ENCHANCEMENT IN MECHANICAL PROPERTIES OF AA2024-T3/SiC/B_4C COMPOSITE

A Project report submitted

in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

MECHANICAL ENGINEERIN G

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(2018- 2022)

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CERTIFICATE

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ACKNOWLEDGEMENT

We express immensely our deep sense of gratitude to **Ch.Mahesawara Rao**, Assistant Professor, Department of Mechanical Engineering, Anil Neerukonda Institute of Technology & Sciences, Sangivalasa, Bheemunipatnam Mandal, Visakhapatnam district for his valuable guidance and encouragement at every stage of the work made it a successful fulfilment.

We were very thankful to **Prof. T.V. Hanumantha Rao**, Principal, Anil Neerukonda Institute of Technology & Sciences for their valuable suggestions.

We were very thankful to **Dr.B.Naga Raju**, Professor, and Head of the Department, Mechanical Engineering, Anil Neerukonda Institute of Technology & Sciences for his valuable guidance and encouragement at every stage of the work made it a successful fulfilment.

We express our sincere thanks to the members of non-teaching staff of Mechanical Engineering for their kind co-operation and support to carry on work.

Last but not the least, we like to convey our thanks to all who have contributed either directly or indirectly for the completion of our work.

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ABSTRACT

The enhancement of manufacturing sector has somewhere advance to the increase in the use of Aluminium metal matrix composites (AMMCs). AMMCs are attracting considerable interest worldwide for automotive, architectural and aerospace sectors because of their superior mechanical and tribological properties. AMMCs possess high specific strength, greater strength to weight ratio at elevated temperature, greater wear resistance as compared to matrix phase. Numerous types of reinforcements in particulate like SiC, Al2O3, B_4C, TiC and ZrSiO4 is used to improve the metallurgical as well as mechanical properties as compared to its base matrix. Various fabrication processes like solid state (Powder Metallurgy) and liquid state processes (Stir casting, Compo-casting, Squeeze Casting, in situ casting routes) were adopted by authors to fabricate AMMCs. Among these processes stir casting is cheapest and simple route for fabrication of AMMCs. This article elaborates detailed process to fabricate AL2024 as matrix material while B_4C and SiC are reinforcements, using stir casting process.

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INTRODUCTION

INTRODUCTION

1.1 CONCEPT OF COMPOSITES

Composite materials are formed by combining two or more materials that have quite different properties, and they do not dissolve or blend into each other. The different materials in the composite work together to give composite unique properties. The reason for their use over traditional materials is because they improve the properties of their base materials and are applicable in many situations.

Composite materials are formed by combining two material parts or components, referred to as constituents:

- **Reinforcement** material (the load bearing material) - generally stiffer and stronger.
- **Matrix** material (the binding / hold everything together material) - generally less stiff and weaker.

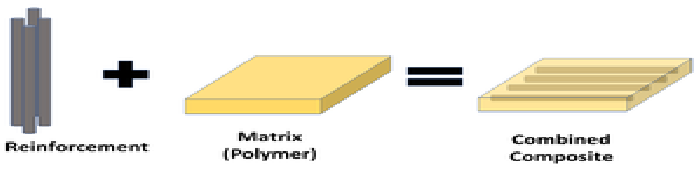


Figure 1.1:Composite material

The matrix holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix. When designed properly, the new combined material exhibits better strength than would each individual material. The many component materials and different processes that can be used make composites extremely versatile and efficient. They typically result in lighter, stronger, more durable solutions compared to traditional materials.

Composites are one of the most widely used materials because of their adaptability to different situations and the relative ease of combination with other materials to serve specific purposes and exhibit desirable properties.

1.2 HISTORY

Humans have used composites for thousands of years. In **3400 B.C** the first man made composites were engineered by the Mesopotamians in Iraq. The ancient society glued wood strips on top of each other at different angles to create plywood. Following this, in around **2181 B.C** the Egyptians started to make death masks out of linen or papyrus soaked in plaster. Later on, both of these societies started to reinforce their materials with straw to strengthen mud bricks, pottery and boats.

In **1200 A.D**, the Mongols began to engineer composite bows which were incredibly effective at the time. These were made out of wood, bamboo, bone, cattle tendons, horn and silk bonded with pine resin.

In the late **1800s**, canoe builders began experimenting with different materials to make paper laminates. They tried gluing layers of kraft paper (sturdy, machine-made paper created from wood pulp) together with shellac.. The first synthetic (man-made) resins that could be converted from liquid to solid (using a chemical process called *polymerization)* were developed between 1870 and 1890. These *polymer resins* are transformed from the liquid state to the solid state by crosslinking the molecules.

In the **1900s** this new-found knowledge about chemicals led to the creation of various plastics such as polyester, phenolic and vinyl. Synthetics then started to be developed, Bakelite was created by the chemist Leo Baekeland. The fact that it did not conduct electricity and was heat resistant meant it could be widely used across many industries.

The **1930s** was an incredibly important time for the advancement of composites. Glass fibre was introduced by Owens Corning who also started the first fibre reinforced polymer (FRP) industry. The resins engineered during this era are still used to this day and, in **1936**, unsaturated polyester resins were patented. Two years later, higher performance resin systems became accessible.

In early **1950's**, manufacturing innovation continued with the developments of pultrusion, vacuum bag molding, and large-scale filament winding. These composites continue to find applications today. Pultrusion is used in the manufacture of linear components such as ladders and moldings. Filament winding is one example of aerospace composite materials.

The first carbon fibre was patented in **1961** and then became commercially available. Then, in the **mid-1990s**, composites were starting to become increasingly common for manufacturing processes and construction due to their relatively cheap cost compared to materials that had been used previously.The composites on a Boeing 787 Dreamliner in the **mid-2000s** substantiated their use for high strength applications.

In future, composites will be manufactured even more according to an integrated design process resulting in the optimum construction according to parameters such as shape, mass, strength, stiffness, durability, costs, etc. Newly developed design tools must be able to instantaneously show customers the influence of a design change on each one of these parameters.

1.3 ADVANTANGES OF COMPOSITE MATERIALS

- **Light Weight:**
  Composites are light in weight compared to most woods and metals. Their lightness is important in automobiles and aircraft, for example, where less weight means better fuel efficiency. Designers of airplanes are greatly concerned with weight, since reducing a craft's weight reduces the amount of fuel it needs, and increases the speeds it can reach.
- **High Strength:**
  Composites can be designed to be far stronger than aluminium or steel. Metals are equally strong in all directions. But composites can be engineered and designed to be strong in a specific direction.
- **Strength Related to Weight:**
  Strength-to-weight ratio is a material's strength in relation to how much it weighs. Some materials are very strong and heavy, such as steel. Other materials can be strong and light, such as bamboo poles. Composite materials can be designed to be both strong and light. This property is why composites are used to build airplane

which need a very high strength material at the lowest possible weight. Composites can be strong without being heavy. Composites have the highest strength-to-weight ratios in structures today.

- **Corrosion Resistance:**

  Composites resist damage from the weather and from harsh chemicals that can eat away at other materials. Composites are good choices where chemicals are handled or stored. Outside, they stand up to severe weather and wide changes in temperature.

- **Design Flexibility:**

  Thermoset Composites give designers nearly unlimited flexibility in designing shapes and forms. They be molded into the most intricate components and can be made a wide range of densities and chemical formulations to have precise performance properties.

- **High-Impact Strength:**

  Composites can be made to absorb impacts—the sudden force of a bullet, for instance, or the blast from an explosion. Because of this property, composites are used in bullet-proof vests and panels, and to shield airplanes, buildings, and military vehicles from explosions.

- **Nonconductive:**

  Composites are nonconductive, meaning they do not conduct electricity. This property makes them suitable for such items as electrical utility poles and the circuit boards in electronics..

1.4 EXAMPLES OF COMPOSITE MATERIALS

Reinforced Concrete:

Concrete has a low tensile strength and is often improved by embedding a structure made from a material with high tensile strength such as steel reinforcing bars, known as rebar. Often used in the foundations of buildings and load bearing walls.

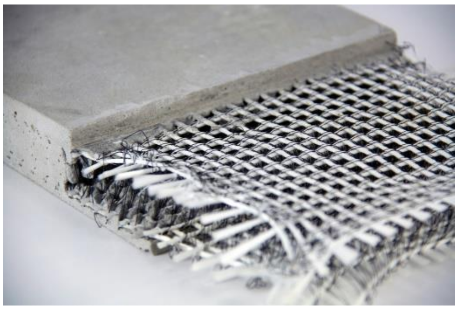


Figure 1.2:Reinforced concrete

Glass Fiber Reinforced Concrete:

Cement poured into a structure of high-strength glass fibers with a high zirconia content. Often used in precast concrete products and exterior facades of buildings to improve the strength of concrete.

Figure 1.3: Glass Fiber reinforced Concrete

Engineered Bamboo:

Bamboo is a wood-like material that is naturally available in hollow cylindrical forms that include regular growth nodes every few inches.Generally speaking, bamboo has higher compressive strength, tensile strength than any wood. As such, it is popular as an engineered product produced with strips of bamboo fiber and glue to form boards.

Figure 1.4: Bamboo pieces

Fiberglass:

A type of material that combines a plastic with glass fiber. Fiber structures may be woven into a fabric or randomly arranged. The result is a relatively inexpensive material that is stronger and more flexible than many metals by weight.

Figure 1.5: Fiberglass Sheet

Plastic Coated Paper:

Paper with a plastic coating as a decorative element or to improve durability. For example, playing cards are often paper coated with a clear plastic.

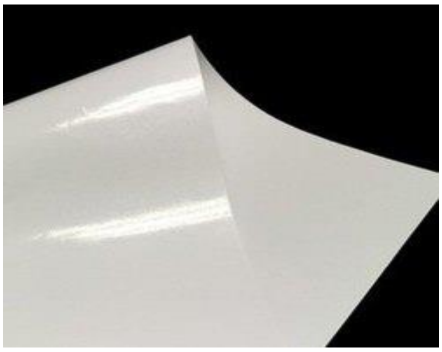


Figure 1.6: Plastic coated paper

Syntactic Foams:

Strong, lightweight materials made by filling metal, plastic or ceramic with hollow spheres known as microballoons. This is often used to great buoyant materials for marine applications such as boat hulls. Syntactic foams are also used in sporting goods such as tennis rackets and soccer balls.

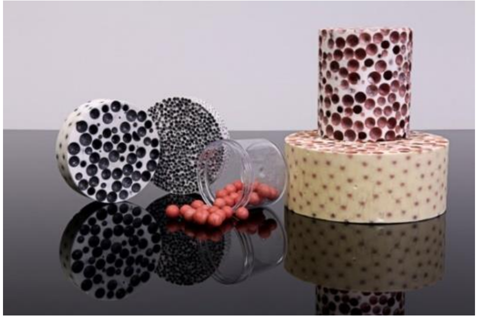


Figure 1.7: Different types of Syntactic Forms

1.5 CLASSIFICATION OF COMPOSITES

The classification of composites is largely based on the materials of the matrix phase and the dispersed phase. In this section, we will classify composites based on matrix material and reinforced material structure.

Classification based on matrix material:

1. Metal Matrix Composites(MMC)
2. Ceramic Matrix Composites(CMC)
3. Polymer Matrix Composites(PMC)

Classification based on reinforced material structure:

1. Particle- reinforced composites
2. Fiber- reinforced composites
3. Structural Composites

1.5.1 METAL MATRIX COMPOSITES

A metal matrix composite system is generally designated simply by the metal alloy designation of the matrix and the material type, volume fraction, and form of the ceramic reinforcement. Metal matrix composites (MMCs) are lightweight structural materials used in a small number of aircraft, helicopters and spacecraft. MMC materials consist of hard reinforcing particles embedded within a metal matrix phase. The matrix of MMCs is usually a low density metal alloy (e.g. aluminium, magnesium or titanium). The metal alloys used in aircraft structures, such as 2024 Al, 7075 Al and Ti–6Al–4 V, are popular matrix materials for many MMCs. Nickel superalloys may be used as the matrix phase in MMCs for high-temperature applications.

The metal matrix phase is strengthened using ceramic or metal oxide in the form of continuous fibres, whiskers or particles. Boron (or borsic, a SiC-coated boron), carbon and silicon carbide (SiC) are often used as continuous fibre reinforcement, and these are distributed through the matrix phase. Silicon carbide, alumina (Al_2O_3) and boron carbide (B_4C) are popular particle reinforcements. The maximum volume content of reinforcement in MMCs is usually below 30%, which is lower than the fibre content of aerospace carbon–epoxy composites (55–65% by volume). Reinforcement contents above about 30% are not often used because of the difficulty in processing, forming and machining of the MMC owing to high hardness and low ductility.

MMCs differ from other composite materials in several ways. Some of these general distinctions are as follows:

- The matrix phase of an MMC is either a pure or alloy metal as opposed to a polymer or ceramic.
- MMCs evidence higher ductility and toughness than ceramics or CMCs, although they have lower ductility and toughness than their respective unreinforced metal matrix alloys.
- The role of the reinforcement in MMCs is to increase strength and modulus as is the case with PMCs. Reinforcement in CMCs is generally to provide improved damage tolerance.
- MMCs have a temperature capability generally higher than polymers and PMCs but less than ceramics and CMCs.
- Low to moderately reinforced MMCs are formable by processes normally associated with unreinforced metals.

MMC Properties and Characteristics:

Metal matrices posses the advantage of being suitable for use in applications requiring a long-term resistance to severe environments over polymeric matrices. It is a fact that the yield strength and modulus of most metals are higher than those for polymers. Another advantage of using metals is that they can be plastically deformed and strengthened by many thermal and mechanical treatments.

The following are some key material properties benefits of MMCs:

- Fire resistant
- Operate in wider range of temperatures

- Do not absorb moisture
- Better electrical and thermal conductivity
- Resistant to radiation damage
- Do not display outgassing
- Light weight
- Good damping and high compression strength
- High specific stiffness and strength.

Applications:

The following are some of the most common application areas of composite metal matrix materials:

- Pushrods for racing engines
- Carbide drills
- Tank armors
- Automotive industry - disc brakes, driveshaft, engine
- Aircraft components - structural component of the jet's landing gear
- Bicycle frames
- Space systems
- High density multi-chip modules in electronics
- Parts in particle accelerators
- Attach plates for high-speed robots

1.5.2 CERAMIC MATRIX COMPOSITES

Ceramic matrix composites are a type of composite with ceramics as both the reinforcement and the matrix material. The reinforcement provides its special properties while the matrix material holds everything together. These composites were developed for applications with demanding thermal and mechanical requirements, such as in aerospace vehicles, nuclear industries, ground transportation, space structures and chemical industries.

Ceramic matrix composites (CMC) are generally made from ceramic fibres or whiskers embedded in a ceramic matrix. These ceramics cover a varied range of inorganic materials that are usually non-metallic and commonly used at high temperatures. Ceramics can be classified into two classes:

- **Traditional or conventional ceramics** – which usually are in monolithic form. They include tiles, bricks, pottery, and a wide range of art materials.
- **Advanced or high-performance ceramics** – which often undergo chemical processing to be derived. These include nitrides, oxides, and carbides of aluminium, silicon, zirconium, and titanium.

Reinforcing materials used for ceramic matrix composites include carbon, alumina, silicon carbide and alumina-silica. The refractory fibre can be in the form of whiskers, particles, long or short fibres, and nano fibres. These fibres have a polycrystalline structure similar to that of conventional ceramics.

The matrix materials used are the same as the reinforcements stated above, with the addition of non-oxide, ultra-high-temperature (UHT) ceramics used for special applications. The advanced ceramics are commonly used in the production of ceramic matrix composites to overcome the main disadvantage of traditional ceramics; namely, their brittleness. The most commonly used CMCs are non-oxide CMCs, such as carbon/silicon carbide (C/SiC), carbon/carbon (C/C), and silicon carbide/silicon carbide (SiC/SiC). Generally, their names follow the fibre material type/matrix material type structure.

Properties of ceramic matrix composites:

Common properties of ceramic matrix composites are:

- High thermal shock and creep resistance
- High temperature resistance
- Excellent resistance to corrosion and wear
- Inertness to aggressive chemicals
- High tensile and compressive strength, thus no sudden failure as compared to conventional ceramics
- Increased fracture toughness due to reinforcement
- Lightweight due to reduced density

Applications of ceramic matrix composites:

Common applications of ceramic matrix composites are:

- Heat exchangers and burner components
- Gas turbine components
- Aerospace industry
- Engine exhaust systems
- Hypersonic vehicles
- Nuclear power industry

1.5.3 POLYMER MATRIX COMPOSITES

Polymer matrix composites are materials made up of fibres that are embedded in an organic polymer matrix. These fibres are introduced to enhance selected properties of the material. Polymer matrix composites (PMCs) are present in almost all aspects of modern life - from gadget components to a vast selection of automotive accessories. Derived from its name, meaning many repeating units, polymers are often made up of branches of carbon and hydrogen chemically linked together to make a chain.

Polymers that are often used as composites are either thermoplastic polymers, thermosetting polymers or elastomers. They are a source of a wide variety of low-priced, raw materials which offer many advantages.

Polymer matrix composites are classified based on their level of strength and stiffness into two distinct types:

- **Reinforced plastics** - confers additional strength by adding embedded fibrous matter into plastics.
- **Advanced Composites** - consists of fibre and matrix combinations that facilitate strength and superior stiffness. They mostly contain high-performance continuous fibres such as high-stiffness glass (S-glass), graphite, aramid, or other organic fibres.

Properties of Polymer Matrix Composites:

Common properties of polymer matrix composites are:

- Good corrosion resistance
- Light weight

- Good abrasion resistance
- High strength along the direction of their reinforcements
- High Stiffness

Applications:

PMCs are regarded due to their low cost and straightforward fabrication methods.

Applications for PMCs include:

- Automotive industry
- Aircraft and aerospace industry
- Sports goods
- Biomedical applications
- Electrical equipment.

1.5.4 FIBER REINFORCED COMPOSITES

Common fiber reinforced composites are composed of fibers and a matrix. Fibers are the reinforcement and the main source of strength while the matrix glues all the fibers together in shape and transfers stresses between the reinforcing fibers. Sometimes, fillers or modifiers might be added to smooth manufacturing process, impart special properties, and/or reduce product cost.

The primary functions of the matrix are to transfer stresses between the reinforcing fibers (hold fibers together) and protect the fibers from mechanical and/or environmental damages. A basic requirement for a matrix material is that its strain at break must be larger than the fibers it is holding. Most matrices are made of resins for their wide variation in properties and relatively low cost.

Fiber-reinforced composites provide improved mechanical properties such as strength, strength-to-weight ratio. It incorporates strong, stiff but brittle fibers into a softer, ductile matrix. The matrix acts as a medium to transfer the load to the fibers that do the majority of heavy lifting.

They are further classified as either **continuous** or **discontinuous fibers.**

Continuous fiber reinforced composites:

In continuous fiber composites, the length of the fibers can vary from a few feet to several thousand feet long. A large advantage is that by allowing a uniform orientation of the raw composite fiber, important design criteria (strength, Y-modulus, CTE) can be enhanced and customized.

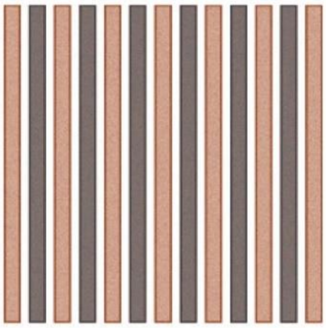


Figure 1.8:Continuous Fibers

As a whole, continuous fiber composites tend to be more expensive than their short, discontinuous fiber counterpart. But it makes up for it by providing significantly improved performance.

Discontinuous fiber reinforced composites:

This sub-division of composites is further broken down into two sub-sub-divisions. They are discontinuous aligned fibers and discontinuous randomly oriented fibers.

1. **Discontinuous aligned fiber composites** have shorter lengths of highly condensed fibers aligned in one fixed direction in a matrix. They can demonstrate mechanical properties comparable to those of unidirectional continuous fiber composites. But the shorter fibers result in diminished ductility of the composite, making them ideal for high-strength, low ductility applications.

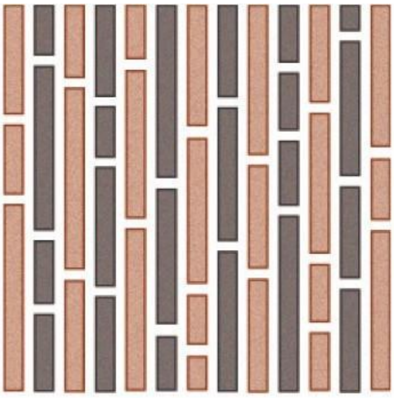


Figure 1.9: Discontinous aligned Fibers

2. **Discontinuous randomly-aligned fiber composites** are made up of short, condensed fibers embedded in all directions of a matrix. Aligned fiber composites

have heightened mechanical properties in only the direction of the reinforcement. This anisotropy can be avoided by randomly embedding the fibers equally in all directions of the matrix. While this may result in decreased peak strength, it provides increased formability at a reduced cost.

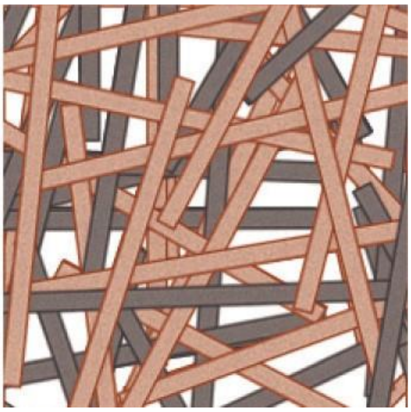


Figure 1.10: Discotinous randomly aligned fibers

Properties of fiber reinforced composites:

- High durability
- Light weight
- Exceptional corrosion resistance
- Cost effective manufacturing

1.5.5 STRUCTURAL COMPOSITES

Structural composites are a special class of composites. Their properties depend not just on those of the constituents but also the geometrical design of various structural elements. Two classes of widely used structural composites are

- laminar composites and
- sandwich composites.

Laminar Composites:

Laminar composites are composed of two-dimensional sheets/layers that have a preferred strength direction. According to specific needs, these layers are stacked and cemented together. Materials like metal sheets, cotton, paper, and woven glass or carbon fibers are embedded in a plastic matrix. Thin coatings, thicker protective coatings, claddings, bimetallic, and laminates are some examples of Laminar composites.

The laminated structure is visible by the naked eye, unlike other matrix-reinforcement composites.

Honeycomb and foam structures are the sub-groups of laminar structure composites. In foam structure, the core thick layer is produced from thermoset foams and other layers are added on both sides of the core foam layer to obtain a stiff and strong material. With this technique, very good materials are produced in terms of strength/weight ratio.

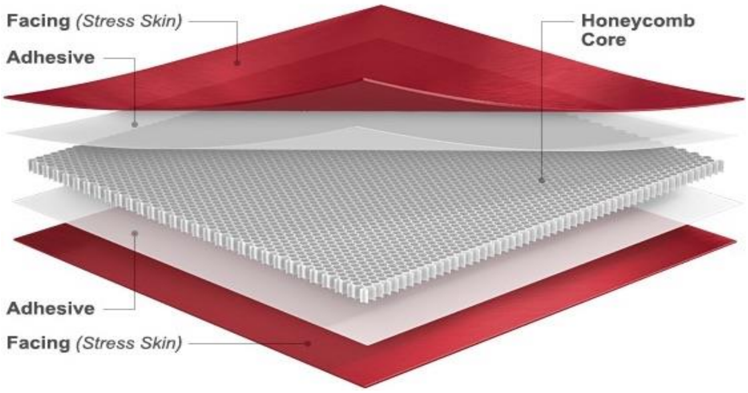


Figure 1.11:Honeycomb structure composites

The logic of honeycomb structure is like foam structure composites in which the core of the material is produced from honeycomb-shaped materials. Layers have added both sides of honeycomb structures to obtain a sandwich shape, in which the strength-to-weight ratio is very important.

Figure 1.12:Foam structure composites

Foam is most frequently used as structural core material for composite laminates, delivering added strength, stiffness, and insulation, without adding weight. Generally, it is easy to handle, readily conforms to shapes, and can be bonded in layers to add thickness.

Sandwich Composites:

A structural sandwich is a special form of a laminated composite comprising a combination of different materials that are bonded to each other so as to utilize the properties of each separate component to the structural advantage of the whole assembly. Typically a sandwich composite consists of three main parts; two thin, stiff and strong faces separated by a thick, light and weaker core. The faces are adhesively bonded to the core to obtain a load transfer between the components.

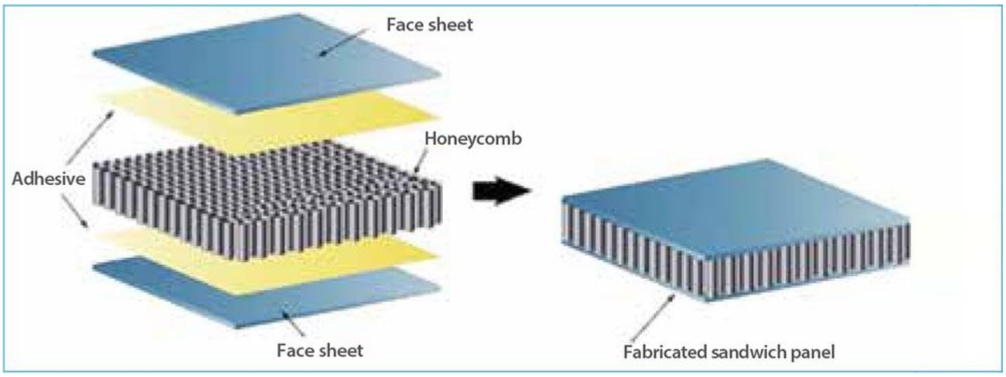


Figure 1.13: Sandwhich Composites

The design principle of a sandwich composite is based on an I-beam, which is an efficient structural shape because as much as possible of the material is placed in the flanges situated farthest from the center of bending or neutral axis. Only enough material is left in the connecting web to make the flanges act in concert and to resist shear and buckling loads. In a sandwich, the faces take the place of the flanges and the core takes the place of the web. The difference is that the core of a sandwich is of a different material from the faces and it is spread out as a continuous support for the faces rather than concentrated in narrow web. The faces act together to form an efficient stress couple or resisting moment counteracting the external bending moment. The core resists shear and stabilize the faces against buckling or wrinkling. The bond between the faces and the core must be strong enough to resist the shear and tensile stresses set up between them. The adhesive that bonds the faces to the core is of critical importance.

1.5.6 PARTICLE-REINFORCED COMPOSITES:

Particle composites consist of particles of one material dispersed in a matrix of a second material. Particles may have any shape or size, but are generally spherical, ellipsoidal, polyhedral, or irregular in shape. They may be added to a liquid matrix that later solidifies; grown in place by a reaction such as agehardening; or they may be pressed together and then inter-diffused via a powder process. The particles may be treated to be made compatible with the matrix, or they may be incorporated without such treatment. Particles are most often used to extend the strength or other properties of inexpensive materials by the addition of other materials.

These are one of the most widely used classes of composite structures due to their ease of availability while being economical. They can be further distinguished based on the strengthening mechanism—**particulate and dispersion-strengthened.**

Dispersion strengthened:

In this case, the size of the particles is comparatively smaller, ranging from 0.01 to 0.1 um. Dispersion strengthened composites have much smaller particle sizes whose interactions with the matrix can be seen at the molecular level. These particle-matrix interactions at the molecular level increase the overall strength of the composite. The small particles also resist dislocation motion throughout the composite in a similar manner to the pinning of precipitate hardened metals.

Examples: Thoria (ThO2) dispersed Nickel alloys have high-temperature strength. Sintered Aluminium Powder (SAP)—where minute flakes of alumina are dispersed on an aluminum matrix.

Particulate:

A particulate composite is characterized as being composed of particles suspended in a matrix. Particles can have virtually any shape, size or configuration. This class of composite contains relatively large amounts of coarse particles. They are often designed to produce unusual combinations of properties rather than necessarily improve them. They can be used with all three matrix types—MMC, CMC, and PMC.

Examples of well-known particulate composites are concrete and particle board.

There are two subclasses of particulates: **flake and filled/skeletal:**

Flake: A flake composite is generally composed of flakes with large ratios of platform area to thickness, suspended in a matrix material (particle board, for example).

Filled/Skeletal: A filled/skeletal composite is composed of a continuous skeletal matrix filled by a second material: for example, a honeycomb core filled with an insulating material.

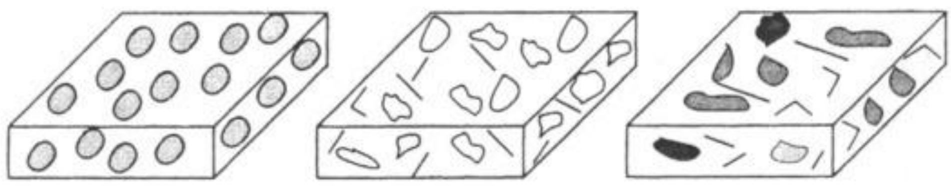


Figure 1.14: Different types of particulates

The response of a particulate composite can be either anisotropic or orthotropic. Such composites are used for many applications in which strength is not a significant component of the design

CHAPTER 2

LITERATURE SURVEY

LITERATURE SURVEY

Ashish Kumar et al. [1] expressed that the need of light weighted materials has led to the use of composites like aluminium (Al) metal matrix composites (AMMCs) for advanced material performance. These days the AMMCs have been considered as the most potential candidate for structural and functional applications. AMMCs composite materials are used in marine, defence, automotive, aerospace, and heat prone areas. Stir casting method is prominent technique for developing metal matrix composites (MMCs) due to its easiness and production at reasonable price with bulk manufacturing competency. The review article contains substantial aspects of stir casting route like; mechanical properties, effect of various reinforcement, various challenges and future research potential in the development of composites.

Divya Chandra et al. [2] expressed that the composite materials have many unique properties which are mostly conventional materials that usually do not comprise. One of these properties is the better volume to weight ratio which is very useful for designing of components of aircrafts, automobiles, domestic appliances and electronic devices. However some challenges occur in this development because of different phases of matrix material and reinforcement materials. Here they had studied, three different aluminium based metal matrix composites that have been developed by varying the percentage of matrix (Al6063) and reinforcement (flyash and Al_2O_3) materials by using stir casting method where the hardness and toughness have been determined. Result showed that the contribution of Al_2O_3 particles played an important role in increasing the hardness of composite material.

N. Subramani et al. [3] expressed that the advanced technology in material science have aided within the discovery and fabrication of recent materials that may be accustomed replace existing materials during a range of applications. Here they had studied to match and characterize the ready MMC of Al 6061 and Al 2024 with the chosen reinforcing materials. The reinforcing material used here are B_4C, SiCp and Graphite within the sort of particles. Addition of varied reinforcements like SiCp, B_4C and graphite to Al matrix can enhance the mechanical and tribological properties. The casting is finished and exploited. The stir casting technique and also the mechanical properties of the MMCs with the

(ASTM E10/2018) standard's are compared with the pure Al6061 and Al 2024. Tensile, hardness, and wear resistance of metallic element metal matrix composites is investigated.

S. Arun Kumar et al. [4] expressed that the aluminium 7075 alloy was reinforced with silicon nitride (Si_3N_4) in the range of 4%, 8% and 12% were fabricated using stir casting route. Casted specimens are heat-treated at various conditions to eliminate the Porosity and X-ray computed tomography and image analyzer techniques were used to measure the Porosity in casting. Further, the casted specimens were tested for chemical composition using Spectro analysis; micro image and micro-hardness are conducted. Dispersion of Si_3N_4 in Al alloy was observed using a scanning electron microscope.

Sabitha Jannet et al. [5] expressed that the AMMC has gained enormous attention in the field of material science. This study is about an eggshell powder which is used as a reinforcement and AA 2024 as the matrix to obtain an AMMC. The use of naturally available resources as reinforcement is being explored to reduce the cost of composites. 7%, 10%, 13% wt percentage of egg shell powder was used to fabricate three different composites. Mechanical characteristics like Tensile strength, hardness, compression strength have been evaluated. The FESEM analysis was carried out to examine the distribution of the reinforcement in the matrix.

M. Ramachandra et al. [6] expressed that in this study, mechanical and corrosion behaviour of aluminium 2024 (Al-2024) alloy reinforced with varying weight percentage (0, 2, 4 and 6%) of ZrO_2 nanoparticles have been investigated. The composite was prepared through stir casting route. The composite samples were subjected to indentation measurement. The electrochemical polarization test was carried out in 3.5% NaCl solution (seawater environment) to evaluate the corrosion resistance of the composites in comparison with alloy. This is increased in a seawater environment due to the addition of ZrO_2 nanoparticles. The corrosion morphology of the samples after corrosion was examined using the scanning electron microscope.

Abhishek Kumar et al. [7] expressed that an MMC is a composite material with at least two constituent parts, one being a metal, other may be another material, such as a ceramic or organic compound. Recently, aluminum and its alloy based cast MMCs are more popular in all the fields of engineering and technology because of their excellent properties. The desired properties are influenced by the solidification behavior of the cast MMCs. This paper had aimed to investigate the best possible predicted results and to carry out the experimental set up of electromagnetic stir casting process in composite materials. It showed significant effect of the mechanical properties such as hardness and tensile strength, and analyzed the microstructure of A359/Al_2O_3.

G. Praveen et al. [8] expressed that an aluminum composites have various demanding fields such as medicine, dental and engineering applications like piston rings, cylindrical blocks . These typically obtain very good mechanical properties with microparticulate reinforcements, ductility decreases with the percentage increase in reinforcements. Microparticles with a lower weight fraction increases the strength of the matrix and retain ductility relative to microparticulate composites. The efficiency of mechanical properties has been significantly improved by the help of ceramic reinforcements such as Al_2O_3, SiC. This paper undertakes the proper research into aluminum alloy wear behavior (Al-6061/Al-2024/Al-7075) which are stir cast by ceramic reinforcements such as Al_2O_3/SiC.

F. Arslan et al. [9] expressed that in this study, metal matrix composites of an aluminum alloy (AA2024) and B4C particles with volume fractions 3, 5, 7, and 10 vol% and with sizes 29 and 71 m were produced using stir-casting technique. The effects of B4C particle content and size of boron carbide on the mechanical properties of the composites such as hardness, 0.2% yield strength, tensile strength, and fracture were investigated. Furthermore, the relation between particle content, microstructure, and particle distribution has been investigated. The hardness of the composites increased with increasing particle volume fraction and with decreasing particle size, although the tensile strength of the composites decreased with increasing particle volume fraction and with decreasing particle size. Scanning electron microscopic observations of the microstructures revealed that dispersion of the coarser sizes of B4C particles was more uniform while the finer particles led to agglomeration of the particles and porosity.

R.P. Swamy et al. [10] expressed that their paper deals through to fabricate Hybrid Composite by heating Al 2024 in furnace at a temperature of around 4000 C. E-Glass fiber & Fly ash will be added to the molten metal with changing weight fractions and stirred strongly. Then the ensuing composition will poured into the mould to obtain hybrid composite casting. Aluminium alloy (2024) is the matrix metal used in the present investigation. Fly ash and e-glass are used as the reinforced materials to produce the composite by stir casting. Fly ash is selected because of it is less expensive and low density reinforcement available in great quantities as solid disposal from thermal power plants. The Test specimen is prepared as per ASTM standards size by machining operations to conduct Tensile, Compression, Hardness, and wear test. The test specimens are furnished for tensile, compression strength and wear as per ASTM standard E8, E9 and G99 respectively using Universal Testing Machine and pin on disk machine. It is seen that the fabricated MMC obtained has got enhanced mechanical strength.

Ashok N. et al. [11] expressed that Al 8011-SiC composites were produced with reinforcement of three different particle sizes of SiC and with different weight fractions (2, 4, and 6%) by the stir casting method. The mechanical properties of the Al8011-SiC composites due to the effect of particle size and different weight fraction of SiC is reported in this paper. Anova (Analysis of variance) and Taguchi method were used to find the optimum parameters for attaining the maximum mechanical properties such as hardness, tensile strength, elongation and toughness of the composites and the results were endorsed by confirmation test. From the result it is observed that with the decrease in particle size and increase in weight fraction of SiC the mechanical properties of the composites increased. Fine particles of SiC (63ìm) exhibit superior hardness, tensile strength, elongation and toughness than the intermediate (76ìm) and coarse particles (89ìm). Al 8011-6wt. %SiC exhibit superior hardness and tensile strength and Al8011-2wt.%SiC exhibit superior elongation and toughness of the composites. Particle size is the most prevailing factor followed by the amount of reinforcement inducing mechanical properties of the composites.

Muralidhar Patel et al. [12] expressed that Al or Al alloy Metal Matrix Composites have wide range of applications i.e. aerospace, automobile etc. due to its lightweight, high tensile strength, high wear resistance. This review paper characterized the SiC particulate reinforced Al Metal Matrix Composites. The SiC particulates are dispersed in Al or Al alloy by liquid state processing route and solid-state processing route. Stir casting liquid processing route has been followed by no. of researchers due to its simplicity and low processing cost and at the time of reinforcement small amount of Mg is added to increase the wettability of SiC in molten Al or Al alloy. When Al or Al alloy reinforced with SiC, then its mechanical and tribological properties are enhanced. The effect of particle size, weight or volume fraction of the SiC on density, porosity, hardness, impact toughness, tensile strength, ductility, sliding wear resistance, slurry erosion resistance, erosion-corrosion resistance, corrosion resistance and fatigue strength of Al or Al alloy MMCs are reported. The effect of extrusion and machinability of the SiC particulate reinforced Al MMCs are also discussed in this review article.

M. Mahendra Boopathi et al. [13] expressed that the present study was aimed at evaluating the physical properties of Aluminium 2024 in the presence of silicon carbide, fly ash and its combinations. In this experimentation stir casting method is used for the fabrication of AMMC. Structural characterization was carried out on metal matrix composites by x-ray diffraction studies and optical microscopy was used for the micro structural studies. The mechanical behaviors of metal matrix composites like density, tensile strength, yield strength, elongation and hardness tests were ascertained by performing carefully designed laboratory experiments that replicate as nearly as possible the service conditions. It was fairly observed that the density of the composites was decreased and the hardness was increased. Correspondingly, the increase in tensile strength was also observed but elongation of the hybrid metal matrix composites in comparison with unreinforced aluminium was decreased. The aluminium-SiC-fly ash hybrid metal matrix composites significantly differed in all of the properties measured.

K. Praveen Kumar et al. [14] expressed that the work has been carried out to produce composites with high strength and good ductility by maximizing a uniform and smooth interface for effective transfer of load and minimizing reinforcement agglomerations/cracking/pull outs. High strength, high entropy alloy (ternary) in particulate (HEAp) form was used as reinforcement in 2024 aluminium. AA 2024-HEAp composite was prepared through stir cast route by dispersing an average particle size of 125 μm as reinforcement with various weight fractions varying between 5% and 15%. Subsequently, billets were hot extruded to 14 mm Ø rods. All the extrudates were thoroughly homogenized with industrial furnace at 100 °C for 24 h. The mechanical behaviour of alloy and composites was studied in terms of resistivity, hardness, and tensile studies. An increment of 62% in hardness has been observed. Increased reinforcement contents enhance the mechanical properties such as yield strength, tensile strength and Young's modulus.

A.K. Mohamed at el. [15] expressed that this study uses the stir-casting technique to combine a semi-solid AA2024 alloy directly with finely-sized β-SiC_p embedded as a powder or with mechanically alloyed granules as a delivery agent. Liquid-state primary fabrication tends to form agglomerates of reinforcement particles, whereas rolling better distributes the composite constituents. Sub-micron reinforcements of low volume fractions do not significantly increase the hardness of the composite materials. Uniaxial tensile testing at elevated temperatures over a wide range of strain rates showed simultaneous increases in the ductility and crack resistance of AA2024 + SiC_p granules embedded as a powder when compared to the non-reinforced control material at lower strain rates, with the same toughness as the control material. The maximum engineering strain of 252.7 ± 19.2% was observed in AA2024/SiC_p at a strain rate of 10^{-4} s^{-1}. This improvement in properties is attributed to grain refinement in the MMCs, leading to pinning events during the straining and ductility increases. The resultant impediments to grain growth and crack propagation allow the fine-sized reinforcements to control dynamic microstructural changes during fatigue. Cube {001}<100> is a dominant texture component in AA2024, whereas the Goss {011}<100> and S {123}<634> components mainly represent the texture of the discontinuously reinforced aluminum matrix.

R. Rajesh at el. [16] expressed that recently, a rapid boom occurred in research and improvements in the aluminum metal matrix composites (AMMCs) area. The Attention is required due to the gains of good mechanical properties and helps their potential across an extensive range of precision and high-end applications.. The review objectives are to provide an outline of the causes that affect the mechanical properties of aluminium 6061 MMCs fabricated through stir casting route and details achievements made with them. The percentage weight of reinforcement particles, preheat temperature and melting temperature will cause the mechanical properties of composites. The selection of reinforcement material and different stir casting parameters are the challenges faced during the fabrication of new materials without compromising its mechanical properties.

Henifi at el. [17] expressed that in the present study, Al2024 alloy powder (Al–Cu–Mg), frequently used in modern technology, reinforced with B_4C, SiC and Al_2O_3 particles were used to produce hybrid composite. Pre-alloyed Al2024 powder and B_4C, SiC, Al_2O_3 reinforcement components were mixed in a three dimensional mixer for 45 min. Mixed powders were compacted at 400 MPa under unidirectional press for the production of powder metal block. These block samples were sintered at 600 °C and then extruded at 500 °C. After then samples were cut with wire erosion method to ensure the appropriate standard dimension for transverse rupture strength tests. Transverse rupture strength and hardness values were determined depending on the type of the reinforcing components. In the study, maximum transverse rupture strength (920 MPa) and hardness value (104 HB) were obtained at Al2024 + 10 % wt B_4C samples. On the other hand, the highest transverse rupture strength (901 MPa) and hardness (98 HB) in hybrid composite materials were obtained at Al2024 + B_4C/SiC samples.

Talha Sunar at el. [18] expressed that in this study, a specific method which is a combination of stir casting and space holder techniques were used to produce open-celled A360 aluminium-B_4C composite foams with regular sized and distributed pores. Weight ratios of reinforcement particles determined as 0.5, 1, 1.5 and 2%. The influences of particle reinforcement on the microstructure and the mechanical behaviour of composite foams were investigated. Microstructures were analysed with optical microscope (OM), scanning electron microscope (SEM). Compression and hardness tests were carried out to observe the effects of reinforcement on mechanical properties. Compression strength properties and hardness of composites increased with the ceramic reinforcement, however the plastic strength of the composite foams showed worsening trend after a certain reinforcement ratio (0.5 wt.%). Energy absorption properties of the composite foams showed parallel trends with compressive strength properties.

Poonam Yadav et al. [19] expressed that an aluminium metal matrix composites (AMMCs), with various reinforcements such as continuous/discontinuous fibers, whiskers, and particulates, have captured the attention due to their superior tribological, mechanical, and micro structural characteristics as compared to bare Al alloy. AMMCs have undergone extensive research and development with different reinforcements in order to obtain the materials with the desired characteristics. In this paper, we present a review on AMMCs produced through stir casting routes. This review focuses on the following aspects: (i) different reinforcing materials in AMMCs; (ii) micro structural study of reinforced metal matrix composites (MMCs) through stir casting. Both reinforcing micro- and nano particles are focused. Micro- and nano reinforced AMMCs have the attractive properties of combination such as the low-weight-to-high-strength rate and, low density; (iii) various tribological and mechanical properties with the consideration of different input parameters; (iv) outlook and perspective.

H. S. Kumaraswamy at el. [20] expressed that a lot of research has taken place in AMC with addition of reinforcements to aluminum like boron carbide, alumina (Al2O3), Silicon carbide(SiC) and fly ash etc. Present review was carried out to bring out the latest developments taken place in AMCs and effect of reinforcements. Influence of mechanical & tribological behavior of aluminum matrix composite has been covered. This study is focused on Al2024 alloy due to commercial easy available and it's widely used for structural purpose in manufacturing sectors. From the present work, it is clearly observed that lot of research has been carried out on addition of alumina, silicon carbide, boron carbide and fly ash to improve the hardness, tensile, yield strength, wear resistance, machinability, good abrasion resistance, high creep resistance, very good dimensional stability, very good stiffness-to weight ratio, strength-weight ratios and enhanced high temperature performance. Making (fabrication) of these advanced engineering materials through stir casting is considered in the present paper.

Ulhas K. at el. [21] expressed that the present review is on the method employed in stir casting such as, how the base metal is melted, at what temperature and state it is to be maintained, what conditions the particulates are added and how the stirring time and stirring speed affect the final composite material. The effect of stirrer design and feeding mechanism has also been discussed. The variation in the type of mixing the particulates into the metal matrix has also been dealt with in the paper. In the introductory part the stir casting methodology with a diagram has been laid out to give an overview of the overall process of casting of metal matrix composites. The limitations of the process are also listed in the paper.

Farooq Muhammad at el. [22] expressed that the researchers employed a hybrid method to optimize the stir casting parameters. The vast number of parameters and their overlap affects the uniform distribution of reinforcement particles. Investigators on their way to the best technique have gotten promising outcomes in their specific situations, but they still need more work to be able to generalize their findings to optimize the stirrer design to get efficient mixing. Due to an experimental technique alone is insufficient for optimizing stir casting parameters, researchers combined theoretical, experimental, statistical, and numerical simulation approaches to get more precise and reliable findings. The design of the experiment (DOE), particularly Taguchi, and other standard statistics such as ANOVA and regression were discovered to be the most often utilized statistical contributions. Recent attempts to simulate stir casting have begun to match the experimental or analog model data by developed numerical software and analytical analysis. Finally, previous study results and suggestions were collected and compared, arranged, revised, and presented simply about the proper stirrer design, stages, and position in that to make the paper unique.

CHAPTER 3

EXPERIMENTAL DETAILS

EXPERIMENTAL DETAILS

3.1 SELECTION OF MATERIAL

The matrix material utilized in the current study is AA2024-T3. 2024 aluminium alloy is an aluminium alloy, with copper as the primary alloying element. It is used in applications requiring high strength to weight ratio, as well as good fatigue resistance. It is weldable only through friction welding, and has average machinability. In older systems of terminology, 2XXX series alloys were known as duralumin. T3 represents that alloy has been furnace solution heat treated, quenched to room temperature, and cold worked. Due to its high strength and fatigue resistance, 2024 is widely used in aircraft, especially wing and fuselage structures under tension. Additionally, since the material is susceptible to thermal shock, 2024 is used in qualification of liquid penetrant tests outside of normal temperature ranges.

Applications of AA2024-T3:It is typically used in

- Truck and Marine components
- Furniture
- Aircraft structural elements such as fuselage and wing structures that carry tension forces
- Pipelines
- Military devices and parts
- Rail road cars
- Tank fittings

Table 3.1 AA2024-T3 Chemical Composition

Elements	Cu	Mg	Si	Fe	Mn	Cr	Zn
Wt %	4.4	1.5	0.5	0.5	0.6	0.1	0.25

Table 3.2 AA2024-T3 Mechanical Properties

Base Material	Al 6061
Density value	2.78 g/cc
Young's modulus value	73.1Gpa
Ultimate Tensile strength value	483Mpa
Elongation at break value	18%
Poisson's ratio value	0.33
Melting temperature value	502 - 638 °C
Thermal conductivity value	121 W/(m-k)
Hardness,Vickers	137

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.

Figure 3.1 SiC Powder

Table: 3.3 Chemical Composition of SiC

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

Table 3.4: Mechanical Properties of SiC

Density	3.1 g/cm^3
Elastic modulus	410 GPa
Poisson's ratio	0.14
Compressive strength	3900 MPa
Hardness	2800 Kg/mm^2

Applications of SiC: It is typically used in

- Fixed and moving turbine components
- Suction box covers
- Seals, bearings
- Ball valve parts
- Hot gas flow liners
- Heat exchangers
- Semiconductor process equipment

3.2.2 Boron Carbide

Boron carbide, (B_4C), crystalline compound of boron and carbon. It is an extremely hard, synthetically produced material that is used in abrasive and wear-resistant products, in lightweight composite materials, and in control rods for nuclear power generation. With a Mohs hardness between 9 and 10, boron carbide is one of the hardest synthetic substances known, being exceeded only by cubic boron nitride and diamond.

Boron carbide is produced by reducing boron oxide with carbon at high temperatures in an electric furnace. After grinding, the black powder is solidified by pressing at temperatures exceeding 2000^oC. Because of its hardness, together with its very low density, it has found application as a reinforcing agent for aluminum in military armour and high-performance bicycles, and its wear resistance has caused it to be employed in sandblasting nozzles and pump seals.

Application of B_4C: It is typically used in

- Mechanical Seal faces
- Blasting Nozzles
- Neutron absorption materials
- Cutting tools and dies
- In brake linings of vehicles

Figure 3.2:B_4C Powder

Table 3.4: Chemical Composition of B_4C

Element	B	C	Ca	Fe	Si	F	Cl
%	80.0	18.1	0.3	1.0	0.5	0.025	0.075

Table 3.5: Properties of B_4C

Density	2.52 g/cm^3.
Hardness	2900 - 3580Kg / mm^2
Young's Modulus	450 - 470 GPa
Ultimate Tensile Strength	500 MPa
Poisson’s Ratio	0.18

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.

Figure 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 3000 °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.

Figure 3.4: Electric Arc Furnace

3.5 FABRICATION AND METHADOLOGY

3.5.1 PRE-HEATING:

Preheating of Reinforcement should be done in order to remove agglomeration, moisture and gases presented in it SIC and B4C are pre heated in Muffle Furnace at a temperature of 250^{o}C before using.

Figure 3.5:Muffle Furnace

Figure 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.

Figure 3.7:Stir Casting Furnace

The Aluminium 2024 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-2024 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.

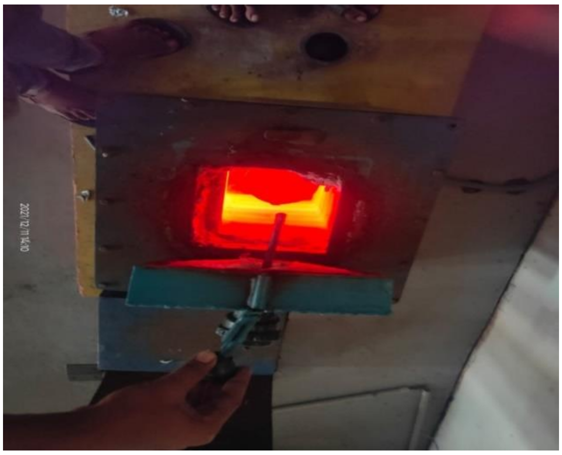


Figure 3.8:Al 2024 in Crucible

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.

Figure 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.

Figure 3.10:Pouring the Molten Liquid into the 6 Finger Die

CHAPTER 4

TESTING TOOLS AND MACHINES

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 figure 4.1.

Figure 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.

Figure 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

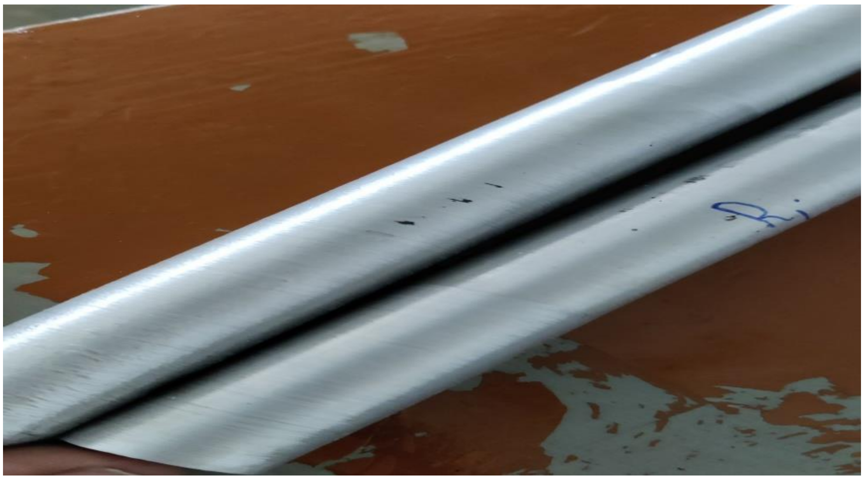


Figure 4.3: After Machining

4.2 TESTS CONDUCTED

- Density
- Tensile
- Compression
- Hardness
- Impact
- Micro Structure

4.2.1 DENSITY TEST

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.

Density is nothing but the ratio of mass to the volume. The density is measured by taking the ratio of weight of specimen in air to the loss of weight in water.

Figure 4.4: Digital weighing Machine

Figure 4.5: Density specimens

4.2.2 TENSILE TEST

Tensile testing, also known as tension testing, is a fundamental material 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.

The Tensile test which is conducted on a universal testing machine at room temperature is a common method to evaluate strength and ductility under static load conditions. The tensile test is carried out by loading a standard specimen gripped at both ends and measuring the resultant elongation of the specimens at various increments of loads.

Figure 4.6:Tensile pieces after machining

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.

Figure 4.7: Universal test machine (UTM)

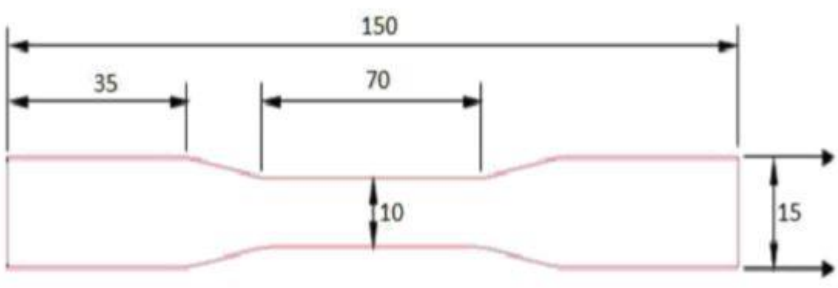


Figure 4.8: Tensile test specimen (ASTM-E08 Standard)

Figure 4.9: Tensile test specimen after testing

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.

.

Figure 4.10: Universal Testing Machine (UTM)

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.

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). Generally, we use UTM for compression test

Figure 4.11: Compression pieces after machining

Figure 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.

The basic principle, as with all common measures of hardness, is to observe materials ability to resist plastic deformation from a standard source. The Vickers test can be used for all metals and has one of the widest scales among hardness test.

The unit of hardness given by test is known as the Vickers Pyramid Number (HV) or Diamond Pyramid Hardness (DPH).The hardness number can be converted into unit pascals, but should not confused with pressure, which uses the same units. The hardness number is determined by the load over the surface area of the indentation and not the area normal to the force, and is therefore not pressure.

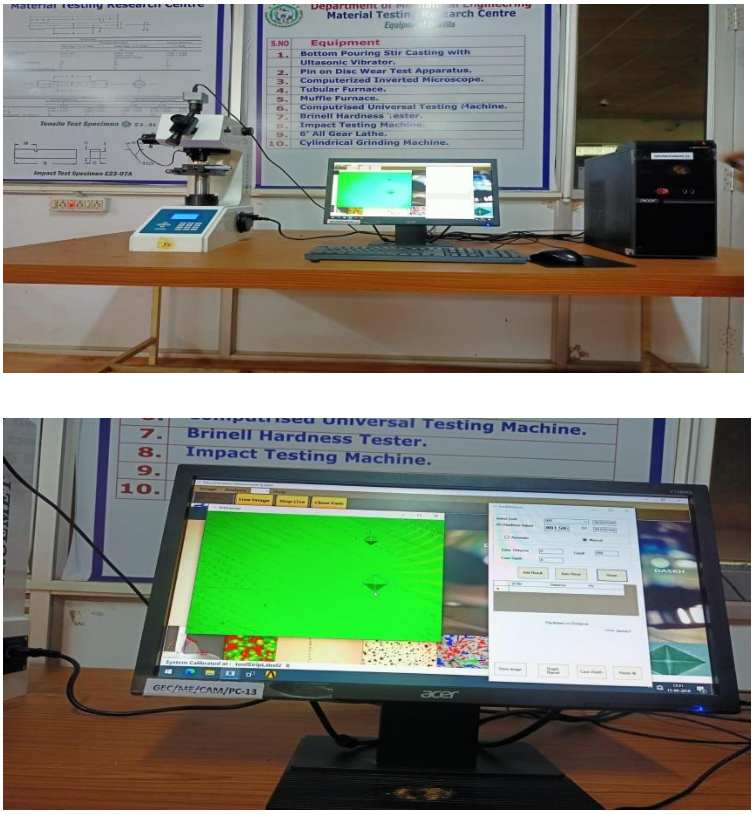


Figure 4.13: Vickers hardness testing machine

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.

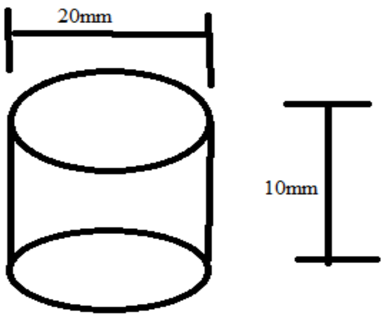


Figure 4.14: Hardness test specimen dimensions

Figure 4.15: Hardness test specimen after testing

4.2.5 IMPACT TEST

The impact is a method for evaluating the toughness, impact strength and notch sensitivity of engineering materials**.** In material science, the Charpy impact test, also known as the Charpy V-notch test, is a standardized high strain rate test which determines the amount of energy absorbed by a material during fracture. Absorbed energy is a measure of the material's notch toughness. It is widely used in industry, since it is easy to prepare and conduct and results can be obtained quickly and cheaply.

The machine consists of a swinging pendulum that has an arm and head. For this test the dimensions of standard specimen are 55 mm x 10 mm x 10mm. It is a simple supported beam. Swinging Head strikes other side of the specimen notch. Pendulum falls from 1.457 m height or from an angle of 1400. The weight swinging hammer is 20.932 kg or 250 N. The specimen struck exactly at its centre i.e. 27.5mm. The machine also has a pedal operated brake, to stop the hammer after the specimen is struck.

Figure 4.16: Impact testing machine

Figure 4.17: Test specimen before testing

Figure 4.18: Test specimen after testing

4.2.6 MICRO STRUCTURE TEST

Microstructural examination is generally performed using optical or scanning electron microscopes to magnify features of the material under analysis. The amount or size of these features can be measured and quantified, and compared to acceptance criteria.

Microstructural evaluation ranges from simple determination of certain parameters such as grain size or coating thickness through porosity and pore structure to full characterization of multi-component systems or evaluation of degradation or failure mechanisms.

Microstructure is the very small-scale structure of a material, defined as the structure of a prepared surface of material as revealed by a microscope above 25x magnification. The microstructure of a material can strongly influences physical properties such as strength, toughness, ductility, hardness, corrosion resistance, high/low temperature behavior or wear resistance. The testing process is going to done with Computer Aided Microscope.

Figure 4.19: Computerised Metallurgical Microscope

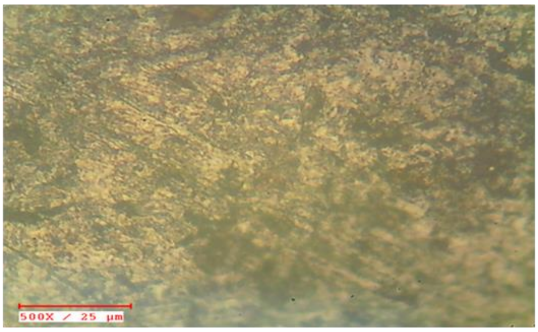


Fig 4.20: PURE ALUMINIUM 2024

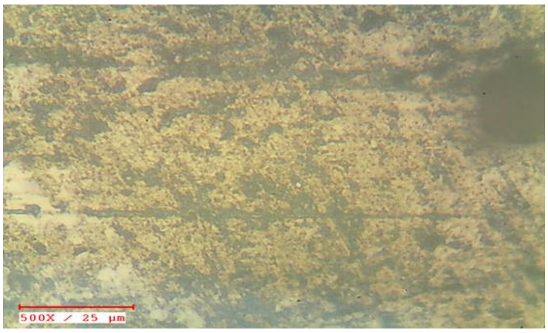


Fig 4.21: 98.5 Al + 0.5% B4C + 1% SiC

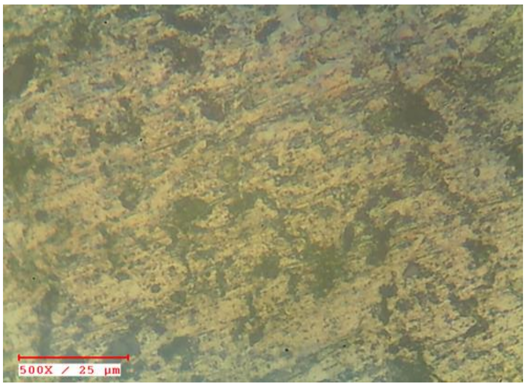


Fig 4.22: 97.5 Al + 0.5% B4C + 2% SiC

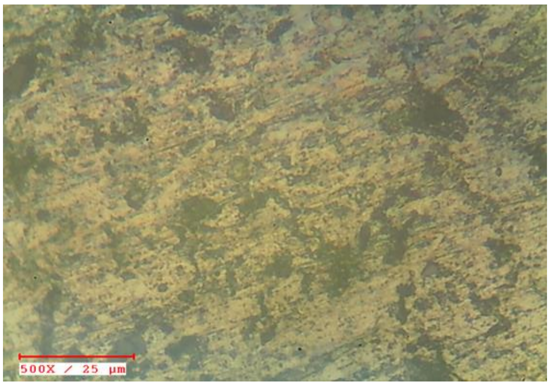


Fig 4.23: 96.5 Al + 0.5 % B4C + 3% SiC

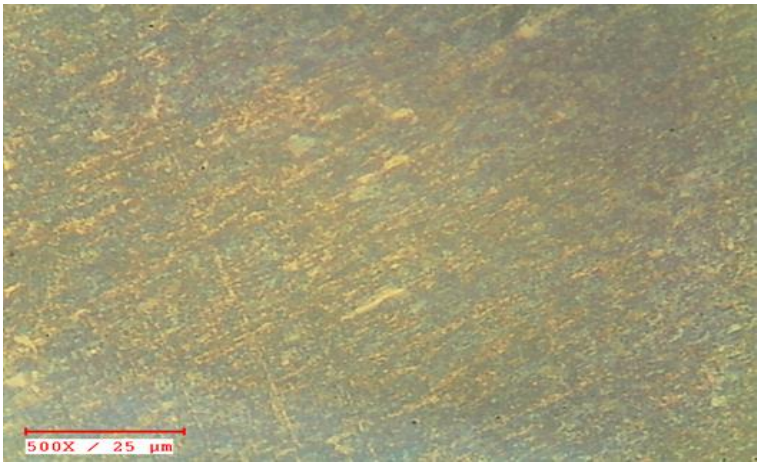


Fig 4.24: 95.5 Al + 0.5% B4C + 4% SiC

CHAPTER 5

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

5.1 DENSITY TEST

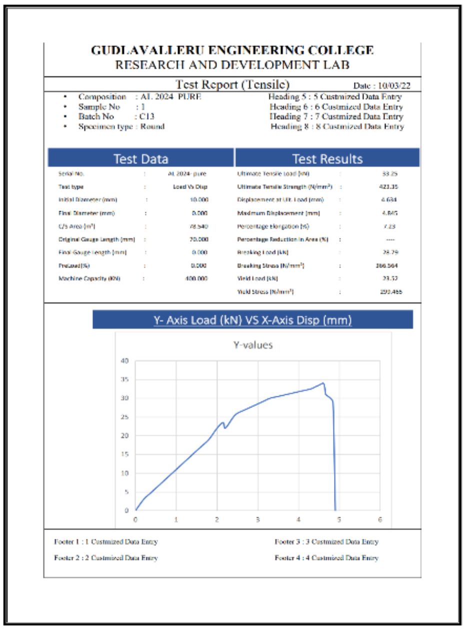
The test performed on the specimens with SiC and B4C reinforcement.

Table5.1 Density Varying with SiC & B4C

COMPOSITION	Density(gm/cc)
PURE	2.587
98.5 Al + 0.5 % B4C + 1% SiC	2.492
97.5 Al + 0.5 % B4C + 2% SiC	2.478
96.5 Al + 0.5 % B4C + 3% SiC	2.451
95.5 Al + 0.5 % B4C + 4% SiC	2.440

5.2 TENSILE TEST

The test performed on the specimens with SiC and B4C reinforcement.



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Test Report (Tensile) Date : 10/03/22

- Composition : AL 2024 PURE
- Sample No : 1
- Batch No : C13
- Specimen type : Round

Heading 5 : 5 Custmized Data Entry
Heading 6 : 6 Custmized Data Entry
Heading 7 : 7 Custmized Data Entry
Heading 8 : 8 Custmized Data Entry

Test Data		Test Results	
Serial No.	AL 2024- pure	Ultimate Tensile Load (kN)	33.25
Test type	Load Vs Disp	Ultimate Tensile Strength (N/mm²)	423.35
Initial Diameter (mm)	10.000	Displacement at Ult. Load (mm)	4.634
Final Diameter (mm)	0.000	Maximum Displacement (mm)	4.845
C/S Area (m²)	78.540	Percentage Elongation (%)	7.23
Original Gauge Length (mm)	70.000	Percentage Reduction in Area (%)	----
Final Gauge Length (mm)	0.000	Breaking Load (kN)	28.79
PreLoad(%)	0.000	Breaking Stress (N/mm²)	366.564
Machine Capacity (KN)	400.000	Yield Load (kN)	23.52
		Yield Stress (N/mm²)	299.465

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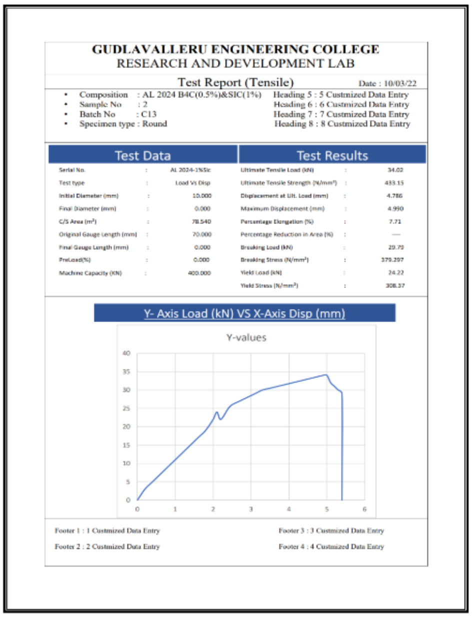
Footer 4 : 4 Custmized Data Entry



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Test Report (Tensile) Date : 10/03/22

- Composition : AL 2024 B4C(0.5%)&SIC(1%)
- Sample No : 2
- Batch No : C13
- Specimen type : Round

Heading 5 : 5 Custmized Data Entry
Heading 6 : 6 Custmized Data Entry
Heading 7 : 7 Custmized Data Entry
Heading 8 : 8 Custmized Data Entry

Test Data		Test Results	
Serial No.	AL 2024-1%Sic	Ultimate Tensile Load (kN)	34.02
Test type	Load Vs Disp	Ultimate Tensile Strength (N/mm²)	433.15
Initial Diameter (mm)	10.000	Displacement at Ult. Load (mm)	4.786
Final Diameter (mm)	0.000	Maximum Displacement (mm)	4.990
C/S Area (m²)	78.540	Percentage Elongation (%)	7.71
Original Gauge Length (mm)	70.000	Percentage Reduction in Area (%)	---
Final Gauge Length (mm)	0.000	Breaking Load (kN)	29.79
PreLoad(%)	0.000	Breaking Stress (N/mm²)	379.297
Machine Capacity (KN)	400.000	Yield Load (kN)	24.22
		Yield Stress (N/mm²)	308.37

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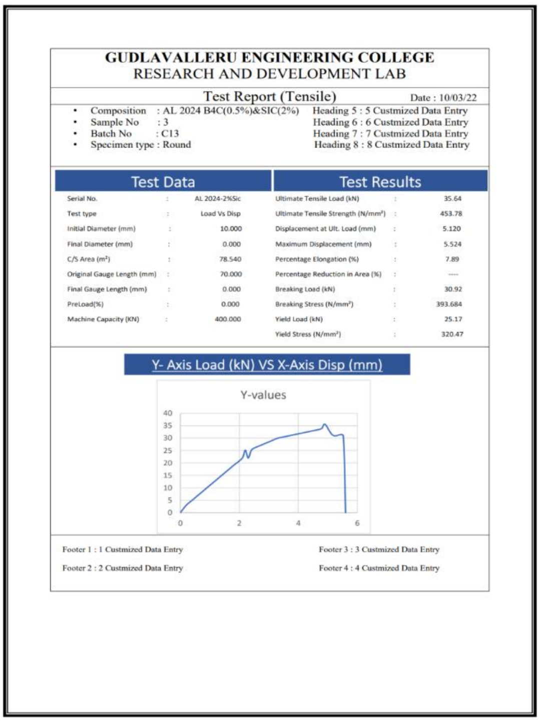
Footer 2 : 2 Customized Data Entry
Footer 3 : 3 Customized Data Entry
Footer 4 : 4 Customized Data Entry



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Test Report (Tensile) Date : 10/03/22

- Composition : AL 2024 B4C(0.5%)&SIC(2%)
- Sample No : 3
- Batch No : C13
- Specimen type : Round

Heading 5 : 5 Custmized Data Entry
Heading 6 : 6 Custmized Data Entry
Heading 7 : 7 Custmized Data Entry
Heading 8 : 8 Custmized Data Entry

Test Data			Test Results		
Serial No.	:	AL 2024-2%Sic	Ultimate Tensile Load (kN)	:	35.64
Test type	:	Load Vs Disp	Ultimate Tensile Strength (N/mm²)	:	453.78
Initial Diameter (mm)	:	10.000	Displacement at Ult. Load (mm)	:	5.120
Final Diameter (mm)	:	0.000	Maximum Displacement (mm)	:	5.524
C/S Area (m²)	:	78.540	Percentage Elongation (%)	:	7.89
Original Gauge Length (mm)	:	70.000	Percentage Reduction in Area (%)	:	----
Final Gauge Length (mm)	:	0.000	Breaking Load (kN)	:	30.92
PreLoad(%)	:	0.000	Breaking Stress (N/mm²)	:	393.684
Machine Capacity (KN)	:	400.000	Yield Load (kN)	:	25.17
			Yield Stress (N/mm²)	:	320.47

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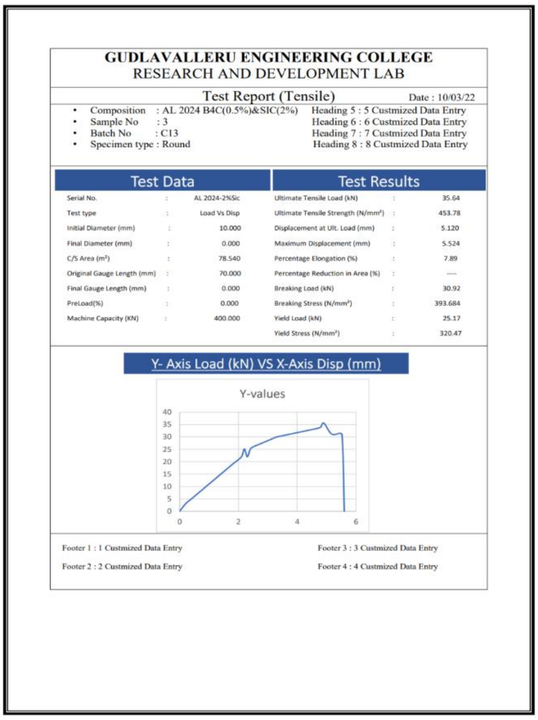
Footer 4 : 4 Custmized Data Entry



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Test Report (Tensile) Date : 10/03/22

- Composition : AL 2024 B4C(0.5%)&SIC(2%)
- Sample No : 3
- Batch No : C13
- Specimen type : Round

Heading 5 : 5 Custmized Data Entry
Heading 6 : 6 Custmized Data Entry
Heading 7 : 7 Custmized Data Entry
Heading 8 : 8 Custmized Data Entry

Test Data			Test Results		
Serial No.	:	AL 2024-2%Sic	Ultimate Tensile Load (kN)	:	35.64
Test type	:	Load Vs Disp	Ultimate Tensile Strength (N/mm²)	:	453.78
Initial Diameter (mm)	:	10.000	Displacement at Ult. Load (mm)	:	5.120
Final Diameter (mm)	:	0.000	Maximum Displacement (mm)	:	5.524
C/S Area (m²)	:	78.540	Percentage Elongation (%)	:	7.89
Original Gauge Length (mm)	:	70.000	Percentage Reduction in Area (%)	:	----
Final Gauge Length (mm)	:	0.000	Breaking Load (kN)	:	30.92
PreLoad(%)	:	0.000	Breaking Stress (N/mm²)	:	393.684
Machine Capacity (KN)	:	400.000	Yield Load (kN)	:	25.17
			Yield Stress (N/mm²)	:	320.47

Y- Axis Load (kN) VS X-Axis Disp (mm)
Y-values

Footer 1 : 1 Custmized Data Entry
Footer 2 : 2 Custmized Data Entry
Footer 3 : 3 Custmized Data Entry
Footer 4 : 4 Custmized Data Entry

Table 5.3 Tensile Strength

Compostion			Ultimate Tensile Strength (N/mm2)	Elongation (%)	Breaking Stress (N/mm^2)	Yield Stress (N/mm^2)
Al (%)	B4C (%)	SiC (%)				
100	-	-	423.35	7.23	366.56	299.46
98.5	0.5	1	433.15	7.71	379.29	308.37
97.5	0.5	2	453.78	7.89	393.68	320.47
96.5	0.5	3	458.49	7.98	400.05	330.65
95.5	0.5	4	464.85	8.10	410.10	335.62

5.3 COMPRESSION TEST

The test performed on the specimens with SiC and B_4C reinforcement.

Table 5.3 Compressive Strength

COMPOSITION	**COMPRESSION STRENGTH(N/mm2)**
PURE	309
98.5 Al + 0.5% B4C + 1% SiC	318.02
97.5 Al + 0.5% B4C + 2% SiC	324.75
96.5 Al + 0.5% B4C + 3% SiC	327.32
95.5 Al + 0.5% B4C + 4% SiC	329.76

5.4 HARDNESS TEST

The hardness test performed on the specimens with SiC and B_4C reinforcement

Table 5.4 Vicker's Hardness

COMPOSITION	**HARDNESS**
PURE	121.02
98.5 Al + 0.5% B4C + 1% SiC	123.16
97.5 Al + 0.5% B4C + 2% SiC	125.09
96.5 Al + 0.5% B4C + 3% SiC	127.56
95.5 Al + 0.5% B4C + 4% SiC	129.01

5.5 CHARPY IMPACT TEST

The impact test performed on the specimens with SiC and B_4C reinforcement

Table 5.5 Charpy Impact Test

Reinforcement	Area of the notch (mm^2)	Initial Energy (J)	Final Energy (J)	Net Energy (J)
PURE	100	300	50	250
98.5 Al + 0.5% B4C + 1% SiC	100	300	48	252
97.5 Al + 0.5% B4C + 2% SiC	100	300	46	254
96.5 Al + 0.5% B4C + 3% SiC	100	300	45	255
95.5 Al + 0.5% B4C + 4% SiC	100	300	44	256

CHAPTER 6

CONCLUSIONS

CONCLUSIONS

Aluminium Metal matrix hybrid composites reinforced with B_4C 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 B_4C in the Al2024 Metal matrix composites.

- The tensile strength has improved with increase in SiC and B_4C reinforcements.
- The compression strength, impact strength, hardness increases by increasing SiC and B_4C reinforcements.
- The Density of the material decreased with increasing the SiC and B_4C reinforcements.
- From the microscopic analysis it is found that the mixing of SiC and B_4C particles in Al2024-T3 has been done properly and the composite has less defects.

CHAPTER 7

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REFERENCES

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