MECHANICAL PROPERTIES INVESTIGATION OF ALUMINIUM SILICON CARBIDE HYBRIDE METAL MATRIX COMPOSITE (MMCs)

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Abstract: Metal Matrix Composites (MMCs) have shown great interest in recent times due to its poetental 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 application has been obstructed by the exact use of silicon carbide* (*SiC) by % , hence high cost of components.Although there are several techniques 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 composities has becoame important area of research interest in Material Science . In view of this , the present study focuses on the behaviour of aluminium silicon carbide* (*AlSiC) hybrid metal matrix composities .The present study was aimed at evaluating the mechanical properties of Aluminium in the presence of silicon carbide with different weight percentage of silicon carbide (*5%,10%,15% & 20%) ***combinations. Consequently Aluminium metal matrix composite combines and exhibits huge strength of the reinforcement with the toughness of the matrix to achieve a combination of desirable properties not avilable in any single conventional metarial . 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% & 20%) ***While keeping all other parameters constant .The results indictate the behavior and properties of material is quite successful to obtain exact use of aluminium silicon carbide metal matrix composites according to the requirement.***
Keywords: Mechanical properties investigation of Aluminium silicon carbide metal matix composites (MMC)

I. INTRODUCTION

Aluminium silicon carbide metal matrix composities are combinations of two or more materials They are 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 in 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 industrial need. AlSiC composites can be easily produced by the stir casting technique due to its good cast ablilty and relatively inexpensive. The stir casting method is economical as well as easy to apply and convenient for masss production. However , the problem encountered for this technique is low wet ability and particle settling but for improving wet ability and particle homogeneity during casting , various methods have been used including coating and oxidizing the reinforcement particles , adding some surface active elements (magnesium, silicon carbide and lithium) into the matrix. Increasing the temperature and stirring of molten matrix composites for an adiquate time period during incorporation. Study of wear properties of AlSiC composite is found that wear rate decreases linearly with increase of SiC content. Mechanical characterization of Al-SiC composite like hardness ,impact strength and material toughness were evaluvated. With the improved value of coefficaient of thermal exapansion of Aluminium composite is one of the reason they are widely used by electronic industries and it has been found that the particles reinforcement of Aluminium matrix composites can improve considerably the strength and hardness of aluminium and its alloys. But , at the same time , the plasticity and ductility can substantially reduced . This will severly affect the safety and reliability of components fabrication from Aluminium matrix composites (AMCs). Mechanical characterization of Aluminium silicon carbide mass fraction of SiC (5% , 10% , 15% and 20%) with Aluminium. Mechanical and Corrosion behaviour of Aluminium Silicon Carbide alloys suitable for spur gear. This paper analyses the tensile strength , impact strength ,shear strength and bending strength of Al-SiC. The development of stress and strain fields in the MMC was analyzed and the mechanical properties like ultimate torsion strength , hardness and ultimate tensile strength of matrix material were explored . It was found that tool particle intraction and stress , strain distribution in the particles of matrix are responsible for particle debonding , surface damage and tool wear during machining MMC.

ALUMINIUM

Aluminium is a metallic element which is represented by symbol Al , having atomic number 13 and melting point is 660.3ºC. It is a silvery –white , soft , nonmagnetic, ductile metal . Aluminium is the third most abundant element after

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oxygen and silicon in the Earth's crust . It is about 8% by weight of the crust, though it is less common in the mantle below . Aluminium metal is so chemically reactive that native specimens are rare and limited to extreme reducing enviroments . Instead of this it is found to be combined with over 270 different minerals . The chief ore of aluminium is bauxite.

Aluminium is remarkable for the metal's low density and for its ability to resist corrosion due to the phenomenon of passivation . Structual components made from aluminium and its alloys are vital to the areospace industry and are important in other areas if transportation and structural materials . The most useful compound of aluminium where least weight is required and can combined to make oxides and sulphates.

Physical Characteristics

Aluminium is a realtively soft , durable , lightweight ,ductile and malleable metal with appearance ranging from silvery to dull gray , depending on the surface roughtness . It is nonmagmetic and does not easily ignite . A fresh film of aluminium serves as a good reflector of visiblelight and an excellent reflector of medium and far infrared radiation,The yield strength of pure aluminium is 7-11 Mpa, while aluminium alloys have yield strengths ranging from 200 – 600 Mpa . Aluminium has about one-third the density and stiffness of steel .It is easily machined ,cast ,drawn and extruded. Aluminium atoms are arranged in a face centered cubic (FCC) structure. Aluminium is a good thermal and electrical conductor, having 59% the conductivity of copper , both thermal and electrical ,while having only 30% of copper's density . Aluminium is capable of being a superconductor , with a superconducting critical temperature of 1.2 kelvin and a critical magnetic field of about 100 gauss (10 milli teslas).

Chemical Characteristics

Corrosion resistance can be excellent due to a thin surface layer of aluminium oxide that forms when the metal is exposed to air to prevent from further oxidation . The strongest aluminium alloys are less corrosion resistance due to galvanic reaction with alloyed copper. This corrosion resistance is also often greatly reduced by aqueous salts in the presence of dissimalar metals.

In highly acidic solutions aluminium reacts with water to form hydrogen and in highly alkaline to form aluminates which protect passication. Chlorides such as common sodium chloride are well known source of corrosion of aluminium and are among the main reason that household plumbing is never made from this metal.

However it resistance to corrosion generally aluminimum is one of the few metals that retains silvery reflectance in finely powdered form, making it an important component of silver colored paints. Aluminium mirror finish has the hightest reflectance of any metal in the 200-400 nm (UV) and the 3,000 – 10 ,000 nm . Aluminium is oxidized by water at temperatures below 280 ºC to produce hydrogen ,aluminium hydroxide and heat.

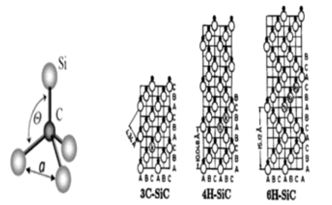
Advantages of Aluminium

physically , chemically and mechanically aluminium is a metal steel , brass , copper ,zinc ,lead or titanium and silicon. It can be melted , cast m formed and machined much like these metals and it conducts electric current . In fact the same equipment and fabrication methods are used as for steel.

Silicon Carbide (SiC)

Silicon carbibe (SiC) also known as carborundum a compund of silicon and carbon with chemical formual SiC. It occours in nature as the extreamly rare mineral moissanite. Silicon carbide powder has been mass produced since 1893 for use as an abrassive . Grains of silicon carbide can be bonded together by sintering to form very hard ceramics that are widely used in applications requiring high endurance, such as car brakes , car clutches and ceramic paltes in bulletproof vests , Electronic applications of silicon carbide as light – emitting diodes (LEDs)) and detectors in early radios were first demonstrated around 1907. Today SiC is used in semiconductor electronics applications that are high temperature ,high –voltage or both . Large single crystals of silicon carbide can be grown by the Lely method: they can be cut into gems known as synthetic moissanite . Silicon carbide with high surface area can be produced from SiO2 contained in plant material ,exceedingly hard ,synthetically produced crystalline compound of silicon and carbon . Its chemical formula is SiC .Since the late 19th century silicon carbide has been an important material for sandpaper ,grinding wheels , and cutting tools . More recently ,it has found application in refractory linings and heating elements for industrial furnces,in wear – resistant parts for pumps and rocket engines , and in semiconducting substrates for light emitting diodes

Structure



(a) Crystal Structure of SiC (b) Stacking sequence of famous polytypes with Ramsdell notation

Silicon carbide exists in about 250 crystalline forms . The polymorphism of SiC is characterised by a large family of crystallin structues called polytypes. They are variations of the same chemical compound that are identical in two dimensions and differ in the third . Thus , they can be viewed as layers stacked in a certain sequence . Alpha silicon carbide (α-Sic) is the most commonly encountered polymorph,it is formed at temperature greater than 1700 ^{0}C and has a hexagonal crystal structure . The beta modification (β-SiC) , with a zinc blended crystal structure similar to diamond,is formed at temperatures below 1700 ^{0}C . The beta form has few commercial uses, although there is now increasing interest in its use as a support for hetrogeneous catalysts ,because of its higher surface area compared to the apha form. Pure SiC is colorless . The brown to black color of industrial product results from iron impurities . The rainbow like luster of the crystals is caused by layer of

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silicon dioxide that forms on the surface.
the high sublimation temperature of SiC (approximately 2700 ^{0}C) makes it useful for bearings and furnace parts . Silicon carbide does not melt at any known pressure . It is also highly inert chemically . There is currently much interest in its use as a semiconductor material in electronics , where its high thermal conductivity ,high electric field breakdown strength and high maximum current density make it more promissing than silicon for high powered devices.SiC also has a very low coefficient of themal expansion (4 x 10 $^{-6}$/K) and experiences no phase transitions that would cause discontinuties in thermal expansion.

Properties

- Low density
- High strength
- High thermal expansion
- High hardness
- High elastic modulus
- Excellent thermal shock resistance
- Superior chemical inertness

Applications

- Abrasives and cuting tools
- Structural material
- Automobile parts
- Electrical systems
- Electronic circuit elements
- LEDs
- Astromomical telescopes
- Heating elements
- Steel production
- Nuclear fuel particles
- Catalyst supporter

ALUMINIUM ALLOYS

Selecting the right alloy for a given application entails consideerations of its tensile strength,density, ductility ,formability , workability,weld ability and corosion resistance . Aluminium alloys are alloys in which aluminium (Al) is the predominant metal. The typical alloying elements are corrper , magnesium ,manganese,silicon and zine. There are two principal classifications , namely casting alloys and wrought alloys, both of which are furterh subdivided into the categories heat-treatable and non-heat – treatable . About 85% of aluminium is used for wrought product , for example rolled plate, foils and extrusions. Cast aluminium alloy yield cost effective products due to its low melting point , although they generally have lower tensile strength than wrought alloys. The most important cast aluminium alloy system is Al-Si ,wher the high levels of silicon (4.0% to 13%) contribute to give good casting characteristics . Aluminuim alloys are widely used in engineering structures and components where light weigth or corrosion resistance is required. Wrought aluminium alloys are used in the shaping processes:rolling ,forging ,extrusion,pressing ,stamping. Cast aluminium alloys comes after sand casting , permenent mould casting die casting , investment casting , centrifugal casting, squeeze casting and continous casting .

Metal Matrix Composites

A metal matrix composite (MMC) is composite material with a least two constituent parts,one being a metal necessarily and the other material may be a different metal or another material, such as a cerimic or organic compound . When at least three materials are present , it is called a hybrid composite. An MMC is complementary to a cermet. Metal composite materials have found application in many areas of daily life for quite some time. Often it is not realized that the application makes use of composite materials. These materials can be produced in every situation from the conventional production and processing of metals. Here , the Dalmation sword with its meander structure , which resultes from welding two types of steel by repeated forging , can be mentioned. Materials like cast iron with graphite or steel with a high carbide content ,as well as tungsten carbides,consisting of carbides and metallic blenders , also belong to this group of composites materials. For many researchers the term metal matrix composite is often equated with the term light metal matrix composites (MMCs). Substantial progress in the development of light metal matrix composites has been achieved in recent decades , so that they could be introduced into the most important applications. In traffic engineering , especially in the automobile industry , MMCs have been used commercially in fiber reinforced pistons and aluminium crank cases with strengthened cylinder surfaces as well as particle strengthened brake disks. These innovatve materials open up unlimited possiblities for modern material science and development; the characteristic of MMCs can be designed into the material ,custom-made ,dependent on the application. From this potential , metal matrix composites fulfill all the desired conceptions of the designer. This material group become interesting for use as constructional and functional materials, if the property profile of conventional material either does not reach the increased standards of specific demands, or is the solution of the problem . However , the technology of MMCs is in compition with other modern materials technologies,for example powder metallurgy. The advantage of the composite material are only realized when there is a reasonable cost performance relationship in the component production . The use of a composite material is obligatory if a special property profile can only be achieved by application of these materals . The possibility of combining various material systems gives the oppertunity for unlimited variation

Prepration of MMCs

There are several methods used for fabrication of MMCs ,but the most suitable process which is used in liquid phase technique.

Liquid Phase Techinque

Liquid state fabrication of Metal Matrix Composite involves incorporation of dispersed phase into a molten matrix metal,followed by its solidification . In order to provide high level of mechanical properties of the composie it should have good interfacial bonding between the dispersed phase and the liquid matrix should be obtained . Bonding improvement

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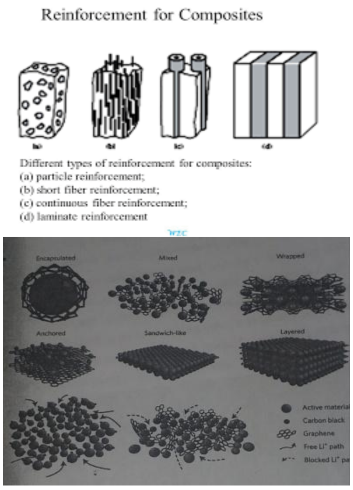
may be achieved by coating the dispersed phase particles. Proper coating not only reduces interfacial energy but also prevents chemical interaction between the dispersed phase and the matrix . The simplest and the most cost effective method of liquid state fabrication is Stir Casting.

Stir Casting

Stir casting is a liquid state method of composite material fabrication ,in wich a dispersed phase (ceramic particles) is mixed with the other molten matrix metal by means of mechanical stirring . The liquid composite material is then cast by conventional casting methods can may also be processed by conventional metal forming technologies.

Composites: MMCs are made by dispersing a reinforcing material into a metal matrix . The reinforcement surface can be coated to prevent a chemical reaction with the matrix . For example , carbon fibers are commonly used in aluminium matrix to synthesize composites showing low density and high strength. However , carbon reacts with aluminium to generate a brittle and water soluable compound Al4C3 on the surface of the fiber . To prevent this reaction , the carbon fibers are coated with nickel or titanium boride.

Matrix: The matrix is the monolithic material into which the reinforcement is embedded and is completely continous. This means that there is a path through the matrix to any point int the material , unlike two matreials sandwiched together . In structural applications of matrix is usually a lighter metal such as aluninium ,magnesium and titanium are used to provide support for the reinforcement. In high temperature application cobalt and cobalt-nickel alloy matrices are used commonly. The selection of suitable matrix alloys is mainly determined by the intended application of the composite material.



Formation of matrix

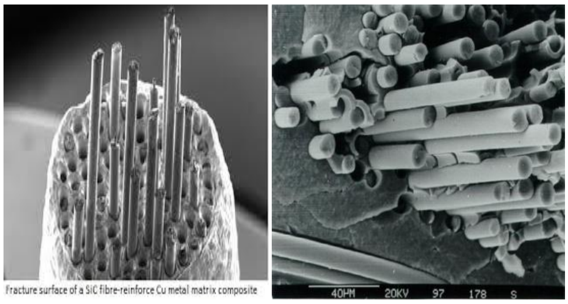
Source:- Singla, M.Chawla, V. Dwivedi, D.D. And Lakhvit, S.(2009) "Development of aluminium based SiC particulate metal matrix composite", J. Miner. Matls Charac. Eng., 8(6),pp.455-467.

For the development of light metal composites material that are mostly easy to process, conventional light metal alloys are applied as matrix materials. Mainly aluminium alloys are used for light weight composites . The matrix is the monolithic material into which the reinforcement is embedded completly continous. This means that there is a path through the matrix to any point in the material sandwitched together.

Reinforcement

The reinforcement material is embedded into a matrix . The reinforcement does not always serve a purely structural tast (reinforcing the compund), or thermal conductivity . The reinforcement can be either continous, or discontinous. Discontinous MMCs can be isotropic, and can be worked with standard metalworking techniques, such as extrusion, forging, or rolling . In addition , they may be machined using conventional techniques,but commonly would need the use of polycrystalline diamond tooling .

Continous reinforcement used conofilament wires or fibers such as carbon fiber or silicon carbide . Because the fibers are embedded into the matrix in a certain direction , the result is an anisotropic structure in which the algnment of the material affects its strength . One of the first MMCs used boron filament as reinforcement . Discontinous reinforcement uses whiskers, short fibers or particles. The most common reinforcing matrial in this catagory are alumina and silicon carbide.



Reinforcement

Source:- Lucas , J.P. Stephens, J.J.and Greulich, F.A. (1991), "the reinforcement of compistion redistrubution in cast aluminium metal matrix composites", Materials Science and Engineering , Vol . 131 (2), pp. 221-230

Aluminium silicon Carbide (AlSiC)

AlSiC is a metal matix composite consisting of aluminium matix with silicon carbide particles. It has high thermal conductivity (180-200 W/m K) and isothrmal can be adjusted to match other materials like silicon and gallium, arsenide chips and various ceramics. It is chiefly used in microelectronics as substrate for power and high density multi-chip modules , where it aids with removal of waste heat AlSiC composits are suitable replacements for copper-molybdenum (CuMo) and copper tungsten (CuW) alloys. They have about 1/3 the weight of copper , 1/5 of CuMo and 1/6 of CuW which makes them suitable for weight senstitive application. They are also stronger and stiffer than copper . They are tough , light weight and strong.

AlSiC parts are typically maufactured by mear net shape approach by creating a SiC performed by metal injection molding of SiC binder slurry is fired to remove the binder then infiltrated under pressure with molten aluminium . The material is fully densed without voids and is hermetic . High

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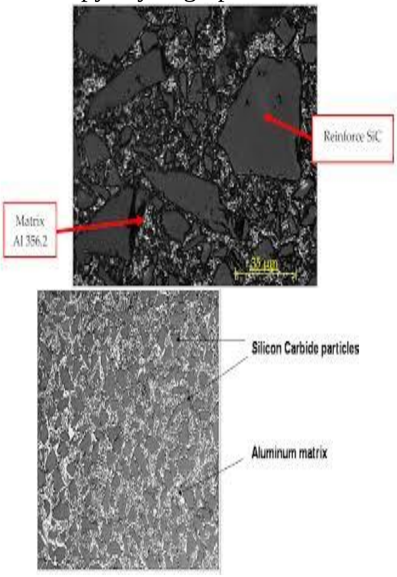
stiffness and low density appears making larger parts with thin wall and manufacturing large fins of heat dissipation . AlSiC can be plated with nickel and nickel – gold or by other metals by thermal spraying. Ceramic and metal insets can be inerted into the preform before aluminium infiltration results in a hermetic seal. AlSiC can also be prepared by mechanical alloying . When lower degree of SiC contents are used parts can be stamped from AlSiC sheets. The aluminium matrix contains high amount of dislocations responsible for the strength of the material . The dislocations are appeared during cooling of the Sic particals due to their different thermal expansion coefficient . A similar material is dymalloy with copper-silver alloy instead of aluminium and diamond instead of silicon carbide . Other materials are copper reinforced with carbon fiber , diamond reinforced with aluminiun and pyrolytic graphite with silicon



Microscopic view of AlSiC

Source :- Nesarikar, A.R. Tiwari, S.N and Graham, E.E (1993),"Al2O3- particle-reinforced aluminium alloy composite",Materials Science and Engineering A ,Vol . 147 (2), pp. 191-199.

Silicon can be added to aluminuim alloys in quantities sufficient to cause a substantial lowering of the melting point . For this reason this alloy system is used entirely for welding wire and brazing filler alloys are non heat treatable but in general tehy pick up enough of the alloy constituents of the parent metal to respond to a limited degree of heat treatment.

Properties

- Low density
- High strength
- Low thermal expansion
- High thermal conductivity
- High hardness
- High elastic modulus
- Excellent thermal shock resistance
- Superior chemical inertness

II. OBJECTIVE OF RESEARCH WORK

To prepare the sample of metal matrix composite of Aluminium and Silicon Carbide of different compositions.
To study the properties of Aluminium Silicon Carbide metal matrix composites for different composition of SiC.
To test the sample of Aluminium Silicon carbide metal matrix composites to evaluate the modulus of rigidity

2: RESEARCH METHODOLOGY

MATERIALS AND METHODS

Properties of Aluminium

Properties of Aluminium	Value
Atomic number	13
Atomic weight(g/mol)	26.98
Valency	3
Crystal structure	FCC
Melting point (^{0}C)	660.2
Boiling point (^{0}C)	2480
Mean specific heat (0 – 100)(cal/g. ^{0}C)	0.219
Thermal conductivity (0-100^{0}C)(cal/cm. ^{0}C)	.57
Co-efficient of linear expansion(0-100)(x10^{-6}/^{0}C)	23.5
Electrical resistivity at 20^{0}C(Ω/cm)	2.69
Density(g/cm^3)	2.68
Modulus of elasticity (gpa)	68.3
Poission's ratio	.34

Properties of major SiCpolytypes

Crystal structure	*3C (β)*	*4H*	*6H(α)*
Space group	***inc blende (cubic)***	***Hexagonal***	***Hexagonal***
Pearson symbol	T^2_d-F3m	C^4_{6V}-P6$_3$mc	C^4_{6V}-P6$_3$mc
Lattice constants (Å)	***cF8***	***hP8***	***hP12***
Desnity (g/cm^3)	***4.3596***	***3.0730; 10.053***	***3.0810: 5.12***
Bandgap (eV)	***3.21***	***3,21***	***3.21***
Thermal conductivity (Wcm^{-1}K^{-1})	***250***	***220***	***220***
Bulk modulus (GPa)	***2.36***	***3.23***	***3.05***

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Preparation of specimen

Specimens of aluminium silicon carbide metal matrix composites was made by the stir casting technique. For investigating the mechanical properties of any material it is very important to make the specimen very precise, since our aim isto know the behaviour of AlSiC MMCs with varying percentage of SiC , we have to be very precise in the composition of the material . To achieve this 1000 gm of specimen has been made for each of the material like 5%,10%,15% & 20% of Sic in Al.

Equipments used for making specimen

S. No	
1	Muffle Furnace
2	Graphite stirrer
3	Graphite crucible & mould
4	Hacksaw
5	Belt grinder
6	Weight machine
7	Lathe machine

Furnace

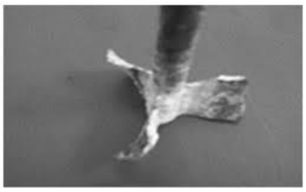
A muffle furnace in historical usage is a furnce in which the subject material is isolated from the fuel and all of the products of combustion including gases and flying ash . After the development of high temperature electric heating elements and widespread electrification in developed countries then new muffle furnce quickly moved to electric designs. Now a days muffle furnce is usually a front loading box type of oven for high temperatuere applications, such as fusing glass, creating enamel coatings, ceramics and soldering and bazing articles. They are also used in many research facilities , for example by chemists in order to determine what proportion of a sample is non – combustible and non-volatile. Some digital controller operator to program up to different temperature segments, scu as ramping , soaking , sintering etc. Also , advances in materials for heating elements , such as molybdenum can now produce working temperatiure upto 1,800 degree celsius (3,272 degree Farenheit), which facilitate more sophisticated metallurgical applications. There is usually no combustion involved in the temperature control of the system, which allows much greater control of temperature uniformly and assures isolation of material being heated from the byproducts of fuel combustion.

Muffle furnce

Muffle furnace was used to heat the material to desired temperatures by conduction,convection or backbody radiation from electrical resistance heating elements. A muffle furnce (sometimes ,retort furnce) in historical usage in a furnce in which the subject material is isolated from the fuel and all of the products of combustion including gases and flying ash . In our muffle furnce we have maximum temperautre of 1300^{0}C was achieved.

Stirrer

The function of a stirrer was to agitate liquids for speeding up reactions. Stirrer was designed to homogenous mixing of liquid, oilment ,solutuion, viscous material and soild-liquid.


Stirrer

Belt Grinder

Belt ginder was used for resistant technology purpose to give a smooth , shiny finsih to manufactured products(Aluminium composites). Belt grinding is an abrasive machining process used on metals and other materials. It is typically used as a finishing process in industry . A belt is coated in abrasive material made to run over the surface to be processed in order to remove material or product to desired finish.


Belt grinder

Power Hack Saw

Power hacksaws are used to cut large sizes (sections) of metal such as steel.cutting diameters of more than 10/15 mm is very hard with normal hand heldsaw. Therefore power hacksaws have been developed to carry out the difficult and time consuming work . The heavy ‘arm’(or electric hacksaw) was a type of hacksaw that was powered either by its own electric motor or saprate motor. A hacksaw is a fine-tooth saw with a blade under tension in a farme,used for cutting materials such as Aluminium alloy into small pieces so is to keep the alloy into crucible.

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Power hacksaw

Graphite Crucible and Mould

A crucible is a refractory container used for metal ,glass and pigment production as well as a number of modern laboratory processes, which can withstand temperature high enough to melt or otherwise alter its contents .historically , they have usually been of clay ,but they can be made of any material with higher temperature resistance than its substances they are designed to hold.

Crucible and their covers are made of high temperature rsistant materials usually procelin , alumina or an inert metal. One of the earliest uses of paltinum was to make crucibles. Ceramics such as alumina ,zirconium and especially magnesia will tolerate the highest temperatures.more rcently metals such as nickel and zirconium have been used . The lid are typically loose fitting to allow gases to escape during heating of a sample inside. Crucible and thier lids come in high form and low form shapes and in various sizes . These samll size crucible and their covers made of porcelin are quite cheap when sold in quantity to laboratories and the crucible are sometimes disposed after use in precise quantitative chemical analysis.

Graphite crucible

Weight Machine

A weight machine is a machine used for measuruing weight ,this uses gravity as the primary source of resistance. Diigital weight machine is used to weight the power of aluminium and silicon carbide for mixing . Al and SiC is weighted on the machine by its different proportion,mixing should be very accurate. In order to maintain the accuracy level high digital weight machine is used.

Lathe Machine

A lathe is a machine tool which rotates the workpiece on its axis to perform various operations such as cutting ,sanding ,knurling,drilling or deformation, facing turning ,with tools that are applied to the workpiece to create an object having symmetry about an axis of rotation

Lathes are used in wood turing ,metal working ,metal spinning ,thermal spraying ,parts reclamation and glass-working. Lathe can be used to shape pottery, the best-known design being the potter's wheel . Most suitably equipped metalworking lathes can also be used to produce most solids of revolution, plane surfaces and screw threads or helices. Ornamental thathes can produce three-dimensional solids of incredible complexity. The workpiece is usually held in palce by either one or two centers,at least one of which can typically be moved horizontally to accommodate varying workpiece lengths . Other work-holding methods include clamping the work about the axis of rotation using a chuck or to a faceplate using clamps.

EXPERIMENTAL WORK

It is very important to know the exact properties and behaviour of the metal so that it can be usd on appropriate postion and to meet the desired requirement . In order to investigate the behaviour of Aluninium silicon carbide metal matrix composites various methods and experiments has been done on differnet composites of the AlSiC , that is percentage of SiC in Aluminium is 5%,10%,15% & 20%.

Properties to be Investigated are .

1. Desnity.
2. Hardness.
3. Engineering strain.
4. Elongation percentage.
5. Ultimate tensile strength.
6. Modulus of ridigity.

Density

The density or the volumetric mass density of a substance is its mass per unit volume. The symbol most often used for densit is ρ(roh). Mathematically density is defined as mass divided by volume.

$$\rho = m/v$$

Where,
ρ is the density
m is the mass
v is the volume

For a pure substance the density has the same mumerical value as its mass concentration. Different materials usually have different densities and density may be relevant to buoyancy, purity and packaging. Osmium and iridium are the densest known elements at standard conditions for temperature and pressure but certain chemical compounds may be denser . To simplify comparision of density across different systems of units, it is sometimes repalced by the dimensionless quantity "relative density" or "specific gravity", i.e. The ratio of the density of the material to that of a standard material, usually water. Thus if the relative density is less than one it means that the substance can float on water.

The density of a material varies with temperature and pressure. This variation is typically small for solids and liquids but it is much greater for gases. Increasing the pressure on an object decreases the volume of the object and thus increases its density. Increasing the temperature of a substance, density decreases and thus increases its volume. In most of materials heating the bottom of fluid results convection from the bottom to the top,due to decrease in the density the heated fluid . This causes it to rise relative to more dense unheated material.

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the reciprocal of the density of a substance is occasionally called its specific volume, a term sometimes used in thermodynamics. Density is an intensive property so that increasing the amount of a substance does not increase its density but only increases its mass.

Sample of aluminium silicon carbide metal matrix composities is taken by varying the percentage of silicon carbide in aluminium. A square sample having length ,width and hight (10x10x10)mm is taken for the investigation of density.

Hardness

The metals hardness is defined as resistance of metal to plastic deformation , usually by intendation. However , the term may also refer to stiffness or temper or to resistance to scratching , abrasion or cutting . It is the property of a metal which gives it the ability to resit from permanent deformation when a load is applied . Hardness ofa material is directly proportional to its resistance and inversely proportional to its deformation. The greater the hardness of the metal , the greater resistance it has to deformation . In metallurgy hardness is defined as the ability of a material to resist plastic deformatiuon . The indentation hardness is the resistance of a material to indentation . This is the usual type of hardness test,in which a pointed or rounded indenter is pressed into a surface under a substantially static load.

Hardness measurement

Brinell's hardness test is done for the investigation of hardness of Aluminium Silicon Carbide metal matrix composites with different compostions. Brinell hardnesss is determined by forcing a hard steel or carbide sphere ifa 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 Brinell's hardness test uses a desk top machine to press a 10mm diameter hardened steel ball into the surface of the test secimen. The machine applies a load of 500 kilograms for soft metals such as copper , brass and thin stock. A 1500 kilograms load is used for aluminium casting and a 3000 kilogram load is used for material such as iron and steel . The load is usually applied for 10 to 15 seconds . After the impression is made diameter of the resulting round impression is measured. 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 indentation the area of a hemisphereical surface is arrived at by multiplying the square of the diameter by 3.14159 and then dividing by 2 . There is calibrated chart is provided , so with the diameter of the indentation the corrosponding 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 Brenell Hardness of 75 was obtained using a 10mm diameter hardened steel with a 500 kilogram load applied for a period of 3 seconds. On tests of extremely hard metals a tungsten carbide ball is substituted for the steel ball. The Brinell ball which makes the deepest and widest indentation is more accurately calculated for multiple grain stuctures ,and any irregularities in the alloy.

Hardness measurement methods

There are mainly three types of hadrness tests used with accuracy by the metals industry i.e. the Brinell's hardness test, the Rockwell hardness test and the Vickers hardness test. The difination of metallurgical ultimate strength and hardness are approximately similar therefore it can be genrally assumed that a strong metal is also a hard metal . The way the three of these hardness tests mesure a metal's hardness is to determin the metal's resistance to the penetration of a non-deformable ball or cone. The test determins the depth which such a ball or cone will sink into the metal, under a given load , within a specified period of time . The followings are the most common hardness test methods used in today's available technology:

1. Brinell's hardness test.
2. Rockwell hardness test.
3. Vickers hardness test.

Brinell's Hardness Test

The Brinell hardness test was one of the most widely used hardness test during the World War II. For measuring armor 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 3,000 kg, then measuring the diameter of the resulting depression. The hardness of the material depends on the resistance which it exerts during a small amount of yielding or plastic deformation. The resistance depends on friction , elasticity ,viscosity ,the intensity and distrubution of plastic strain produced by a given tool during indentation.

Brinell's Hardness Testing machine

It is determined by forcing a hard steel or carbide sphere of a specified diameter uner a specified load into the surface of a material and measuring the diameter if the indentation left after the test. The Brinell hardness number , or simply 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 BHN is calculated according to the following formula .

$$BHN = \mathbf{F/}\ \Pi\mathbf{/2}\ \ X\ (D - (D^2 - D_i^{2}))^{1/2}$$

Where;

BHN = The Brinell's hardness number.

F = The imposed load in kg.

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D = The diameter of the spherical indenter in mm.

Di = Diameter of the resulting indenter impression in mm.

Procedure

The specimen is placed securely upon the anvil of Brinell' hardness measuring instrument. Elevate the specimen so that it comes into contact with penetrator and put the specimen under a preliminary or minor load without shock. The major load of 1500 n is allied. Watch the pointer until it comes to rest and wait for 15 seconds. Remove the major load. Read the Rockwell hardness number on the hardness scale. Measure the resulting daimeter of indenter impression. Putting the values in the formula and BHN number is found out.

Precaution

1. Brinell's test should be performed on smooth ,flat specimens from which dirt and scale have been removed.

2. The test should not be made on specimens that are so thin that the impression penetrates through the metal.

3. Impression should not be made too close to the edge of the specimen.

Engineering Strain

The engineering strain is expressed as the ratio of total deformation to the initial dimension of the material body in which the forces are being applied . To investigate the engineering strain of AlSiC MMCs net elongation and percentage of elongation should be known. In order to the elongation percentage of AlSiC MMCs univeral testing is done on the universal testing machine.

Universal testing machine

The tensile test is conducted on UTM . It is a hydrauclically pump operated , it has oil in oil sump, a load dial indicator and central buttons. The left has upper ,middle and lower cross heads i.e; specimen grips (or jaws). Idle cross head can be moved up and down for adjustment . The pipes connecting the lift and right pats are oil pipes through which the oil is pumped under pressure which flows towards the left parts to move the coss-heads.

Universal Testing Machine.

Various machine and structure components are subjected to tensile loading in numerous applications. For safe design of the components , there ultimate tensile strength and ductility can be determined before actual use. Tensile test can be conducted on UTM . A material when subjected to a tensile load it resists the applied load by developinf internal resisting forces. These resistance comes due to atomic bonding between atoms of the material.the resisting force for unit normal cross-section area is known as stress . The value of stress in material goes on increasing with increase in applied tensile load,but it has a certain maximum limit also. The minimum stress , at which a material fails, is called ultimate tensile strength. The end of elastic limit is indicated by the yield point(load). This can be seen during experiment as expalined later in procedure with increase in loading beyond elastic limit original cross-section area (Ao) goes on decreasing and finally reduced to its minimum value when the specimen breaks.

Procedure

Measure the original length and diameter of the specimen . The length may either be length of gauge section which is on the specimen with a preset punch or the total length of the specimen Insert the specimen into grips of the testing machine and attach strain- measuring device to it . Begin the load application and record load versus elongation data. Take readings more friquently as yield point is approached . Measure elongation values with the help of dividers and ruler. Continue the test till fracture occurs. By joining the two broken halves of the specimen together , measure the final length and diameter of specimen.

Precautions

1. The specimen should be prepared in proper dimensions.

2. The specimen should properly fit between the jaws.

3. Take readings carefully

4. After breaking of specimen stop the machine.

The engineering normal strain or engineering extensional strain or normal stain (e) of a material line element axially loaded is expressed as the change in length ΔL per unit of the original length L of the line element or fibes. The normal strain is positve stain if the material fiber ae stretched and negative if they are compressed . Thus , we have

$$e = \Delta L/L = (L^1 - L)/L$$

Where ,

e is the engineering normal stain.

L is the original length.

L^1 is the final length.

The engineering shear strain is defined as the tangent of that angle, and is equal to the length of deformation at its maximum divided by the perpendicular length in the plane of force application which sometimes makes it easier to calculate. A strain is measure of deformation representing the displacement between particles in the body relative to a reference length . A stain is generally a tensor quantity. Physical insight into strains can be gained by observing that a given stain decomposed into normal strain , and the amount of distortion associated with the sliding of place layers over each other is the shear stain,

within a deforming body. This could be applied by

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elongation, shortening or volume changes or angular distortion. Universal testing machine is generally used to find the eingineering strain of a material so it is also used for the AlSiC MMCs. It is very precise and gives accurate value.

Elongation Percentages

Elongation percentage is found out to know the real deformation taking place along the radius and length with the different percentage composition of SiC in the aluminium silicon carbide MMCs. It is found that as the percentage of SiC increases in aluminium the percentage of elongation decreases as it results that the material is getting harder and more stiff.

Ultimate Tensile Strength (UTS)

Ultimate tensile strength is the maximum stress that a material can withstand while being stretched or pulled before failing or breaking. Tensile strength is not the same as compressive strength and the values can be quite different . Some materials will break sharply , without plastic deformation which is called as brittle fracture or failure. Some are more ductile, including most metals,which will experience some plastic deformation and possibly necking before fracture. The UTS is usually found by performing a tensile test and recording the stress versus stain values . The highest point of the stress-strain curve is the UTS. It is an intensive property therfore its value does not depend on the shape and size of the specimen. However , it depends on other factors , such as the prepration of the specimen , the presence of surface defects and the temperature of the test enviroment and material. Tensile strength are rarely used in the design of ductile mambers but they are important in brittle members. They are tabulated for common materials such as alloys, composite materials, ceramics, plastics and wood. Tensile strength is defined as a stress, which is measured as force per unit area . For some non-homogenous materials or for asssembled components, it can be recored just as a force or as a force per unit width. In the International System of Units (SI), its unit is written as pascal(Pa).

The tensile test is most applied one , of all mechinical tests. In this test ends of the test piece are fixed into the grips connected to a straining device and to a load measuring device . If the appled load is small enough, the deformation of any solid body is entirely elastic . An elastically deformed solid will returen to its original form as soon as the load is removed. However , if the load is too large ,plastic deformation will occure and the material can be deforme permanently. The initial part of the tension curve which is recoverable immediatly after unloading is termed as elastic and the rest of the curve which represents the manner in which solid undergoes plastic deformation is termed as plastic. The stresses below which the deformation is essentially entirely elastic is known as the yield strength of the material. In some material the onset of plastic deformation is denoted by a sudden drop in load indicating both an upper and a lower yield point. However , some materials do not exhibit a sharp yield point . During plastic deformation , at larger extensions strain hardening cannot compensate for the decrease .this stage the “ultimate strength” which is defined as the ratio of the load on the specimen to original cross-sectional area , reaches a maximum value . Further loading will eventually cause ‘neck’ formation and finally rupture.

Procedure

Measure the original length and diameter of the specimen. The length may either be length of gauge section which is marked on the specimen with a preset punch or the total length of the specimen. Insert the specimen into grips of the test machine and attach strain-measuring device to it. Begin the load application and record load versus elongation data. Take readings more frequently as yield point is approached. Measure elongation values with the help of a divider and a ruler. Continue the test till fracture occurs. By joining the two broken halves of the specimen together measure the final length and diameter of specimen.

Precautions

1. If the strain measuring device is an extensometer it should be removed before necking begins.

2. Measure deflection on scale accurately and carefully.

Modulus of Rigidity

A torsion test is done to measure the modulus of rigidity of any material by maximum twisting forces. It is an extreamly common test used in material mechanics to measure how much of a twist a certain material can withstand before cracking or breaking. This applied pressure os referred to as torque. Materials typically used in the manufacturing industry, such as metal fasteners and beams , are often subjected to torsion testing to determin their strength under stress.

There are three broad categories under which a torsion test can take place: failure testing, proof testing and operational testing . Failure testing involves twisting the material until it breaks. Proof testing observes whether a material can bear a certain amount of torque load over a given period of time . Operational testing tests specific products to confirm their elastic limit before going on the market.

It is critical for the results of each torsion test to be recorded . Recording is done through creating a stress-strain diagram with the angle of twist values on the X-axis and the torque values on the Y- axis . Using a tosion testing apparatus , twisting is performed at quarter-degree increments with the torque that it can withstand recorded . The strain corrosponds to the twist angle , and the stress corrosponds to the torque measured.

The elastic limit of any material is the point at which it can no longer return to its original shape and size. The elasic limit determined by a torsion test is equal to the slop of the line from the start of testing to the proportional limit. This relationship was first measured by Sir Robert Hooke in 1678.Hooke’s law states that stress is directly proportional to strain until the proportional limit is reached ,at which point the object tested will begin to show signs of stress. After testing, metal materials are categorized as being either ductile or britlle . Ductile metals such as steel or aluminium have high elastic limits and can withstand a great deal of stain before breaking. Brittle materials such as cast iron and

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concrete have low elastic limits and do not require much strain before rupturing.

Without performing a torsion test , materials would not be properly vetted before being released for industrial use. It is of paramount importance that the ability for a material to bear certain amount of twisting is accurately measured . Otherwise ,structures and machines that depend on such materials could break down causing instability, work flow interruption or even significant damage and injury.

Torsion testing machine

A torsion test is quite instrumental in determining the value of modulus of rigidity of a metallic specimen . The value of modulus of rigidity of a metallic specimen. The value of modulus of rigidity can be found out through observations made during the experiment by using the torsion equation.

$$T / Ip = . (C \times \theta) / l = q / r$$
$$Ip = \Pi/32 \times 10^4$$

Where ,

T = Torque applied (N-m).
Ip = Polar moment of inertia (m^4).
C = Modulus of ridigity (N/m^2).
θ = Angle of twist (radian).
l = Length of the shaft (m).
q = shear stress (N/m^2).
r = Distance of element from center of shaft (m).

Procedure

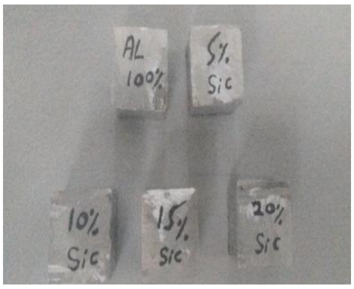
Select the driving dogs to suit the size of the size of the specimen and clamp it in the machine by adjusting the length of the specimen by means of a sliding spindle. Measure the diameter at about three places and take average value . Choose the appropriate range by capacity change lever . Set the maximum load pointer to zero. Set the protector to zero for convenience and clamp it by means of knurled screw . Carry out straining by rotating the hand wheel in either direction . Load the machine in suitable increments . Then load out to failure as to cause equal increments of strain reading. Plot a torque – twist (T – θ) graph . Read off co-ordinates of a convenient point from the straight line portion of the torque twist (T – θ) graph and calculate the value of C by using relation.

Precaution

1. Measure the dimension of the specimen carefully.
2. Measure the angle of twist acurately for the corresponding value of Torque.

III. RESULTS AND DISCUSSION

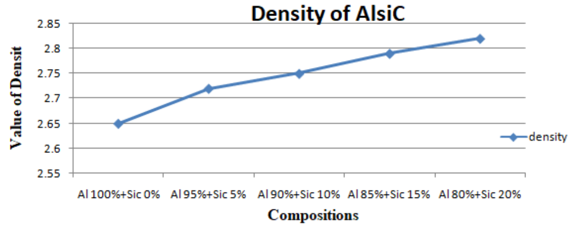
Density



Specimen of AlSiC MMCs for density test

Density of AlSiC MMCs with different compositions

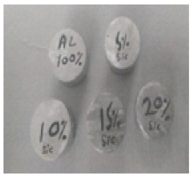
AlSiC	Al(100%+SiC(0%)	Al(95%+SiC(5%)	Al(90%+SiC(10%)	Al(85%+SiC(15%)	Al(80%+SiC(20%)
Density(g/cm^3)	2.65	2.72	2.75	2.79	2.82



Density of AlSiC MMCs with different composition

It is found that the density increases gradually with increase in percentage of SiC in Aluminium. Silicon having less density than aluminium but due to presence of carbide in the metal matrix composites the weight increases.

Hardness



Specimen of AlSiC MMCs for hardness tes

Brinell's hardness of AlSiC MMCs with different compositions

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

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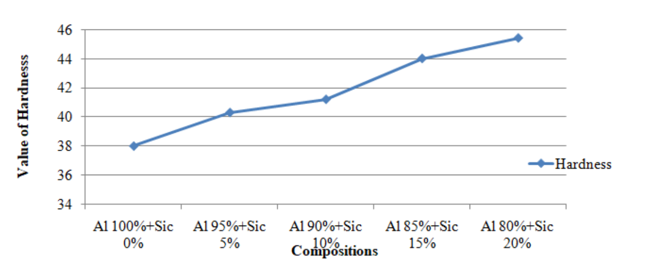
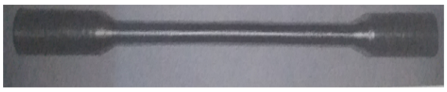
Engineering strain of AlSiC MMCs with different composition



Hardness of AlSiC MMCs with different composition

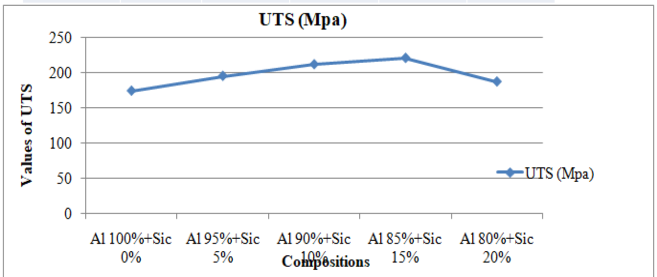
It is found that the hardness of Aluminium silicon carbide metal matrix composites increases gradually in increase in the % of SiC in the composition. Addition of very small percentage of silicon carbide in Aluminium gives much increase in hardness which result a harder material with low density .

Engineering strain



Specimen of AlSiC MMCs for tensil test

AlSiC	Al(100% +SiC(0%)	Al(95% +SiC(5%)	Al(90% +SiC(10%)	Al(85% +SiC(15%)	Al(80% +SiC(20%)
Strain e ΔL/L	.2	.193	.185	.177	.169



Ultimate tensile strength of AlSiC MMCs with different composition

It is found that the ultimate tensile strength of AlSiC MMCs increases with increase in the wt% of the SiC. But at 20% of AlSic it decreases with respect to 15% of AlSiC, this proves that the strength increases up to 15% and it shows brittle property as the composition of SiC gets higher.

Ultimate Tensile Strength) UTS)

Ultimate tensile strength of AlSiC MMCs with different compositions

AlSiC	Al(100% +SiC(0%)	Al(95% +SiC(5%)	Al(90% +SiC(10%)	Al(85% +SiC(15%)	Al(80% +SiC(20%)
UTS (Mpa)	174.43	195.62	212.15	221.23	187.55

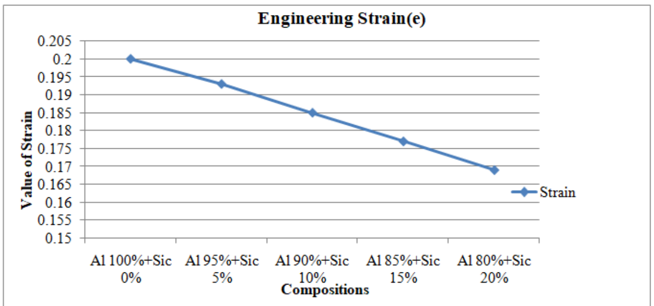
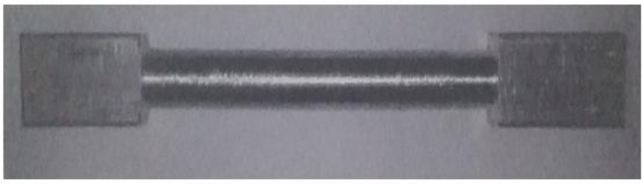


Fig.27 Strain of AlSiC MMCs with different composition

It is found that the strain of Aluminium silicon carbide metal matrix composites decreases respectively with increase in the % of SiC in Aluminium. This also proves that the elasticity and ductility of the AlSiC MMCs is decreasing respectively

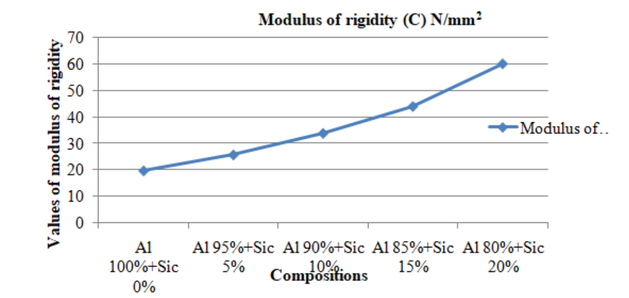
Modulus of Rigidity



Specimen of AlSiC for Torsion test

Torsion test of AlSiC MMCs with different compositions

AlSiC	Al(100% +SiC(0%)	Al(95% +SiC(5%)	Al(90% +SiC(10%)	Al(85% +SiC(15%)	Al(80% +SiC(20%)
Modulus of rigidity(C) N/mm²	19.80	25.79	33.87	43.99	60.05



Ultimate tensile strength of AlSiC MMCs with different composition

It is found that the modulus of rigidity increases with increase in % of SiC in AlSiC MMCs .Torque is also increases to break the specimen .With the relation of torsion ,modulus of rigidity is calculated

IV. SUMMARY AND CONCLUSION

Summary:

Aluminum Silicon carbide alloy composite materials are widely used and applications like engineering structures, industry and electronic applications, sporting goods etc. The

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properties of aluminum metal matrix composite mostly depend on the processing method which is capable of producing good properties to meet the industrial need. Study of wear properties Al-SiC composite is found that wear rate decreases linearly with increasing of SiC content. Mechanical properties of Al-SiC MMCs like hardness, density, engineering strain, elongation percentage, ultimate tensile strength and modulus of rigidity were evaluated. With the improved value of coefficient of thermal expansion of Aluminum composites is one of the reasons they are widely used by electronic industries and it has been found that the particles reinforcement of aluminum matrix composites can improve considerably the strength and hardness of aluminum and its alloys. Mechanical properties of Aluminum silicon carbide by mass fraction of SiC (5%, 10%, 15%, and 20%). Mechanical and Corrosion behavior of Aluminum Silicon Carbide metal matrix composites are suitable for spur gear, aerospace material, structural material, automobile parts, and astronomical telescopes.

V. CONCLUSION

Following are the conclusion from present work:-

1. Mechanical properties of AlSiC metal composites are investigated.

2. Density of the AlSiC with different composition of SiC metal matrix composites is investigated. Very little increase in density, but very high increase in strength and hardness.

3. It appears that the hardness increase results in elongation % of AISiC metal matrix composites. It is also found that the elongation tends to decrease according to the increase in weight percentage of silicon carbide and hence it leads to increase in hardness.

4. Ultimate tensile strength of the aluminum silicon carbide metal matrix composites increases gradually a the increased composition of the silicon carbide in it, but at 15% of SiC in Al give the best tensile strength as per the weight percentage ratio

5. Modulus of rigidity is increased with increase in % of SiC in Aluminium, Torque also increases as the % increases but the twisting angle decreases respectively results that the AlSiC getting rigid with the pressure of SiC.

Scope of Future Work:-

1. This can further be extended by varying the % 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.

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