrication of aluminium metal matrix composites. To investigate the properties of AlSiC, experiments have been conducted by varying weight fraction of SiC (5%, 10%, 15% and 20%) while keeping all other parameters constant. The results indicate the behavior and properties of material is quite successful to obtain exact use of aluminum silicon carbide according to the requirement.

KEY WORD:- Mechanical properties investigation of Aluminium silicon carbide metal matrix composites (MMC)

INTRODUCTION

Aluminium silicon carbide metal matrix composites are combinations of two or more materials. They made by combining two or more materials in such a way that the resulting materials have certain design properties or improved properties. Aluminium Silicon carbide alloy composite materials are widely used and applications like engineering structures, industry and electronic applications, sporting goods etc. The properties of aluminium metal matrix composite mostly depend on the processing method which is capable of producing good properties to meet the industry need. Al-SiC composites can be more easily produced by the stir casting technique due to its good casting ability and relatively inexpensive. The stir casting method is economical as well as easy to apply and convenient for mass production. Study of wear properties of Al-SiC composite is found that wear rate decreases linearly with increasing SiC content. Mechanical characterization of Al-SiC composite like density, hardness, elongation%, toughness and tensile strength were evaluated. The improved value of tensile strength for Aluminium composites is one of the reasons they are widely used in industry it has been found that particle reinforced aluminium matrix composites can improve considerably the strength and hardness of aluminium and its alloys. However, at the same time, the plasticity and ductility can substantially reduced. This will severely affect the safety and reliability of components fabricated from Aluminium matrix composites (AMCs). Mechanical characterization of Aluminium silicon carbide mass fraction of SiC (5%, 10%, 15%, and 20%) with Aluminium is analyzed. The maximum tensile strength has been obtained at 15% SiC ratio according to other parameters. Mechanical and Corrosion behavior of Aluminium Silicon Carbide alloys is suitable for spur gear, shaft and many other mechanical components. An analytical or experimental method is often unable to explore the behavior of a metal matrix composite (MMC) during machining due to the complex deformation and interactions among particles, tool and matrix. The development of stress and strain fields in the MMC was analyzed and physical phenomena, particle bonding, displacements and homogeneous deformation of matrix material were explored.

Material and methods

The aluminum silicon carbide (AlSiC) metal matrix composites with different composition of silicon carbide (SiC) is purchased from calcutta scientific metal works, Kolkata, west Bengal, india.

Experimental work

Specimens for the experiments are made from the rod form of AlSiC of different composition for the different tests. Density, hardness, and elongation behavior of AlSiC with different weight percentages is calculated with deferent set of measuring machine.

Density

The density a substance is its mass per unit volume. The symbol most often used for density is ***ρ***. Mathematically, density is defined as mass divided by volume.

$$\rho = \frac{m}{V},$$

where *ρ* is the density, *m* is the mass, and *V* is the volume.

For a pure substance the density has the same numerical value as its mass concentration. Different materials usually have different densities, and density may be relevant to buoyancy, purity and packaging.

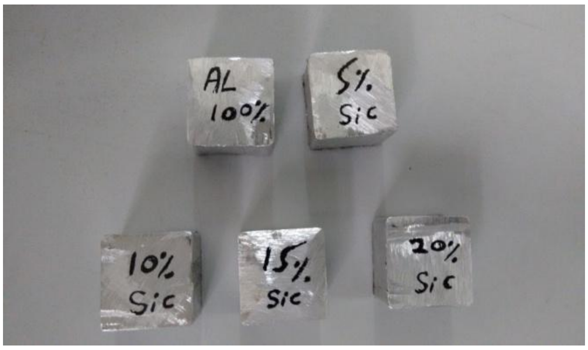


Fig.1 AlSiC MMCs sample to analyze density

The density of a material varies with temperature and pressure but here other parameters are kept constant. Increasing the pressure on an object decreases the volume of the object and thus increases its density. Silicone has less density than aluminum but due to presence of carbide the density of aluminum silicon carbide metal matrix composites density of the material increases.

Table.1 AlSiC MMCs and their density respectively

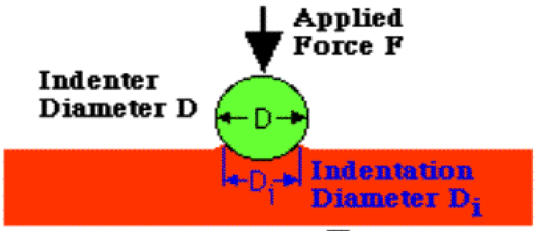
AlSiC	Al(100%)	SiC(5%)	SiC(10%)	SiC(15%)	SiC(20%)
Density g/cm^3	2.65	2.72	2.75	2.79	2.82

Hardness

Brinell hardness test done for the investigation of hardness of AlSiC with different composition. 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 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 by 2. There is 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. The Brinell ball makes the deepest and widest indentation is more accurately calculated for multiple grain structures, and any irregularities in 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 (Figure 3):

Fig.2 Brinell hardness test machine



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

Fig.3 Process of indentation and formula

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

Table.2 AlSiC MMCs and their hardness respectively

AlSiC	Al 100% + SiC 0%	Al 95% + SiC 5%	Al 90% + SiC 10%	Al 85% + SiC 15%	Al 80% + SiC 20%
Hardness(BHN)	38	40.3	41.2	44	45.4

Tensile test

Tensile test is also known as tension testing is a fundamental materials science in which a sample is subjected to a controlled tension until failure. The results from the test are commonly used to select a material for an application and to predict how a material will react under other types of forces. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area. A tensile specimen is a standardized sample cross-section. It has two shoulders and a gauge in between.

Fig.4 Sample of AlSiC for tensile test

The shoulders are large so they can be readily gripped, whereas the gauge section has a smaller cross-section so that the deformation and failure can occur in this area. The repeatability of a testing machine can be found by using special test specimens meticulously made to be as similar as possible.

A standard specimen is prepared in a round or a square section along the gauge length, depending on the standard used. Both ends of the specimens should have sufficient length and a surface condition such that they are firmly gripped during testing. The initial gauge length Lo is standardized (in several countries) and varies with the diameter (Do) or the cross-sectional area (Ao) of the specimen

Necking in engineering or materials science, is a mode of tensile deformation where relatively large amounts of strain localize disproportionately in a small region of the material. The resulting prominent decrease in local cross-sectional area provides the basis for the name "neck". Because the local strains in the neck are large, necking is often closely associated with yielding, a form of plastic deformation associated with ductile materials, often metals or polymers. Necking results from instability during tensile deformation when a material's cross-sectional area decreases by a greater proportion than the material strain hardens. During tensile deformation the material decreases in cross-sectional area. During tensile deformation the material strain hardens. The amount of hardening varies with extent of deformation.

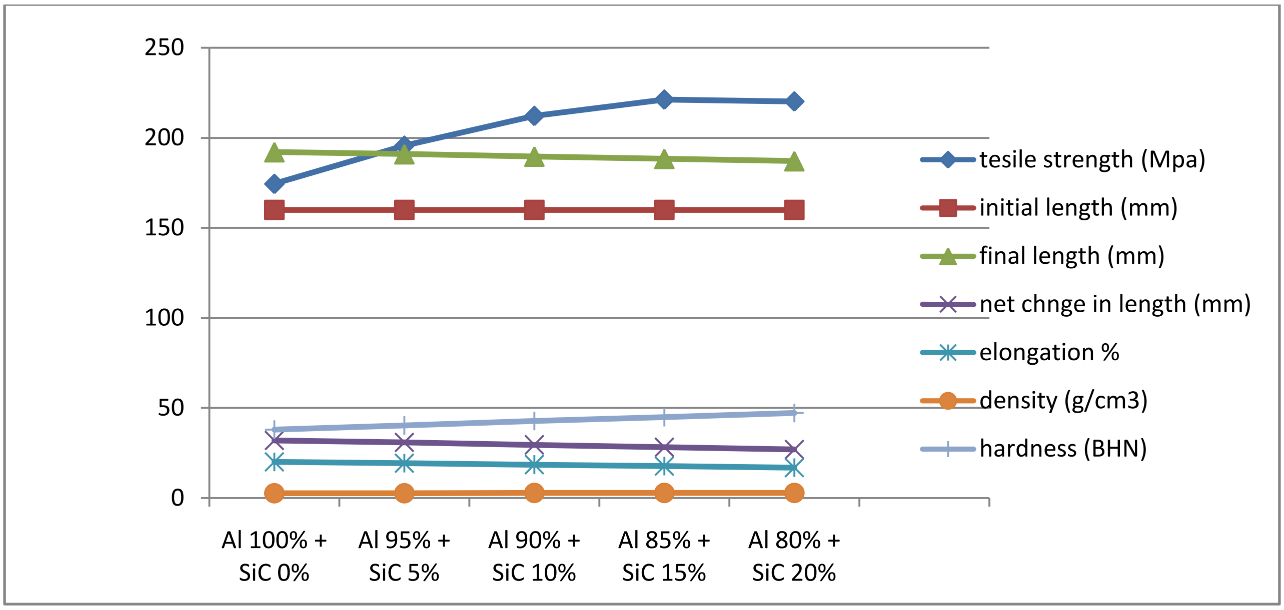
The test process involves placing the test specimen in the testing machine and slowly extending it until it fractures. During this process, the elongation of the gauge section is recorded against the applied force. The data is manipulated so that it is not specific to the geometry of the test sample. The elongation measurement is used to calculate the engineering strain (ε), using the following equation:-

$$\varepsilon = \frac{\Delta L}{L_0} = \frac{L - L_0}{L_0}$$

Where, ΔL is the change in gauge length, L_0 is the initial gauge length, and L is the final length

Table.3 AlSiC MMCs with different mechanical properties

AlSic	Al 100% + SiC 0%	Al 95% + SiC 5%	Al 90% + SiC 10%	Al 85% + SiC 15%	Al 80% + SiC 20%
Tensile strength (Mpa)	174.43	195.62	212.15	221.23	187.55
Initial length Lo (mm)	160	160	160	160	160
Final length Lf (mm)	192	190.88	189.60	188.32	187.04
Net change in length (Lf-Lo) mm	32	30.88	29.60	28.32	27.04
Elongation (e) %	20	19.3	18.5	17.7	16.9



Graph **1** AlSiC MMCs with different mechanical properties

RESULT AND DISCUSSION

1. Mechanical properties of AlSiC metal matrix composites are investigated.
2. It is found that the elongation tends to decreases according to the increase in weight percentage of silicon carbide and hence it leads to increase in hardness.
3. Density of the AlSiC with different composition of SiC metal matrix composites is investigated. Little increase in density results very high increase in strength.
4. It appears that the hardness increases results to decrease in elongation % of AlSiC metal matrix composites.
5. Tensile strength of the aluminum silicon carbide metal matrix composites increases gradually at the increased composition of the silicon in it but prebrably at 15% of SiC in Al give the best tensile strength as per the weight percentage ratio.

Scope of future work:

1. This can further be extended by varying the weight % of SiC and by varying the composition of AlSiC metal matrix composites.
2. Heat treatment can be done to improve the properties.
3. Results can be varied by varying reinforcement grain size.

REFERENCES

[1]. Adiamak, M.(2006), ''Selected properties of aluminium base composites reinforced with intermetallic particles'', J. Achiev. Matls Manufac. Tech., 14(1–2), pp. 43–47.
[2]. Alaneme, K.K. and Aluko, A.O.(2012), ''Production and age-hardening behaviour of borax pre-mixed SiC reinforced Al–Mg-Si alloy composites developed by double stir casting technique'', West Indian J. Eng., 34(1–2), pp. 80–85.
[3]. ASTM E 8M ''Standard test method for tension testing of metallic materials (metric) in annual book of ASTM standards'', Philadelphia, ASTM (1991).
[4]. Balasivanandha, S., Kaarunamoorthy, L., Kaithiresan, S. and Mohan, B. (2006),"Influence of stirring speed and stirring time on distribution of particles in cast metal matrix composite", Journal of Material Processing Technology, Vol. 171, pp. 268-273
[5]. Bayram, A., Uguz, A. and Durmus, A.(2001), ''Rapid determination of the fracture toughness of metallic materials using circumferentially notched bars'', J. Mater. Eng. Perform., 11(5), pp. 571–576.
[6]. B.E. Novich, R.W. Adams, and K.P. Fennessy (1995), "Metal Matrix Composites for Single Chip and Multichip Microprocessor

Packaging," Proceedings of the International Electronics Packaging Conference, IEPS, San Diego CA, September 24-27.

[7]. C.G.Kang, S.Ray and P.K.Rohatgi(1994), Mater. Sci. Eng. A188, 193.

[8]. Composites in Lubricated Sliding Conditions", Tribology in Industry, Vol. 35, No. 2 (2013) pp.148-154.

[9]. Christy, T.V., Murugan, N. and Kumar, S.(2010), ''A comparative study on the microstructures and mechanical properties of Al 6061 alloy and the MMC Al 6061/TiB2/12p'', J. Miner. Matls Charac. Eng., 9(1), pp. 57–65.

[10]. Chawla, V., Manoj, S., Dwivedi, D.D. and Lakhvit, S.(2009), ''Development of aluminium based SiC particulate metal matrix composites'', J. Miner. Matls Charac. Eng., 8(6), pp. 455–467.

[11]. Dieter, G.E.(1998), Mechanical Metallurgy, S.I. Metric, Ed., p. 358. McGraw-Hill, Singapore.

[12]. D.M. Skibo, D.M. Schuster, L. Jolla(1988), Process for preparation of composite materials containing nonmetallic particles in a metallic matrix, and composite materials made by, US Patent No. 4 786 467.