EXPERIMENTAL STUDIES ON MECHANICAL PROPERTIES OF AL6061/SiC/ AL_2O_3 COMPOSITE

A project report submitted in partial fulfillment of the requirement for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

MECHANICAL ENGINEERING

Submitted by

PINISETTY SRINIVAS KALYAN	318126520155
CHITTELLA VENKATA SATISH	318126520133
SHAIKH HAMEED	318126520161
KARTHIK ROY	318126520144

Under the guidance of

Mrs. B KRISHNA PRAFULLA

Assistant Professor

DEPARTMENT OF MECHANICAL ENGINEERING

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY AND SCIENCES(A)

Sangivalasa, Bheemunipatnam (Mandal), Visakhapatnam-531162

PRAGNANAM BRAHMA

ANITS

CERTIFICATE

This is to certify that the project work entitled "**Experimental Studies on Mechanical Properties of Al6061/SiC/ Al_2O_3 Composite**" has been carried out by **PINISETTY SRINIVAS KALYAN (318126520155), CHITTELLA VENKATA SATISH (318126520133), SHAIKH HAMEED (318126520161), KARTHIK ROY(318126520144)** under the esteemed guidance of **Mrs. B. KRISHNA PRAFULLA**, in the partial fulfillment of the requirements for the award of Degree of Bachelor of Technology in Mechanical Engineering Anil Neerukonda Institute Of Technology & Sciences(A), Visakhapatnam.

APPROVED BY:

(Dr. B. NAGARAJU)

Head of the department

Dept. of Mechanical Engineering

ANITS, Sangivalasa

Visakhapatnam

PROFESSOR & HEAD
Department of Mechanical Engineering
ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES
Sangivalasa 531 162 VISAKHAPATNAM Dist A.P

PROJECT GUIDE:

(Mrs. B. KRISHNA PRAFULLA)

Project guide

Dept. of Mechanical Engineering

ANITS, Sangivalasa

Visakhapatnam

THIS PROJECT IS APPROVED BY THE BOARD OF EXAMINERS

INTERNAL EXAMINER: 28.5.22

PROFESSOR & HEAD
Department of Mechanical Engineering
ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES
Sangivalasa-531 162 VISAKHAPATNAM Dist. A.P.

EXTERNAL EXAMINER: 28/5/22

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PINISETTY SRINIVAS KALYAN

CHITTELLA VENKATA SATISH

SHAIKH HAMEED

KARTHIK ROY

ABSTRACT

Hybrid composite materials have recently been used in a variety of engineering applications due to its diverse qualities such as light weight, high strength, low cost, ease of structure creation and so on. For interior and exterior applications, the vehicle industry mostly uses composites and hybrid kinds of Aluminium. The mechanical characteristics of a hybrid composite consisting of Al6061/SiC/Al_2O_3 produced by stir casting process were evaluated in the present work. The mechanical properties of the composite are shown to have improved as a result of the findings. The maximum properties were achieved at 97% Al6061+1.5%SiC+1.5%Al_2O_3combinations and the results obtained are tensile strength: 338.5 MPa, compression strength: 86.3 MPa, hardness: 94.36 VHN and impact strength: 2.10 N/mm^2 respectively.

Key words: Al-6061 hybrid metal matrix composite, Silicon Carbide (SiC), Aluminium Oxide (Al_2O_3), Mechanical properties.

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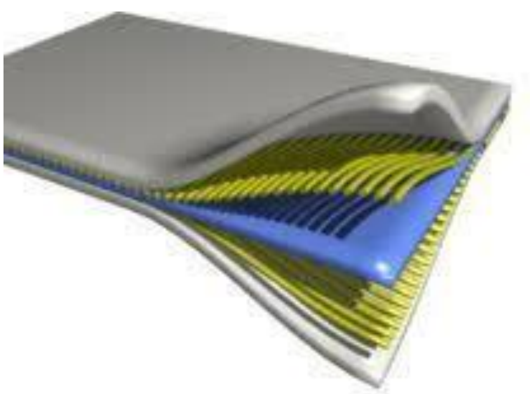
1. INTODUCTION

- **WHAT IS A COMPOSITE? :** A composite material (also known as a composition material or composite, which is the popular word) is one that is made up of two or more constituent materials. These constituent materials have significantly different chemical or physical properties and are combined to form a material with features that are not present in the individual constituents. Individual constituents stay separate and distinct inside the finished construction, distinguishing composites from mixes and solid solutions.



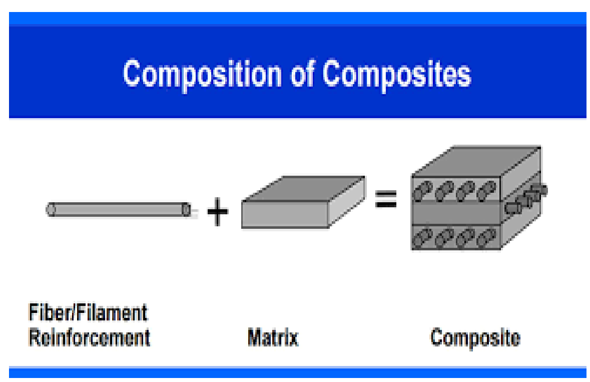


Fig 0-1 COMPOSITES

1.1 HISTORY OF COMPOSITE:

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

Wattle and daub are one of the oldest composite materials, at over 6000 years old. Concrete is also a composite material and is used more than any other synthetic 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 Earthward 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.
- 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-grey 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 concrete from post-Roman times into the 20th century, with some properties superior to manufactured Portland cement.
- 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.
- Papier-mâché, a composite of paper and glue, has been used for hundreds of years.
- One of the most common and familiar composites is fibreglass, in which small glass fibres 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.

1.2 APPLICATION OF COMPOSITE MATERIALS:

The Egyptians used straw-strengthened, sun-dried, and clay bricks in construction activities many thousand years ago, which was the first known application of composite materials. Since then, composite materials have progressed significantly. They now promise new goods with exceptional strength, stiffness, chemical resistance, and temperature resistance.

Civil engineering constructions such as roadways and buildings, where ceramic (cement) matrix composite materials are widely utilized, have the highest tonnage application for composite materials.

Reinforced plastics and advanced composites are the two types of composite materials that remain on the market. The advanced composites' main customer has been the military. A clear demand for quicker and more durable aircraft and missiles has generated a lot of research and development in this field. Furthermore, the military and civil aerospace were frequently the only clients who could afford the exorbitant pricing and lengthy lead times associated with limited volume sophisticated materials. Reinforced plastics account for 90% of the civilian market and are based on glass fibre reinforcements in commodity, thermosetting resins, primarily unsaturated polyesters and their derivatives. This paper will focus on Fibre Reinforced Plastics (FRP), which has been around for nearly fifty years.They have generally been used to replace traditional materials such as wood, aluminium and steel. Significant advantages of fibre reinforced plastics over these traditional materials include higher strength, lighter weight, greater corrosion resistance, dimensional stability, higher dielectric strength, and improved design flexibility.

1.3 TYPES OF COMPOSITES:

Matrix:

The composite materials have a continuous bulk phase which is known as the matrix. It holds the reinforcement to form the desired shape.

Examples: Polymers, Metals or Ceramics.

Reinforcement:

The dispersed non-continuous phase is usually harder and stronger is known as reinforcement. It improves the overall mechanical properties of the matrix.

Example: Fibers, Particles, Flakes, and fillers.

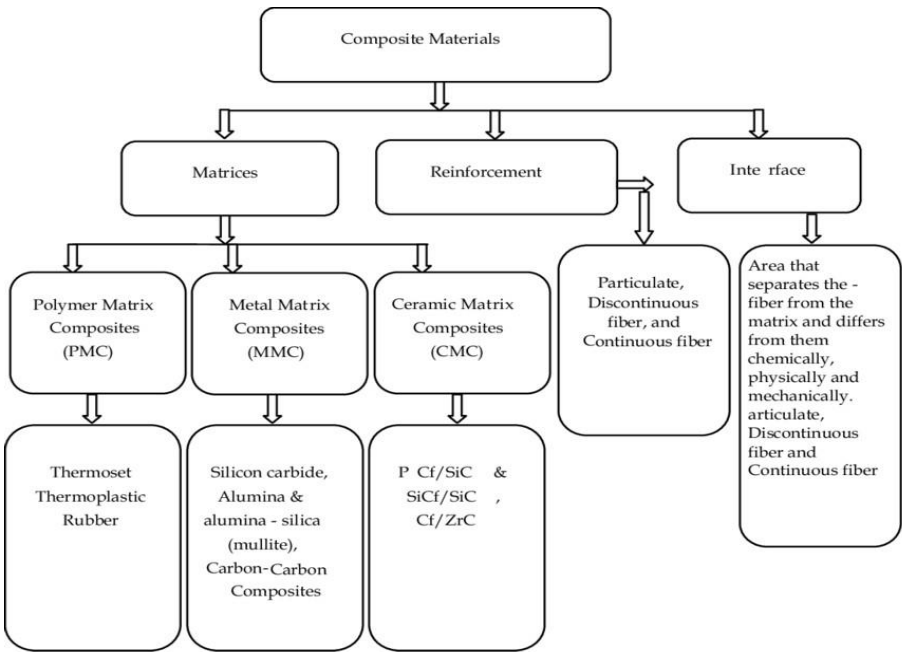


Fig 0-2 FLOW CHART OF COMPOSITE MATERIALS

1.3.1 TYPES OF MATRICES:

There are three main types of composite matrix materials:

- Ceramic matrix composites (CMCs) are a type of composite material with a ceramic matrix. A ceramic fibre reinforced ceramic (CFRC) material is made up of ceramic fibers embedded in a ceramic matrix. Any ceramic material can be used for the matrix and fibers. CMC materials were created to overcome the major drawbacks of traditional technical ceramics, such as low fracture toughness, brittleness, and inadequate thermal shock resistance.

- Metal matrix - Metal matrix composites (MMCs) are composite materials that contain at least two constituent parts – a metal and another material or a different metal. The metal matrix is reinforced with the other material to improve strength and wear. Where three or more constituent parts are present, it is called a hybrid composite. In structural applications, the matrix is usually composed of a lighter metal such as magnesium, titanium, or aluminium. In high temperature applications, cobalt and cobalt-nickel alloy matrices are common. Typical MMC's manufacturing is basically divided into three types: solid, liquid, and vapor. Continuous carbon, silicon carbide, or ceramic fibers are some of the materials that can be embedded in a metallic matrix material. MMCs are fire resistant, operate in a wide range of temperatures, do not absorb moisture, and possess better electrical and thermal conductivity. They have also found applications to be resistant to radiation damage, and to not suffer from outgassing. Most metals and alloys make good matrices for composite applications.

  Thermoset, thermoplastic, and rubber are the three sub-types of polymer matrix composites (PMCs). A polymer is a big molecule made up of structural units that are joined by covalent chemical connections. PMCs are made up of a polymer matrix and a distributed fibre reinforcing phase. They are less expensive because to simpler manufacture procedures. PMCs are less dense than metals or ceramics, can withstand air and other types of corrosion, and have a higher barrier to electrical current conduction.

1.3.2 TYPES OF REINFORCEMENTS: The four types of reinforcement include:

- **Positive reinforcement:** Positive reinforcement entails doing something to encourage a child's response, such as praising them when they complete a task. This will encourage the child to participate in the task.

- **Negative reinforcement:** This entails taking away something to stimulate reaction, such as deferring payment until the project is completed. To get paid, the employee would stay motivated until the end of the job.

- **Punishment:** To change behavior, you must add something unpleasant. For instance, yelling at a child who has misbehaved. In this case, the child would link punishment with every negative behavior. This would keep the child from repeating the same mistake.

- **Extinction:** This entails removing or deleting anything in order to change a reaction. This is known as extinction or negative punishment. For instance, a teenager comes home late, and the parents curb their phone usage. Next time, the teenager would think before breaking the curfew.

1.4 COMPOSITES MANUFACTURING METHODS:

1. Solid state methods:
    - Powder Metallurgy
    - Foil Diffusion
2. Liquid state methods:
    - Electroplating and Electroforming
    - Spray Deposition
    - Stir Casting
    - Squeeze Casting
    - Pressure Infiltration
    - Reactive Processing
3. Physical Vapor Deposition
4. In-situ Fabrication Technique

1.5 SOLID STATE METHODS:

1.5.1 POWDER METALLURGY:

Powder metallurgy (PM) is a metalworking method that uses metal powders to produce precision metal components. At normal temperature, the metal powder is pressed into product shape. The powder is then heated, which causes it to fuse together without melting.

The three processes of the PM process are: mixing, compacting, and sintering, in that order.

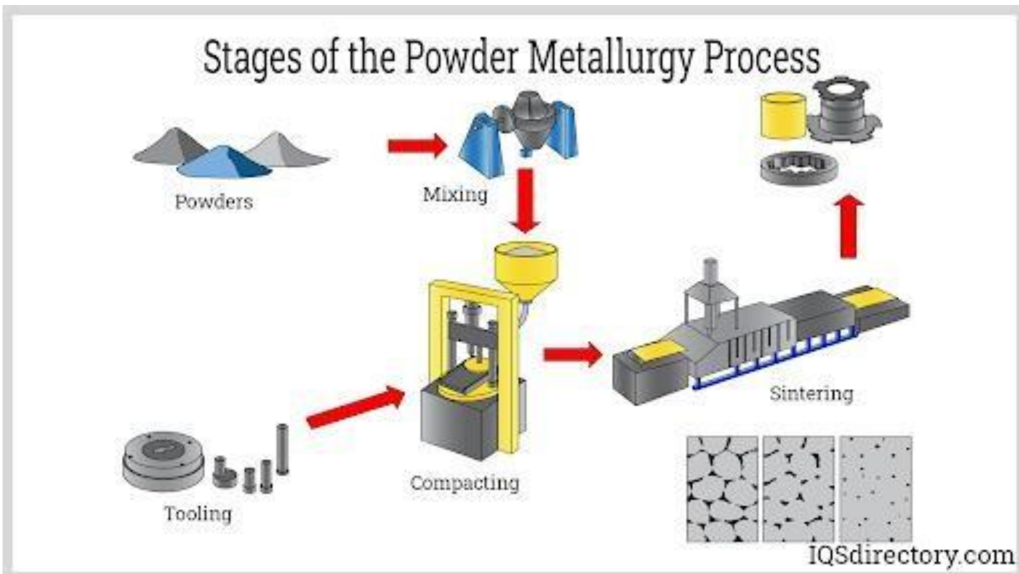


Fig 0-3 POWDER METALLURGY

Mixing: It's made into a homogeneous blend of elemental powders or alloy powders. Powders of various alloys or lubricants may be added depending on the necessity.

Compacting: A precise die is used to place a controlled amount of the mixed powder, which is subsequently pressed or compacted at pressures ranging from 100 to 1000 MPA. The compacting pressure required is determined by the particle properties and form, the mixing process, and the lubricant employed. Generally, this is done at room temperature. The vehicle is commonly referred as as "green compact."

Sintering: The green compact is heated to an appropriate temperature in a protected environment furnace, which is below the melting point of the metal. Endothermic gas, dissociated ammonia hydrogen, and nitrogen are common sintering atmospheres. The temperature at which metals sinter differs.Additional procedures on sintered PM components are sometimes performed to increase their qualities or impart unique characteristics.

1.5.2 FOIL DIFFUSION BONDING:

Metal foil layers are placed between long fibres and pressed through a matrix. This process is commonly used to make fibre reinforced MMC from matrix material sheets or foils. For the efficacy of inter diffusion, principally metal or metal alloys in the form of sheets and reinforcement material in the form of fibre are chemically surface trusted. These fibres are placed in a predefined arrangement on the metal foil, and bonding is accomplished by pressing directly. However, before diffusion bonding, the fibres are occasionally coated by plasma spraying or ion plating to improve bonding strength. The solid line depicts this. Following bonding, secondary machining is performed. The pressure and temperature used, as well as the time it takes for diffusion bonding to form, differ depending on the composite system. This is, however, the most costly technique of producing MMC materials.

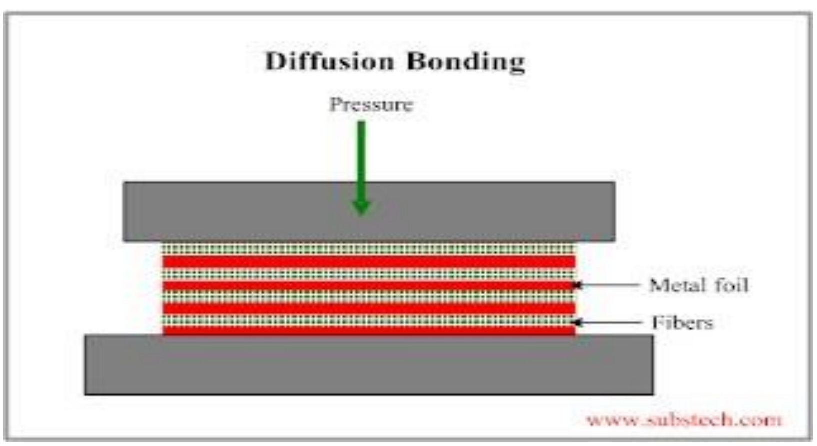


Fig 0-4 FOIL DIFFUSION BONDING

1.6 LIQUID STATE METHODS:

1.6.1 ELECTROPLATING AND ELECTROFORMING:

Electroplating is a method of reducing dissolved metal to generate a thin, coherent metal coating on an electrode using electric current. Electrical oxidation of anions on a solid substrate is sometimes referred to as this. Electroplating is usually used to alter an object's surface attributes (such as abrasion and wear resistance, corrosion protection, lubricity, and aesthetic features), but it can also be used to add thickness to undersized parts or to electroform items. The electroplating process is known as electro deposition**.** It is analogous to a concentration cell acting in reverse. In one procedure, the component to be plated serves as the circuit's cathode, while the anode is constructed of the metal to be plated on the part. Both components are submerged in an electrolyte, which contains one or more dissolved metal salts as well as other ions that allow electricity to flow. The anode receives a direct current from a power supply, which oxidizes the metal atoms in it and allows them to dissolve in the solution. The dissolved metal ions in the electrolyte solution are decreased at the cathode's interface with the solution, causing them to "plate out" onto the cathode.. The rate at which the anode is dissolved is equal to the rate at which the cathode is plated, vis-à-vis the current through the circuit. In this manner, the ions in the electrolyte bath are continuously replenished by the anode.

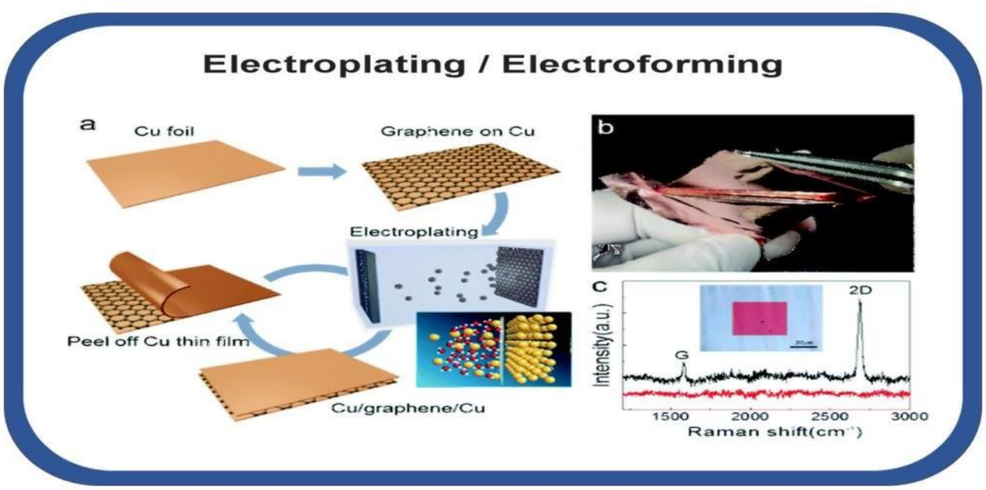


Fig 0-5 ELECTROPLATING AND ELECTROFORMING

1.6.2 STIR CASTING:

Stir casting processes are currently the most straightforward and cost-effective means of producing MMCs. This method entails mechanically mixing the reinforcement particles into a molten metal bath and transferring the mixture directly to a shape mould prior to complicated solidification. The key to this method is to ensure that the particulate reinforcement and the molten metal are well mixed. The main benefit of this method is that MMC production costs are extremely low.

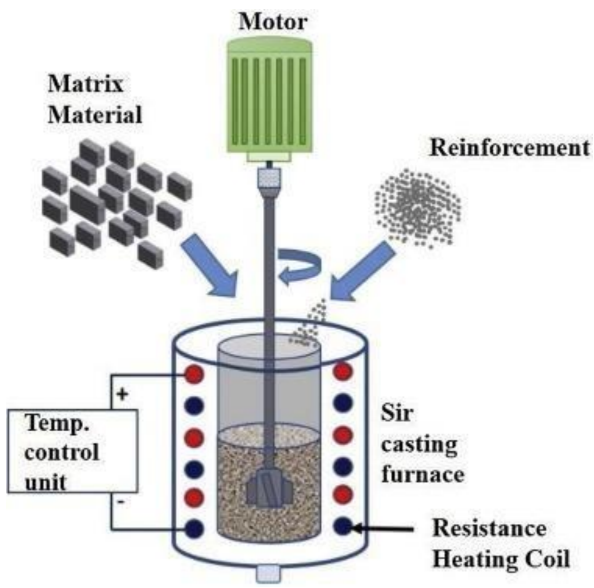


Fig 0-6 STIR CASTING

1.6.3 PRESSURE INFILTRATION:

Molten metal is infiltrated into the reinforcement through use a kind of pressure such an gas pressure This process can also be called their-tow infiltration Fibre tows can be infiltrated by passing through a bath of molten metal Usually the fibres must be coated in line to promote wetting Once the infiltrated wines produced they must be assembled into to perform and gives a secondary consolidation process to produce a component Secondary consolidation is accomplished through diffusion bonding or hot molding in the two phase liquid and solid region. This method is desirable in producing relatively small size composite specimens having unidirectional properties.

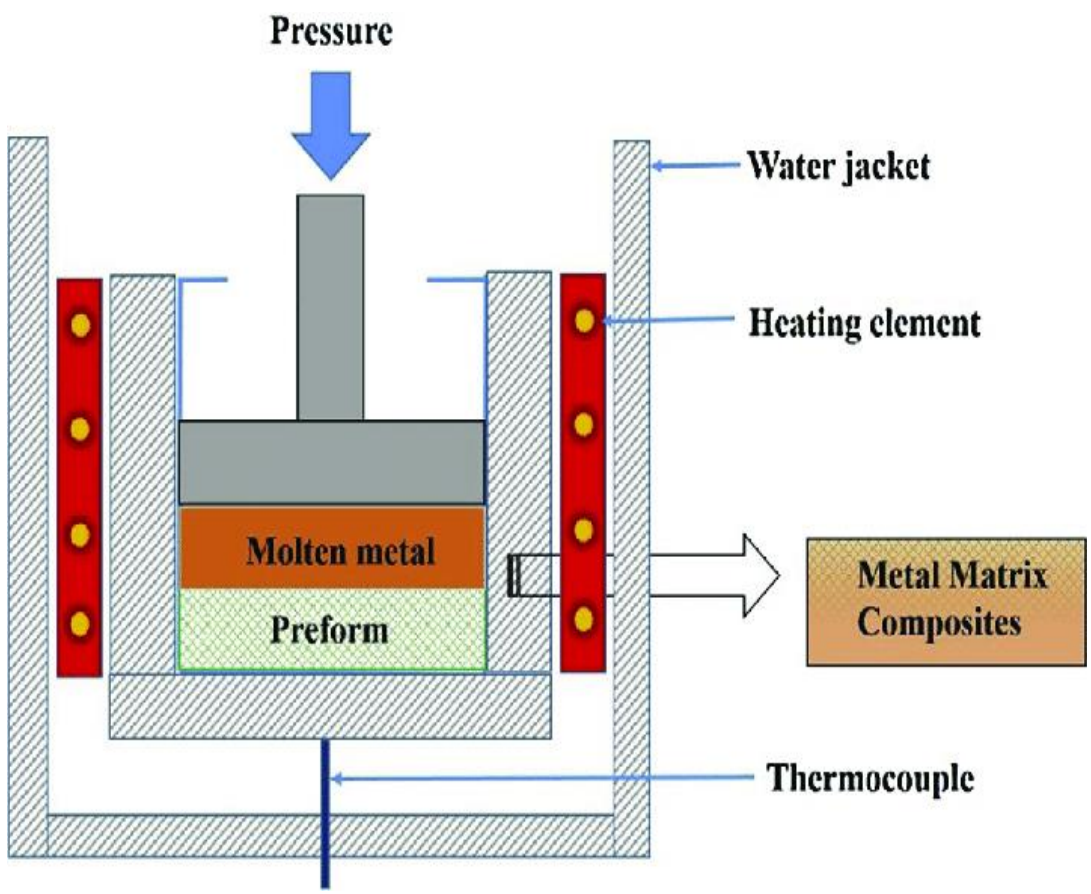


Fig 0-7 PRESSURE INFILTRATION

1.6.4 SQUEEZE CASTING:

Squeeze casting is a procedure that combines casting and forging to produce the highest mechanical qualities possible in a cast product. The development of the squeeze casting method can open up a world of possibilities for the fabrication of hitherto commercialized aluminium alloy components, as well as for import substitution of crucial components. The molten metal is put into the bottom half of a preheated die to begin the operation. As soon as the metal begins to harden. During the solidification process, the upper half of the die shuts and begins to apply pressure. When compared to forging, the amount of pressure applied is substantially smaller.

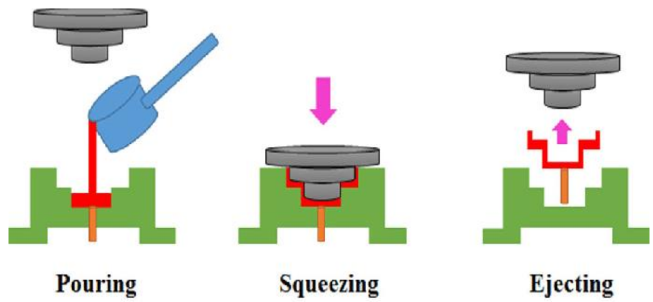


Fig 0-8 SQUEEZE CASTING

1.6.5 SPRAY DEPOSITION:

Spray forming, also known as spray casting, spray deposition, and in-situ compaction, is a method of casting near net shape metal components with homogeneous microstructures by deposition of semi-solid sprayed droplets onto a shaped substrate. The molten metal exits the furnace as a thin freefalling stream that is broken up into droplets by an annular array of gas jets, and these droplets then move downwards, accelerated by the gas jets, to strike a substrate. Deposition continues, gradually building up a spray formed billet of metal on the substrate.

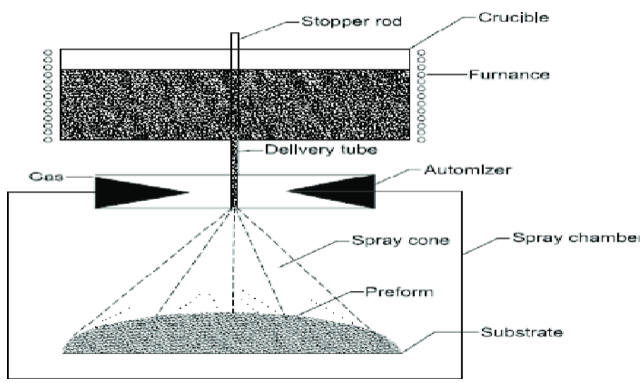


Fig 0-9 SPRAY DEPOSITION

1.6.6 PHYSICAL VAPOUR DEPOSITION:

PVD stands for physical vapour deposition and refers to a number of vacuum deposition techniques that can be used to create thin films and coatings. PVD is defined as a technique in which a material transitions from a condensed to a vapour phase before returning to a thin film. Phase of condensation. Sputtering and evaporation are the two most frequent PVD techniques. PVD is used to make objects that require thin films for mechanical, optical, chemical, or electrical purposes. Most other surfaces inside the vacuum chamber, including the fixturing required to hold the pieces, are unavoidably deposited with the source material.

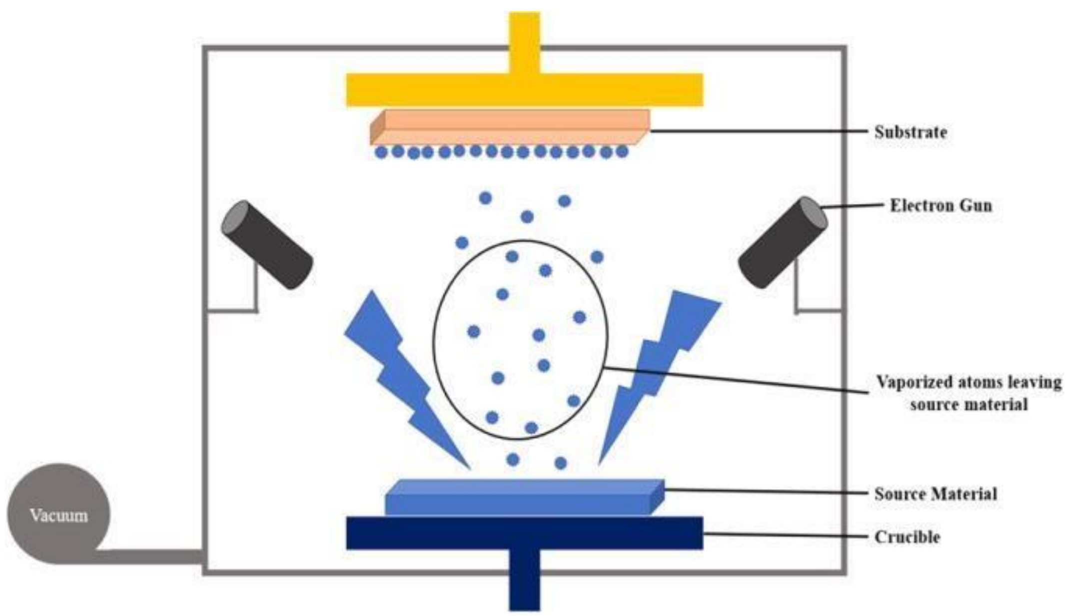


Fig 0-10 PHYSICAL VAPOUR DEPOSITION

1.7 CASTING:

Casting is a manufacturing method in which a liquid substance is poured into a mould with a hollow hole of the required shape and solidified. To complete the process, the solidified portion, also known as a casting, is ejected or broken out of the mould. Epoxy, concrete, plaster, and clay are examples of casting materials that cure after mixing two or more components together. Casting is most commonly used to create intricate shapes that would be difficult or expensive to create using other procedures. Rather than fabricating by combining multiple small parts, heavy equipment such as machine tool beds and ship propellers can be readily cast in the needed size.

TYPES OF CASTING:

1.7.1 SAND CASTING:

Sand casting is produced specialized factories called as foundries. Over 60% of all metal castings are produced via sand casting process. Steel, iron and most non-ferrous alloys are obtained by sand casting.

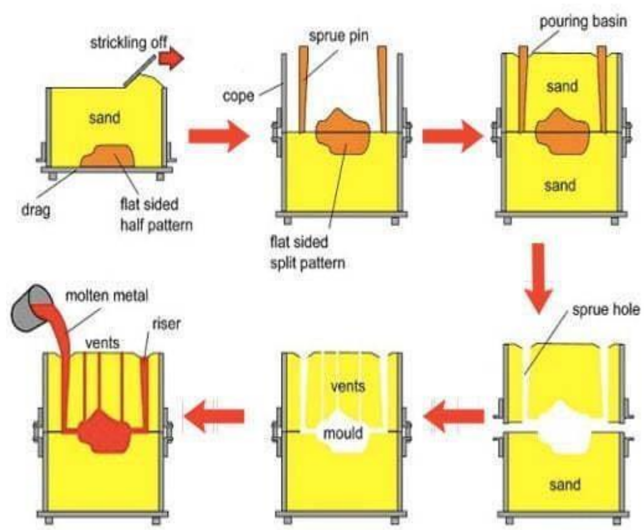


Fig 1-11 SAND CASTING PROCESS

Advantages:

- Nearly Any Alloy
- Low Tooling Cost
- Versatile – Size, Weight, Shape
- Any Quantity
- Timing

Disadvantages:

- Lower Dimensional Accuracy
- Pattern Maintenance
- Surface Finish

Applications:

Automotive engine block, cylinder head, crankshaft, and other castings.

1.7.2 INVESTMENT CASTING:

It is manufacturing process in which a wax pattern is used to shape a disposable ceramic mold. The wax pattern is made in the exact shape of the item to be cast. This pattern is coated with a refractory ceramic material.

Making patterns in fusible materials, covering the pattern's surface with numerous layers of refractory materials, and then melting the pattern out of the mould shell to get a mould without a parting surface that can be filled after baking at high temperatures.

Fig 1-12 INVESTMENT CASTING PROCESS

Advantages:

- Excellent surface finish.
- Tight dimensional tolerances.
- Complex and intricate shapes may be produced.
- Capability to cast thin walls.
- Wide variety of metals and alloys (ferrous and nonferrous) may be cast.
- Draft is not required in the moulds design.
- Low material waste.

Disadvantages:

- Individual patterns are required for each casting.
- Limited casting dimensions.
- Relatively high cost (tooling cost, labour cost).

Applications:

It is suitable for the production of small parts with complex shapes, high precision requirements, or other processing that is difficult to perform, such as turbine engine blades.

1.7.3 DIE CASTING:

It is a metal casting process in which molten metal is forced into a steel mold under high pressure into a mold cavity. The steel molds, known as dies, are fabricated to produce castings with intricate shapes in a manner that insures both accuracy and repeatability.

The high-pressure metal liquid is pressed into a precision metal mould cavity at high speed, and the metal liquid is cooled and solidified under pressure to form a casting.

Advantages:

- The metal liquid is subjected to high pressure and the flow rate is fast during die casting.
- Good product quality, stable size, and good interchangeability.

- High production efficiency and die casting moulds can be used many times.
- It is suitable for mass production with good economic benefits.

Disadvantages:

- The casting is prone to produce fine pores and shrinkage.
- The die-casting parts have low plasticity and should not work under impact load and vibration.
- When die casting of high melting point alloy, the life of the mould is low, which affects the expansion of die casting production.

Applications:

Die castings were first applied in the automotive industry and the instrument industry, and then gradually expanded to various industries, such as agricultural machinery, machine tool industry, electronics industry, national defense industry, computers, medical equipment, clocks, cameras, and daily hardware.

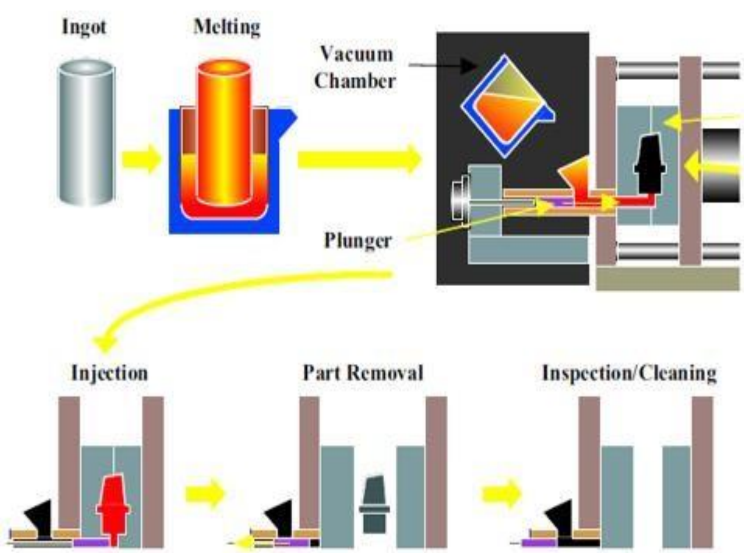


Fig 1-14 DIE CASTING PROCESS

1.7.4 LOW PRESSURE DIE CASTING:

LPDC is a common process used in foundries today in which molten metal slowly fills the die, reducing turbulence. Automotive applications include wheels, steering suspension and engine components.

Refers to the method of making liquid metal fill a mould under a low pressure (0.02 – 0.06MPa) and crystallize under pressure to form a casting.

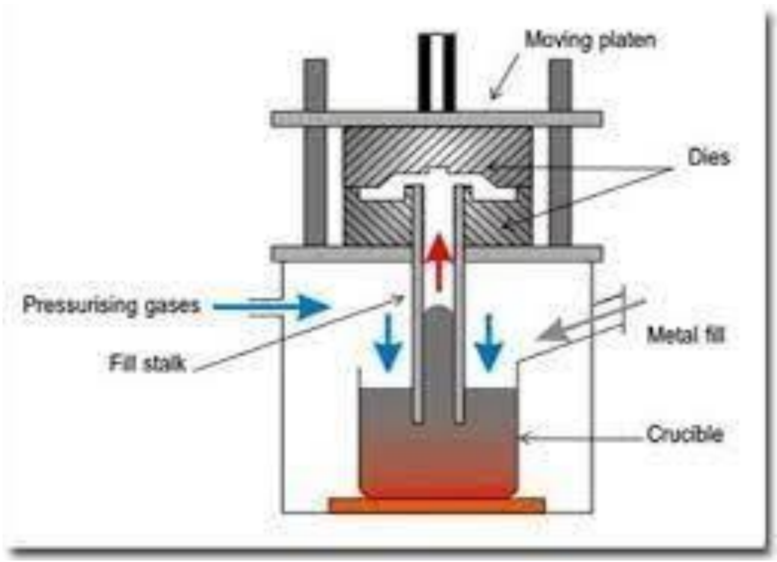


Fig 1-15 LPDC PROCESS

Advantages:

The casting crystallises and solidifies under pressure, allowing for adequate feeding and a compact structure, as well as better liquid metal recovery. In most cases, a riser is unnecessary, and the non-condensed metal in the riser can be refluxed back into the crucible for reuse, considerably improving the liquid metal recovery rate.

Filling castings with pure molten metal improves their purity. The molten metal filling is stable, which reduces or eliminates tumbling, impact, and splash of metal liquid during filling, as well as the formation of oxidation slag.

Filling liquid metal under pressure improves its fluidity, which is useful for the development of castings with a clear contour and smooth surface, as well as for the formation of huge thin-wall castings.

Disadvantages:

- Large investment in equipment and moulds
- In the production of aluminium alloy castings, the crucible and riser are in contact with the liquid metal for a long time, which is easy to be eroded and scrapped, and will also increase the iron content of the liquid metal and deteriorate the performance.

Applications:

Low-pressure die casting is mainly used to produce aluminium alloy and magnesium alloy parts, such as automobile hubs in the automobile industry, cylinder block, cylinder head, piston, missile shell, impeller, wind guide wheel and other castings with complex shape and high-quality requirements. Low-pressure casting can also be applied to small copper alloy castings, such as pipe fittings, faucets in bathrooms, etc.

1.7.5 CENTRIFUGAL CASTING:

It is a casting method in which molten metal is poured into a rotating mould, and the mould is filled and solidified under the action of centrifugal force.

The centrifugal casting method is the method to produce pipes by pouring molten metal into a rapidly spinning cylindrical mold in which centrifugal force from the rotation exerts pressure on the molten metal.

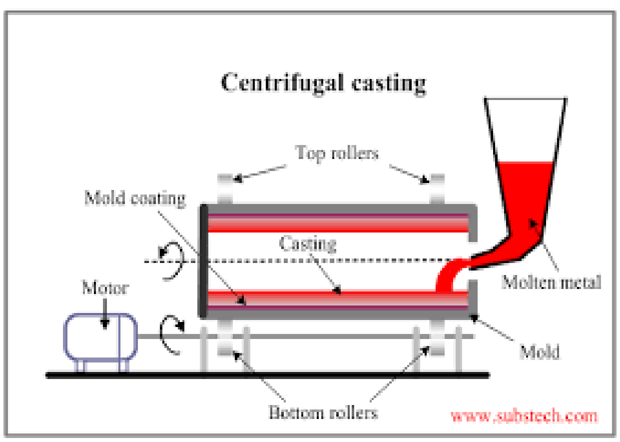


Fig 1-16 CENTRIFUGAL CASTING PROCESS

Advantages:

- There is almost no metal consumption in the pouring system and the riser system, which improves the process yield.
- The core can be omitted when producing hollow castings, so the metal filling ability can be greatly improved when producing long tubular castings.
- The casting has high density, few defects such as pores and slag inclusion, and high mechanical properties.
- It is easy to manufacture composite metal castings of barrels and sleeves.

Disadvantages:

- There are certain limitations when used in the production of special shaped castings.
- The diameter of the inner hole of the casting is not accurate, the surface of the inner hole is rough, the quality is poor, and the machining allowance is large.
- The casting is prone to specific gravity segregation.

Applications:

Centrifugal casting was first used to produce cast pipes. At home and abroad, metallurgy, mining, transportation, irrigation and drainage machinery, aviation, national defense, automotive and other industries have used centrifugal casting processes to produce steel, iron and non-ferrous carbon alloy castings.

Among them, the production of centrifugal cast iron tubes, internal combustion engine cylinder liners and shaft sleeves is the most common.

1.7.6 GRAVITY DIE CASTING:

It is a permanent mould casting process, where the molten metal is poured from a vessel or ladle into the mould. The mould cavity fills with no force other than gravity.

It refers to a molding method in which liquid metal is filled with a metal mould under the action of gravity and cooled and solidified in the mould to obtain a casting.

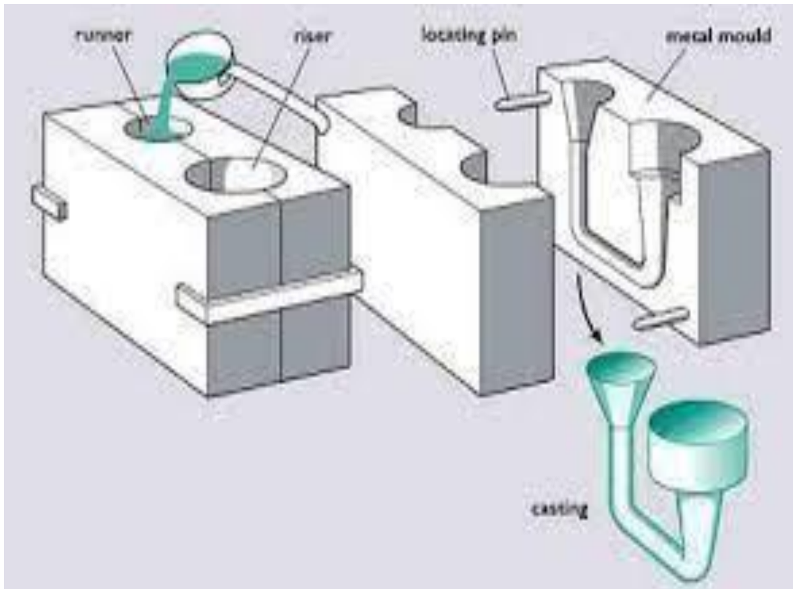


Fig 1-17 GRAVITY DIE CASTING PROCESS

Advantages:

- The metal mould has large thermal conductivity and heat capacity, fast cooling speed, dense casting structure, and mechanical properties about 15% higher than sand casting.
- It can obtain castings with higher dimensional accuracy and lower surface roughness and has good quality stability.
- Because the sand core is not used and rarely used, the environment is improved, dust and harmful gases are reduced, and labor intensity is reduced.

Disadvantages:

- The metal mould itself is non-breathable, and certain measures must be taken to evacuate the air and air generated by the sand core in the cavity.
- The metal mould has no concession, and cracks are easy to occur when the casting is solidified.
- Metal moulds have a longer manufacturing cycle and higher cost. Therefore, good economic effects can only be shown when mass produced.

Applications:

Metal casting is suitable for large-scale production of non-ferrous alloy castings such as aluminium alloys and magnesium alloys with complex shapes.

1.7.7 SQUEEZE DIE CASTING:

It is also called liquid forging, is a hybrid metal forming process that combines permanent mold casting with die forging in a single step in which a specific amount of molten metal alloy is poured into a preheated and lubricated die and subsequently forged and solidified under pressure.

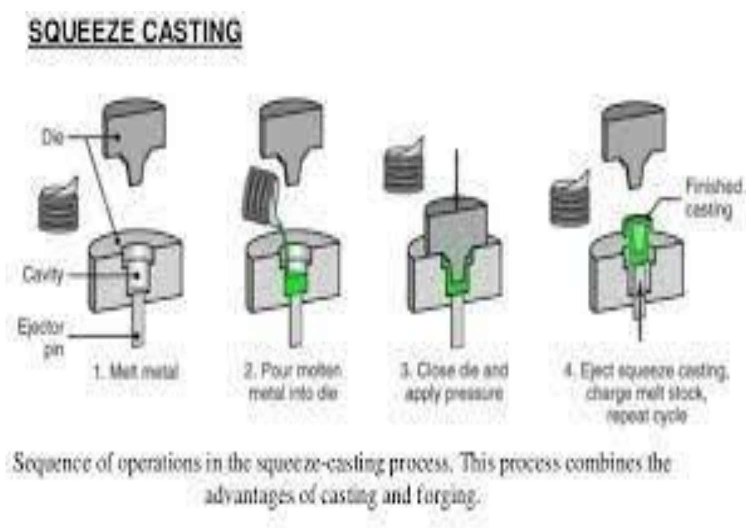


Fig 1-18 SQUEEZE CASTING PROCESS

Advantages:

- Offers a broader range of shapes and components than other manufacturing methods
- Little or no machining required post casting process
- Low levels of porosity
- Good surface texture

Disadvantages:

- Costs are very high due to complex tooling
- No flexibility as tooling is dedicated to specific components
- Process needs to be accurately controlled which slows the cycle time down and increases process costs.
- High costs mean high production volumes are necessary to justify equipment investment.

1.7.8 CONTINUOUS CASTING:

It is also called strand casting, is the process whereby molten metal is solidified into a "semifinished" billet, bloom, or slab for subsequent rolling in the finishing mills.Within the mould, the molten steel freezes against the water-cooled copper mould walls forming a solid shell.

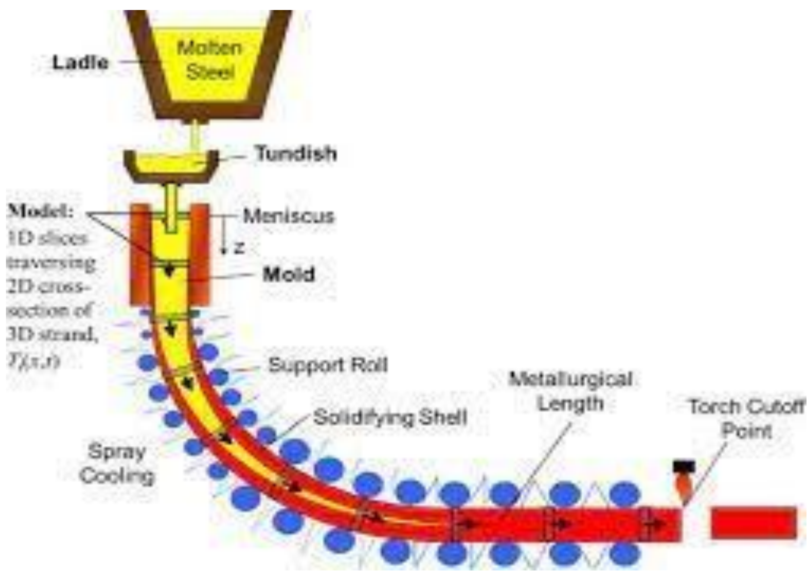


Fig 1-19 CONTINUOUS CASTING PROCESS

Advantages:

- Continuous castings are perfect for pressure applications. They are consistently homogeneous and dense.
- Less machining stock is needed.
- Less material is wasted than some other casting methods.

- These castings are straight and concentric, meaning there is no deviation. You get the same product every time.
- Suppliers often maintain stock of standard products, available to distributors on demand.

Disadvantages:

- There are a few limitations to consider when looking at continuous casting. The biggest is the cost of setup. Due to both the high cost of creating a mold and the time spent setting up the machine for each project, it is not practical to use this method for small quantities or for special shapes of a product.

Applications:

- Continuous casting is rapidly getting used for steel casting. In 2003 nearly 32% of the steel bars were produced by continuous casting. The vertical cast can be used for semi-continuous casting like billets, ingots, bars, etc.

CHAPTER 2

LITERATURE REVIEW

1. An Investigation on the Mechanical Behaviors of Al 6061–B4C Metal Matrix Composites

Authors: Abdullah Gocer & M. Baki Karamis

Metal matrix composite materials with ceramic reinforcements have better mechanical characteristics. Because of their extreme hardness, ceramic particles also improve the wear behaviour of these materials. The wear properties of Al 6061–B4C composite materials reinforced with B4C in various sizes were examined in this research. Al 6061 particles are sintered at 550°C for 2 hours under 450 MPa pressure after being blended with B4C powders in three different sizes at a volume fraction of 10%. Direct extrusion was used to turn the billets into composite bars. Some hybrid composites with graphite reinforcement were also created. On the wear behaviour of the composite, the impacts of B4C reinforcement size, shear rate, heat treatment, and graphite reinforcement were examined.

2. A Review on Machining and Tribological Behaviors of Aluminium Hybrid Composites

Authors: GanesanPandi[a] Saravanan Muthusamy

Aluminium hybrid metal matrix composites have been widely used as substitute materials in automobile, aero space and structural applications because of their high wear resistance and strength to weight ratio. Manufacturing these types of composites is growing worldwide. Hybrid metal matrix composites are advance engineering materials reinforced with two or more different materials which posses combined and improved physical, mechanical and tribological properties. The present study deals with aluminium metal matrix composites with multiple reinforcement showing improved mechanical and tribological properties. The addition of graphite content to aluminium composites improves the tensile strength, elastic modulus and machinability due to the solid lubricating property of the graphite particles. It also increases the thermal and electrical conductivity that can improve the conducting capability of these composites. The effect of adding alumina into aluminium composites also increases the tribological and mechanical properties. The addition of the fly ash also increases the properties such as tensile strength, compressive strength, yield strength and hardness of the aluminium composites and hence it can be a better substitute for single reinforced composites.

3. Mechanical Characterization of Stir Cast Al 6063 TiO_2-Cu Reinforced Hybrid Metal Matrix Composites

Authors: N Lokesh , b Manoj , K Srikanth

Aluminium based metal matrix composites find varied applications in aerospace, defence, automobile, sports equipment and electronics due to their favourable properties viz. light weight, high strength and coefficient of thermal expansion. Al 6063 is a low strength castable alloy with moderate hardness and strength and finds application in truck wheels and rail road cars. The addition of refractory reinforcement generally improves the hardness, tensile strength and high temperature properties of the material. The present investigation focuses on characterization of metal matrix composites based on Al6063 matrix reinforced with different percentages of Cu and TiO_2 particles. Accordingly Al 6063 -TiO_2-Cu composite of 5,10 &15 wt% Cu as reinforcement are manufactured using conventional stir casting technique. Specimens are prepared as per the ASTM standards and microstructure investigation, tensile, impact and hardness measurements have been correlated with the percentage of Cu particles.

4. Studies on mechanical and thermal behaviors of Al6061- SiC-Gr-ZrO_2 nano hybrid composites

Authors: N Jagadeesh , A P Senthil kumar

The goal of this study is to use a novel technology to create a hybrid nano composite material with a metal matrix Al6061, reinforcements of Silicon Carbide (SiC), Zirconia or Zirconium dioxide (ZrO2), and Graphite (Gr). These reinforcements are added in 0.75 percent increments to each sample. To make nano particles for the manufacture of new material, a high-energy ball milling machine is used. The innovative stir casting method brings these elements together. Then, for hardness, tensile, and thermal conductivity tests, nano composite specimens are created. The addition of reinforcing component has increased the composites' hardness greatly. Then the Tensile strengths are increases as well as decreases with enlarged amount of reinforcements.

5. Investigation of mechanical properties of Al6061/Al2O3-SiC composites fabricated by stir casting

Authors: Vinod Kumar Rohilla , Rachin goyal

Lighter and energy efficient materials are requirement of current era. Aluminium and its composites are one of the possible answers to these requirements. In the present research work, Al6061/Al2O3 -SiC Composite has been fabricated by Stir casting process. The weight percentage of Al2O3 have been varied from 3% to 9%, whereas SiC has been kept constant at 6% for all the samples. After successful fabrication of Al6061/Al2O3 -SiC Composite, tensile strength, percentage elongation and micro hardness have been analyzed. It has been observed that the tensile strength increases with the increase in Al2O3 percentage, whereas percentage elongation decreases with the increase in Al2O3 percentage. Micro-hardness increases up to 6% Al2O3 and then starts decreasing.

6. Enhancement of mechanical and tribological properties of SiC- and CB-reinforced aluminium 7075 hybrid composites through friction stir processing

Authors: Pratap Roy , Subhash Singh

Because of its great strength and light weight, aluminium alloy is widely used in the aerospace and automobile industries. Stir casting was employed to fabricate aluminium alloy 7075 reinforced with silicon carbide (SiC) and carbon black (CB) particles in this study. X-ray diffraction, energy dispersive X-ray analysis, and field emission scanning electron microscopy (FE-SEM) all indicated the presence of SiC and CB particles in an aluminium matrix with a uniform distribution. Furthermore, as-cast composites were friction stir processed (FSP) using the appropriate processing parameters: tool speed, feed rate, and tool tilt angle. The mechanical and microstructural characteristics of the composites were evaluated using a universal testing machine and optical microscopy before and after FSP.

The unique property of as-cast AA7075/SiC/CB is that it has a 2.5-fold increase in ultimate tensile strength while also having a significant increase in ductility. As indicated in the FE-SEM investigation, ductile failure could be a plausible fracture process. The tribological behaviour of the synthesised composites was also investigated under dry sliding conditions before and after FSP, with the results indicating a considerable increase in the composites' wearing capacity. Weight loss of the various composites was also studied by modifying three input variable process parameters, followed by analysis of variance and regression analysis. The addition of 5% SiC and 5% CB in the composites can provide superior mechanical and wear properties when compared to the base alloy.

7. Production and Mechanical Testing of Aluminium Alloy Based Hybrid Metal Matrix Composite

Authors: M C Gowri Shankar, Yogesh Prasad , Deepak Kumar

The goal of this research is to uniformly disperse Aluminum Oxide (Al2O3) and Graphite (Gr) particles in an Aluminum Alloy Matrix to create a hybrid composite, and then investigate and analyse the mechanical properties of the generated composite. Al2O3 and Gr particles were less than 45 microns in size. The hybrid composite with % Al2O3 and 0.5 percent, 1 percent Gr and 4 percent Al2O3 and 0.5 percent, 1 percent Gr is made using the stir casting technique. In Non-Heat Treated (NHT) circumstances, the composites were investigated for density changes owing to reinforcements, hardness, tensile strength, and wear behaviour. The testing were carried out to ASTM criteria in a laboratory setting. Under dry conditions, the Pin-On-Disc machine is used to test the sliding wear behaviour.

8. Effect of interfacial-active elements addition on the incorporation of micron-sized SiC particles in molten pure aluminum

Authors: M Mohammadpour, D Brabazon

The poor wettability of ceramic particles by liquid metal is a fundamental problem in the manufacturing of cast metal matrix composites (MMCs). The effect of 1% Ca, Mg, Si, Ti, Zn, and Zr interfacial-active alloying elements on the integration of micron-sized SiC particles into molten pure aluminium using the vortex casting process at 680 °C was investigated in this study. The findings revealed that Ti, Zr, Zn, and Si were not effective in boosting particulate incorporation, whereas Ca and, in particular, Mg were quite beneficial in increasing particulate incorporation. In addition, samples containing Ti and Zr generated Al3Ti and Al3Zr intermetallic phases, resulting in hybrid MMCs with a larger proportion of Ti.

9. Stir casting process for manufacture of Al–SiC composites

Authors: Shahin Soltani, Rasoul Azari Khosroshahi , Reza Taherzadeh Mousavian

Stir casting is a cost-effective method for producing aluminium matrix composites. Many variables influence the final microstructure and mechanical properties of the composites during this procedure. Micron-sized SiC particles were employed as reinforcement in this study to make Al-3 wt% SiC composites at two different casting temperatures (680 and 850 °C) and stirring times (2 and 6 min). Scanning electron microscopy (SEM) and high-resolution transition electron microscope (HRTEM) examinations were used to analyse factors such as reactivity at the matrix/ceramic interface, porosity, ceramic incorporation, and particle agglomeration. The shorter stirring period is required for ceramic incorporation to accomplish metal/ceramic bonding at the interface, according to microstructural characterizations.

10. Mechanical and Wear Properties of Al6063 Metal Matrix Composite Reinforced with Al2O3 Particles

Authors: Abdul Nazeer, Mir Safiulla

Due to its strength-to-weight ratio, ease of forming, cost-effectiveness, and high aesthetic appeal, composite material has largely supplanted traditional material in recent years.

Metal matrix composites have successfully replaced aluminium matrix composites in structural applications in the fields of automobiles, construction, aerospace, marine, and medicine, among others. Aluminum matrix composites are widely accepted for their high strength-to-weight ratio, ease of fabrication, corrosion resistance, and wear resistance, among other benefits. The effect of alumina Al2O3 when reinforced with aluminium 6063 matrix was investigated in this work. A liquid metallurgical approach (Stir Casting Technique) was used to make the composite, and the reinforcement was changed from 0 to 8wt percent in steps of 2wt percent. On constructed composite systems, mechanical, wear, fractography, and X-ray diffraction tests were performed.

11. Preparation of 6061Al-Al_2O_3 MMC's by Stir Casting and Evaluation of Mechanical and Wear Properties

Authors: V Bharat, V Auradi

Aluminum MMCs are chosen over other traditional materials in aerospace, automotive, and marine applications because to increased features such as high strength-to-weight ratio, strong wear resistance, and so on. In this study, a liquid metallurgical technique, specifically stir casting, was used to create metal matrix composites with 6061Al as the matrix material and ceramic Al2O3 particulates as reinforcement. The amount of reinforcement added varies from 6 to 12 percent in 3 percent increments. To improve wettability and distribution, reinforcement particles were warmed to 200 degrees Celsius and then disseminated in three phases into the vortex of molten Al6061 alloy.

To achieve homogenous particle distribution, specimens from the core region of the casting were taken for microstructural evaluation of the above produced composites. To determine the level of improvement, hardness and tensile characteristics of the produced composite were measured before and after the addition of Al2O3 particles. The composites' microstructural analysis revealed a very uniform distribution and some grain refinement in the specimens. Furthermore, as compared to an unreinforced 6061Al matrix, composites have higher hardness and tensile characteristics, and increasing the reinforcing level has resulted in even better hardness and tensile strength.

12. Prepration & Analysis For Some Mechanical Property Of Aluminium Based Metal Matrix Composite Reinforced With Sic & Fly Ash

Authors: Er. Sandeep Kumar Ravesh , Dr. T. K. Garg

The study discusses the production of aluminum-based metal matrix composites and the mechanical properties of these composites, such as hardness, toughness, and tensile strength.

The goal of this work was to produce an aluminum-based silicon carbide particulate MMC with the goal of developing a traditional low-cast way of generating MMCs and obtaining homogenous dispersion of ceramic material. The stir casting technique was used to achieve this goal. The matrix and reinforcement materials were chosen to be Aluminium 6061 (97.06 percent C.P) and SiC, Fly Ash, respectively. The experiment was carried out by altering the weight fraction of SiC (2.5, 5%, 7.5, and 10%) while leaving all other parameters constant.

CHAPTER 3

EXPERIMENTAL DETAILS

3.1 SELECTION OF MATERIAL

The matrix material utilized in the current study is Al6061. The distinctive alloying parts are magnesium, copper, manganese, element, and atomic number 30. It belongs to a gaggle of hypo mixture Al-Si alloys and includes a wide field of application within the automotive and aeronautics industries. Besides this, the Al 6061 alloy is employed as a matrix for getting composites that have Associate in Nursing increased wear resistance, favourable mechanical properties at temperature, and increased mechanical properties at elevated temperatures. Al 6061 alloys naturally have Associate in nursing modulus of elasticity of regarding 70GPa. In general, stiffer and lighter styles are achieved with Al 6061 alloys than is feasible with steels.

Applications of Al6061: It is typically used in

- Truck frames
- Rail coaches
- Military and commercial bridges
- Ship building operations
- Towers and pylons
- Rivets
- Aerospace applications (i.e., helicopter rotor skins)
- Transport operations.

Table 3.1 Al6061 Chemical Composition

Elements	Cu	Mg	Si	Fe	Mn	Cr	Zn
Wt %	0.4	1.2	0.8	0.7	0.15	0.45	0.25

Table 3.2 Al 6061 Mechanical Properties

Base Material	**Al 6061**
Density value	2.7 g/cm^3
Young's modulus value	68.9Gpa
Tensile strength value	124-290Mpa
Elongation at break value	12-25%
Poisson's ratio value	0.33
Melting temperature value	585°c
Thermal conductivity value	151-202 W/(m-k)
Linear thermal expansion coefficient value	2.32X10
Specific heat capacity value	897 J/(kg-k)

3.2 REINFORCEMENTS

3.2.1 Silicon Carbide

Silicon Carbide is that the sole matter of carbon and component. It was made by the warmth electro-substance response of sand and carbon. Nowadays the texture has been formed into a top-quality specialized grade fired with wonderful mechanical properties. Compared with carbon fiber, carbide fiber will maintain sensible performance beneath extreme conditions.

Silicon carbide fibre has sensible properties in these aspects, additionally pretty much as good compatibility with ceramics and metal matrix; therefore it is employed to strengthen composite materials.

Table: 3.3 Chemical Composition of SiC

Element	**Si**	**SiO_2**	**Fe**	**Al**	**C**
%	0.3	5	0.08	0.1	0.3

Fig. 3.1 SiC POWDER

3.2.2 Composition of Al_2O_3: Aluminium oxide, normally remarked as aluminium oxide, possesses robust ionic put down atomic bonding giving rise to its fascinating material characteristics. It will exist in many crystalline parts that all revert to the foremost stable polygon alpha phase at elevated temperatures.

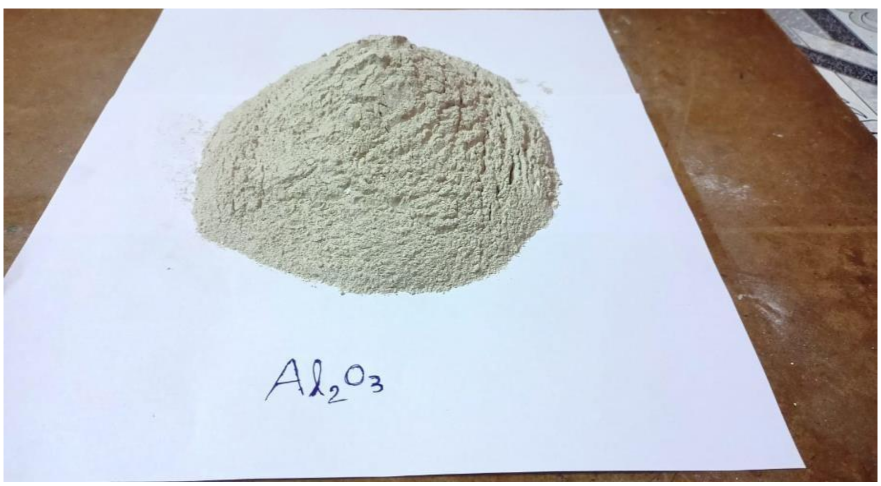


Fig. 3.2 AL_2O_3 POWDER

Properties:

1. Density - 3.428 g/cm^3
2. Tensile strength - 665MPa
3. Young's modulus - 215GPa

Key properties of Al_2O_3

- High strength and high stiffness
- Hard and wear-resistant
- Good size and shape capability
- Good thermal conductivity
- High temperature applications.

3.3 MUFFLE-FURNACE

A furnace is one of the most elements of your HVAC system. Once you set your thermostat, you activate the chamber to start heating air. a disciple switches on and circulates this heated air through your home. However, the warmth is transferred to the air depends on the kind of furnace.

A **muffle furnace** or **muffle oven** (sometimes **retort furnace** in historical usage could be a chamber inside which the theme material is segregated from the fuel and all of the product of burning, just as gases and flying debris. at the point when the occasion of high-temperature warming parts and boundless charge in created nations, new mute heaters immediately delighted to electrical styles.

Fig: 3.3 MUFFLE FURNACE

One will set the desired temperature by pressing red colour push by finger, hold a similar in pressing position and temporary worker by rotating coarse, fine knobs and unharness the finer from the push. When emotional push, junction rectifier show of controller indicates an actual temperature of furnace. There are four main styles of furnaces: gas, oil, electric, and fuel. Electrical furnaces will heat the air by exposing heated parts, whereas alternative styles of furnaces generally need a device or chamber that warms the encompassing air.

3.4. ELECTRIC ARC FURNACE

An Electric arc furna**ce** (**EAF**) is a furnace that heat charged material by means that of an electrical arc. Mechanical circular segment heaters place size from small units of around one-ton ability (utilized in foundries for assembling fashioned iron items) as much as 400 ton units utilized for optional steelmaking. Circular segment heaters used in investigation research centres and by dental specialists may have a capacity of exclusively around dozen grams. Modern flash chamber temperatures will reach one,800 °C (3,272 °F), while research centre units will surpass three,000 °C (5,432 °F). Circular segment heaters differ from enlistment heaters, in this, the charged material is straightforwardly presented to an electrical bend, and furthermore the flow inside the chamber terminals goes through the charged material.

Fig: 3.4 ELECTRIC ARC FURNACE

3.5. FABRICATION and METHADOLOGY

.3.5.1. PRE-HEATING:

Preheating of Reinforcement ought to be exhausted to get rid of agglomeration, wetness, and gases conferred in it. Assault and Al_2O_3 are preheated in a Muffle chamber at a temperature of 3500c for one day. A six-finger die is preheated for one hour at 400^{o}c in Arc chamber such, the liquefied metal doesn't get solid quick.

Fig: 3.5. MUFFLE FURNACE

Fig.3.6. ELECTRIC ARC FURNACE

3.5.2. STIR CASTING

Stir casting could be a liquid state technique for the manufacture of composite materials, within which a dispersed particle is combined with a liquefied metal matrix by means that of mechanical stirring. Stir Casting is that the simple technique of liquid state fabrication

It is one of all the foremost appropriate techniques for manufacturing metal matrix composites for various combinations of ceramic and metals.

It could be a sort of easy operation, lower price of production and production capabilities created this system versatile.

In recent past composites as well as steel and titanium-based alloys have additionally been rumoured. The hybrid composites are a brand new age of metal framework composites to achieve desired properties at a nearer approximation of real desires. These might have the potential of satisfying the recent demands of advanced engineering applications

Fig: 3.7. Stir Casting Furnace

The Aluminium 6061 is placed within the vessel nearly 800gm-1000gm as per our demand of dying as shown in fig. shut the lid on the vessel and wait until the bottom material turns into liquid and add the reinforcements I Chronicles,2% consistent with the load of the Al-6061 within the chamber.

3.5.3. CRUCIBLE

Crucible is that the instrumentality within which the metal is molten then poured into a mould to perform casting. The fabric of mould ought to have a more freezing point, more strength {and ought to |and will| and may} be a sensible conductor of warmth so that heat loss should be low. They are many materials on the market for this purpose like SiC, solid steel, and atomic number 6. For our necessities, the SiC vessel is good for suited, but the price is incredibly high therefore can't be afforded. We have got taken here an atomic number 6 vessel that serves our functions as its melting temperature is 2700°C that is way on top of operating temperature. The vessel is formed in an exceedingly form of a cylinder with decrease diameter so that the high portion remains a cylinder but the lowest half takes the form of a hemisphere. A handle is connected to the aspect of the vessel to carry it whereas putting it within the chamber and whereas gushing hot metal into the mould cavity. It will face up to terribly high temperatures and is employed for metal, glass, and for pigment production additionally as a variety of newly laboratory processes.

Fig: 3.8. Al6061 in Crucible

3.5.4. STIRRER

The strategy used in the manufacture of MMC needs the scattered particles that are the ceramic particles (SiC) to be blended in a strong state inside the fluid metal. Consequently for the uniform blend of the ceramic particles inside the fluid metal, it's necessary that the combination be mixed well. Thus, a stirrer is required which might withstand the warm temperature and doesn't affect the virtue of the composite. The stirrer is made of a chrome steel pole whose face is associated with a nuclear number 6 fan. It's driven by a ½ H.P. AC engine and pivots at a disturbing 400 rates. The stirrer is embedded upward into the vessel concerning 33% of its tallness once adding the fired particles. Here we've given approaches to mixing through outside mediums that might be associated with the chamber at any reason through the most elevated.

Fig: 3.9. Adding Of Reinforcement According To Their Percentages

3.5.5. CASTING ON MOLTEN ALUMINIUM

Subsequent to preparing the form, the liquefied metallic component was filled the shape pass on from the vessel and was left to set. When the projecting is finished, it had been isolated from the shape as displayed in the figure 3.10.

Fig: 3.10. Pouring The Molten Liquid Into The 6 Finger Die

CHAPTER 4

TESTING TOOLS AND MACHINES

4.1. CAST IN THE MOULD

The 6 finger die was opened after the mould poured in the die gets solidify and then we get the shape of the die with cast of aluminium with mixture of the reinforcements as shown in

Fig: 4.1 After Casting

4.1.1. MACHINING

Machining is any of different cycles where a piece of crude material is cut into an ideal last shape and size by a controlled material-expulsion measure. The cycles that have this normal topic, controlled material evacuation, are today all in all known as subtractive assembling, in qualification from cycles of controlled material expansion, which are known as added substance fabricating. Precisely what the "controlled" a piece of the definition infers can shift, however it quite often suggests the utilization of machine instruments (notwithstanding power apparatuses and hand devices). Machining is a piece of the assembling of many metal items, however it can likewise be utilized on materials like wood, plastic, artistic, and composites. An individual who has some expertise in machining is known as a mechanical engineer. A room, building, or organization where machining is done is known as a machine shop. Quite a bit of present day machining is completed by PC mathematical control (CNC), in which PCs are utilized to control the development and activity of the plants, machines, and other cutting machines.

In turning, a cutting instrument with a solitary forefront is utilized to eliminate material from a pivoting work piece to create a round and hollow shape. The essential movement is given by turning the work piece, and the feed movement is accomplished by moving the cutting instrument gradually toward a path corresponding to the hub of revolution of the work piece.

Fig: 4.2 During Machining

A cutting device has at least one sharp front lines and is made of a material that is more enthusiastically than the work material. The state of the art serves to isolate chip from the parent work material. Associated with the forefront are the two surfaces of the apparatus:

- The rake face; and
- The flank.

The rake face which coordinates the progression of recently shaped chip, is arranged at a specific point is known as the rake point "α". It is estimated comparative with the plane opposite to the work surface. The rake point can be positive or negative. The flank of the instrument gives a leeway between the device and the recently shaped work surface, hence shielding the surface from scraped area, which would debase the completion. This point between the work surface and the flank surface is known as the help point. There are two essential kinds of cutting instruments:

- Single point device; and
- Multiple-state of the art device

A solitary point device makes them cut edge and is utilized for turning, exhausting and arranging. During machining, the place of the device infiltrates underneath the first work surface of the work part. The fact is in some cases adjusted to a specific range, called the nose sweep.

Different state of the art devices have more than one forefront and typically accomplish their movement comparative with the work part by turning. Penetrating and processing use pivoting numerous state of the art apparatuses. Albeit the states of these instruments are unique in relation to a solitary point device, numerous components of hardware math are comparative.

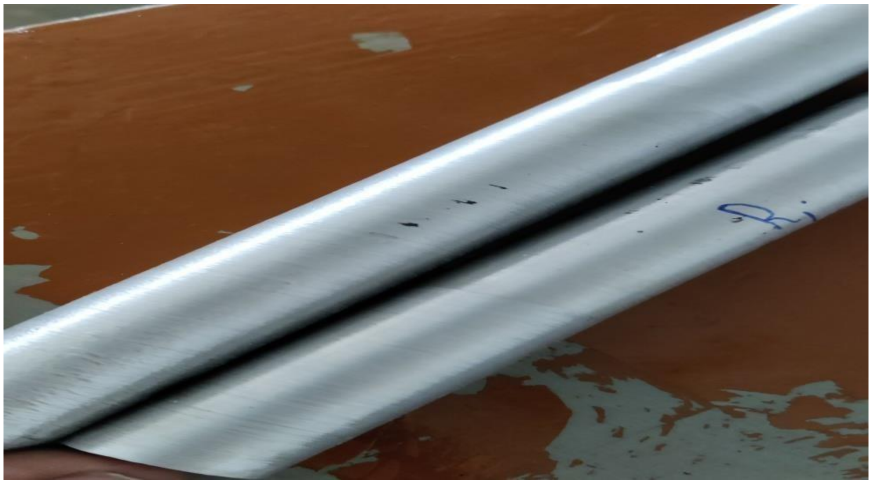


Fig: 4.3. After Machining

4.2. Tests Conducted

- Density
- Tensile
- Compression
- Hardness

4.2.1. DENSITY

The density of the composites was gotten by the Archimedean strategy for gauging little pieces cut from the composite chamber first in air and afterward in water, while the hypothetical density was determined utilizing the blend rule as per the weight part of the molecule.

Fig 4.4 Density Measurement Apparatus

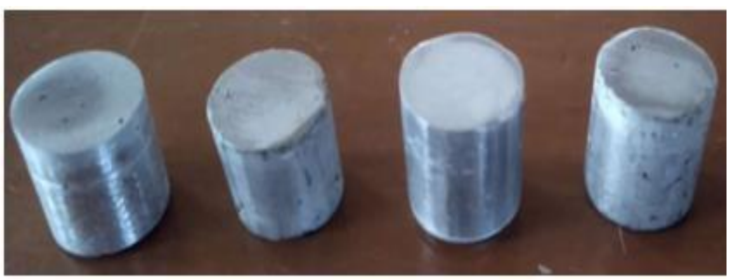


Fig 4.5 Density Measurement Tested Specimens

4.2.2. TENSILE TEST

One material property that is broadly utilized and perceived is the strength of a material. In any case, what does "strength" mean? "Strength" can have numerous implications, so let us investigate what is implied by the strength of a material. We will take a gander at an exceptionally simple test that gives heaps of data about the strength or the mechanical conduct of a material, called the malleable test.

Fig 4.6 Tensile Pieces after Machining

The fundamental thought of a pliable test is to put an example of a material between two installations called "grasps" which clasp the material. The material has known measurements, similar to length and cross-sectional region. We then, at that point start to apply weight to the material held toward one side while the opposite end is fixed. We continue to expand the weight (frequently called the heap or power) while simultaneously estimating the adjustment of length of the example.

Fig. 4.7 Universal Testing Machine (UTM)

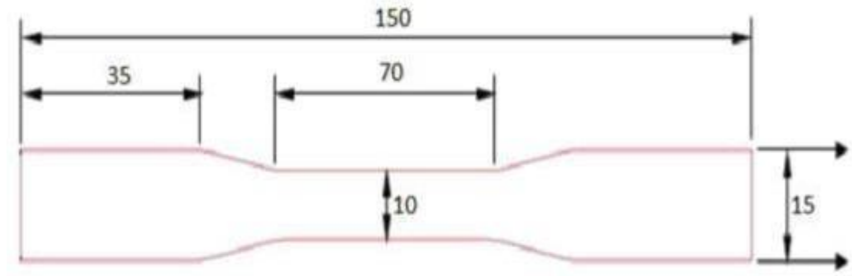


Fig 4.8 Tensile Test Specimen (ASTM-E08Standard)

Fig 4.9 Tensile Test Specimen after testing (ASTM-E08Standard)

4.2.3. COMPRESSION TEST

A compression test is any test wherein a material encounters contradicting powers that push internal upon the example from inverse sides or is generally packed, "crushed", squashed, or smoothed.

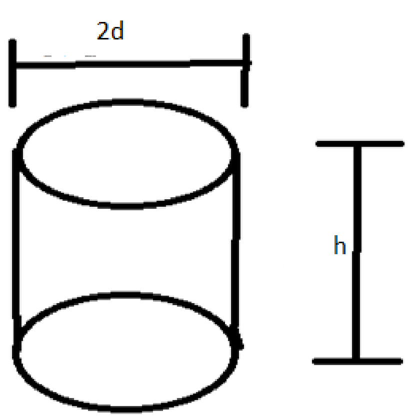


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Fig 4.10 Compression test Specimen

The test is for the most part positioned in the middle of two plates that disseminate the applied burden across the whole surface space of two inverse countenances of the test and afterward the plates are moved together by a widespread test machine making the example level. A compacted test is typically abbreviated toward the applied powers and extends toward the path opposite to the power. A pressure test is basically something contrary to the more normal strain test.

Fig 4.11 Compression Pieces after Machining

Fig 4.12 Compression Pieces after testing

4.2.4. VICKERS HARDNESS TEST

`The hardness of a material can be determined by Brinell Rockwell and Vickers hardness test. In Vickers hardness test, diamond indentation is used to determine the hardness. Vickers test decides the hardness by the estimation of the profundity of infiltration of an indenter under load more than contrasted with the entrance made by a preload. There are various scales, meant by a solitary letter, that utilization various burdens or indenters.

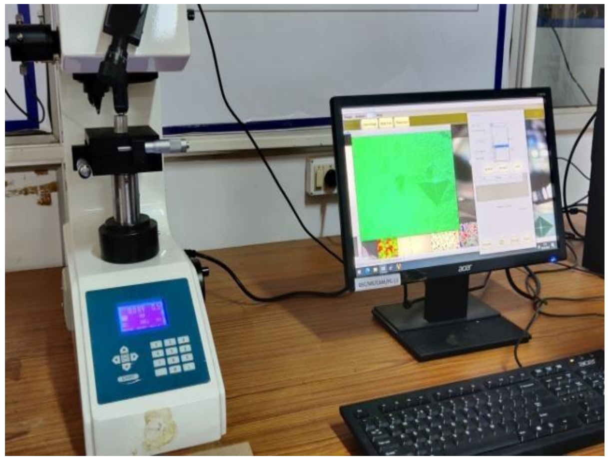

Fig 4.13 Vickers Hardness Testing Machine

The hardness of the Al6061 alloy and composites was determined with Vickers Micro Hardness Tester (LECOAT700 Micro hardness Tester). The dimension of each specimen for hardness testing was 20x10mmand each specimen was grinded and polished to obtain a flat smooth surface. During the testing, a load of 100gm. was applied for 10s on the specimen through square based diamond indenter and the hardness readings taken in a standard manner.

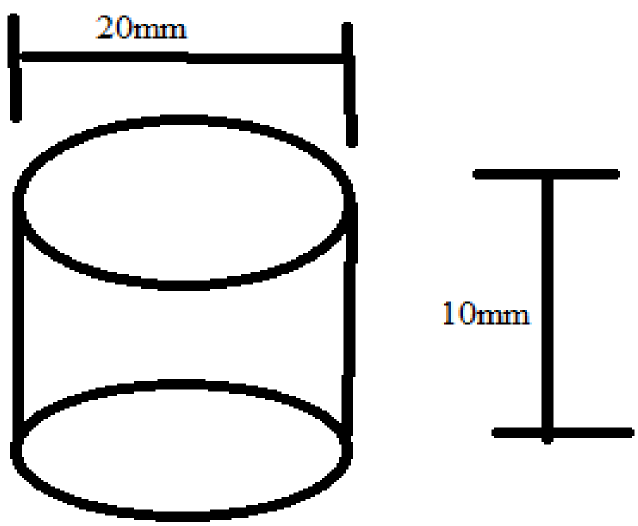

Fig 4.14 Hardness test Specimen dimensions

Fig 4.15 Hardness test Specimens after testing

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Density Test

The test performed on the specimens with SiC and Al_2O_3 (mixture of both SiC and Al_2O_3 with equal %) reinforcement.

Table 5.1 Density Varying with SiC & Al_2O_3

S.No	Sample	Measured
1	Al 6061	2.700 g/cm^3
2	Al6061+ 1% (Al_2O_3+SiC)	2.716 g/cm^3
3	Al 6061 + 2% (Al_2O_3+SiC)	2.724 g/cm^3
4	Al 6061 + 3% (Al_2O_3+SiC)	2.740 g/cm^3

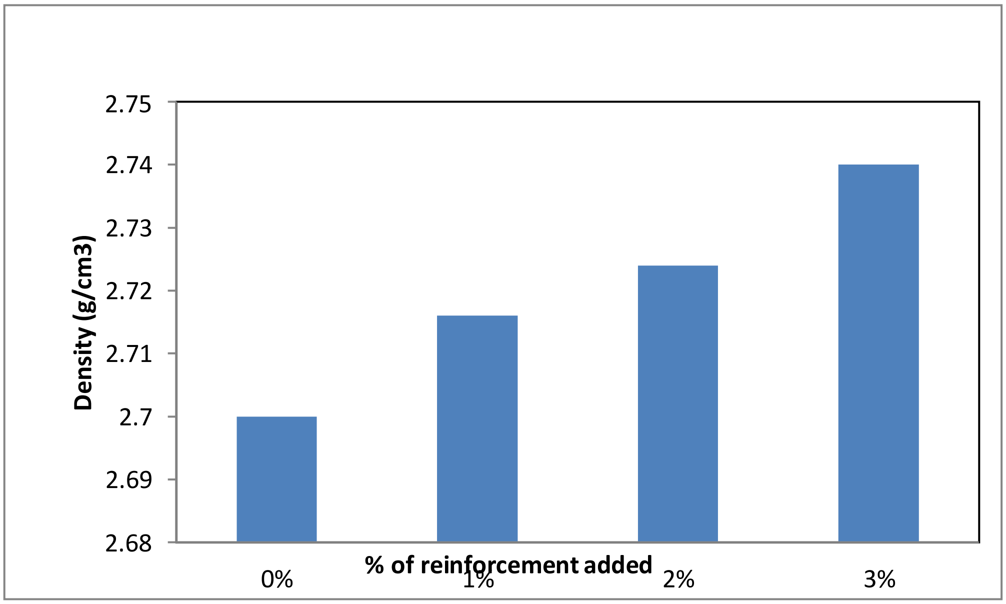

Fig: 5.1 Density v/s % of Reinforcement

5.2 Tensile Test

The test performed on the specimens with SiC and Al_2O_3 (mixture of both SiC and Al_2O_3 with equal %) reinforcement.

Table 5.2 Tensile Strength

S.No	% of reinforcement	Avg. Tensile strength (MPa) of Al_2O_3+SiC
1	0	310
2	1	270.84
3	2	285.33
4	3	298.58

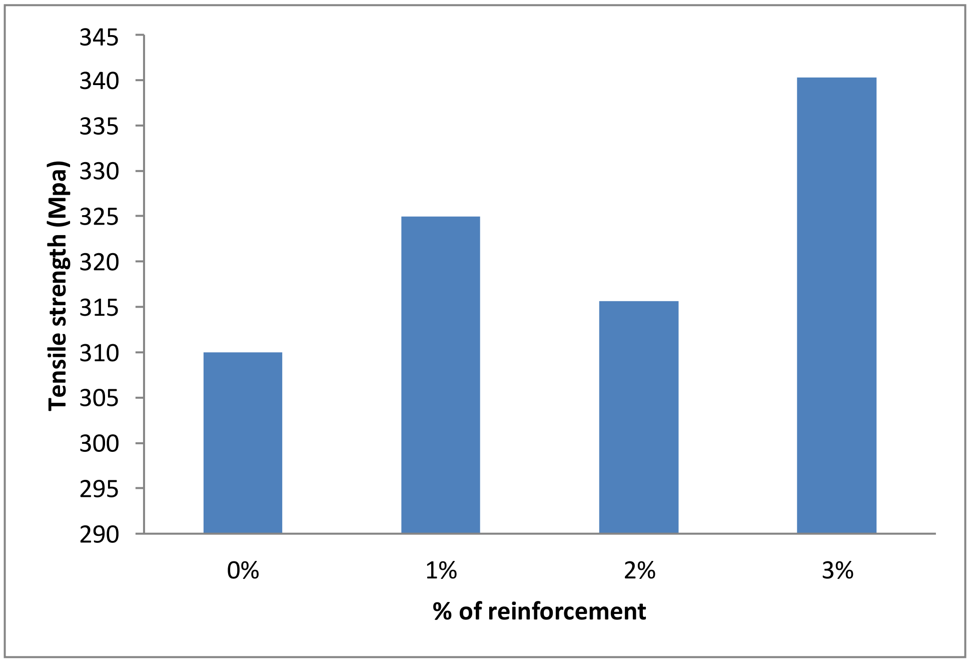

Fig 5.2 Tensile Strength v/s% of Reinforcement

5.3 Compression Test

The test performed on the specimens with SiC and Al_2O_3 (mixture of both SiC and Al_2O_3 with equal %) reinforcement.

Table 5.3 Compressive Strength

S.No	% of reinforcement	Avg . Compressive strength (Mpa) of Al_2O_3+SiC
1	0	63.6
2	1	76.4
3	2	82.8
4	3	89.17

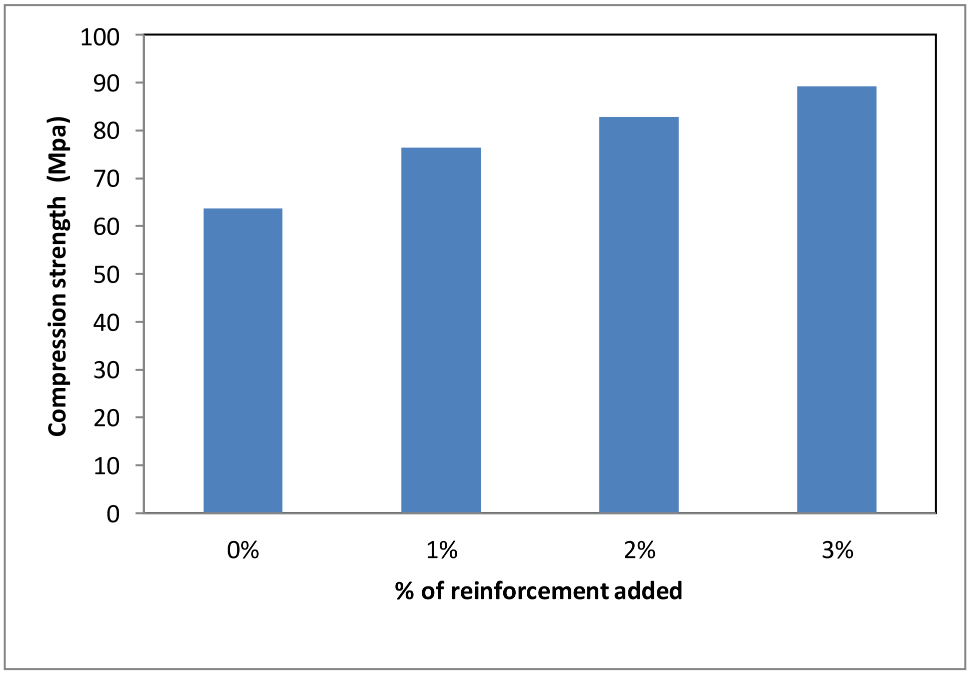

Fig: 5.3 Compression Strength v/s % of Reinforcement

5.4 Hardness Test

The hardness test performed on the specimens with SiC and Al_2O_3 (mixture of both SiC and Al_2O_3 with equal %) reinforcement

Table 5.4 Vicker's Hardness

S.No	%of reinforcement	Avg . VHN of Al_2O_3+SiC
1	0	78.94
2	1	80.82
3	2	86.04
4	3	93.66

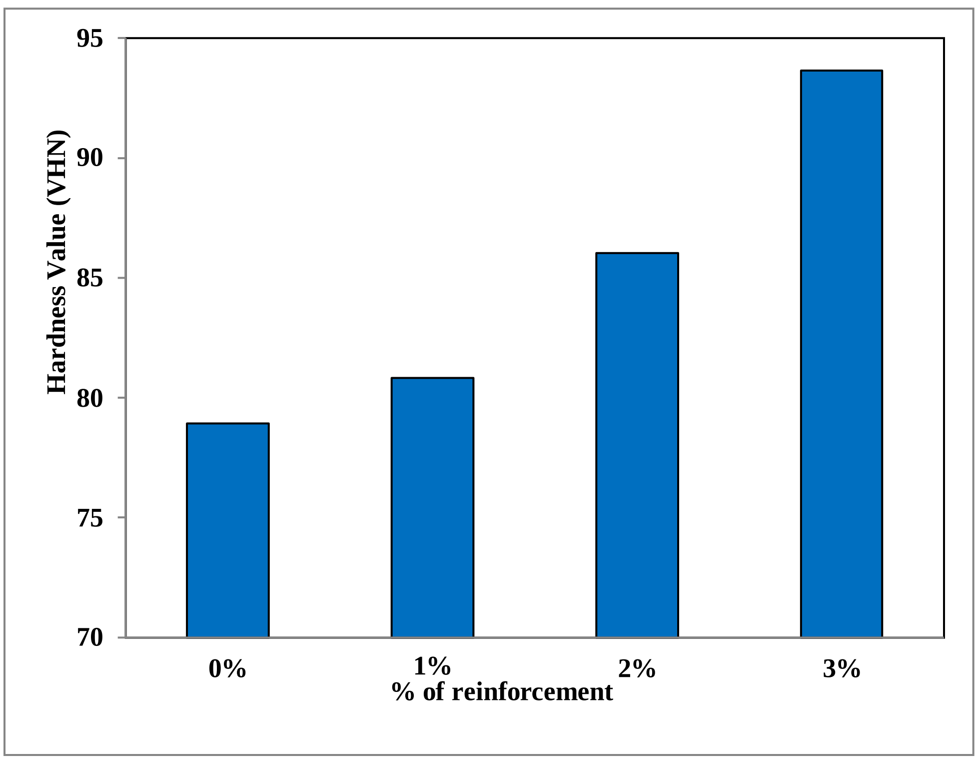

Fig 5.4 Hardness v/s % of Reinforcement

CHAPTER 6

CONCLUSIONS

Aluminium Metal matrix hybrid composites reinforced with Al_2O_3 and SiC are fabricated by stir casting technique. Composites are made at three different weight fractions of reinforcements for density, micro structure, tensile test, and compression test and hardness measurement. The micro structural studies revealed that there is a fairly uniform distribution of SiC particles and somewhat non uniform distribution Al_2O_3 in the Al6061 Metal matrix composites.

- The tensile strength has improved with increase in SiC and Al_2O_3 reinforcements.
- The compression strength also increases by increasing SiC and Al_2O_3 reinforcements
- The Density of the material increased with increasing the SiC and Al_2O_3 reinforcements.
- Hardness of the pure Aluminium is up to 80 HB but our composite having more Hardness number.

CHAPTER 7

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