AL-SIO2 METAL MARTIX COMPOSITES

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ABSTRACT

Aluminium - based metal matrix composites (AMMCs) are fast emerging due to their favorable properties like light weight, low density, high specific strength, high hardness, high temperature and thermal shock resistance, superior wear and corrosive resistance as compared to ordinary alloys is another added property. In the present work samples were prepared using Al- SiO_2 and machining operation is performed to obtain required shape and size for smoothing the surfaces. Also performed Prerequisite operation for performing tensile test, impact, hardness and compression and microstructure. It is observed from the results that significant increase of reinforcement of element as well as produces better mechanical properties such as impact toughness and hardness. But tensile strength showed different trend machinability properties of the selected material. Microstructure analysis is done on the specimens and it was found that for different weight fractions of SiO_2 matrix composites and the MMC phases are uniformly distributed. Successful incorporation of SiO_2 in base pure aluminium is found by the micro structural examination in the Optical microscope. Upon examination, it is observed that the fine grains in the matrix are SiO_2 and the coarse grains are Al. Similar results for the different specimens of variable compositions are evaluated.

CHAPTER-1 **INTRODUCTION**

Over the past two-three decades, there has been a gradual shift from monolithic to composite materials in order to meet the increasing demand for lighter, high performance, environment friendly, corrosion and wear resistant materials. The advancement in research in material science has progressed towards the synthesis of new light weight, high performance engineering materials like composites. Metallic matrix hybrid composites are one among them. Metal matrix composites (MMCs) are being extensively used and researched. Particle reinforced Aluminium Metal Matrix Composites have gained significant interest among researchers for their exceptional engineering properties. These materials are known to be difficult to machine due to the hardness and abrasive nature of reinforcement particles like silicon dioxide (SiO_2). The MMCs have a wide range of applications, particularly in the fields of aerospace, defence and automobiles. MMCs can be synthesized by reinforcing the base matrix alloy with more than one type of reinforcements, each having various desirable properties.

Metal matrix composites have become the essential materials for various engineering applications like in the fields of aerospace, marine and automobile engineering due to their high strength, stiffness and resistance to high temperatures. They have received considerable attention in recent years because of their high strength, stiffness, and low density. These properties enhance their scope of application in automotive and tribological works.

Fabrication of MMCs possesses several difficulties like porosity formation, poor wet ability and improper distribution of the reinforcement. Achieving a homogenous distribution of reinforcement is of utmost importance. A new technique for synthesizing the cast Aluminium matrix composites has been proposed to improve the wet ability between the alloy and the reinforcement. In this method, all the materials are placed in a crucible and heated in an inert atmosphere at 800ºC until the metal melts and followed by a two-step stirring action to achieve uniform distribution of reinforcement. The fabrication technique plays a major role in the improvement of mechanical and tribological properties.

The performance characteristics of Aluminium alloyreinforced with different weight fraction of SiO_2 fabricated through stir casting are checked. The size and type of reinforcement used also plays a significant role in determining the mechanical and tribological properties of the composites. Aluminium based silicon dioxide particulate metal matrix composites are fabricated using a two-step mixing method of stir casting technique by varying the weight fraction of SiO_2 showed an increase in hardness and impact strength values with increase in weight fraction of SiO_2. The tribological characteristics are considered to be one of the main factors controlling the performance of the composite.The tribological properties of aluminium matrix composites reinforced with short steel fibers prepared by vortex method have been investigated. The results showed that particulate reinforcement is most beneficial for improving the properties.

The objective of this project is to produce low density, high strength aluminium composites .In this project the composites were prepared by stir casting process, various percentages of aluminium-SiO_2 samples used to prepare different compositions. The specimens were studied for their mechanical properties and its micro structure was observed.

1.1 Composite materials The word "composite" means "consisting of two or more distinct parts." Therefore a material containing two or more distinct constituent materials or phases can be considered as a composite material. It is composed of two or more distinct phases (matrix phase and reinforcing phase) and having bulk properties which are significantly different from those of any of the constituent materials.

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Most of the common materials (metals, alloys, doped ceramics and polymers mixed with additives) also have a small amount of dispersed phases in their structures, however they are not considered as composite materials since their properties are similar to those of their base constituents (physical property of steel are similar to those of pure iron) .

Favorable properties of composites materials are high stiffness and high strength, low density, high temperature stability, high electrical and thermal conductivity, adjustable coefficient of thermal expansion, corrosion resistance, improved wear resistance etc. Composites are used not only for their structural properties, but also for their electrical, thermal, tribological, and environmental applications.

1.2

- Greater strength and Improved stiffness
- Reduced density (weight) and Improved high temperature properties
- Controlled thermal expansion coefficient
- Thermal/heat management
- Enhanced and tailored electrical performance
- Improved abrasion and wear resistance
- Control of mass (especially in reciprocating applications)
- Improved damping capabilities Excellent strength to weight ratios can be achieved by
- composite material This is expressed as strength divided by density.
- Laminate patterns and ply build up in a part can be tailored to give desired mechanical properties.
- It is easier to achieve smooth aerodynamic profile for drag reduction. Complex double curvature parts with
  smooth profile can be obtained.
- Composites offer excellent resistance to corrosion, chemical attack and outside weathering
- High strength at high temperature and have longer life.

These advantages can be quantified for better appreciation. AMC material systems offer superior combination of

Advantages of composites

properties (profile of properties) in such a manner that today no existing monolithic material can rival it. Over the years, AMCs have been tried and implemented in numerous structural, non-structural and functional applications in different engineering sectors. The driving forces for the utilization of AMCs in these sectors include performance, economic and environmental benefits. The key benefits of AMCs in transportation sector are lower fuel consumption, lesser noise and lower airborne emissions. With an increase in stringent environmental regulations and emphasis on improved fuel economy, use of AMCs in transport sector will be inevitable and desirable in the coming years. AMCs are intended to substitute monolithic materials including aluminium alloys, ferrous alloys, titanium alloys and polymer based composites in several applications. It has now been realized that for substitution of AMCs in place of monolithic materials in engineering system to be wide spread, there is a compelling need to redesign the whole system to gain additional weight and volume savings. In fact, according to the UK Advisory Council on Science and Technology, AMCs can be viewed either as a replacement for existing materials, but with superior properties, or as a means of enabling radical changes in system or product design.

1.3 Limitations of Composites

The major limitations of composites are listed below:

✓ Mechanical Characterization of a composite structure is more complex than that of a metal structure The fabrication cost of composites is high Rework and repairing are difficult.
✓ They do not have a high combination of strength and fracture toughness as compared to metals.

1.4 Applications of Composites

✓ In aerospace, the body, cockpit and the aerofoil shaped wings are made of composites which are tough, light weight and durable.
✓ In automotive industry, body panels of passenger cars as well as race cars are made of composites. Other applications include composite leaf spring and composite drive shaft.
✓ In civil engineering, composite bridge structures, retrofit of existing bridges, underground pressure vessel etc.
✓ Sports equipments, golf clubs, water skis, basket balls and bicycles In many other medical equipments, sports and agricultural applications.

1.5 Classification of Composites

Composites are commonly classified at two distinct levels.
The major composite classes include

- Organic matrix composites (OMC)
- Polymer matrix composites (PMC)
- Carbon matrix composites (CMC)
- Metal matrix composites (MMC)
- Ceramic matrix composites (CMC)

The second level of classification is based on reinforcement form. i.e.

- Fibre reinforced composites
- Particulate reinforced composites
- Structural composites

1.5.1 Ceramic matrix Composites

One of the prime objectives of producing ceramic matrix composites is to increase the toughness of the material. It is often found that there is a considerable improvement in the strength and stiffness of the ceramic matrix composites.

1.5.2 Polymer Matrix Composites

The most commonly used matrix materials are polymeric. In general, the mechanical properties of polymers are inadequate for structural purposes. In particular their strength and stiffness are low compared to metals and ceramics. These constraints can be overcome by reinforcing other materials with polymers. Secondly the processing of polymer matrix composites does not involve high pressure and doesn't require high temperature. Also equipment required for manufacturing polymer matrix composites are simpler. For this reason polymer matrix composites are developed rapidly and are gradually becoming popular for structural applications. There are two types of polymer composites: (a) Fiber reinforced polymer (FRP) (b) Particle reinforced polymer (PRP)

1.5.3 Fiber Reinforced Polymer

Common fiber reinforced composites are composed of fibers and a matrix. Fibers are the reinforcement and the main source of strength, while the matrix glues all the fibers together in shape and transfers stresses between the reinforcing fibers. Sometimes, filler might be added to smoothen the manufacturing process, impart special properties to the composites, and / or reduce the production cost. A fiber is characterized by its length being much greater than its crosssectional dimensions. The dimensions of the reinforcement determine its capability of contributing its properties to the composite. Fibers are highly effective in improving the fracture resistance of the matrix since a reinforcement having long dimensions discourages the growth of incipient cracks normal to the surface of the reinforcement that might otherwise lead to failure, particularly with brittle matrices. Man-made filaments or fibers of non-polymeric materials exhibit much higher strength along their length since large flaws, which may be present in the bulk material, are minimized due to the small cross-sectional dimensions of the fiber.

1.5.4 Particle Reinforced Polymer

Particles used for reinforcement include ceramics and glasses such as small mineral particles, metal particles such as aluminium and amorphous materials, including polymers and carbon black. Particles are used to increase the modules of the matrix and to decrease the ductility of the matrix.

A reinforcement is considered a 'particle' if all of its dimensions are roughly equal. Thus particulate reinforced composites include those reinforced by spheres, rods, flakes and other shapes of roughly equal axis. Whisker reinforcement with aspect ratio between 20 to 100 is often considered together with particulates in MMCs In particulate composites the reinforcement is of particle nature. It may be spherical, cubic, tetragonal, a platelet, or of other regular or irregular shape. In general, particles are not very effective in improving fracture resistance but they enhance the stiffness of the composite to a limited extent. Particle fillers are widely used to improve other properties of matrix materials such as to modify the thermal and electrical conductivities, improve performance at elevated temperatures, reduce friction, increase wear and abrasion resistance, improve machinability, increase surface hardness and reduce shrinkage. Orientation of the molecular structure is responsible for high strength and stiffness

1.6 Metal Matrix Composites (MMC)

A metal matrix composite (MMC) is a composite material with at least two constituent parts, one of them being a metal. The other material can be a different metal or another material, such as a ceramic or an organic compound. In MMCs, the reinforcement usually takes the form of particles, whiskers, short fibers, or continuous fibers. Metal matrix composites (MMCs) possess significantly improved properties which include high specific strength, specific modulus, and damping capacity and better wear resistance as compared to unreinforced alloys. There has been a steady rise in interest for composites containing low density and low cost reinforcements. Metal matrix composites (MMCs), like all composites constitute of at least two chemically and physically distinct phases, suitably distributed to provide properties not obtainable with either of the individual phases. Metal Matrix

Composites are composed of a metallic matrix (Al, Mg, Fe, Cu etc.) and a dispersed ceramic (oxide, carbides) or metallic phase(Pb, Mo, W etc.).

Higher strength, fracture toughness and stiffness are offered by metal matrices. Metal matrices can withstand elevated temperature in a corrosive environment better than polymer composites. Titanium, aluminum and magnesium are the popular matrix metals. These are particularly useful for aircraft applications. As a result of these favorable attributes, metal matrix composites are considered for a wide range of applications such as combustion chamber nozzle (in rockets and space shuttles), housings, tubing's, cables, heat exchangers, structural members etc.

Ceramic reinforcements may be silicon carbide, boron, alumina, silicon nitride, boron carbide, boron nitride etc. whereas metallic reinforcements may be tungsten, beryllium etc. MMC are used in Space Shuttle, commercial airliners, electronic substrates, bicycles, automobiles, and golf clubs and for a variety of other applications. When compared to polymer matrix composites, the advantages of MMC lie in their retention of strength and stiffness at elevated temperatures, better abrasion and creep resistance. Most MMC are still in the development stage or the early stages of production and are not as widely established as polymer matrix composites. The main disadvantage of MMCs is their high costs of fabrication, which has caused limitations on their actual applications. There are also advantages in some of the physical attributes of MMC such as no significant moisture absorption properties, non-in flammability, low electrical and thermal conductivities and resistance to most radiations. MMC have existed for the past 30 years and a wide range of MMCs have been studied.

1.6.1 Compared to monolithic metals, MMCs have the following properties in excess

✓ Higher strength-to-density ratios
✓ Higher stiffness-to-density ratios Better fatigue resistance
✓ Better elevated temperature properties
✓ Lower coefficients of thermal expansion
✓ Better wear resistance

1.6.2 The advantages of MMCs over polymer matrix composites

✓ Higher temperature capability
✓ Fire resistance
✓ Higher transverse stiffness and strength No moisture absorption
✓ Higher electrical and thermal conductivities
✓ Better radiation resistance
✓ Better transverse properties
✓ Improved joining characteristics

Various combinations of matrices and reinforcements have been tried on since work on MMCs began in the late 1950s. However, MMC technology is still in the early stages of development, and other important systems undoubtedly will emerge. Numerous metals have been used as matrices. The most important have been aluminium, titanium, magnesium, and copper alloys and super alloys. **1.6.3 The most important MMC systems**

i) Aluminium matrix

Continuous fibers: boron, silicon carbide, alumina, graphite

Discontinuous fibers: alumina, alumina-silica

Whiskers: silicon carbide
Particulates: silica, boron carbide. ii) Magnesium matrix
Continuous fibers: graphite, alumina

Whiskers: silica

Particulates: silicon carbide, boron carbide.

1.7 Introduction to Aluminum Matrix Composites

Aluminium is a highly popular matrix for the metal matrix composites (MMCs). The Al alloys are quite attractive as a result of their low density, their capability to be strengthened by precipitation, high corrosion resistance, high thermal and electrical conductivity, and high damping capacity. Aluminium Matrix Composites (AMCs) have been widely studied since the 1920s and are now used in sporting goods, electronic packaging, and amours and in automotive industries. They offer a large variety of mechanical properties depending on the chemical composition of the Al-matrix. They are usually reinforced by Al_2O_3, SiO_2, C but Sic, B, BN, B_4C, may also be considered. The aluminium matrices are in general Al-Si, Al-Cu, and alloys.

Literature review

CHAPTER-2 LITERATURE REVIEW

2.1 Literature Review on Metal Matrix composites

In the present industrial scenario subjected to rapid changes in various trends. Unlike the olden days, the focus is now on improving material aspects of a product rather than finding new ways of synthesis. This fundamental shift in thinking has lead to Material Science becoming an important subject for every industrial discipline. Under the same aegis, started exploring avenues within material science that could lead to a useful application after future development. This prompted to start investigating with composites, particularly those with polyester resin as the fillers. With our present project, hope to successfully investigate the mechanical properties of various combinations of matrix and reinforcement. A Composite, in engineering sense, is any material that has been physically assembled to form one single bulk without physical blending to foam a homogeneous material. Composite materials should satisfy the following conditions:

✓ It must be manufactured and not occur naturally.
✓ It must consist of two or more physically or chemically distinct, suitably arranged or distributed phases with an interface separating them.
✓ It must have characteristics not depicted by any one component in isolation.

A composite consists of a matrix as well as reinforcement. The matrix surrounds the reinforcement and supports it by maintaining its relative position. Composite materials are an emerging field with a lot of innovation going on since the past few years. A lot of technical papers and manufacturing processes were studied before deciding upon the most feasible process for our project. The following details presents a detailed review of the literature related to this project.

Shen, Y.L., Williams al [1] studied the compressive and impact properties of hybrid composites.their research on Metal Matrix Composites (MMCs) have evoked a keen interest in recent times for potential applications in aerospace and automotive industries owing to their superior strength to weight ratio and high temperature resistanceIn their project, The correlation between tensile and indentation behavior

Lloyd, D.J., Lagace, H., Mcleod, A. and Morris, P.L [2]. (Studied mechanical properties of hybrid polymer composite plates through experimental particle-reinforced metal matrix composites (MMCs) was examined
D.M. Skibo, D.M. Schuster], L. Jolla [3], The effects of particle size, particle volume fraction, and matrix aging characteristics on the interrelationship between tensile strength and macro-hardness were investigated They considered ASTM standard for different experiments of tensile test, impact test for specimen preparation
Balasivanandha, S., Kaarunamoorthy [4], L., Kaithiresan, analysed the Process for preparation of composites were successfully synthesized, using different stirring speeds and stirring times. The microstructure of the produced composites was examined by optical microscope and scanning electron microscope. The Brinell hardness test was performed on the composite specimens from base of the cast to top.

Hashim, J., Looney, L. and Hashmi, M.S.J. [5] contributed A critical step in the processing of cast, particle reinforced, metal matrix composites (MMCs) is the incorporation of the ceramic particles into the molten matrix alloy. Therefore, in a foundry MMC fabrication method, wettability of the reinforcement particles by the matrix alloy is one aspect of the process that must be optimised. In general, the reinforcement ceramic particles are very difficult to wet by a liquid metal.

CHAPTER-3 EXPERIMENTATION

3.1 Material required

(a) Aluminium

(b)SiO_2 – 140 mesh

(c) Density ofSiO_2 -2.65 gm/cc

(d)Density Al -2.7 kg/m^3

(e)Melting point-630.33^0

(f)Thermal conductivity- 244 W/mK

In this project, stir casting process employed for making the Al- sio_2 metal matrix composites (MMCs). Stir casting process has the benefits of being economical as well as faster. Different Aluminium specimens with varying percentages are taken and performing some mechanical properties on them. Fig. 3.1 show the Aluminium and SiO_2 Powder samples

Fig. 3.1 Powder samples

Particle Incorporation Rate 3.2

It has been observed from experimental data that a good dispersion is achieved when the particle incorporation rate (PIR) lies in the range of 10-20 gm/min. Dispersion of particles reduces significantly when the particle incorporation rate is gm/min. High PIR leads to agglomeration of particles followed by their rejection from the alloy melt. It is observed 40-30 that there is no dispersion of particles for particle incorporation rate above 40 gm/min. At such high rates (>40gm/min), the particles settle at the bottom of the crucible without getting wetted by the liquid alloy. The reduction in particle dispersion with increased PIR is due to the agglomeration of the particles at the top of the melt. The agglomerates are difficult to wet by .aluminium melt and hence they tend to settle at the bottom

(a) Pure Aluminium sample

(b) SiO_2sample

Particle Size and Amount 3.3

It has been noticed that the particle size and amount affects the synthesis process of the composite. When the particle size is very small (< 20 μm), it results in agglomeration either at the bottom or at the top of the melt in the crucible. It is observed that if particle size is much too small, particles tend to float on the surface of melt. Fine particles have a tendency to agglomerate during synthesis, when added above a certain amount, depending upon its size. These agglomerates entrap air and there is a decrease in their density. A combined effect of decrease in density, buoyant force of the melt and stirring action results in the flotation of these agglomerates on liquid melt during synthesis. Large particle size (>200 μm) results in the nondispersion of particles and settling of particles at the bottom of the crucible. In this study, the average size of reinforcement .particles is 50 μm

Melt temperature 3.4
The temperature of the melt is maintained at 700-800ºC as the increase in the reinforcement particles amount increases the melt viscosity, which hinders stirring speed. It has been experimentally found that the melt temperature of 700800ºC is optimal for controlling the stirring speed and for effective dispersion. Moreover, the optimum temperature of Alalloy melt for the dispersion of particles lies in the range of 740-800ºC. As the temperature falls below 700ºC, the viscosity of the melt increases and after the addition of reinforcement particles the rise in viscosity is too high that it results in the solidification of melt. If the temperature is maintained above 800ºC, the viscosity of melt reduces so much that it results in .the settling of particles in the melt without dispersing them in the melt during stirring

Material Selection 3.5
Aluminium is the attractive physical and mechanical properties. They are lightweight, low costs of production (with sand casting technology), easy to machine and have good recycling possibilities (up to 95 %). Due to these facts, their application in automotive and other industries is increasing. One of the major applications in automotive industry is the replacement of material for engine cylinder blocks, which was traditionally being made entirely of grey cast iron. Use of Al as a substitution for engine cylinder blocks made of grey cast iron, has many positive aspects such as reduction of engine mass, lower fuel consumption and therefore reduced pollution. Aluminium alloys are also used for the manufacturing of wheels. Unfortunately, most aluminium alloys, especially those suitable for mass production from the technological-economic aspect, do not have satisfactory wear resistance, i.e. their Tribological properties are relatively poor. In such cases there is a need to improve wear .resistance of aluminium alloys, i.e. to provide Tribological properties similar to those of grey cast iron or even better

The Process of Stir casting of the Composite specimens 3.6

a. .Stir Casting set up is set at 720˚C
b. The required temperature is achieved within 25-30 minutes & now the Aluminium alloy is placed in .crucible at 720^0C
c. The pure alloy melts completely within 95-100 minutes & the reinforcements i.e., SiO_2 is set up to pre .heat at this temperature
d. .The flue gases are removed from reinforcements at this temperature when heated for 30 minutes
e. .Once again, the aluminium alloy is heated for 30 minutes but the temperature is maintained at 800^0C
f. .After the metal is completely melted, the temperature is reduced again to 720^0C
g. .Cleaverol powder is now added to the melt as a flux material and slag that is formed is removed
h. .SiO2 is now added slowly and uniformly while the stirring speed is kept at 700rpm
i. Now, Magnesium is added to increase the wettability of the hybrid melt Steady stirring is done for 5 minutes and the melt is now kept idle at the temperature for 2-3 minutes. Pouring is then done into the die .and casting were obtained

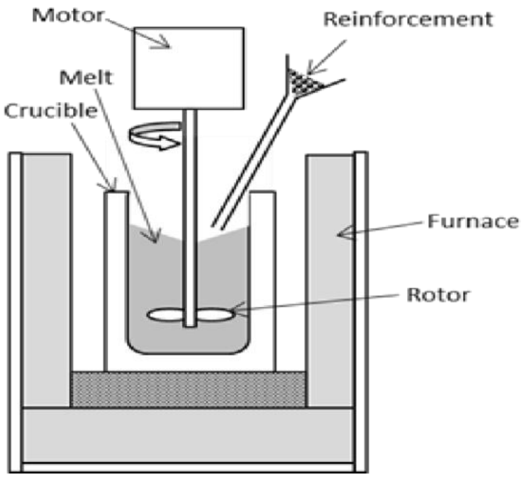


Fig.3.2 Schematic representation of stir casting

Fig. 3.3 Actual stir casting

Pre-treatment of SiO2 3.7

Before incorporating the SiO_2 particulates in to the molten metal, pre-heating was done to 900 °C for 12 h to remove the carbonaceous material and Fig. 3.3 shows that preheated SiO_2 Particulatesto remove moisture and gases from the surface of the particulates. If moisture and gases are present, there are chances of agglomeration due to the presence of entrapped air in the particles. The preheating furnace is kept close to the stir casting set up to avoid any drop in the temperature of SiO_2 .particles during the transportation of particles from the preheating furnace to the stir casting setup

Design of rotor 3.8

Design of the rotor is an important factor to be considered for stir casting process as it is responsible for the vortex formation and for the uniform distribution of reinforcements. Various designs and materials are available but rotors made of stainless steel are more durable when compared to metallic stirrers. A three blade rotor has been designed which is durable .and effective in particle dispersion for the present work

Fig. 3.5 Three blade rotor

Rotor positioning 3.9

Experimentally, it has been found that an effective vortex is formed when the stirrer is at 1/3rd of the melt's height from the bottom. It has been observed that if the height is raised to more than 1/3rd of the melt's height from the bottom, a small and ineffective vortex is formed, which results in the insufficient dispersion of reinforcement particles. Also it has been found that, if the height is less than 1/3rd of the melt's height from the bottom, the vortex disappears and particle dispersion is stopped. In this study, the approximate height of melt in the crucible is kept at 9 cm from the bottom and stirrer height is kept .at 3cmfrom the bottom

Stirring speed and time 3.10

A mechanical force can be utilized to overcome the surface tension to improve wettability. The speed of stirring has been raised up to a constant speed of 700 rpm as it is the maximum speed at which a smooth vortex is formed without any melt turbulence and spattering. It has been experimentally found that when stirring the stirring speed is less than 700 rpm, an ineffective vortex is formed that leads to non-dispersion of particles in the aluminum melt. When the speed is raised up to 800 rpm, there is occurrence of turbulence and spattering of melt. Time of stirring depends on the amount of reinforcement particles to be dispersed in the aluminium alloy melt. After the complete addition of reinforcements, stirring has been .continued for 5 minutes for better distribution

The weights of SiO_2 to be taken for the specimens of different compositions are calculated below

Fig. 3.10 Stirring Process

Fig 3.11 After Mixing

Fig. 3.13 Die for specimens

After the SiO_2has been mixed with the melt, it is poured into previously prepared iron moulds of the desired shape. Here we

ig.

Fig.3.15 After Solidification Test specimens 3.16

have prepareddumble specimen and square cross-section specimen. The castings are removed after it has solidified and then machined. After the particles disperse uniformly in the molten metal, the crucible is removed from furnace with the help of .tongs and the molten metal is poured into the moulds

Fig. 3.13 Pouring Molten Metal in Moulds Fig. 3.14 Specimen After Casting

The pouring process is shown in the Fig. 3.13 above. When pouring, care should be taken Sothat minimum time is lapsed between removing the crucible from furnace and pouring of the melt into the moulds. Also, no spatter or splash should be formed during pouring. After the castings have solidified, the cope and drag boxes are opened, the castings are removed and .the specimens are named A, B etc. to indicate the composition

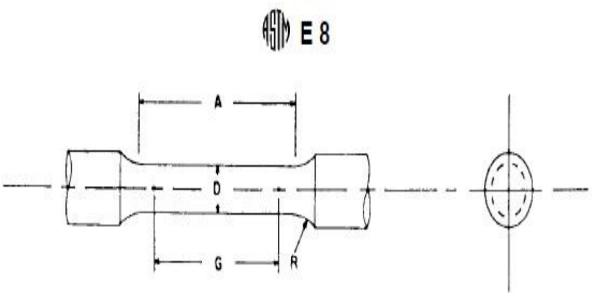
Fig. 3.17 Before Machinig

Fig. 3.18 After Machining

Specimens after Die casting 3.15

Specimen preparation

As per ASTM standards E8 the specimen is machined by lathe



	Dimensions				
	Standard Specimen	Small-Size Specimens Proportional to Standard			
	in.	in.	in.	in.	in.
Nominal Diameter	0.500	0.350	0.250	0.160	0.113
G—Gage length	2.000 ± 0.005	1.400 ± 0.005	1.000 ± 0.005	0.640 ± 0.005	0.450 ± 0.005
D—Diameter (Note 1)	0.500 ± 0.010	0.350 ± 0.007	0.250 ± 0.005	0.160 ± 0.003	0.113 ± 0.002
R—Radius of fillet, min	⅜	¼	3⁄16	5⁄32	3⁄32
A—Length of reduced section, min (Note 2)	2¼	1¾	1¼	¾	⅝

(a) ASTM Standards Machining
Machining is any of various processes in which a piece of raw material is cut into a desired final shape and size by a controlled
.material-removal process. The many processes that have this common theme are the controlled material removal
Types of machining operations for specimen preparation

ASTME8 standard specimen is prepared by different manufacturing processes namely turning, drilling, boring and milling. .These operations are performed with high accuracy to prepare the ASTM E8 specimen as per the above sketch

Turning it is a cutting tool with a single cutting edge is used to remove material from a rotating workpiece to generate a cylindrical shape. The primary motion is provided by rotating the workpiece, and the feed motion is achieved by moving the .cutting tool slowly in a direction parallel to the axis of rotation of the work piece

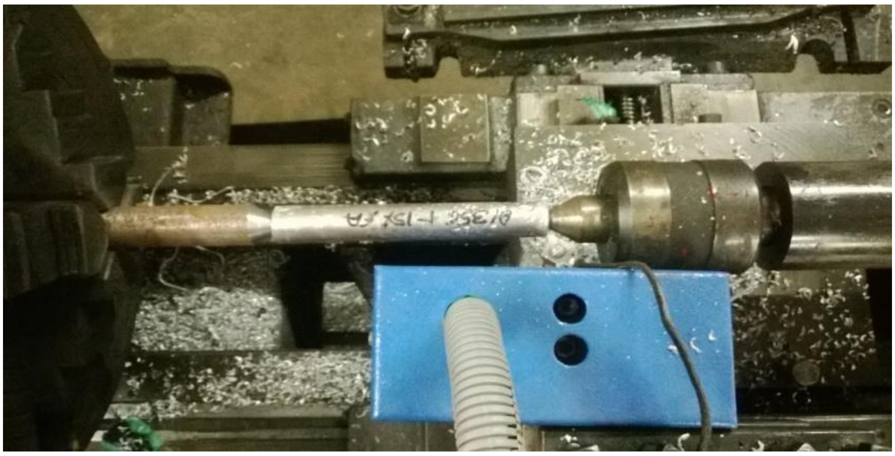


Fig. 3.19 Marching process

Other conventional machining operations include shaping, step turning, chamfering. Also, similar abrasive .operations are often included within the category of machining

Fig. 3.20 After Machining Specimens

One of the problems encountered in metal matrix composite processing is the settling of reinforcement particles during melt holding or casting. The mechanical stirrer used during stirring, the melt temperature and the type, amount and nature of particles are some of the factors to be considered. The method of introduction of the particles into the matrix melt is one of .the most important aspects of this casting process

:The particles can be introduced and mixed with the melt in a number of ways. Some of these are 1. Injection of the particles through injection gun, wherein the particles mix with the melt as bubbles rise through the ;melt

2. Addition of particles into molten stream as the mould is filled
3. ;Spray casting of droplets of atomized molten metal along with particles onto a substrate
4. .Dispersion of fine particles in the melt by centrifugal action

The vortex method is one of the better known approaches to obtain a uniform distribution of the reinforcement in the matrix alloy. The melt is stirred vigorously to form a vortex at the surface of the melt, and reinforcement material is introduced at .the side of the vortex. Stirring is continued for a few minutes before the slurry is cast

Synthesis of Aluminium /silicon dioxide composites

The most crucial parameters for synthesizing the composite using stir casting he process are: rotor design and position, stirring speed and time, melting and pouring temperatures, particle preheating temperature, particle incorporation rate, mould type and size, and reinforcement particle size and amount. These parameters are discussed in detail in the following .sections

Testing the Mechanical Properties 3.17

After the metal matrix composites have been fabricated, they are tested for their mechanical properties to ascertain their viability to be used in engineering applications and also the fruitfulness of this project. For finding out the mechanical properties of the prepared metal matrix specimens, we have performed tensile test and impact test and hardness and .compression test on them

Universal testing machine 3.18

Uniaxial tensile test is known as a basic and universal engineering test to achieve material parameters such as ultimate strength, yield strength, % elongation, % area of reduction and Young's modulus. These important parameters obtained from the
.standard tensile testing are useful for the selection of engineering materials for any applications required

When a specimen is subjected to an external tensile loading, the metal will undergo elastic and plastic deformation. Initially, the metal will elastically deform giving a linear relationship of load and extension. These two parameters are then used for .the calculation of the engineering stress and engineering strain to give a relationship

During elastic deformation, the engineering stress-strain relationship follows the Hook's Law and the slope of the curve .indicates the Young's modulus (E)

The stress is directly proportional to strain up to the elastic limit. On further loading the material undergoes plastic .deformation and ultimate tensile load is reached after which necking occurs and finally the material fails Tensile test 3.19

The tensile strength of the casting is measured on the universal testing machine. The specimen is placed in the UTM and held firmly between the jaws of the UTM. Once the machine is started it begins to apply an increasing load on the specimen. .Throughout the test the control system and its associated software will record the load and extension

As the sample is loaded, close the valve and record the load and elongation at regular load intervals up to the yield point (when the load starts increasing slowly while the elongation increases rapidly). The elongation is measured with respect to gauge length using an extensometer. Continue to load the sample until it breaks; paying close attention to load indicator and record the load at failure. Observe and note the maximum load on the follower needle. Using dial calipers measure the final .gauge length

Fig. 3.22 After Tensile Test Specimens

In similar manner, perform the tensile test on the 1%, 2%, 3%, and 4% and pure specimens. Finally, the readings are observed
.to calculate the stress, strain and modulus of elasticity

Impact test 3.20

For finding out the impact strength of the composite, izod test is performed. Impact tests are designed to measure the resistance to failure of a material to suddenly applied force. The test measures the impact energy or the energy absorbed prior to fracture.Izod test specimens have a ‘Notch machined across one of the larger faces. The notch is 2mm deep with 45^0 angle .and 0.25 mm radius along the base. The dimension of the specimen for Izod test is 75mm x 10mm x 10mm

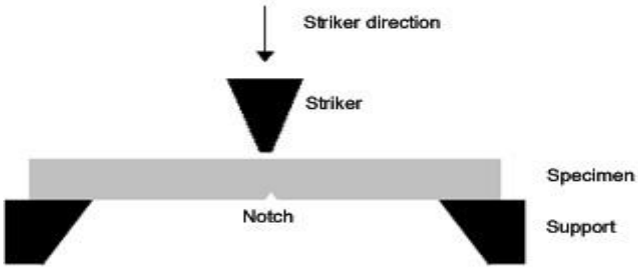


Fig. 3.23 Schematic of izod test

The izod test involves striking the specimen with a striker mounted at the end of a pendulum. The test piece is fixed in place at both ends and the striker impacts the test piece immediately behind the machined notch. The weight of the hammer is .Kg or 250N 20.932

1. The pure aluminium specimen is fixed, as such the notch faces the striking the edge. See that the pointer of the scale is positioned at the zero value. Release the hammer from its standard height, so that it fractures the

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specimen and rises to a certain height. The pointer moves along the direction of the hammer rod this indicates the load. Read the scale reading as shown by the pointer as the toughness of material in joules (or) in kgf.m (1joule=9.81 kgf.m-m).The .pure aluminium is breaking at a certain load

2. .Similarly, the other specimens are tested for their impact strengths. The values are later tabulated and compared

Fig. 3.25 Tested Specimens

At the point of impact, the striker has a known amount of kinetic energy. The impact energy is calculated based on the height to which the striker would have risen, if no test specimen was in place, and this is compared to the height to which the striker actually rises

Hardness Test (Vickers Hardness Test) 3.21
The Vickers hardness test was developed in 1921 by Robert L.Smith and George E.Sandland at Vickers ltd. The Vickers test is often easier to use than other hardness tests since the required calculations are independent of the size of the indenter, and the indenter can be used for all materials irrespective of hardness. The basic principle as with all common
.measures of hardness is to observe the questioned material's ability to resist plastic deformation from a standard source
The principle used in this method of testing is similar to that of brinell test. Vicker's test aims at determining the hardness of specimen of small cross sections, surface hardened elements and specimens having very high hardness
(a) Applications Of Vicker's Pyramid
Vicker's pyramid is suitable for wide range of materials, including materials too hard for Brinell such as cutting tools and heat .treated components and nitrided parts. Also used for thin materials

Fig. 3. 26 Vicker's Test Equipment

Fig 3.27 After Test Specimens

COMPRESSION TEST 3.22
Compression test is also conducted on universal testing machine (UTM) in similar as tensile test, but the direction of loading is reversed. Brittle materials are poor in tension. They are better only in bearing higher compressive stresses. Generally brittle materials are ceramics, bricks, concrete, cast iron, plastics etc. are tested in compression to evaluate their strength. Usually cylindrical specimen and geometrical prisms are used for testing. The length of the test piece generally will be three Times. .TheDiameter

Test Procedure

.Take two frictionless bearing plates of 75 mm diameter .1
.Place the specimen on the base plate of the load frame (sandwiched between the end plates) .2
.Place a hardened steel ball on the bearing plate .3
.Adjust the centre line of the specimen such that the proving ring and the steel ball are in the same line .4

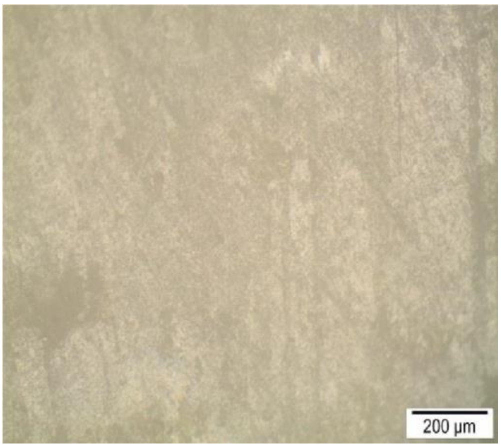
.Fix a dial gauge to measure the vertical compression of the specimen .5
.Adjust the gear position on the load frame to give suitable vertical displacement .6
.Start applying the load and record the readings of the proving ring dial and compression dial for every 5 mm compression .7 .Continue loading till failure is complete .8
.Draw the sketch of the failure pattern in the specimen .9

Fig. 3.29Test Specimens

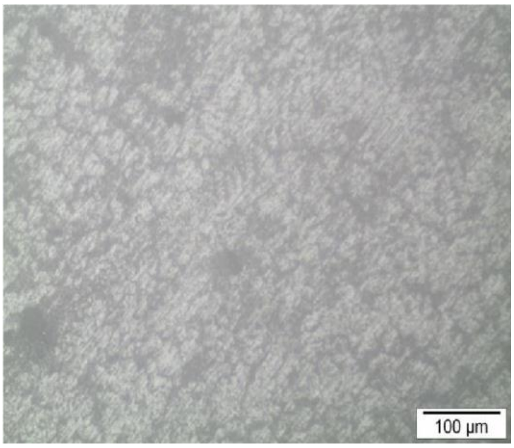
Micro structure 3.23

Different kinds of optical microscope are generally used to examine flat, polished and etched specimens: like reflection microscope and an inverted microscope. Recording the image is achieved using a digital camera working through the eyepiece. Typically, microstructure analysis of metals confirms structure and property relationships. Examinations are completed according to detailed procedures and applicable industry standards to assure reliable results. All results are documented in Certified Test Reports

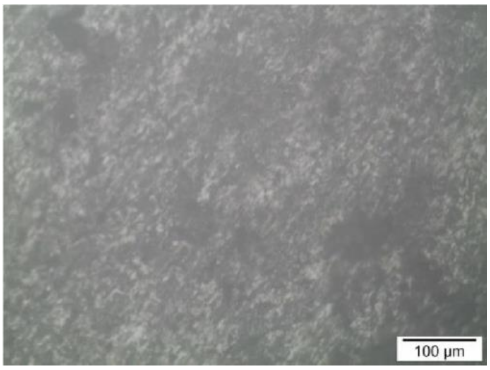

Fig. 3.30 Optical Microscope

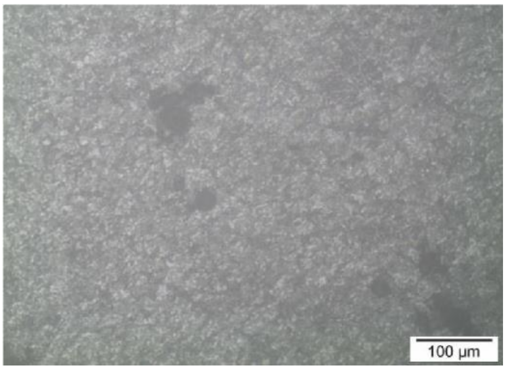


(a) Pure AL

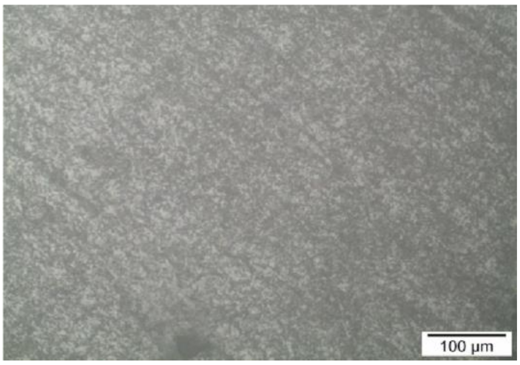


(b) 1% of SiO_2





(c) 2% SiO2 (d) 3%SiO2



(d) 4%SiO2

Fig. 3.31 Microstructures of various compositions

Procedure for obtaining Microstructure of specimen

A careful preparation of specimen and good magnification are needed for microscopic examination. Proper preparation of the specimen and the material's surface requires that a rigid step-by-step process be followed. The first step is carefully selecting a small sample of the material to undergo microstructure analysis with consideration given to location and orientation. This step is followed by sectioning, mounting, grinding, polishing and etching to reveal accurate microstructure
.and content

- Mounting of Specimen: Metallographic specimens are typically "mounted" using a hot compression thermosetting resin.Mounting a specimen provides a safe, standardized, and ergonomic way by which to hold a sample during the grinding and polishing operations. After mounting, the specimen is wet ground to reveal the surface of the metal. The specimen is successively ground with finer and finer abrasive media. Silicon carbide abrasive paper .was the first method of grinding and is still used today
- Emery papers are used for sanding down hard and rough surfaces of the rough specimens produced for obtaining microstructure. It gives a smooth, shiny finish to manufactured products. Silicon Carbide emery papers available in very coarse grits all the way through to micro-grits, common in wet applications. Grit size refers to the size of the particles of abrading materials embedded in the emery paper. Several different standards have been established for grit size. These standards establish not only the average grit size, but also the allowable variation from the average. The grit size used for obtaining microstructure of AL-SiO_2MMC's are 220P, 320P, 400P & 600P .respectively where, "P" refers to European FEPA (Federation of European Producers of Abrasives) "P" grade
- Keller's reagent is a mixture of nitric acid, hydrochloric acid, and hydrofluoric acid, used to etch aluminium alloys to reveal their grain boundaries and orientations. It is also sometimes called Dix–Keller reagent. It is prepared by :mixing the following constituents in specified proportions
- Nitric Acid (HNO_3) = 5ml
- Hydrochloric Acid (HCl) = 3ml
- Hydrofluoric Acid (HF) = 2ml
- Distilled Water = 190ml

.The specimens that are polished using Emery papers are now dipped in Keller's reagent for 20 seconds

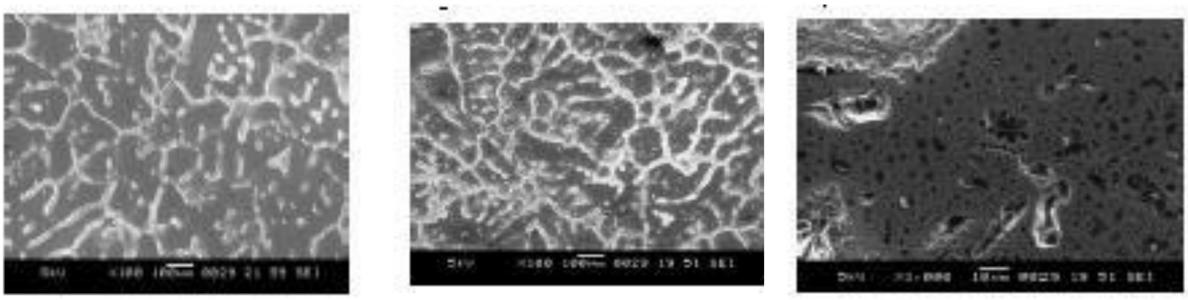
Detailed viewing of samples is done with a metallurgical microscope that has a system of lenses (objectives and eyepiece) so .that different magnifications (50µm, 100µm, 200µm) can be achieved

Scanningelectron microscopy 3.25

Samples with pure metal and reinforced metal are studied for micro structural characterization studies by using a Scanning Electron Microscope. The characterization is done after etching and polishing the samples. The photographs of Micrographs .are taken at variable accelerating voltages for the best possible resolution using the secondary electron imaging

Particle Size Analysis

The milled powder was studied for particle size. About 500 ml of distilled water was taken in the sample holder. Then the .instrument was run under an ultrasonic displacement of about 10.00 micron and a pump speed 1900 rpm



a) SiO_2 %1 **b)** SiO_2 %2 **c)** SiO_2 %3

Fig. 32 Scanning electron microscope of pure Aluminium with different percentages

Conclusions and Future scope

CHAPTER- 5 CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSIONS

After conduction the experimentation on the prepared specimens, it is observed that there is a considerable increase in
the strength and hardness of the composites. The strength and hardness tend to increase with the increase in % of SiO2 in the composite, but only upto certain composition which is different for the tensile strength and hardness.

- The maximum tensile strength (Ultimate Strength) for 3 % composition specimen is 192.82MPa.
- From the impact strength of the specimens, it has been observed that specimen B i.e. at 1 % SiO_2composition, the maximum Strength is obtained.
- From the Hardness Test we observed that specimen 3% is having a high Hardness number i.e., 156VHN.
- From the tests 3 % SiO_2 Al composite for high compression strength.

5.2 FUTURE SCOPE

- ✓ There is an increase in interest in utilizing composite materials for aerospace and automobile engineering same material can be carried out at nano level
- ✓ The production of crankshafts, helper springs and structures by metal matrix composites will see large reduction so
the efficient and durability tests have to be evaluated

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