STUDY OF MECHANICAL PROPERTIES OF GROUND NUT SHELL ASH AND SILICON CARBIDE DISPERSION STRENGTHENED ALUMINIUM 6061 METAL MATRIX COMPOSITES

A project report submitted in partial fulfilment of the requirements for the award of the Degree of

BACHELOR OF TECHNOLOGY

IN

MECHANICAL ENGINEERING

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CERTIFICATE

This is to certify that this project report entitled **'STUDY OF MECHANICAL PROPERTIES OF GROUND NUT SHELL ASH AND SILICAON CARBIDE DISPERSION STRENGTHENEDALUMINUIM 6061 METAL MATRIX COMPOSITES'** has been carried by **K.TARAKESWARA RAO (315126520105), M.YUVA CHAITANYA (315126520123). K.SURESH (315126520099), K.NIKHITA (315126520078), K.ATCHUTH RAM (315126520084)** under the esteemed guidance of **MS. M. AMARESWARI REDDY,** in partial fulfilment of requirements for the award of **Bachelor of Technology** in Department of **Mechanical engineering.**

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ABSTRACT

Aluminum Hybrid Reinforcement Technology is a response to the dynamic ever-increasing service requirement of industries such as aerospace, transportation, marine due to its high ductility, highly conductive, lightweight and high strength to weight ratio. The mechanical properties of hybrid aluminum composites reinforced with groundnut shell ash (GSA) and silicon carbide (SiC) has been investigated. GSA and SiC with different mix ratios (56.56% , 44.4% , 66.6% : 33.3% , 77.7% : 22.3%) constituted 3wt% of the reinforcing phase, while the matrix material was Al-Mg-Si alloy (Al 6061). The hybrid composites were produced via stir casting technique. After getting specimens from stir casting , The specimens were machined according to ASTM standards and tested using UTM (Universal testing machine) and Brinell hardness machine. And these mechanical properties were compared with pure Al6061 material. And the results are plotted on graphs. It is observed that tensile strength of the pure sample is more than the hybrid Aluminium metal matrix composite. It was decreased from 0 to 4 grams of GSA and slightly increased from 4 to 6 grams of GSA and then it was decreased. It is observed that compressive strength is maximum for the sample which contains 6 grams of GSA. It is observed that compressive strength is decreased from maximum point i.e at 6 grams of GSA to the point where GSA content is 8 grams. It is observed that hardness value increased with the weights of GSA Upto 8 grams of GSA it is increased after that is decreased. The hardness of hybrid MMC is constant from 6 to 8 grams of GSA in reinforcing phase.

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INTRODUCTION

Chapter 1

INTRODUCTION

1.1 COMPOSITE MATERIAL

A composite material (also called a composition material , which is the common name) is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure, differentiating composites from mixtures and solid solutions.

The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials.

More recently, researchers have also begun to actively include sensing, actuation, computation and communication into composites, which are known as Robotic Materials. Typical engineered composite materials include:

- Reinforced concrete and masonry
- Composite wood such as plywood
- Reinforced plastics, such as fibre-reinforced polymer or fiberglass
- Ceramic matrix composites (composite ceramic and metal matrices)
- Metal matrix composites
- and other Advanced composite materials

1.1.1HISTORY

The earliest man-made composite materials were straw and mud combined to form bricks for building construction. Ancient brick-making was documented by Egyptian tomb paintings.

Wattle and daub is one of the oldest man-made composite materials, at over 6000 years old. Concrete is also a composite material, and is used more than any other man-made material in the world. As of 2006, about 7.5 billion cubic metres of concrete are made each year more than one cubic metre for every person on Earth.

- Woody plants, both true wood from trees and such plants as palms and bamboo, yield natural composites that were used prehistorically by mankind and are still used widely in construction and scaffolding.
- Plywood 3400 BC by the Ancient Mesopotamians; gluing wood at different angles gives better properties than natural wood.
- Cartonnage layers of linen or papyrus soaked in plaster dates to the First Intermediate Period of Egypt c. 2181–2055 BC and was used for death masks.
- Cob (material) Mud Bricks, or Mud Walls, (using mud (clay) with straw or gravel as a binder) have been used for thousands of years.
- Concrete was described by Vitruvius, writing around 25 BC in his Ten Books on Architecture, distinguished types of aggregate appropriate for the preparation of lime mortars. For structural mortars, he recommended pozzolana, which were volcanic sands from the sand like beds of Pozzuoli brownish-yellow-gray in colour near Naples and reddish-brown at Rome. Vitruvius specifies a ratio of 1 part lime to 3 parts pozzolana for cements used in buildings and a 1:2 ratio of lime to pulvis Puteolanus for underwater work, essentially the same ratio mixed today for concrete used at sea. Natural cement-stones, after burning, produced cements used in concretes from post-Roman times into the 20th century, with some properties superior to manufactured Portland cement.
- Papier-mache, a composite of paper and glue, has been used for hundreds of years.
- The first artificial fibre reinforced plastic was bakelite which dates to 1907, although natural polymers such as shellac predate it.
- One of the most common and familiar composite is fibre glass, in which small glass fibre are embedded within a polymeric material (normally an epoxy or polyester). The glass fibre is relatively strong and stiff (but also brittle), whereas the polymer is ductile (but also weak and flexible). Thus the resulting fibreglass is relatively stiff, strong, flexible, and ductile.

1.1.2 EXAMPLES

Concrete is the most common artificial composite material of all and typically consists of loose stones (aggregate) held with a matrix of cement. Concrete is an inexpensive material, and will not compress or shatter even under quite a large compressive force. However, concrete cannot survive tensile loading (i.e., if stretched it will quickly break apart). Therefore, to give concrete the ability to resist being stretched, steel bars, which can resist high stretching forces, are often added to concrete to form reinforced concrete

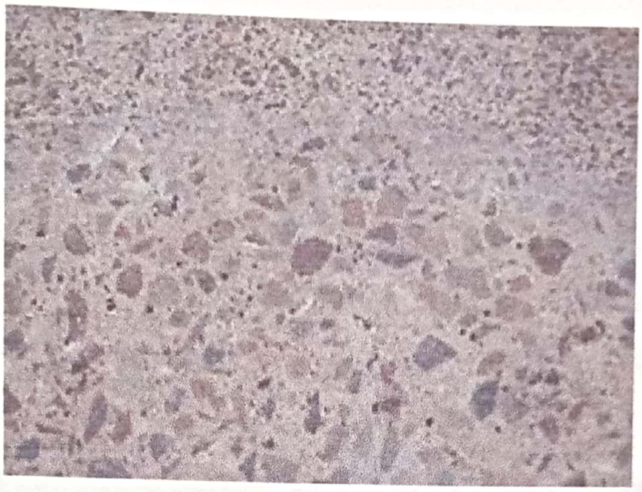

Fig. 1.1 Concrete

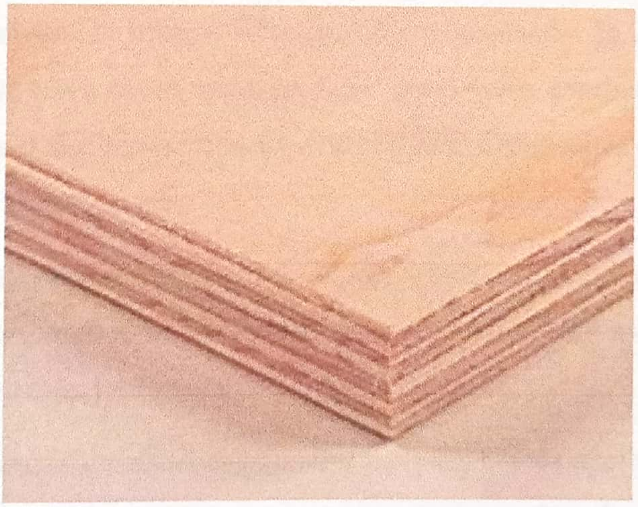

Fig. 1.2 Plywood

1.1.3 APPLICATIONS

Fibre-reinforced composite materials have gained popularity (despite their generally high cost) in high-performance products that need to be lightweight, yet strong enough to take harsh loading conditions such as aerospace components (tails, wings, fuselages, propellers), boat and scull hulls, bicycle frames and racing car bodies. Other uses include fishing rods, storage tanks, swimming pool panels, and baseball bats. The Boeing 787 and Airbus A350 structures including the wings and fuselage are composed largely of composites. Composite materials are also becoming more common in the realm of orthopedic surgery, and it is the most common hockey stick material.

Carbon composite is a key material in today's launch vehicles and heat shields for the re-entry phase of spacecraft. It is widely used in solar panel substrates, antenna reflectors and yokes of spacecraft. It is also used in payload adapters, inter-stage structures and heat shields of launch vehicles. Furthermore, disk brake systems of airplanes and racing cars are using carbon/carbon material, and the composite material with carbon fibres silicon carbide matrix has been introduced in luxury vehicles and sports cars.

In 2006, a Fibre-reinforced composite pool panel was introduced for in-ground swimming pools, residential as well as commercial, as a non-corrosive alternative to galvanized steel.

In 2007, an all-composite military Humvee was introduced by TPI Composites Inc and Armor Holdings Inc, the first all-composite military vehicle. By using composites the vehicle is lighter, allowing higher payloads. In 2008, carbon fibre and DuPont Kevlar (five times stronger than steel) were combined with enhanced thermoset resins to make military transit cases by ECS Composites creating 30-percent lighter cases with high strength.

Pipes and fittings for various purpose like transportation of potable water, fire-Fig.hting, irrigation, seawater, desalinated water, chemical and industrial waste, and sewage are now manufactured in glass reinforced plastics.

Composite materials used in tensile structures for facade application provides the advantage of being translucent. The woven base cloth combined with the appropriate coating allows better light transmission. This provides a very comfortable level of illumination compared to the full brightness of outside.

The wings of wind turbines, in growing sizes in the order of 50 m length are fabricated in composites since several years.

Two-lower-leg-amputees run on carbon-composite spring-like artifical feet as quick as healthy sportsmen.

High pressure gas cylinders typically about 7–9 litre volume x 300 bar pressure for firemen are nowadays constructed from carbon composite. Type-4-cylinders include metal only as boss that carries the thread to screw in the valve.

1.2 METAL MATRIX COMPOSITES(MMC)

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-soluble compound Al_4C_3 on the surface of the fibre. To prevent this reaction, the carbon fibres are coated with nickel or titanium boride.

1.2.1 MATRIX

The matrix is the monolithic material into which the reinforcement is embedded, and is completely continuous. This means that there is a path through the matrix to any point in the material, unlike two materials sandwiched together. In structural applications, the matrix is usually a lighter metal such as aluminum, magnesium, or titanium, and provides a compliant support for the reinforcement. In high-temperature applications, cobalt and cobalt–nickel alloy matrices are common.

1.2.2 REINFORCEENT

The reinforcement material is embedded into a matrix. The reinforcement does not always serve a purely structural task (reinforcing the compound), but is also used to change physical properties such as wear resistance, friction coefficient, or thermal conductivity. The reinforcement can be either continuous, or discontinuous. Discontinuous 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 polycrystaline diamond tooling (PCD).Continuous reinforcement uses monofilament 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 alignment of the material affects its strength. One of the first MMCs used boron filament as reinforcement. Discontinuous reinforcement uses "whiskers", short fibers, or particles. The most common reinforcing materials in this category are alumina and silicon carbide.[1]

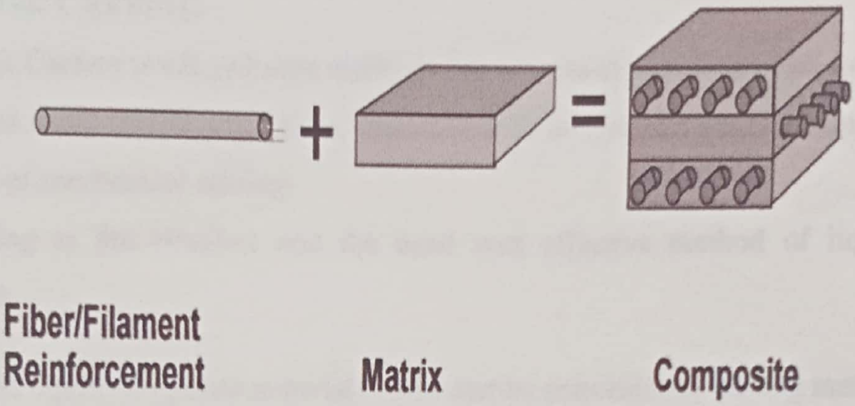

Fig. 1.3 Composite material

1.3 FABRICATION OF METAL MATRIX COMPOSITES

There are three ways to fabricate metal matrix composites

- Liquid state method
- Solid state method
- Semi solid state method

1.3.1 LIQUID STATE METHODS

Liquid state fabrication of Metal Matrix Composites 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 composite, good interfacial bonding (wetting) between the dispersed phase and the liquid matrix should be obtained.

Wetting improvement may be achieved by coating the dispersed phase particles (fibers). Proper coating not only reduces interfacial energy, but also prevents chemical interaction between the dispersed phase and the matrix.

The methods of liquid state fabrication of Metal Matrix Composites:

- Stir Casting
- Infiltration
- Gas Pressure Infiltration
- Squeeze Casting Infiltration
- Pressure Die Infiltration

1.3.1.1 STIR CASTING

Stir Casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short fibers) is mixed with a molten matrix metal by means of mechanical stirring.

Stir Casting is the simplest and the most cost effective method of liquid state fabrication.

The liquid composite material is then cast by conventional casting methods and may also be processed by conventional Metal forming technologies.

Stir Casting is characterized by the following features:

- Content of dispersed phase is limited (usually not more than 30 vol.%).
- Distribution of dispersed phase throughout the matrix is not perfectly homogeneous:
- There are local clouds (clusters) of the dispersed particles (fibers);
- There may be gravity segregation of the dispersed phase due to a difference in the densities of the dispersed and matrix phase.
- The technology is relatively simple and low cost.
- Distribution of dispersed phase may be improved if the matrix is in semi-solid condition.
- The method using stirring metal composite materials in semi-solid state is called Rheocasting.
- High viscosity of the semi-solid matrix material enables better mixing.

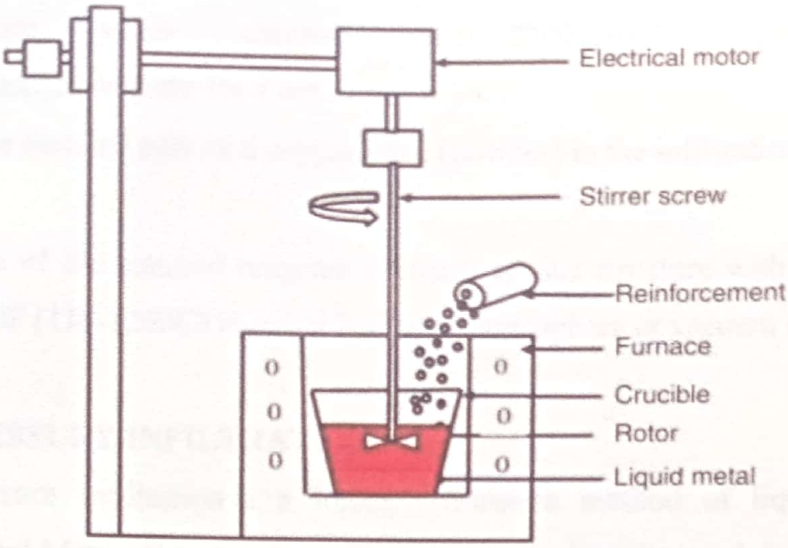

Fig. 1.4 Stir Casting equipment

1.3.1.2 INFILTRATION

Infiltration is a liquid state method of composite materials fabrication, in which a preformed dispersed phase (ceramic particles, fibers, woven) is soaked in a molten matrix metal, which fills the space between the dispersed phase inclusions. The motive force of an infiltration process may be either capillary force of the dispersed phase (spontaneous infiltration) or an external pressure (gaseous, mechanical, electromagnetic, centrifugal or ultrasonic) applied to the liquid matrix phase (forced infiltration).Infiltration is one of the methods of preparation of tungsten-copper composites.

The principal steps of the technology are as follows

- Tungsten Powder preparation with average particle size of about 1-5 mm.
- Optional step: Coating the powder with nickel. Total nickel content is about 0.04%.
- Mixing the tungsten powder with a polymer binder.
- Compacting the powder by a molding method (Metal injection molding, die pressing, isostatic pressing). Compaction should provide the predetermined porosity level (apparent density) of the tungsten structure.
- Solvent debinding.

- Sintering the green compact at 2200-2400F (1204-1315C) in Hydrogen atmosphere for 2 hrs.
- Placing the sintered part on a copper plate (powder) in the infiltration/sintering furnace.
- Infiltration of the sintered tungsten skeleton porous structure with copper at 2100-2300F (110-1260C) in either hydrogen atmosphere or vacuum for 1 hour.

1.3.1.3 GAS PRESSURE INFILTRATION

Gas Pressure Infiltration is a forced infiltration method of liquid phase fabrication of Metal Matrix Composites, using a pressurized gas for applying pressure on the molten metal and forcing it to penetrate into a preformed dispersed phase.

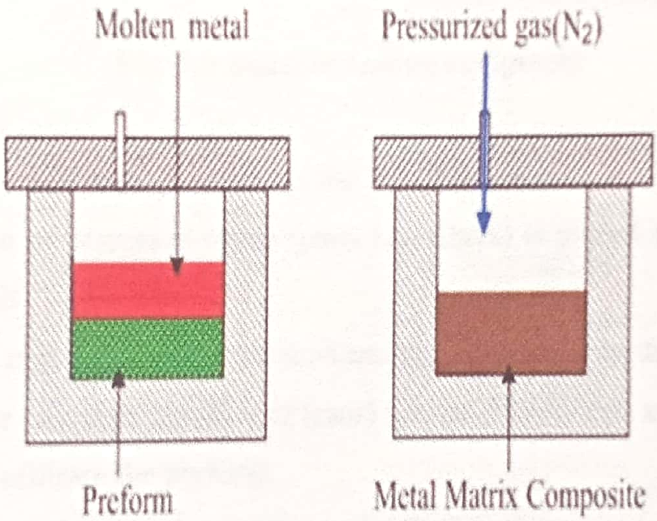

Fig. 1.5 Gas Pressure Infiltration

Gas Pressure Infiltration method is used for manufacturing large composite parts. The method allows using non-coated fibers due to short contact time of the fibers with the hot metal. In contrast to the methods using mechanical force, Gas Pressure Infiltration.

1.3.1.4 SQUEEZE CASTING INFILTRATION

Squeeze Casting Infiltration is a forced infiltration method of liquid phase fabrication of Metal Matrix Composites, using a movable mould part (ram) for applying pressure on the molten metal and forcing it to penetrate into a performed dispersed phase, placed into the lower fixed mold part.

Squeeze Casting Infiltration method is similar to the Squeeze casting technique used for metal alloys casting.

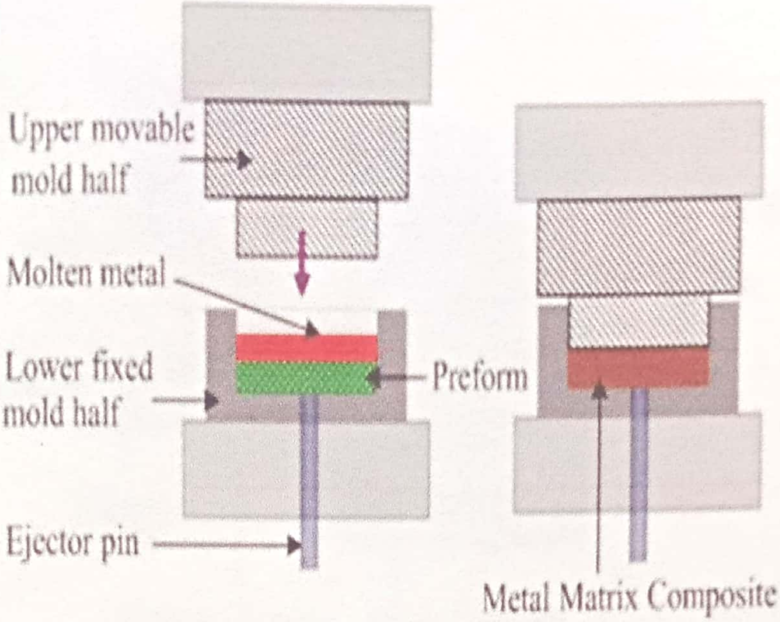

Fig. 1.6 Squeeze casting equipment

Squeeze Casting Infiltration process has the following steps:

- A preform of dispersed phase (particles, fibers) is placed into the lower fixed mould half.
- A molten metal in a predetermined amount is poured into the lower mould half.
- The upper movable mould half (ram) moves downwards and forces the liquid metal to infiltrate the preform.
- The infiltrated material solidifies under the pressure.
- The part is removed from the mould by means of the ejector pin.
- The method is used for manufacturing simple small parts (automotive engine pistons from aluminum alloy reinforced by alumina short fibers).

1.3.1.5 PRESSURE DIE INFILTRATION

Pressure Die Infiltration is a forced infiltration method of liquid phase fabrication of Metal Matrix Composites, using a Die casting technology, when a preformed dispersed phase (particles, fibers) is placed into a die (mould) which is then filled with a molten metal entering the die through a sprue and penetrating into the preform under the pressure of a movable piston (plunger).

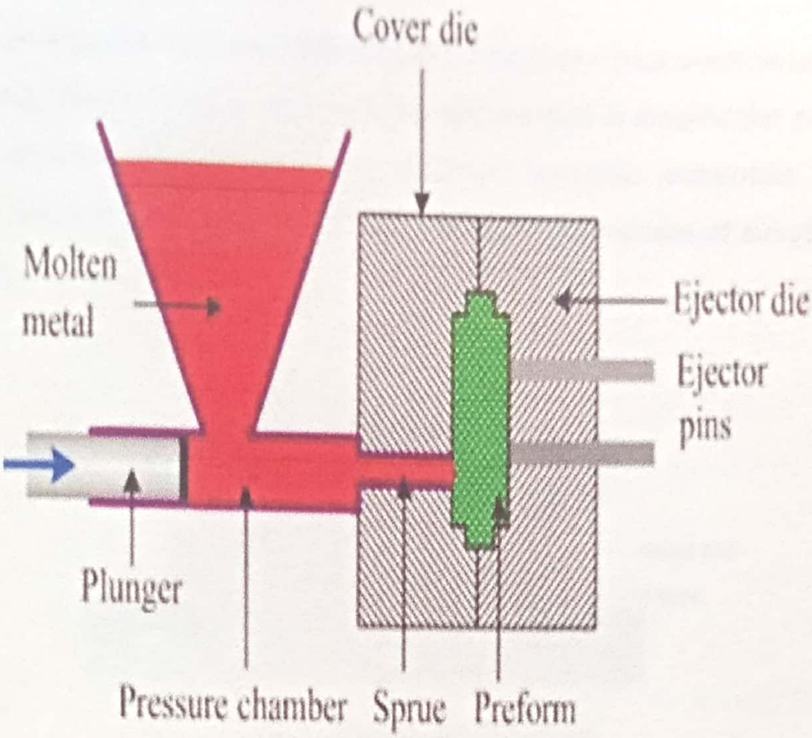

Fig. 1.7 Pressure die infiltration

1.3.2 SOLID STATE METHODS

It is the process, in which Metal Matrix Composites are formed as a result of bonding matrix metal and dispersed phase due to mutual diffusion occurring between them in solid states at elevated temperature and under pressure. Low temperature of solid state fabrication process (as compared to Liquid state fabrication of Metal Matrix Composites) depresses undesirable reactions on the boundary between the matrix and dispersed phases. Metal Matrix Composites may be deformed also after sintering operation by rolling, Forging, pressing, Drawing or Extrusion. The deformation operation may be either cold (below the recrystallization temperature) or hot (above the Recrystallyzation temperature).Deformation of sintered composite materials with dispersed phase in form of short fibers results in a preferred orientation of the fibers and anisotropy of the material properties (enhanced strength along the fibers orientation). There are two principal groups of solid state fabrication of Metal Matrix Composites:

- Diffusion bonding
- Sintering

1.3.2.1 DIFFUSION BONDING

Diffusion Bonding is a solid state fabrication method, in which a matrix in form of foils and a dispersed phase in form of long fibers are stacked in a particular order and then pressed at elevated temperature. The finished laminate composite material has a multilayer structure. Diffusion Bonding is used for fabrication of simple shape parts (plates, tubes).

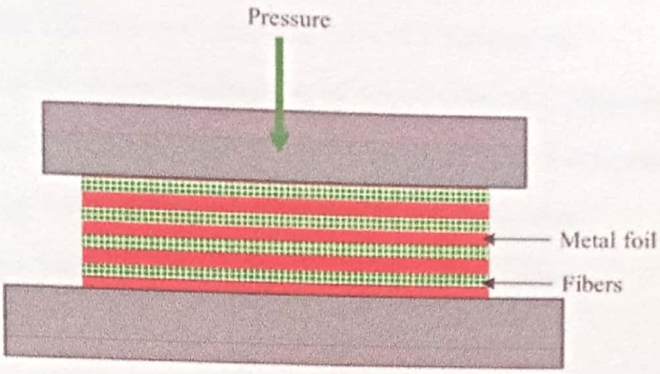

Fig. 1.8 Diffusion Bonding

ROLL BONDING is a process of combined Rolling (hot or cold) strips of two different metals (e.g. steel and aluminum alloy) resulted in formation of a laminated composite material with a metallurgical bonding between the two layers.

WIRE/FIBER WINDING is a process of combined winding continuous ceramic fibers and metallic wires followed by pressing at elevated temperature.

1.3.2.2 SINTERING

Sintering fabrication of Metal Matrix Composites is a process, in which a powder of a matrix metal is mixed with a powder of dispersed phase in form of particles or short fibers for subsequent compacting and sintering in solid state (sometimes with some presence of liquid).

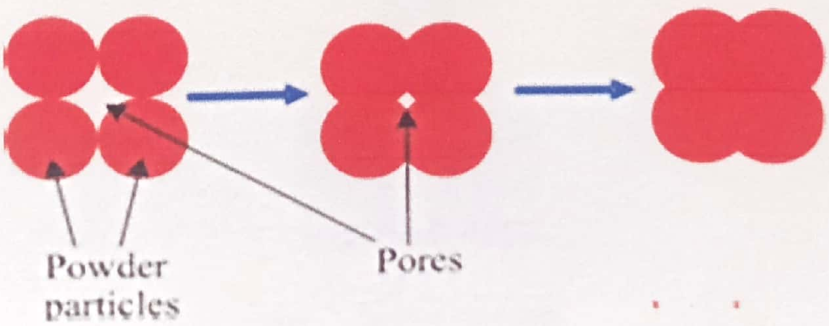

Fig. 1.9 Sintering

Sintering is the method involving consolidation of powder grains by heating the "green" compact part to a high temperature below the melting point, when the material of the separate particles diffuse to the neighboring powder particles.In contrast to the liquid state fabrication of Metal Matrix Composites, sintering method allows obtaining materials containing up to 50% of dispersed phase.When sintering is combined with a deformation operation, the fabrication methods are called:

- Hot Pressing Fabrication of Metal Matrix Composites
- Hot Isostatic Pressing Fabrication of Metal Matrix Composites
- Hot Powder Extrusion Fabrication of Metal Matrix Composites
- Hot Pressing Fabrication of Metal Matrix Composites
- Hot Pressing Fabrication of Metal Matrix Composites

HOT PRESSING FABRICATION OF METAL MATRIX COMPOSITES

Hot Pressing Fabrication of Metal Matrix Composites – sintering under a unidirectional pressure applied by a hot press;

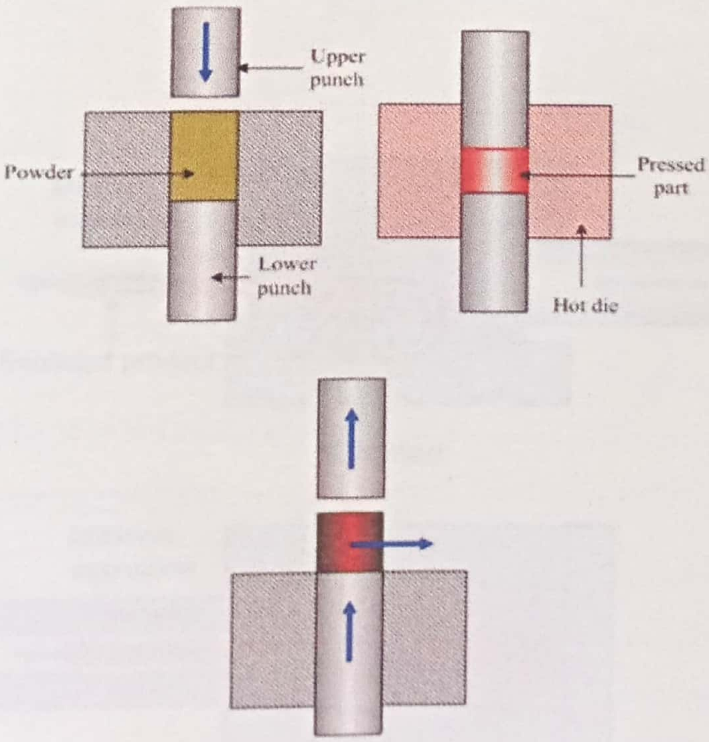

Fig. 1.10 Hot pressing

Hot Isostatic Pressing Fabrication of Metal Matrix Composites – sintering under a pressure applied from multiple directions through a liquid or gaseous medium surrounding the compacted part and at elevated temperature;

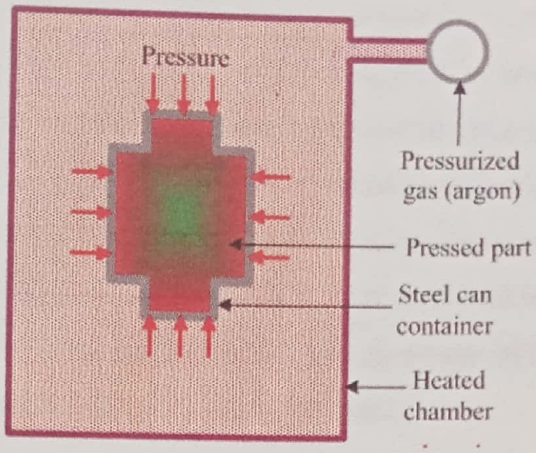

Fig. 1.11 Hot Isostatic Pressing Fabrication

Hot Powder Extrusion Fabrication of Metal Matrix Composites

Hot Powder Extrusion Fabrication of Metal Matrix Composites – sintering under a pressure applied by an extruder at elevated temperature.

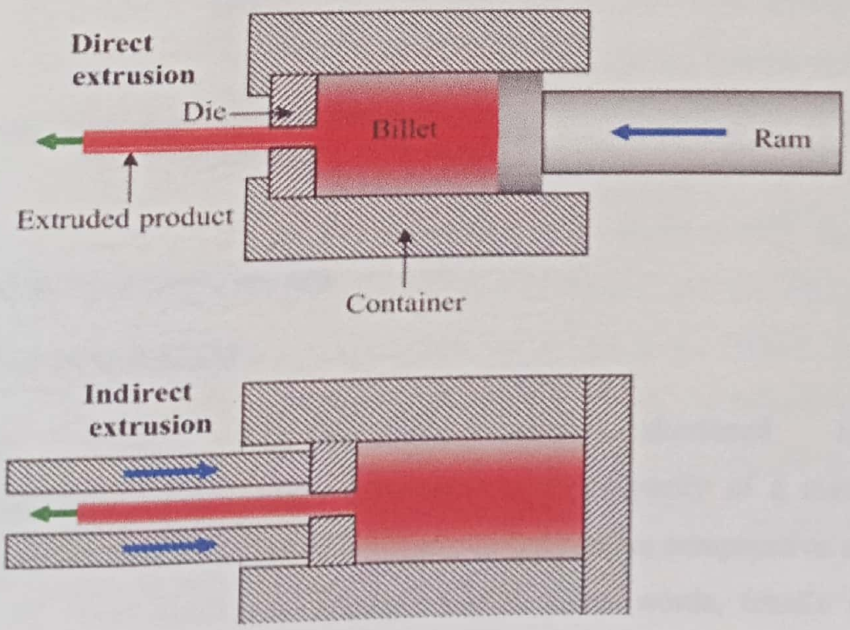

Fig. 1.12 Hot Powder Extrusion Fabrication

1.3.3 SEMI-SOLID POWDER PROCESSING (SPP)

Semi-solid powder processing (SPP) combines the advantages of powder metallurgy and Semi-solid form in. In contrast to traditional bulk semi-solid forming, the procession able the mixing of various powders for improved properties and eliminates Post- processing steps required for powder metallurgy routes. In general, four basic steps are involved in SPP: powder preparation, powder pre-compaction, heating and Semi-solid forming. SPP has been applied to produce net-shaped metal matrix composites (MMCs) with low reinforcement loading (<30%). Previous work has demonstrated the potential to produce composites with high efficiency, low cost and good compositional control with promising microstructures. Melting metallurgy for the production of MMCs is at present of greater technical importance than powder metallurgy. It is more economical and has the advantage of being able to use well proven casting processes for the production of MMCs.

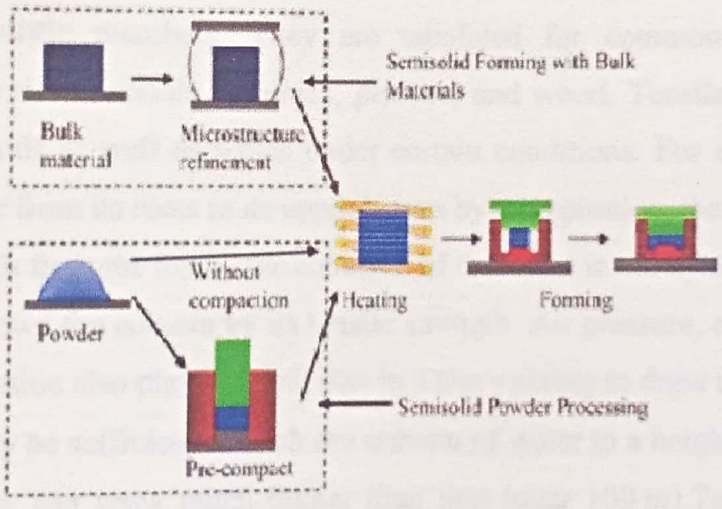

Fig. 1.13 Semi solid powder Processing

1.4 MECHANICAL PROPERTIES

1.4.1 TENSILE STRENGTH

Ultimate tensile strength (UTS), often shortened to tensile strength (TS), ultimate strength within equations, is the capacity of a material or structure to withstand loads tending to elongate, as opposed to compressive strength, which withstands loads tending to reduce size. In other words, tensile strength resists tension (being pulled apart), whereas compressive strength resists compression (being pushed together). Ultimate tensile strength is measured by the maximum stress that a material can withstand while being stretched or pulled before breaking. In the study of strength of materials, tensile strength, compressive strength, and shear strength can be analysed independently. Some materials break very sharply, without plastic deformation, in what is called a brittle failure. Others, which are more ductile, including most metals, experience some plastic deformation and possibly necking before fracture. The UTS is usually found by performing a tensile test and recording the engineering stress versus strain. The highest point of the stress–strain curve (see point 1 on the engineering stress–strain diagrams below) is the UTS. It is an intensive property; therefore its value does not depend on the size of the test specimen. However, it is dependent on other factors, such as the preparation of the specimen, the presence or otherwise of surface defects, and the temperature of the test environment and material.

Tensile strengths are rarely used in the design of ductile members, but they are important in brittle members. They are tabulated for common materials such as alloys, composite materials, ceramics, plastics, and wood. Tensile strength can be defined for liquids as well as solids under certain conditions. For example, when a tree draws water from its roots to its upper leaves by transpiration, the column of water is pulled upwards from the top by the cohesion of the water in the xylem, and this force is transmitted down the column by its tensile strength. Air pressure, osmotic pressure, and capillary tension also plays a small part in a tree's ability to draw up water, but this alone would only be sufficient to push the column of water to a height of less than ten metres, and trees can grow much higher than that (over 100 m).Tensile strength is defined as a stress, which is measured as force per unit area. For some non-homogeneous materials (or for assembled components) it can be reported just as a force or as a force per unit width. In the International System of Units (SI), the unit is the pascal (Pa) (or a multiple thereof, often mega pascals (MPa), using the SI prefix mega); or, equivalently to pascals, newtons per square metre (N/m^2). A United States customary unit is pounds per square inch (lb/in^2 or psi), or kilo-pounds per square inch (ksi or sometimes kpsi), which is equal to 1000 psi; kilo-pounds per square inch are commonly used in one country (US), when measuring tensile strengths.

1.4.1.1 TENSILE TESTING: Tensile testing, also known as tension testing, is a fundamental materials science and engineering test in which a sample is subjected to a controlled tension until failure. Properties that are directly measured via a tensile test are ultimate tensile strength, breaking strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined: Young's modulus, Poisson's ratio, yield strength, and strain-hardening characteristics. Universal Testing Machine is the most commonly used for obtaining the mechanical characteristics of isotropic materials. Some materials use biaxial tensile testing.

1.4.1.2 TENSILE SPECIMEN

According to ASTM Standards, to carry out Tensile strength test on Universal Testing Machine the specimen must be of particular shape and must have some Standard Dimensions. The main factor for calculation of tensile strength is the gauge length of the specimen we have prepared.

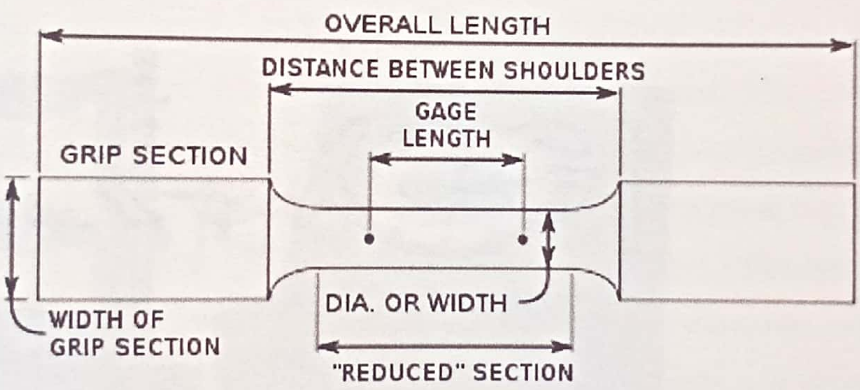

Fig. 1.14 Tensile specimen

1.4.1.3 EQUIPMENT

Tensile testing is most often carried out at a material testing laboratory. The ASTM D638 is among the most common tensile testing protocols. The ASTM D638 measures plastics tensile properties including ultimate tensile strength, yield strength, elongation and Poisson's ratio. The most common testing machine used in tensile testing is the Universal Testing Machine. This type of machine has two cross heads; one is adjusted for the length of the specimen and the other is driven to apply tension to the test specimen. There are two types: hydraulic powered and electromagnetically powered machines. The machine must have the proper capabilities for the test specimen being tested. There are four main parameters: force capacity, speed, precision and accuracy. Force capacity refers to the fact that the machine must be able to generate enough force to fracture the specimen. The machine must be able to apply the force quickly or slowly enough to properly mimic the actual application. Finally, the machine must be able to accurately and precisely measure the gauge length and forces applied; for instance, a large machine that is designed to measure long elongations may not work with a brittle material that experiences short elongations prior to fracturing. Alignment of the test specimen in the testing machine is critical, because if the specimen is misaligned, either at an angle or offset to one side, the machine will exert a bending force on the specimen. This is especially bad for brittle materials, because it will dramatically skew the results. This situation can be minimized by using spherical seats or U-joints between the grips and the test machine. If the initial portion of the stress–strain curve is curved and not linear, it indicates the specimen is misaligned in the testing machine.

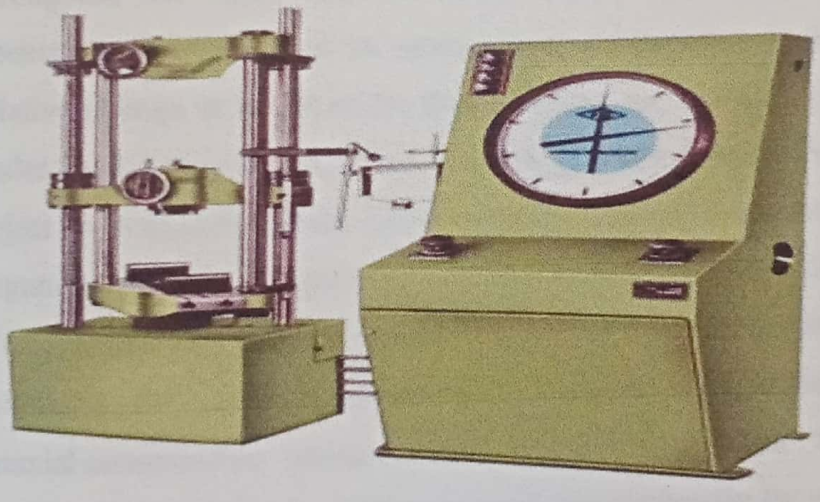

Fig. 1.15 Universal testing machine

1.4.2 COMPRESSIVE STRENGTH

Compressive strength or compression strength is the capacity of a material or structure to withstand loads tending to reduce size, as opposed to tensile strength, which withstands loads tending to elongate. In other words, compressive strength resists compression (being pushed together), whereas tensile strength resists tension (being pulled apart). In the study of strength of materials, tensile strength, compressive strength, and shear strength can be analysed independently.

Some materials fracture at their compressive strength limit; others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load. Compressive strength is a key value for design of structures. Compressive strength is often measured on a universal testing machine; these range from very small table-top systems to ones with over 53 MN capacity. Measurements of compressive strength are affected by the specific test method and conditions of measurement. Compressive strengths are usually reported in relationship to a specific technical standard. When a specimen of material is loaded in such a way that it extends it is said to be in tension. On the other hand, if the material compresses and shortens it is said to be in compression. On an atomic level, the molecules or atoms are forced apart when in tension whereas in compression they are forced together. Since atoms in solids always try to find an equilibrium position, and distance between other atoms, forces arise throughout the entire material which oppose both tension or compression. The phenomena prevailing on an atomic level are therefore similar. The "strain" is the relative change in length under applied stress; positive strain characterizes an object under tension load which tends to lengthen it, and a compressive stress that shortens an object gives negative strain. Tension tends to pull small sideways deflections back into alignment, while compression tends to amplify such deflection into buckling .Compressive strength is measured on materials, components, and structures. By definition, the ultimate compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. The compressive strength is usually obtained experimentally by means of a compressive test. The apparatus used for this experiment is the same as that used in a tensile test. However, rather than applying a uniaxial tensile load, a uniaxial compressive load is applied. As can be imagined, the specimen (usually cylindrical) is shortened as well as spread laterally. The compressive strength of the material would correspond to the stress at the red point shown on the curve. In a compression test, there is a linear region where the material follows Hooke's law. Hence, for this region, where, this time, E refers to the Young's Modulus for compression. In this region, the material deforms elastically and returns to its original length when the stress is removed.

This linear region terminates at what is known as the yield point. Above this point the material behaves plastically and will not return to its original length once the load is

removed. There is a difference between the engineering stress and the true stress. By its basic definition the uniaxial stress is given by:

$$\sigma = F/A$$

where F = Load applied [N], A = Area [m^2]

1.4.3 HARDNESS

Hardness is a characteristic of a material, not a fundamental physical property. It is defined as the resistance to indentation, and it is determined by measuring the permanent depth of the indentation.

1.4.3.1 BRINELL HARDNESS TEST

The hardness of a material is its resistance to penetration under a localized pressure or resistance to abrasion. Hardness tests provide an accurate, rapid, and economical way of determining the resistance of material to deformation. The hardness can be measured by measuring the resistance of a material to indentation. Normally a ball, cone or a pyramid type of indenter made up of hardened steel, normally used. In a test a pre- determined load is applied by pressing the indenter at right angles to the surface to be tested. The hardness of the material depends on the resistance, which it exerts during a small amount of yielding and plastic straining.

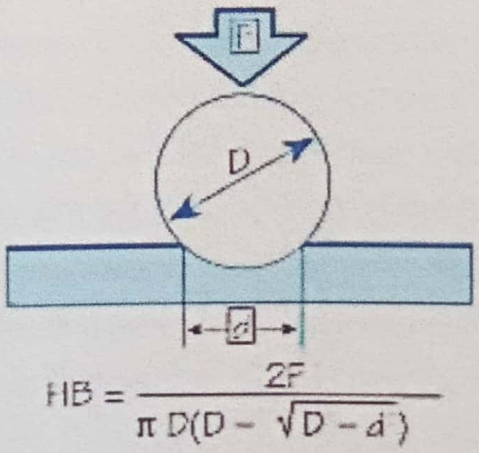

Fig.1.16 Brinell hardness test

Chapter 2

LITERATURE REVIEW

Chapter 2

LITERATURE REVIEW

This chapter deals with an extensive literature survey on the present research work. This literature search provides a background and guide for the entire study. Many authors gave different ideas related to their works on Hybrid metal matrix composite materials. The different papers reviewed are listed below.

K.Venkatesan, et al [1] experimented to prepare hybrid aluminium metal matrix composite to study its machining and mechanical properties. Preparation of hybrid aluminium metal matrix composite is made by reinforcing Silicon carbide and Titanium di boride. The hardness test shows addition of reinforcement SiC and TiB2 increases hardness value. But increase in reinforcement up to 15 wt % reveals reduction in hardness value. From tensile test results it has been observed that addition of reinforcement SiC to base metal added 20% strength to the composite but addition of TiB2 reduction in 50 - 60% strength is recorded. The cast composite specimens were carefully machined. The analysis of variance method shows that % of TiB2 reinforcement is the most influential parameter which affects surface quality and its contribution is 38.86%. Tool wear analysis was carried out to study tool wear pattern, built-up edge formation, influence of TiB2 on tool wear and how these factors affects surface quality of cast composite. Analysis proves TiB2 cause high tool wear, poor surface finish and built-up edge formation affects surface quality.

Kenneth Kanayo Alaneme, et al [2] investigated the mechanical properties of aluminium hybrid composites reinforced with groundnut shell ash (GSA) and silicon carbide. GSA and silicon carbide with different mix ratios (10:0, 7.5:2.5, 5.0:5.0, 2.5:7.5 and 0:10) constituted 6 and 10 wt % of the reinforcing phase, while the matrix material was Al–Mg–Si alloy. The hybrid composites were produced via a two step stir casting technique. The results show that with increasing GSA in the reinforcing phase, the hardness, Ultimate tensile strength (UTS) and specific strength of the composites decreased slightly for both 6 and 10 wt.% reinforced Al–Mg–Si based composites owing to the amount of the oxides of Al, Si, Ca, K2 and Mg present in the composition of GSA. However, the percentage elongation improved marginally and was generally invariant to increasing GSA content while the fracture toughness increased with increasing GSA content. GSA offered a favourable influence on the mechanical properties of Al–Mg–Si hybrid composites comparable to that of rice husk ash and bamboo leaf ash.

B.Vijaya Ramnath, et al [3] has been found that the increase in volume fraction of Al2O3 decreases the fracture toughness of the Al MMC. and compressive strength of Al MMCs increase with the addition of Zircon sand reinforcementEffect of different reinforcement on AMCs on the mechanical properties like tensile strength, strain, hardness, wear and fatigue is also discussed in detail. Hence in this work he concluded SiC reinforced Al MMCs have high wear resistance and compressive strength of Al MMCs increases with addition of Zircon sand reinforcement.

J.Jenix Rino, et al [4] Observed that Aluminum alloys are widely used in aerospace and automobile industries due to their low density and good mechanical properties, better corrosion resistance and wear, low thermal coefficient of expansion as compared to conventional metals and alloys. The aim involved in designing metal matrix composite materials is to combine the desirable attributes of metals and Ceramics. This review article is written for initiating new researches on development of aluminium metal matrix composites with hybrid reinforcement. The following conclusions can be drawn from the present review, Aluminium alloy matrix composites reinforced with Hybrid can be successfully synthesized by the stir casting method. For synthesizing of hybrid composite by stir casting process, stirrer design and position, stirring speed and time, melting and pouring temperature, particle-preheating temperature, particle incorporation rate, mould type and size, and reinforcement particle size and amount are the important process parameters. With the addition of hybrid reinforcement instead of single reinforcement the hardness, toughness, strength, corrosive and wear resistance of the composite will be increasing further increased.

Rohit Sharma, et al [5] The present study deals with the addition of reinforcements such as graphite, fly ash, silicon carbide, red mud, organic material etc. to the Aluminium matrix in various proportions. An effort has been made to review the different combinations of the composites and how they affect the properties of the different alloys of aluminium. The investigation shows that Al metal matrix composites can be replaced with other conventional metals for better performance and longer life. Hardness shows the best results when the silicon carbide is employed at 25% weight percent. Hardness increases with the increase in silicon carbide but decreases with increase in graphite. Hence to obtain an optimum hardness of the desired number, both the reinforced material can be used in proper proportions. Several reinforced materials such as graphite, fly ash, red mud and alumina has shown better results pertaining to tensile strength when compared to Silicon carbide. For the improvement of compressive strength, fly ash particles are the most appropriate ones as it indurates the base alloy. Ductility is one such property which tends to decrease with the addition of reinforced material. It decreases constantly when silicon carbide is reinforced whereas in the case of fly ash, it decreases drastically up to the addition of 10% and then gradually. niform distribution is apparently more evident in Aluminium-Graphite composite rather than aluminium-silicon carbide. The addition of graphite results in the decrease in the thermal expansion of the composite..

Jhony James.S, et al [6] made an effort to fabricate and compare the properties of aluminium metal matrix composites. Two specimens were fabricated by adding 10 wt % of SiC and TiB2 with aluminium metal matrix. The two specimens were fabricated using stir casting route with bottom pouring technique. Morphology of the cast composites reinforced with SiC 10 wt % and TiB2 10 wt % were studied in detail by optical microscopy to analyse particle distribution in the aluminium metal phase. The hardness test and its comparison show that the hardness value of SiC composite is higher than TiB2 composite. Mechanical testing was carried out on the tensile samples prepared from the two cast composite specimens. From tensile test results it has been observed that the tensile strength of TiB2 composite is 30 % higher than SiC composite. Wear test was carried out to study the wear resistance behaviour of cast composites. Wear test analysis proves that the wear resistance behaviour of TiB2 composite is higher than SiC compositeMicro Structural analysis shows the presence of SiC and TiB2 and its distribution in the metal matrix. It has been concluded from hardness test that hardness value of SiC is higher than TiB2 composites. This comparative study concludes TiB2 composites have higher tensile strength than SiC.

S. Suresh and N. Sheinbaga Vinayaga Moorthi [7] Presented a review of Al based metal matrix composite reinforced with TiB2 particles developed after 1997. This paper presents an overview of Al-TiB2 MMC on aspects relating to the formation of TiB2, development of Al-TiB2,mechanical characteristics, thermodynamic calculation, wear behaviour of Al-TiB2,cycle fatigue response of insitu Al based composite ,processing, microstructure, properties and application are discussed. It has been shown that addition of TiB2 particles to Al casting alloys has a direct effect on some important features such as microstructure, thermal properties and mechanical properties. The wear rate of the composite also improves significantly with the TiB2 content. The study also shows that wear rate is a strong function of TiB2 content rather than the overall hardness of the composite. It is suggested that wear rate per unit amount of reinforcement should be taken into consideration to explain the load carrying capacity of MMCs.

2.1 SCOPE OF THIS PROJECT

From all the above reviews it has been observed that although many works have been carried out on the production of metal matrix composites and testing of metal matrix composites still it has not been implemented in practice due to some of the properties of metal matrix composites are not much increased and also some properties were drastically decreased .Hence in the present work we are fabricating an Al 6061 metal matrix composites which are reinforced with Silicon carbide(SiC) and Groundnut shell ash(GSA) to study the affect on mechanical properties of metal matrix composites such as tensile strength and compression strength and hardness.

Chapter 3

EXPERIMENTAL PROCEDURE

Chapter 3

EXPERIMENTAL PROCEDURE

3.1 MATERIAL DESCRIPTION

Here we have used Al 6061 as matrix material and it is reinforced with the materials Silicon carbide (SiC) and Groundnut shell Ash(GSA). The properties and description of these materials are discussed below.

3.1.1 ALUMINIUM 6061

It is precipitation-hardened Aluminum alloy, containing magnesium and silicon as its major alloying elements. Originally called "Alloy 61S", it was developed in 1935. It has good mechanical properties, exhibits good weldability, and is very commonly extruded(second in popularity only to 6063). It is one of the most common alloys of aluminum for general-purpose use.

It is commonly available in pre-tempered grades such as 6061-O (annealed), tempered grades such as 6061-T6 (solutionized and artificially aged) and 6061-T651 (solutionized, stress-relieved stretched and artificially aged)

3.1.1.1 CHEMICAL COMPOSITION

The alloy composition of Al 6061 is

- Silicon minimum 0.4%, maximum 0.8% by weight
- Iron no minimum, maximum 0.7%
- Copper minimum 0.15%, maximum 0.4%
- Manganese no minimum, maximum 0.15%
- Magnesium minimum 0.8%, maximum 1.2%
- Chromium minimum 0.04%, maximum 0.35%
- Zinc no minimum, maximum 0.25%
- Titanium no minimum, maximum 0.15%
- Other elements no more than 0.05% each, 0.15% total
- Remainder aluminum (95.85–98.56%)

3.1.1.2 MECHANICAL PROPERTIES

T6 temper 6061 has an ultimate tensile strength of at least 290 MPa (42,000 psi) and yield strength of at least 240 MPa (35,000 psi). More typical values are 310 MPa (45 ksi) and 270 MPa (39 skip), respectively In thicknesses of 6.35 mm (0.250 in) or less, it has elongation of 8% or more; in thicker sections, it has elongation of 10%. T651 temper has similar mechanical properties. The typical value for thermal conductivity for 6061-T6 at 25 °C (77 °F) is around 152 W/m K. A material data sheet defines the fatigue limit under cyclic load as 97 MPa (14,000 psi) for 500,000,000 completely reversed cycles using a standard RR Moore test machine and specimen. Note that aluminum does not exhibit a well defined "knee" on its S-n graph, so there is some debate as to how many cycles equates to "infinite life". Also note the actual value of fatigue limit for an application can be dramatically affected by the conventional de-rating factors of loading, gradient, and surface finish.

3.1.1.3 APPLICATIONS

Al6061 is highly weldable, for example using tungsten inert gas welding (TIG) or metal inert gas welding (MIG). Typically, after welding, the properties near the weld are those of 6061-T4, a loss of strength of around 40%. The material can be re-heat-treated to restore near -T6 temper for the whole piece. After welding, the material can naturally age and restore some of its strength as well. Most strength is recovered in the first few days to a few weeks. Nevertheless, the Aluminum Design Manual (Aluminum Association) recommends the design strength of the material adjacent to the weld to be taken as 165 MPa/24000 PSI without proper heat treatment after the welding. Typical filler material is 4043 or 5356.

Al6061 is an alloy used in the production of extrusions long constant cross-section structural shapes produced by pushing metal through a shaped die.

Al6061 is an alloy that is suitable for hot forging. The billet is heated through an induction furnace and forged using a closed Die process. This particular alloy is suitable for open die forgings. Automotive parts, ATV parts, and industrial parts are just some of the uses as a forging. Aluminum 6061 can be forged into flat or round bars, rings, blocks, discs and blanks, hollows, and spindles. 6061 can be forged into special and custom shapes.

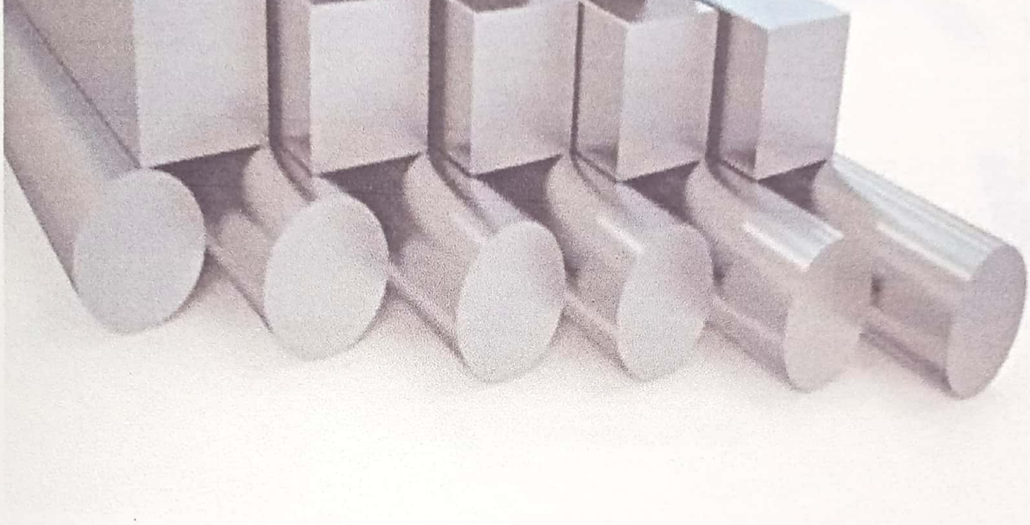

Fig. 3.1 Aluminium 6061

3.1.2 SILICON CARBIDE

It is also known as Carborundum i.e semiconductor containing silicon and carbon. It occurs in nature as the extremely rare mineral moissanite. Synthetic SiC powder has been mass-produced since 1893 for use as an abrasive. 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 plates in bulletproof vests. Electronic applications of silicon carbide such as light-emitting diodes (LEDs) and detectors in early radios were first demonstrated around 1907. SiC is used in semiconductor electronics devices that operate at high temperatures or high voltages, or both. Large single crystals of silicon carbide can be grown by the Lely method and they can be cut into gems known as synthetic moissanite. SiC with high surface area can be produced from SiO_2contained in plant material.

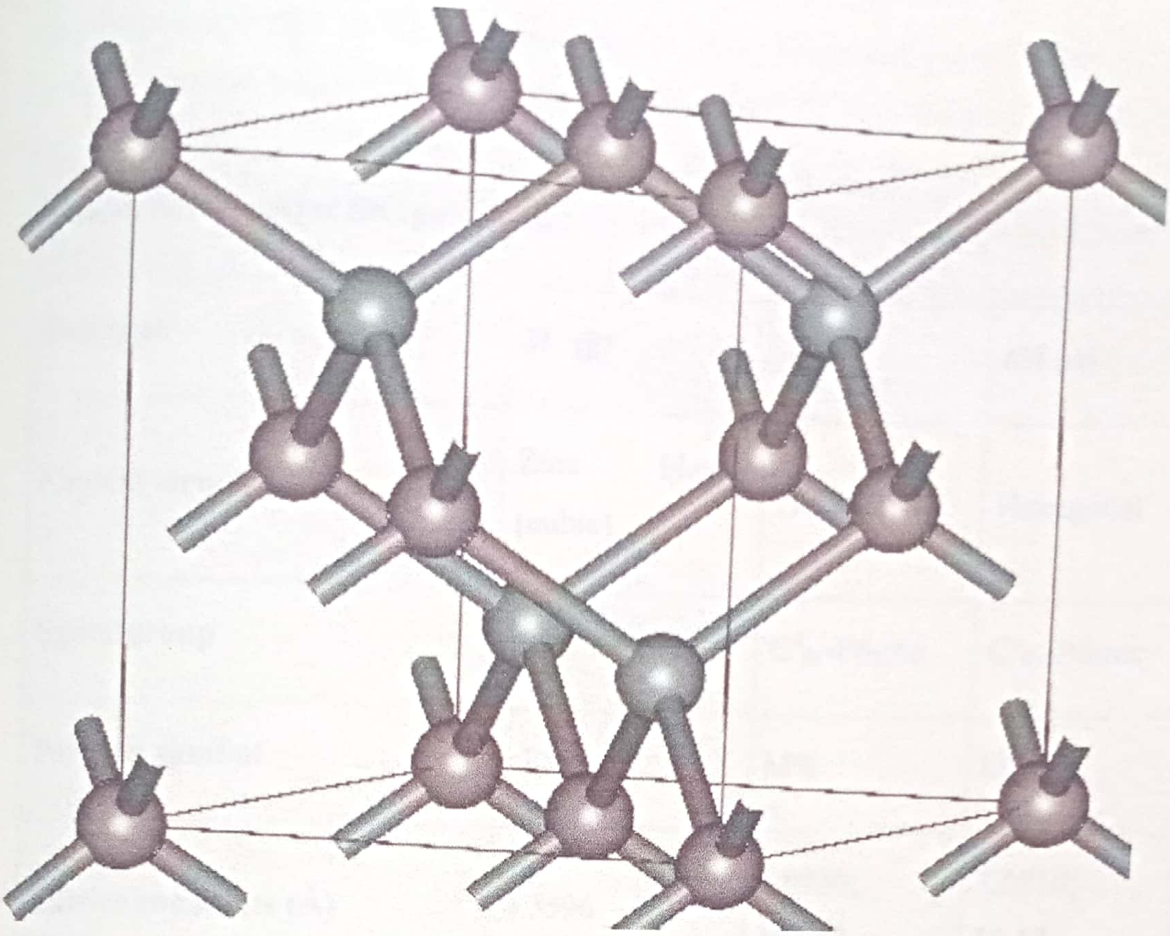

Fig. 3.2 Structure of SiC

3.1.2.1 STRUCTURE AND PROPERTIES

Silicon carbide exists in about 250 crystalline forms The polymorphism of SiC is characterized by a large family of similar crystalline structures 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's formed at temperatures greater than 1700 °C and has a hexagonal crystal structure (similar to Wurtzite). The beta modification (β-SiC), with a zinc blende crystal structure (similar to diamond), is formed at temperatures below 1700 °C. Until recently, the beta form has had relatively few commercial uses, although there is now increasing interest in its use as a support for heterogeneous catalysts, owing to its higher surface area compared to the alpha form.

Properties of major SiC polytypes

Polytype	3C (β)	4H	6H (α)
Crystal structure	Zinc blende (cubic)	Hexagonal	Hexagonal
Space group	T^2_d-F43m	C^4_{6v}-$P6_3mc$	C^4_{6v}-$P6_3mc$
Pearson symbol	cF8	hP8	hP12
Lattice constants (Å)	4.3596	3.0730; 10.053	3.0810; 15.12
Density (g/cm³)	3.21	3.21	3.21
Bandgap (eV)	2.36	3.23	3.05
Bulk modulus (GPa)	250	220	220
Thermal conductivity (W $m^{-1}K^{-1}$) At 300K	360	370	490

Table 3.1 Properties of SiC

Pure SiC is colourless. The brown to black colour of the industrial product results from iron impurities. The rainbow-like lustre of the crystals is caused by a passivation layer of silicon dioxide that forms on the surface.

The high sublimation temperature of SiC (approximately 2700 °C) makes it useful for bearings and furnace parts. Silicon carbide does not melt at any known temperature. 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 promising than silicon for high-powered devices. SiC also has a very low coefficient of thermal expansion (4.0×10^{-6}/K) and experiences no phase transitions that would cause discontinuities in thermal expansion.

3.1.2.2 APPLICATIONS

Steel production

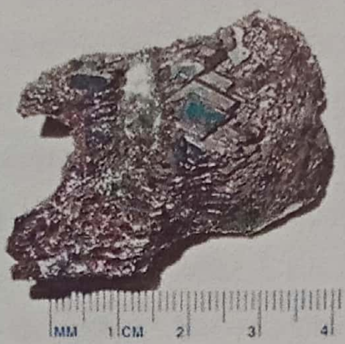

Fig. 3.3 Steel Production

Silicon carbide, dissolved in a basic oxygen furnace used for making steel, acts as a fuel. The additional energy liberated allows the furnace to process more scrap with the same charge of hot metal. It can also be used to raise tap temperatures and adjust the carbon and silicon content. Silicon carbide is cheaper than a combination of ferrosilicon and carbon, produces cleaner steel and lower emissions due to low levels of trace elements, has a low gas content, and does not lower the temperature of steel.

Catalyst support

The natural resistance to oxidation exhibited by silicon carbide, as well as the discovery of new ways to synthesize the cubic β-Sic form, with its larger surface area, has led to significant interest in its use as a heterogeneous catalyst support. This form has already been employed as a catalyst support for the oxidation of hydrocarbons, such as n-butane, to maleic anhydride.

Carborundum printmaking

Silicon carbide is used in a collagraph printmaking technique. Carborundum grit is applied in a paste to the surface of an aluminium plate. When the paste is dry, ink is applied and trapped in its granular surface, then wiped from the bare areas of the plate. The ink plate is then printed onto paper in a rolling-bed press used for intaglio printmaking. The result is a print of painted marks embossed into the paper.

3.1.3 GROUNDNET SHELL ASH

The Groundnut Shell which is obtained from the local factory is burnt openly in atmosphere to obtain the ash. Approximately by burning 28 kg of the groundnut shell the ash obtained is nearly 1.5 Kg. The colour of the ash obtained is grayish black. But this ash cannot be used directly for composite preparation as it contains un burnt carbon so we have to do carbonization of the ash obtained, for this we kept the ash obtained from burning of shells of groundnut in the furnace at 600°C for 6 hours the mass of the ash left out after doing this is approximately 990 grams and the color of the ash changed into grayish white after this process. Now the reinforcement obtained can be used for development of composites. The reinforcement is pre heated to the temperature of 600°C before incorporating to the molten metal in furnace. The composition of GSA is

Constituents	Composition
Al_2O_3	5.93%
SiO_2	17.61%
Fe_2O_3	3.43%
MgO	9.79%
P_2O_5	16.31%
CaO	9.89%
Na_2O	4.85%
SO_3^-	3.67%
K_2O	18.26%
Cl	1.72%
ZnO	0.57%
TiO_2	0.22%
SrO	0.10%
Mno	0.08%

Table 3.2 GSA composition after carbonization

Among the most investigated industrial and agro waste derivatives that have been used as reinforcing materials in AMCs include coal fly ash (FA), red mud, rise husk these reinforcing materials usally have lower densities than the synthetic reinforcing materials (silicon carbide)-3.18g/cc)g GSA obtained from combustion of groundnut shell is another agro waste derivative that should be considered as potential reinforcing material in composite development. Firstly, nominal chemical compositions of GSA show a high alumina and silica content which are known to function as reinforcing materials. In this research work, we considered the use of GSA and SiC as hybrid reinforcements in the development of Al-Mg-Si based composites. The micro structural features, density measurements and mechanical properties were investigated to ascertain the viability of using GSA as a reinforcing material in the development of aluminium matrix composites

Fig. 3.4 Groundnut shell ash (GSA)

3.2 METAL MATRIX COMPOSITES FABRICATION

Here we are using Stir casting process to produce the composites. The process started with the determination of the quantities of GSA and SiC .We used liquid state method i.e Stir casting technique. It is discontinuous reinforcement is stirred into molten metal which is allowed to solidify.

3.2.1 WEIGHT RATIOS OF REINFORCEMENT MATERIALS TAKEN

As we came to know from research we have done, 600grams of aluminium6061 gives 3 specimens of ASTM standards. SiC and GSA with different mix ratios (56.56% :44.4% , 66.6% : 33.3% , 77.7% : 22.2) constituted 3 wt.% of reinforcing phase while the matrix material was Al6061.The unreinforced alloy was designated as A0 to differentiate it from the composite grades. The composite produced were given designations based on the weight percent of reinforcing phase and the weight of SiC and GSA in the reinforcement.

Fig. 3.5 Billets of Al6061 material

Fig. 3.6 Filler Materials in Aluminium foil

The filler materials SiC and GSA were packed in aluminium foil as shown in Fig. 3.6 so that the process of mixing these material with Al6061

3.2.2 STIR CASTING PROCEDURE

Stir casting is a liquid state method for fabrication of composite materials, in which a dispersed phase (here we used SiC and GSA) is mixed with molten metal matrix (Al6061) by means of mechanical stirring. It is used because stir casting is the simplest and the most cost effective method of liquid state fabrication.it consists of a speed regulator, stirrer, electric motor, muffle furnace and thermos couple. A thermocouple has inserted and it gives the feedback of the temperature inside the furnace here we maintained temperature 850°C in order to minimize the chemical reaction between substance.

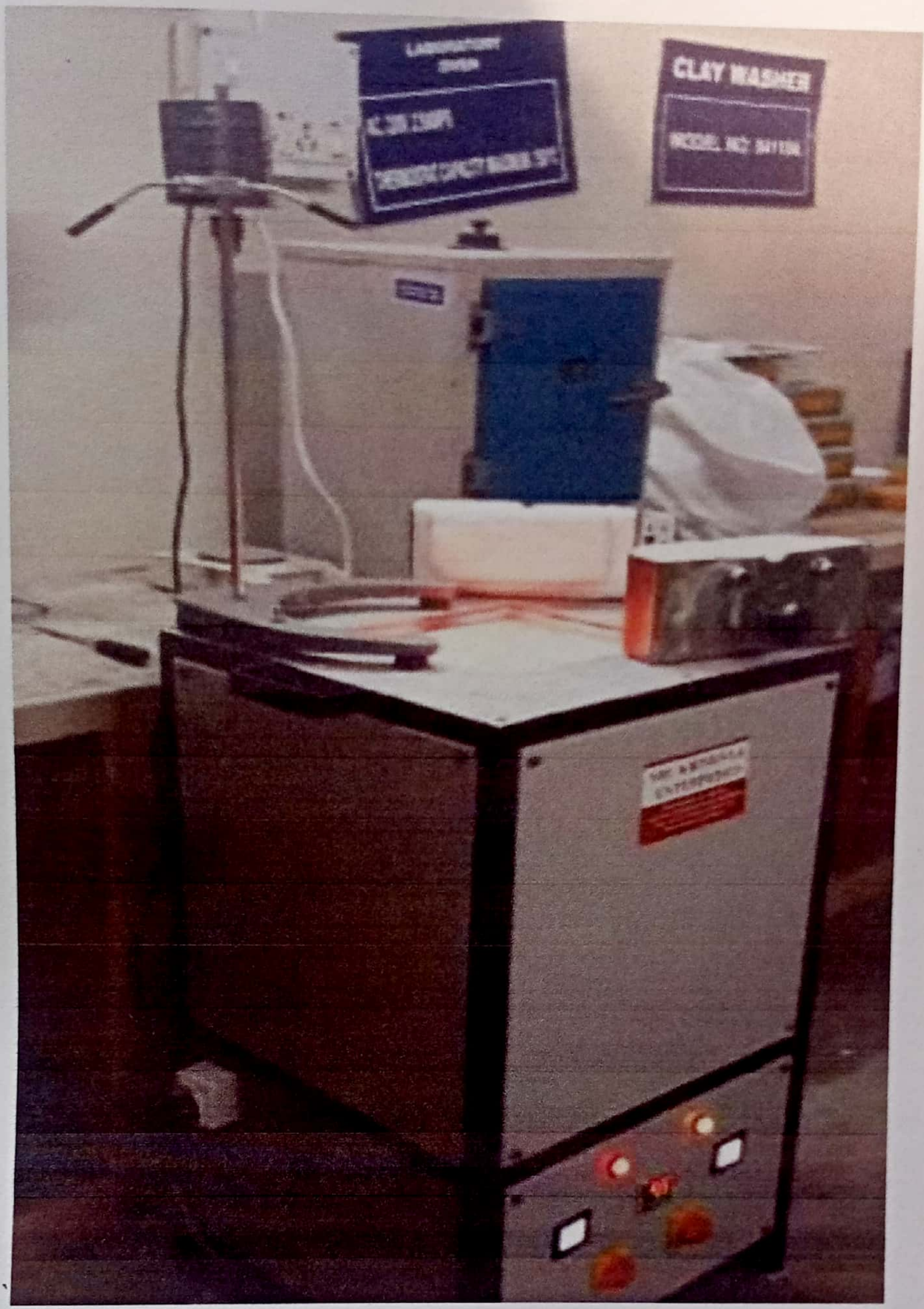

Fig. 3.7 Stir casting equipment

3.2.2.1 MELTING OF AL 6061 MATERIAL

Initially The Al6061 plate was cut into small billets and 600gms of Al 6061 material was taken into crucible. Here we used crucible of 1 kg capacity which is numbered as 4 according to ASTM standards. Then the crucible is placed in a furnace and heated gradually until the temperature reached to 875°C. Here we used fluxes(mixtures of chloride and fluoride salts) to reduce the melt oxidation , minimize penetration of the atmospheric hydrogen , absorb non-metallic inclusions suspended in the melt keep the furnace wall clean from the built. The furnace we used is shown below.

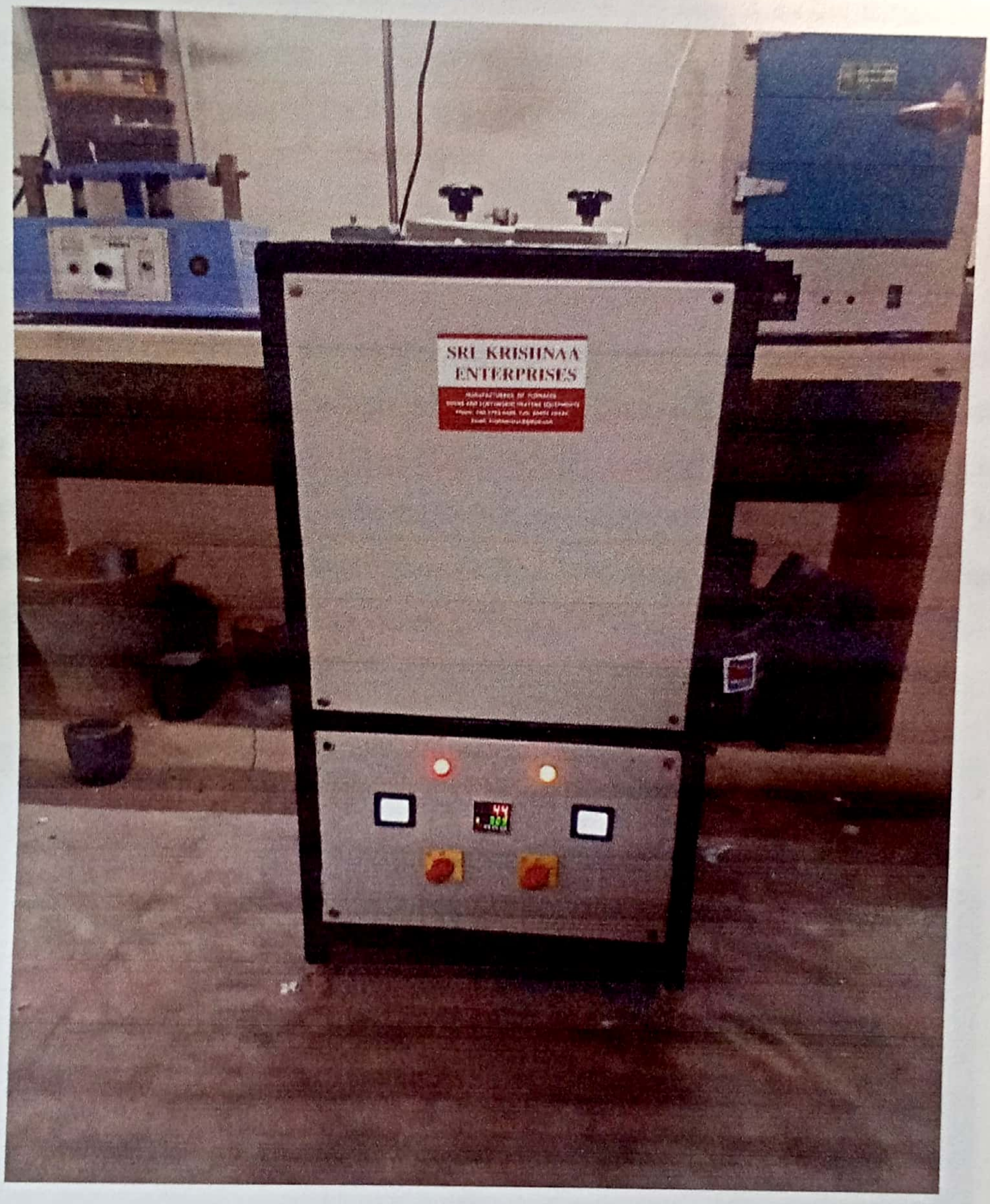

Fig. 3.8 Heating Furnace

3.2.2.2 PREPERATION OF GROUNDNUT SHELL ASH

The Groundnut Shell which is obtained from the local factory is burnt openly in atmosphere to obtain the ash. Approximately by burning 28 kg of the groundnut shell the ash obtained is nearly 1.5 Kg. The colour of the ash obtained is grayish black. But this ash cannot be used directly for composite preparation as it contains un burnt carbon so we have to do carbonization of the ash obtained, for this we kept the ash obtained from burning of shells of groundnut in the furnace at 600°C for 6 hours the mass of the ash left out after doing this is approximately 990 grams and the color of the ash changed into grayish white after this process. Now the reinforcement obtained can be used for development of composites. The reinforcement is pre heated to the temperature of 600°C before incorporating to the molten metal in furnace. The groundnut shell is packed with aluminium coil for the purpose of proper mixing.

3.2.2.3 PREPERAION OF SPECIMENS

Initially we melted the Al6061 material in furnace and this crucible of molten metal brought to stir casting equipment. The stirrer blade is fixed to the rotating spindle and it is rotated with 300rpm. Then the reinforcing materials GSA and SiC are added at a time. Now after proper mixing the molten metal is poured into a metal die(Fig. 3.6). Then specimens obtain in cylindrical shape. The dimensions of the cylindrical specimen are 160mm length and 20mm diameter as shown in Fig. 3.7

Fig. 3.9 Pouring of Molten Metal

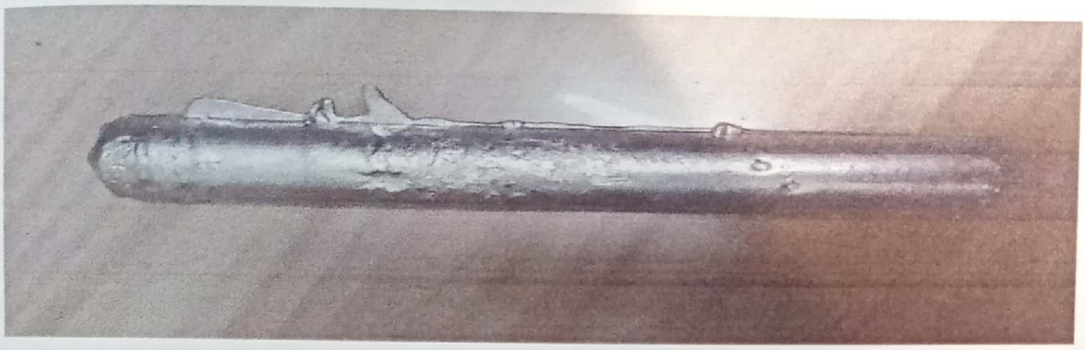

Fig. 3.10 Cylindrical Specimen

3.3 MACHINING OF SPECIMENS

In this project we done three tests that are tensile, compression and hardness test. For each test we machined the specimen according to ASTM standards by using lathe machine (Fig. 3.8). For tensile strength the specimen dimensions are 12mm diameter and 75mm length between two fittings. For compression test the specimen dimensions are 40mm length and 16mm diameter and for hardness test dimensions are 10mm length and 16mm diameter. This machining is done for all mix ratios of above discussed.

Fig. 3.11 Machining of Specimens

3.4TESTING OF SPECIMENS

3.4.1TESTING OF TENSILE STRENGTH

The specimen is fixed to the UTM (universal testing machine) by using two valves one is pressure valve another valve is pressure release valve, the load is applied gradually and after certain load is reached the specimen got fractured ,which is the maximum load that the specimen can withstand before it gets fractured. The setup is as shown in Fig. 3.12.

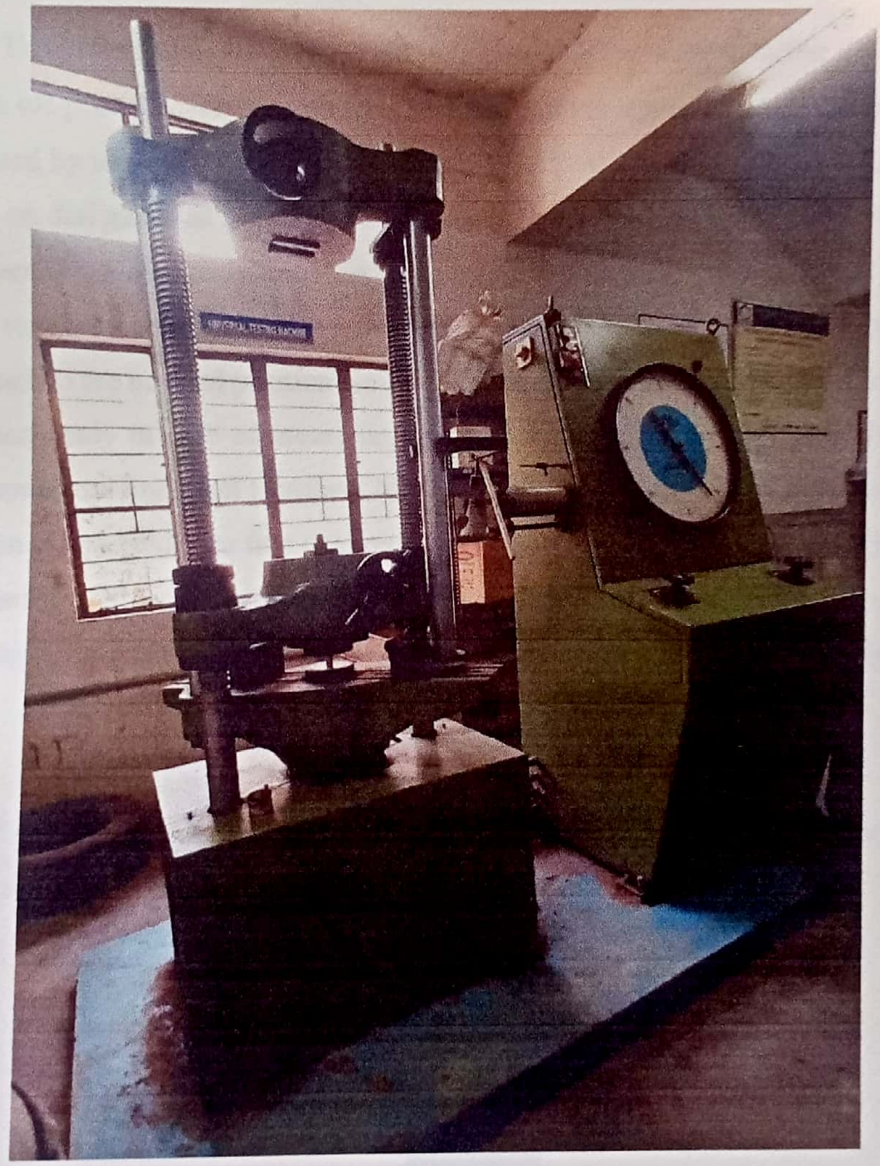

Fig. 3.12 Universal Testing Machine

The ultimate tensile strength is calculated by using the below formula

Ultimate tensile strength = (maximum load /cross sectional area of specimen)

3.4.2 TESTING OF COMPRESSION STRENGTH

The specimen is kept on the lower table of a Universal testing machine and proper load is selected. The compressive load is applied by opening the pressure valve and the load is applied gradually. As the wood specimen breaks at ultimate strength the pointer moves back and the load at that point is noted.

Compression test is calculated by using below formula

Compression strength = (maximum load /cross sectional area of specimen)

3.4.3 TESTING OF HARDNESS

The proper load for indentation is selected on the selector when the load lever is in the off position. The specimen is placed securely upon the anvil. The specimen is elevated by using a hand wheel and the specimen will push the indenter and show a reading on dial gauge as a small pointer reading at '3' and long pointer reading '0' The load lever is turned slowly until load is brought in to action with out jerks. The long pointer reaches a steady position when the indentation is completed. then the lever is taken back to the no-load position slowly. This specific machine is used for application of the load only in case of measuring the Brinell hardness number and gives direct measurement of Rockwell Hardness Number. The hand wheel is turned back and the specimen is removed. The first reading is not taken into consideration. The diameter of the indentation is measured by using a microscope. The procedure is repeated 3 times for taking average value. The BHN is calculated by using the following formula.

$$B.H.N = \frac{2P}{\pi D(D-\sqrt{(D^2-d^2)}}$$

Where P = Load in kg A = Surface Area of indentation. D = Dia meter of the indenter in mm d = Diameter of the indentation in mm

Fig. 3.13 Brinell Hardness test

Chapter 4

RESULTS AND DISCUSSION

Chapter 4

RESULTS AND CONCLUSIONS

4.1 RESULTS

The Mechanical Properties such as ultimate tensile strength, compression strength and Hardness are determined for all mix Ratios of Al6061 metal matrix composite specimens and we compared that properties with the properties of pure Al6061. 18 grams of Reinforcing materials (SiC and GSA) which constituted 3wt% of Al 6061 which is 600grams. This 3 wt% is divided into 3 mix ratios that are (56.56% : 44.4% , 66.6% : 33.3% , 77.7% : 22.3%) The results are tabulated below.

S.NO	MIX RATIO OF SiC AND GSA IN 3wt.%	ULTINATE TENSILE STRENGTH (N/mm^2)	COMPRESSIVE STRENGTH (N/mm^2)	HARDNESS (BRINELL)
1	PURE ALUMINIUM 6061	230.9	240.2	138
2	77.7% : 22.3%	90.11	228.7	185
3	66.6% : 33.3%	97.23	370.5	185
4	56.56% : 44.4%	75.15	203.91	159

Table 4.1 Values of mechanical properties for Different mix Ratio of SiC and GSA

4.1.1 GRAPHICAL REPRESENTATION OF THE MECHANICAL PROPERTIES WITH DIFFERENT OF MIX RATIOS OF REINFORCING MATERIALS

The graph is plotted between ultimate tensile strength and variation of weight of GSA. Ultimate tensile strength is taken on Y axis and weights of GSA are taken in X axis. The obtained graph is shown in below Fig. 4.1.

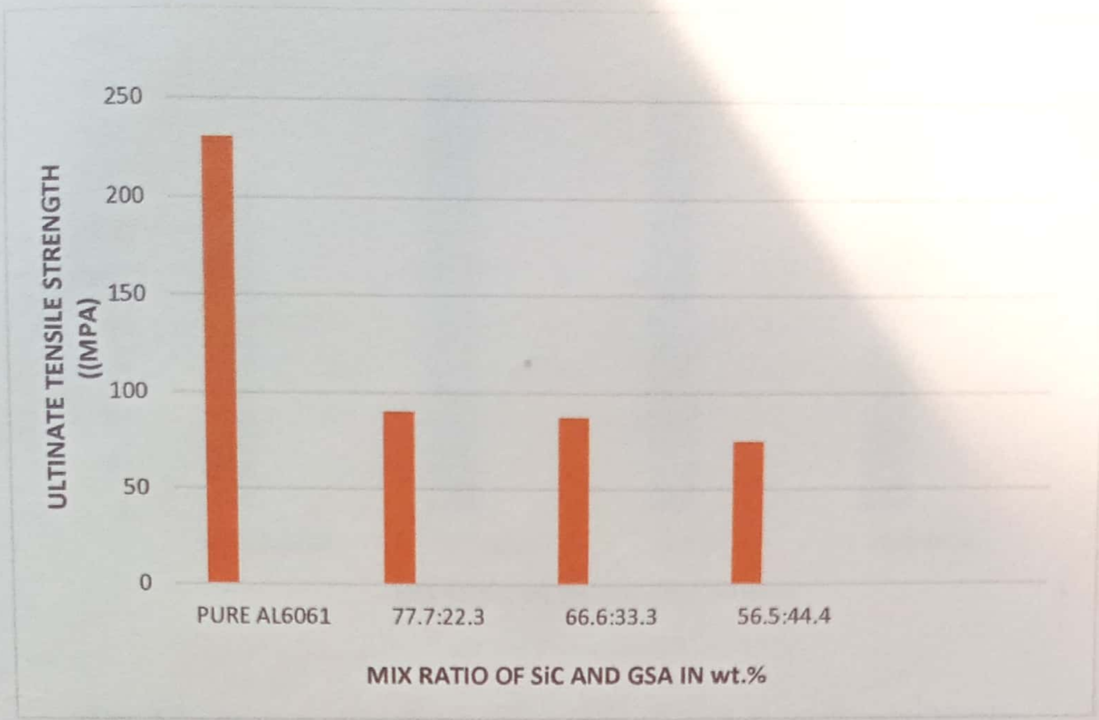

Fig. 4.1 variation of ultimate tensile strength with weight of GSA in reinforcing phase

The next graph is plotted between compressive strength taken on Y axis and weights of GSA on X axis. The graph is shown in Fig. 4.2

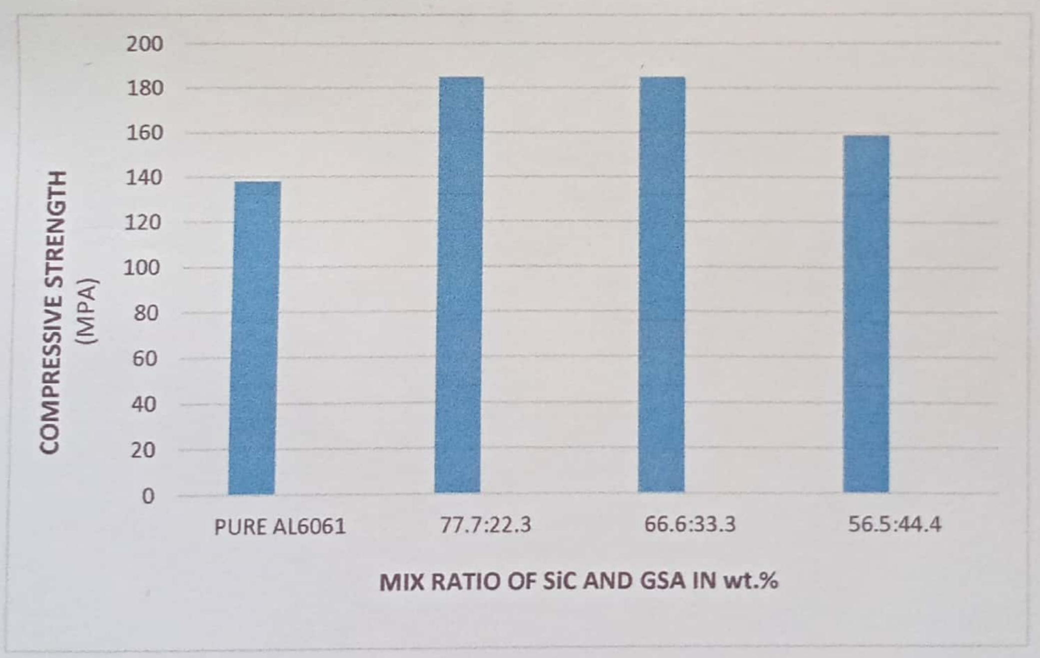

Fig. 4.2 Variation of Compressive strength with weight of GSA in reinforcing phase

The next graph is plotted between hardness taken on Y axis and weights of GSA on X axis. The graph is shown in Fig. 4.3.

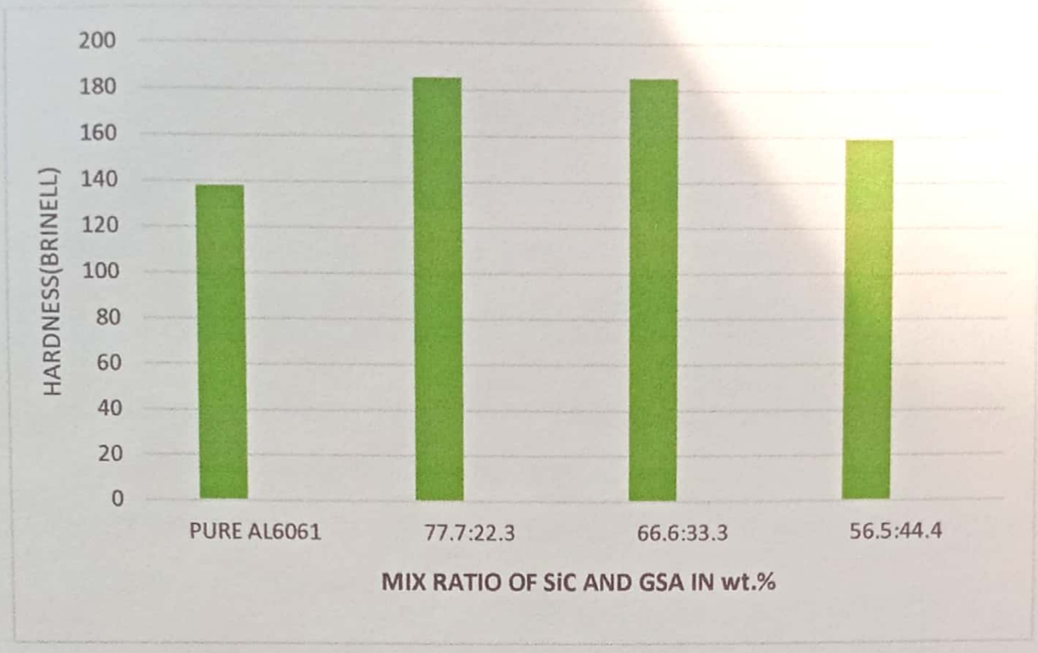

Fig. 4.3 variation of hardness with weight of GSA in reinforcing phase

Chapter 5

CONCLUSIONS

Chapter 5

CONCLUSIONS

The results obtained from different tests are presented as per the order discussed in this report. i.e., Tensile, compression and hardness results.

5.1 THE CONCLUSIONS DRAWN FROM THE TENSILE TEST RESULTS

- It is observed that tensile strength of the pure sample is more than the hybrid Aluminium metal matrix composite.
- It was decreased from 0 to 4 grams of GSA and slightly increased from 4 to 6 grams of GSA and then it was decreased.

5.2 THE CONCLUSIONS DRAWN FROM THE COMPRESSION STRENGTH RESULTS

- It is observed that compressive strength is maximum for the sample which contains 6 grams of GSA.
- It is observed that compressive strength is decreased from maximum point i.e at 6 grams of GSA to the point where GSA content is 8 grams

5.3 THE CONCLUSIONS DRAWN FROM HARDESS TEST RESULTS

- It is observed that hardness value increased with the weights of GSA
- Upto 8 grams of GSA it is increased after that is decreased
- The hardness of hybrid MMC is constant from 6 to 8 grams of GSA in reinforcing phase.

5.4 FINAL CONCLUTION

At 66.6% : 33.3% mix ratio of SiC and GSA in Reinforcement, The compression strength and hardness is maximum than that of all mix ratios that we have taken. So it can be Used in aerospace applications where hardness is required

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