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DEVELOPMENT AND TESTING OF WC-FeAlCOMPOSITE BY STIR CASTING METHOD

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ABSTRACT

Aluminium based MMCs are one of the most useful materials due to their high specific strength, low density and stiffness and increased fatigue resistance which make them suitable for various wear and structural applications in various sector such as aerospace industry, automobile industry, medical sector, sports etc. In the aerospace sector, automobile sector the material used for parts ofaircraft, satellites automotive vehicles need high temperature stability, high strength, low density, thus to fulfil the requirement of this it is important to develop a new product which can fulfil all these requirement. Present research work on to develop a new material composite that fulfil all this need. In the present work, an attempt has been made to study the effect of addition of WC as reinforcement in FeAl metal matrix composites which decrease the tensile strength of material.FeAl inter metallic compound has a low density, high melting point and good oxidation and corrosion resistance and high hardness, Here, in the present research work WC – 0, 1,2, 3wt % FeAl composites will be developed by stir casting route and their properties will be examined.The relative density of the various sintered composites will be determined by the Archimedes' principle. The tensile and compressive strength of the composite are determine by using of Universal testing machine. The impact strength of the composite are determine by using of impactand Charpy test. The hardness of the composites was determined using a Vickers micro hardness tester, Brinell harness testing and Rockwell hardness testing machine and the wear strength of thecomposite are examined by pin on disk wear tester. It was found that both the hardness and the wear resistance of the various WC-FeAl sintered composites increased with the increase in FeAl content.

KEYWORDS: Iron, Aluminum, Tungsten Carbide, Stir Casting method, Mechanical

Property.

CHAPTER 1 INTRODUCTION

1.1 Background and Motivation

Current applications require materials that have a mixture of many properties such as high strength, light weights, high toughness, resistance to corrosion, high abrasion, impact resistance, etc. a real model is that the gift enthusiasm for the advancement of materials that have nice commonality to weight proportion affordable for vehicle applications wherever potency with improved engine performance is turning into additional essential. Currently the requirements of recent materials discover which may be used beneath adverse environmental conditions. of these qualities ar inherit existence in a very single material referred to as material. A structure comprises 2 or many different materials, which are mixed in order to produce a better and recognizable material. Or the contrary, a textile (material structural or compositional abbreviations) could be a mistreatment material produced with a minimum of two components with essentially extraordinary physical or artificial properties which, once combined, result in a fabric that does not have the same attributes as the individual components. The materials are natural or not natural. Within the finished structure the individual segments are distinct and clear. In the finished structure, the individual components are distinct and clear. The new material could be favored for a few reasons: traditional models incorporate materials that ar additional grounded, lighter, or more cost-effective once contrasted with customary materials.

For instance, fortified cement (made of cement and steel) has protection from weight andto twisting force Projectile verification glass (made of glass and plastic) is progressively imperviable to have an effect on Solid itself may be a composite material, one among the foremost seasoned synthetic composites, utilised quite another synthetic material on the earth. Wood may be a trademark composite of polyose strands during a structure ofpolymer. The earliest synthetic composite materials were straw and dirt joined structure blocks for structure development. Fiber-fortified polymers are in wide use these days, as is glass-strengthened plastic. The customary word 'composite' offers a small sign of the tremendous scope of individual mixes engaged with this category of fabric.[1-3]

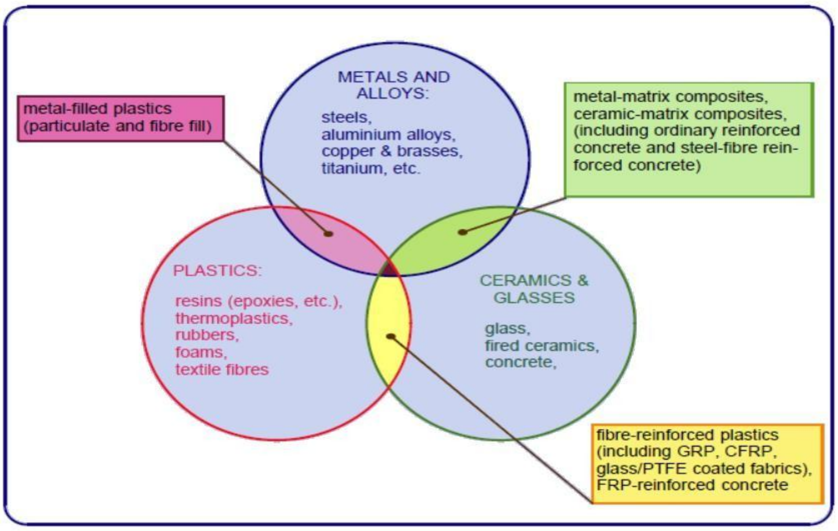


Figure 1.1: Relationships between categories of engineering materials.

We have mentioned some a lot of acquainted one, however figure one.1 has given an easy plan for simplicity that is accessible to the content scientist and his consumer, style engineer. Initial of all, every cluster of materials - metal, ceramic and compound – is already some acquainted materials that may be delineate as composites. A combination of challenging ceramic compounds comprises of several members of the most popular and largest cluster of general ingredients in the steel family. These particles are generally like plates, generally pointed, and infrequently spherical or plane figure polymers are usually 2 phases, within which there's a matrix of sentimental or soft particles of a tricky compound.

This is an ideal example of wood, as we've got seen. And within the matrix of solid hydrous cement, with a complete of sand particles and classified sizes, is a superb example of ceramic / ceramic composite. Such materials have been renowned for many years, and content scientists have learned to control their properties through their microstructuring dominant. This suggests what are the number, format, and distribution that we will show as a reinforcement section.

The idea of blending elements within the boundaries of the content category may be a natural extension of this concept. extraordinarily rigid, or noncombustible, or simply low cost, additionally to creating polymers to fill ceramic powder for plastic; to make machine tips to make a variety of materials to be used as 'cermet’s’ to feature extremely rigid, or resistance, or thermal-stationary ceramic particles into metals, in cutting exhausting metals at high speed or high temperatures are enabled; There are solely 2 samples of necessary events in our exploitation of those materials.

1.1.1 Conventional material and their limitations

to determine metal, plastic and ceramics ' relative strengths and weaknesses, it's troublesome to arrange a table of fabric attributes, as a result of every of those rules covers the whole family of the fabric at intervals that the vary of properties is commonly the distinction between the shape is broadly speaking divided into 3 sections, however, compared to normal words, a number of the additional obvious benefits of various forms ofmaterials and you'll be able to scrutinize the injury. At a simplified level, then

- **Plastics** are of denseness. They need nice transient compound obstruction, but they are available up short on a heat dependableness and simply moderate protection from natural corruption (particularly attributable to photograph concoction impacts of daylight). We require weak mechanical properties, but are assembled and joined effectively.
- **Ceramic** will be of less density (though some are dense). They need nice thermal stability and that they are proof against many varieties of attack (friction, clothing, rust). Though because of their chemical bondage the inside is extremely sturdy and powerful, they're all brittle and might solely be fashioned and formed with problem.
- **Metals** are principally through high density - solely atomic number 12, metallic element and glucinium will contend with the plastic during this regard. Many of us have sensible heat stability and that they will be created rust resistant by alloy. They need useful mechanical properties and high toughness, and are moderately simple and large, it's mostlythe results of their flexibility and resistance that they become the well-liked engineering material to interrupt metals into a class.

1.2 More and more composite materials are required every day. Industries such as components, aircraft, vehicles, underwater transport, machinery, etc. today require products which combine strength and rigidity off-wall. Composite materials have also been developed to meet these sectors ' needs. Superior combinations of characteristics may be obtained before composite materials exist. Composite materials typically combine two phases, matrix and renovation. Matrix is the fragmented segment that covers the strengthening process. In general, the matrix portion is low, ductile and persistent and the reinforcement segment is strong, tiring and discontinuous. Strengthens all kinds of fibers, particles and flakes. Composites are exposed to mixture frameworks that demonstrate that their relative proportions and properties regulate the composite framework properties very highly.

Therefore,the goods can be built to satisfy property needs by adjusting the degree fraction of the phases in question. Other composites are made of natural materials, bone, etc. Wood could be a fibrous structure consisting of polymer cellulose-bolstered matrix fibers. The high strength of cellulose fibers is attached to a much harder material, the polymer which combines the matrix with the fibres. The boot bone is also a function composed of thin, flexible collagen filaments that are part of the mineral network. Moreover, concrete is a normally used material. This is a mixture of small stones, asphalt and sand. To enhance the longevity of the concrete, a combination of concrete and metal rods or wires was made. The roof is commonly referred to as hybrid reinforced concrete

1.3 Composite material

The material consists of 2 or additional constituent material that has totally different physical or chemical properties, that amendment the structure. Element material doesn't fully immerse or merge in one another; it means they need their own identity although they add the concert.

Components that conjure the fabric are primarily of 2 varieties, matrix binders and also the second is that the strength or filler component. Matrix binders are various types of polymers, metals, pottery, etc. Similarly, the reinforcement of fibers, particles, flexes and so on will differ. The matrix binder provides reinforcement of bulk degree catches in an orderly pattern.

To determine metals, plastics and ceramics ' relative strengths and weaknesses, it is difficult to prepare a table of material attributes, because each of these rules covers the entire family of the material within which the range of properties is often the difference between The form is broadly divided into three sections, however, compared to ordinary words, some of the more obvious advantages of different types of materials and You can look at the damage. At a simplified level, then

1.3.1 Properties of Composites

A variety of the most advanced engineering products actually include composite materials. This class of composites has received great attention in a wide range of industries thanks toits excellent qualities and potential applications. A new material can be developed with the desired combination of properties by combining two or more specific materials. This may include a mix of features such as lightweight, high strength, corrosion resistance etc.[4-5]

The following properties of composites make them a promising material for use in different applications

I. High power for weight ratio

A composite material is the only material that can be engineered for strength and toughness. Its complex property combination makes it popular in the car and aerospace industries. Today, composites are one of the most popular weight performance components. The composites are of low weight compared to most conventional metals, alloys and porcelain. Composites can be used to produce light-weight vehicles that can improve fuel efficiency due to their low weight. Composites have a net loss of weight ofapproximately 20-5%.

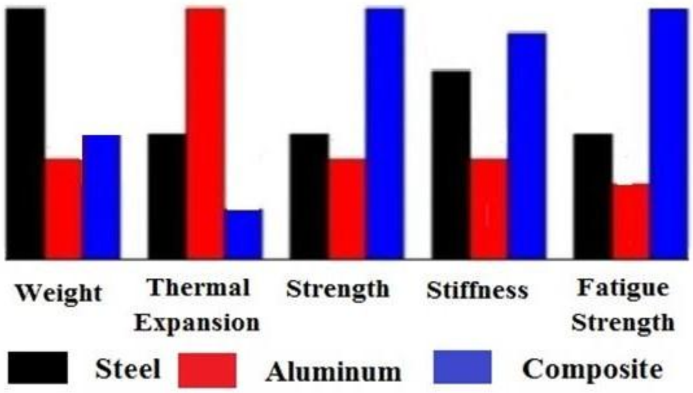


Figure 1.2: Compression of various properties of steel, Al and composites.

II. Strength

III. Power is the most important property of the material used in industries such as automotive and aerospace. In most environments, composites can replace metals and ceramics by improving mechanical characteristics. A composite material combines high matrix and strengthening characteristics and has the right to increased properties, as opposed to monolithic materials. Not only does composite content lower weight and building costs, it also increases crawling, fatigue strength, durability, corrosion resistance, oxidation and high temperature.

IV. Corrosion resistance

Composite materials have good weather characteristics and withstand a multitude of chemicals. Composites are the best choice for corrosive material-including structures. The final content plays an important role in rising corrosion metal losses. We prevent the loss of metal due to extreme environmental conditions and chemical substances which damage other items. This is why construction materials are used to build tanks, cylinders, liquids, walls, huts and truck frames for chemical storage.

1.3.2 Types of Composite

Composites can be classified into two ways

1.3.2.1 On basis of reinforcement: On this basis composites are classified in three categories

I. Particle reinforced composite

a) Large particle

b) Dispersion strengthened

II. Fibre reinforced composite

a) Continuous

b) Discontinuous

III. Structural composite

a) Laminates

b) Sandwich panels

1.3.2.2 On basis of matrix material: On this basis composites are classified in four categories:

1. **Metal matrix composites (MMCs)**
2. **Ceramic matrix composites (CMCs)**
3. **Polymer matrix composites (PMCs)**
4. **Hybrid matrix composites (HMCs)**

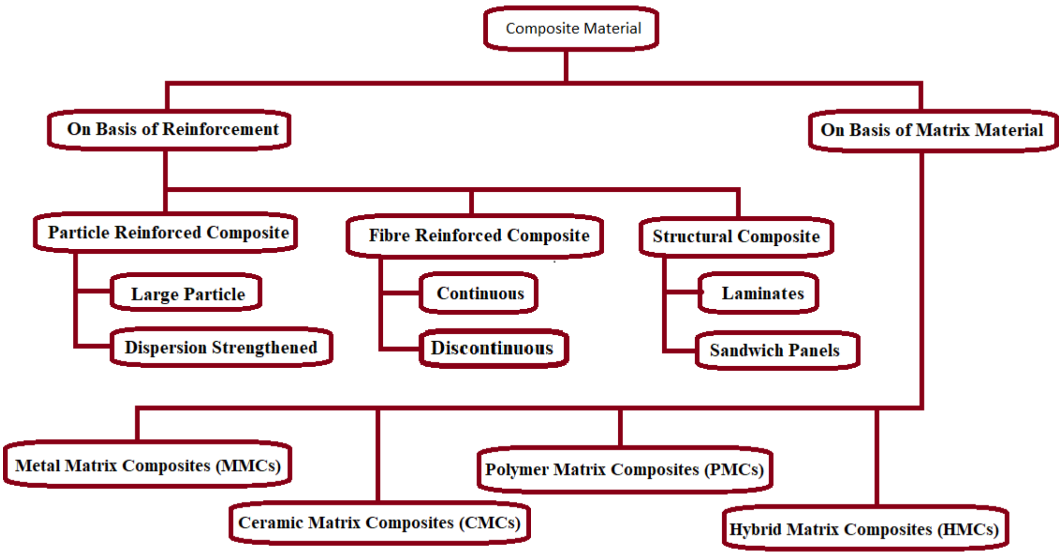


Figure 1.3: Classification of composites based on matrices.

I. Metal matrix composites (MMCs) – Material matrix composites (MMCs) are composites containing at least 2 components–one material and another material or product separately. The metal frame is strengthened to boost wear and tear with the opposite material. A cross breed composite is named when a minimum of three components are available. In auxiliary applications like magnesium, titanium or copper, the grid is usually constructed with a lighter element. In high temperature applications atomic number 27 and cobalt-nickel alloy matrices are popular. The standard development of MMC is categorized into three main types: solid, liquid and steam. Continuous steel, carbide or innovative filaments calculate certain components that are deeply rooted in an extremely metallic network content. The MMCs are thermoproof, have a wide range of temperatures, are non- wet, and have better power and heat conductivity. The existing systems must also be moth resistant to radiation damage and not be impaired by the ill effects of fatigue. Hybrid matrices include some metals and alloys.[6-8,6-9]

II. Ceramic matrix composites (CMCs) – Composite ceramic matrix (CMCs) measures a square subgroup of composite material. The ceramic fibers are placed on the ceramic matrix and thus enhanced ceramic material (CFRP) type ceramic fibre. The grid and filaments are made from all ceramic materials. Some maladministrators such as low breakage power, vulnerability and minimal heat stun obstruction were expected to be disrupted by CMC products, which is seen through the historically advanced development of iron.

III. The Polymer Matrix composites (PMC)–Polymer Matrix Composites (PMC) are classified into three sub-varieties: thermoset, thermoplastic and rubber. A huge polymer composed of structural units restructured and secondary chemical reactions could be a polymer. PMC is a compound matrix with a fibrous reinforcement structure. They become healthier for simpler production methods. PMC is less thick than metals and ceramics which face various forms of environment and corrosion and have excellent resistance to electric current transmission.

IV. Hybrid Matrix Composites (HMCs) –Hybrid composites most often involve the kind of fiber reinforced structures, which are sometimes resin-based, in which 2 square measuring forms of fibers are included in one matrix. Any combination of different materials will be a hybrid. Mixing sheets of metallic material alloy with laminates of fiber- reinforced rosin as a related type of stratified hybrid within an industrial product ARALL and the intermixing in a single rosin or metal matrix with fiber and particulate fillers creates another hybrid composite species. In parts of applications, the well-known aim of hybrid operation is to use GRPs or Kevlar-fiber-reinforced (KFRP) natural toughness to offset the perceived crucible of typical CFRPs. The designer wants to read the vital facet of exploitation hybrids: provided that the underlying mechanisms for stiffening, strengthening and toughening are adequately understood, they make possible even closer composite properties that respond to specific needs than those achieved using single fiber composites.

1.2.3 Metal Matrix Composites

1.2.4 Bimetallic matrices, strengthened by ceramic particles or fibre, square measurement referred to as metal matrix composites or MMCs are compository materials. Thus, MMCs consist mainly of 2 phases, the primary metal matrixsection and the secondary reinforcement section. Various primary and secondary section square measurement functions given below.[9]

1.2.5 Functions of the Matrix Material (Primary Phase)

- Provides the mass style of a chunk or material product
- Holds the embedded site, sometimes the envelope and rarely hide it.
- The matrix shares charge within the secondary stage when the load is applied, sometimes it distorts so that the strain is actually generated by electronic equipment.

1.2.6 Function of the Reinforcing Phase (Secondary Phase)

Matrix binds the fiber together, mixing it in vital unpleasant directions. The load added to the material is then passed via the matrix to the fibre, the principal component assisting the composites, the flexile and the shear powers, yet because of the overall strength to withstand the tensile weight. The power of reinforced composites with small fibers to support any kind of load depends on the matrix's presence in the style of the medium of load transfer, and the potential for this charge transfer is also directly connectedto the fiber / matrix bond standard.

The matrix should separate the fibers from each other so that they act as separate units. Many bolstered fibers with an extremely variable quality brittle stable field. Once such material is used as a fine fiber, fibers are not only robust monolithically in the same concrete; however, the additional benefit is that they do not fail disastrously. In fact, the strength of the fiber bundle differs from a monolithic rod with an equal weight-bearing capability. Nevertheless, these advantages for the total fibers will be full only if the matrix divides the fibers from each other so that the cracks can not be transferred through the touch sequence of the fibers which result in completely breakable composites.

Matrix ought to defend mechanical harm (such as friction) and bolstered filaments by environmental attack. Since several resins used as matrices for optical fiber permit the dissemination of water, thus this work isn't usually completed in several GRP materials and environmental harm which ends up from stress. the fundamental nature of the matrix in cement solely affects the traditional optical fiber and alkali-resistant spectacles during which the zichronium develops (Procter & Yale, 1980) in a trial to counter it. For composites like MMC or CMC running at high temperatures, the matrix can get to defend the fiber from aerophilic attack.

A versatile matrix may provide a tool for breaking or forestalling fractures that occur from damaged fiber. On the opposite, matrix on a breakable matrix fibre may rely onits function as a split dagger. The matrix may also be crucial in speeding up the brutality overall through its ' grip ' on fiber (interfacial bond power).

Most matrix materials are weak and versatile compared to common strengthened filaments and their strengths and moduli are typically neglected to calculate the general properties. Nevertheless, metals are structural materials and their underlying shear rigidity and compression in MMC are necessary to determine the rigidity of the scissors and the overall compression behavior.

The ability to consolidate a given material depends mostly on the power to perform this or some matrix tasks; however there are usually alternative concepts. We tend to currently take into account the potential properties of various sections of matrix material.

1.3 Method of fabrication

Metal-matrix composites will be invented by many techniques. Fabrication of MMCs will be generally divided into 3 classes of fabrication techniques. And these area unit additional sub-categories in numerous techniques. These are some of the main strategies listed below.

Solid state processes

The solid state process is a highly important technique for MMC processes and is used to create MMCs with the best mechanical properties. This method is used to produce a reasonable reinforcement distribution within the metal matrix so that we are able to obtain an equal overall microform structure. Several required robust processes for metallurgy systems, diffusion bonding and processing deformation

I. Powder metallurgy

The matrix and therefore the reinforcing powders are combined to ensure consistent delivery. The mixed powder is cold, isotatically or uniformly pressed and a compact, unexperienced sample is obtained. This novice compacted sample is finally placed ina stove and our test is obtained. The PM and the sintering process usually involve three basic steps: powder (pulverization), compaction of the matrix and sintering. The compaction is mainly done at temperature and the sintering process is used mainly in extreme temperatures at gas pressure and under a very controlled atmosphere composition. A additional non-compulsory operation is usually carried out for special properties or greater accuracy, such as a coining or heat treatment.

II. Diffusion bonding

Diffusion bonding can be a solid state process technique that can connect metals like and completely different. The connection of alternating layers of skinny metal foil or metal wires is included. This approach is based on the solid state diffusion theory. It involves an interaction between the atoms of the 2 metals over a long time below a high temperature and high pressure. Diffusion bonding is completed by sealing the 2 metal elements to be soldered contiguously with their surfaces. Such aluminum surfaces should be smooth and unbroken alloof from degradation of any chemical components before connection. When the aluminum surfaces are clamped, Nursingd pressures associate heating in an elevated temperature unit for the assembly of the ultimate product. A mechanical pressure is applied throughout the heating process through the hammer. Often Assist to avoid oxidation in the inert environment used in diffusion bonding procedure in nursing. The diffusion bonding does not include filler metal, so the extra weight is not a donation. The joint space tends to indicate any bottom metal of equal strength and extreme temperature tolerance. The ultimate product has very little plastic deformation and residual stress, but throughout the diffusion method there is no external contamination.

III. Deformation processing

This method is used for deforming the composite material.

1.3.3 Liquid state processes

Liquid state process of MMC looks to be adopting a large adoption because of the advantages related to the reference of liquid compared to metal powder. The likelihood of manufacturing numerous complicated sizes exploitation liquid metals quite simply. A number of the techniques documented by researchers are intrusion, dispersion, spraying, unaltered fabrication, compression casting, stir casting, and compositing.

Liquid is plagued by several defects compared to state process, during which therea scarcity of replica is related to incomplete management of process standards, and a few unwanted chemical reactions on liquid metal interface and reinforcement

I. Infiltration Process

In the liquid mode, intrusion involves the infiltration by liquid metal of fibrous or particulate filler. The infiltration method of MMC is not simple and simple due to problems with the metal strength in the main due to the liquid metal. Whereas a fiber preform infiltration method is likely to be a reaction between fluid metal and fiber that basically eliminates the properties of fiber. However, it will be harmful for fiber coating to occur as a result of surface oxidation to be exposed to primary intrusion air. The pressurized liquid metal intrusion method of developed MMC is used for intrusion of ceramic preform by reactive metal alloys like al-MG.

II. Dispersion Process

This process involves the reinforcing of the metal structure. Through combining two stages, mechanical forces are necessary because most structures do not have sufficient humidity. The downside of the dispersion process is its small cost and can often be handled in addition to removing it. The main limitation of this method is that the matrix is clustered during the entire contact time and combination, and the gas entry presence causes continuous deformity during the reaction process.

III. Spray Process

Strengthening the MMC particle may also be developed to cover the use of non- continuous spraying processes, which can replace monolithic alloys fully. A unique example is a co-spray method using a shower device to generate thirteen complete matrix atoms at intervals the hot inorganic compound particle field unit. For effective procedures, the required area unit, which is highly sensitive to variation, requires a whole particle size. This technique is quick and automatic, although this is often a liquid-based method. The metal alloys will include carbides of a lateral quantitative (length / diameter) ratio of 3-4 and volume fractions up to 20. A constructive goal of the regulation is to provide versatility in the production of specific composites than alternative methods. On the contrary, the strategy is dear to the costly capital.

IV. Liquid infiltration

This includes the infiltration by liquid metal of fibrous or particle reinforcement. MMC intrusion in the liquid section is not easy, mainly because of problems with the weighing of liquid metal ceramic strengthening. When fluid preform is well finished, the fiber and liquefied metal also have a reaction that greatly reduces the fiber properties. Fiber coatings are added before penetration, enhancing the wetting and allowing the surface reaction control, producing and delivering promising performance. The disadvantage in this case is that fiber coatings should not be exposed before infiltration in the air, because the coating surface is oxidized.

V. Squeeze casting or pressure infiltration

This requires the formation of a fibrous orpre-forming liquid metal. Pressure is applied to full solidification. Forcing the liquefied metal through small troughs of fibrous preform prevents the constant wetting of the solidified metal by the liquefied metal. Composites produced by this method profit from the reduced reaction from the brief time period between the power and liquefied product. These composites are usually free of casting defects such as cavities for consistency or shrinking.

VI. Stir Casting

In the process of stir-casting, the bolstered section is mechanically distributed within the liquefied matrix. The production of the mustard compound of metal matrix began in 1968, when SR produced the mixture of metallic liquefied material with ceramic powder and added the particles of aluminum oxide into the metal product. Mechanical interval stirring of the furnace could be an important part of this technique. As a consequence, liquefied alloys are often used for ceramic particles for construction, permanent mold casting or sand casting. Stirring Casting is suitable for composites with a volume of strength of a fraction of 30 minutes. In general, the composites are transportedin order to reduce the outlet, to refine the microscopic structure and to homogenize strength distribution. A major concern with the casting system is the isolation of the reinforced materials throughout the casting process by melting , surfacing or disposing of the strengthening particulates. The ultimate distribution of particles within the solid depends on physical and method parameters, such as particle melting at melting speed, mixing strength, relative density and concrete. Counting of particulate distribution within the fluidized matrix, pure mechanical stirrer mathematics, the value added in stirring parameter position of the mechanical stirrer, melting temperature and particle characteristics.[10]

A two-stage mixing method could be an interesting new development. This method heats the matrix content higher than its liquid temperature, so that the metal is completely unfrozen. The melting is then cooled in semi-solid state between the liquid and also the solid points at temperature. At this stage, the particles are added value and previously mixed. The solution is fully liquid heated and well mixed. This two-stage mixing method was used in aluminum development.

The most economical stir is the well-established metal matrix composite manufacturing methods. That is why it is actually the most fashionable commercial way to build aluminum-based composites.

1.3.4 Deposition techniques

This technique is based on the diffusion link between the reinforcement and the matrix. This approach involves the covering of individual fibers in matrix material for the production of the composite form. The most downside in deposition is that they need the time to be prepared. Many deposition methods are usable, such as immersion plating, electroplating, spray deposition, chemical vapor deposition (CVD) and physical vapor deposition (PVD), etc.

I. Electroplating-In the presence of electrical current, electroplating produces a coating with a particle solution of the required material. Fibers are injured on a board which acts as a cathode and plates are placed in the bathroom with an anode of the matrix of the required material.

II. Spray action–sometimes curved fibers are applied in a foil-coated drum and liquefied metal springs to create a monotape.

III. Immersion plating–This method is also called dipping and is similar to penetration plating, other than to the continuous passing of fiber towers into liquefied metal baths.

IV. Spray deposition–This method involves uniquely winding fibers onto a film- covered frame, then showering liquid metal to create a monotape.

V. Chemical Vapor Deposition-The evaporated product decomposes or binds to a substratum with another vaporized chemical to build a surface coating. The process usually takes place at high temperatures.

VI. Physical vapor deposition–This technique is also used in multifunctional MMCs, especially in the production of millimicrons.

1.4 Applications

The applicability of car technology in blocking systems, piston rods, piston pins, pistons, frames, spring valve caps, brake discs, brake pads, carbon shaft etc. is applied highly. Applications for spindle tubes, reinforcements, blades and gearbox covers, turbines and other applications are required for military and civil aviation. MMC has been used in the aerospace industry to manufacture medical components in frames, strengths, airports, joining components etc.

CHAPTER 2 LITERATURE REVIEW

2. Literature review

This chapter provides information on the past work related to the current analysis through numerous literature reviews.

2.1 Literature review (properties of material)

Gomez The Boron Carbide Aluminum Matrix Composite Boron Carbide (B4C) test is carried out with solid-state processes in the form of reinforced aluminum composites (AMCs). For this analysis and to specifically compare the results, sic was used for the general matrix cases of the aluminum alloy AA6061. Two entirely different reinforcements have been taken into account. Comparative analysis of each composite of Sic and B4C based and connected with microstructural choices on mechanical and tribological properties. It concluded that its most valuable value was 100% B4C with increased strength, strength and strength for composites. Composites had steadily increased dynamic friction with respect to tribology, but lower wear rates than unrelated aluminum alloys. Automotive systems are reliable as a split disk.[11]

Ravi kant Deals with the study of aluminum matrix composites. Specific additives are combined in the Iron Aluminide (FeAl) during this four alloy. The slippery wear behavior of Alloy is tested. During the test, they observe that Alloy-1's strength and hardness are low because of Alloy-1 graphite. Alloy 2 and alloy-3 show similar power and rigidity, but their hard ZrC and tic carbide rates are significantly higher than that of Alloy-1 duet. Lower carbide fraction results in less strength and hardness than Alloy-2. Alloy 4 has the largest carbon (and carbide) content and the greatest power and rigidity. Therefore, the strength of these alloys is determined by the amount of carbide and the hardness.[12]

Ryoichi Furushima and Kiyotaka Katou have been investigating the wear and tear activities of FeAl ceramic, sintered with PCS (pulse sintering) technique and the vacuum sintering technique. The implementation of advanced pulse sintering processes enables the WC-FeAl composite to be densified under the liquid phase formation at temperatures below FeAl. The variation in the temperature of sintering results in an important distinction between the microstructure of the composite. While the vacuum sintering technique sample determines some WC grain and large FeAl phases. The materials in the WC-FeAl device thus obtain superior mechanical properties, such as stiffness and bending power of Vickers.[13]

Schmitt, K.S. Kumar, A. Kauffmann, X. Li, F. Stein, M. Heilmaier They studied the compressive flatness of Fe-61Al alloy and Fe-58Al and Fe-62Al alloys with Fe Alloy, FeAl2 and other eutectoid alloys, both of which were seriously examined at high temperatures. The time / stress output of the creep rate suggests a definite plateau. Lamellar coarsening in the colony only contributes to the downsizing of the creep rate to the minimum. The presence of a proeutectoid phase (FeAl or FeAl2) is responsible for a decrease in creep resistance. The activation energy 309–321 kJ / mol in FeAl is higher, even though it is stoichio-metric and almost stochio-metric under these reportable FeAls.[14]

Singh RK, Kumar D and KumarA The study of Al-SiC-Cu Metal Matrix wear behavioral studies using Taguchi orthogonal array configuration for different reinforcement materials, load, sliding pace, and distance. The most significant parameter for wear behaviour, the wt parameter, i.e. the strength weight is while both L (load) andS (sliding speed) parameters are also important within this specific range. Displacement slides have the least impact on the stock of plastic wear. Taguchi analysis identifies the optimum combination of minimum wear method parameters in proportion to weight, quantity and maximum reinforcement level in relation to lower load levels, slippery speed and sliding distance. This study shows that an adequate regulation of system parameters could contribute to an improved Al-SiC-Cu style for tribological purposes. The microstructure study of worn surfaces determines that largely abrasive mechanisms of wear with traced mechanisms of adhesive wear have occurred in wear tracks.[15]

S. Azem, M. Nechiche, K. Taibi FeAl intermetallic compound experiments were synthesized at 1100 ° C under vacuum by sintering the FE-32.5 percent SHS watts. FeAl powder from grinding has been combined with copper so that sintering may produce an MMCP. It's been noted:-10 Wt. Zip copper is insufficient for material thickening: FeAl particles transmitted microprocessor sintering copper that showed excellent porosity within the sample. Using 50-wt. Percent Cu, dispersion in concrete phase during sintering is inadequate. In the liquid phase, fluid aspiration is accentuated and causes the body'spresence within the matrix. The high energy of feather powder gives particle size and microprocess. Better uniformity and honest thickness provided by the frying mix with copper. Nevertheless, there is a perforation in the matrix after the diffusion of copper in the samples. Analysis by EDS-X showed that Al and Fay's leader has collapsed, increasing its rigidity.[16]

Raminder Singh Bhatia Kudleepsingh was work on the event of metallic element alloy Al-12%Si with the additions of various reinforcements in terms of varied weight percentages. At higher reinforcement levels, agglomeration was determined within the matrix that is due to the raised particle-particle interactions. The durability of composites increases to 100% aluminum by increasing the reinforcement content. Higher quantities of enhancements will increase matrix discontinuities, leading to lower strength. The hard phases in the matrix prevent the high order deformations and the elongation of the fabric. The hardest, composite uncovered decreased wear and the presence of an acceptablegraphite content (5 percent) have not occured uniform tribolayer studies. The shaped layer facilitates the sliding speed and the increased mass wear and COF of composites.[17]

M AMaleque, A AAdebisi, and N Izzati has Examine the fracture mechanism of aluminium composite. The aluminum compound (Al-Mg / SiCp) is investigated to see fatigue life and impact resistance, considering the load fraction of reinforcement and also the influence of temperature on fracture toughness. By the check the mechanism accountable for the phenomena includes load transfer from the Al matrix alloy phase to the high strength and stiffness of the incorporated SiCp. The reinforcement weight fraction of 20 wtcSiCp recorded the optimum and longest fatigue life strength because of the best variety of cycle attained compared to different reinforcement variations that successively influences the modulus of elasticity. On the opposite hand, the 25 wtcSiCp shows a rather shorter fatigue life than 20 wtcSiCp composite at most stress level of 200MPa. This could be ascribed to decrease in cyclic ductility that is because of the presence of considerable quantity of SiCp reinforcement that induces brittleness within the fatigue properties. With 200th by weight of reinforcement, the expansion of cracks is hindered by the SiCp impact that provides a barrier proof against dislocation movement and also acts as a load bearer in order to resist the crack propagation.[18]

Ehsan Ghasali, Ali Fazili Al-TiC Composites of the metal matrix were effectively manufactured using spark fire, microwave and traditional sintering processes. The low sintering temperature and pressure technique resulted in mechanical properties and proper microstructure in comparison with the other sintering methods. Because of the higher temperature and period of sintering, the tic decomposition and accumulation of TiO and CO caused the exhausted CO gas to produce porosity in a microstructure of the samples by microwave or traditional sintering. With the same mechanical properties as the microwave and traditional samples, the sintered samples from SPS reached a near maximum density at a reduced sintering level.[19]

M. Uthayakumar The sliding dry wearing of B4C strengthened aluminum with5-hitter Sic and5-hitter Hybrid Alloy was tested using a pin in the disk tribometer. The wear performance of the hybrid composites was evaluated for load ranges from 20 to 100 N at one to five m / s. For evaluation of wear mechanism impacts of sic and B4C particles, a detailed metallurgical exam and energy dispersion analysis have been carried out. The Focused Ion Beam (FIB) technique is used to describe the tribal layers that form the composite surfaces. The experimental results demonstrate the wear resistance of the hybrid composites at loads of up to 60 N with sliding speeds of 1 4 m / s. The working activity of particle reinforcement improves wear tolerance with small quantities of SiC and B4C.[20]

C. Colin has been investigating the effect of certain processing parameters on the range of 12 millimeter diameter interfacial response, reinforced cast aluminum composites with continuous stainless steel fiber. The total fiber / matrix interface reaction layer thickness was determined with the image analysis. The reaction was mediated by a coating or from a surface below few millimeters below the display, once the casting was rendered in a color at room temperature. The results show that before the liquid metal is discharged it is the most important part of the reaction. The surface reaction varies by the infiltration parameters and optimisation features, such as fiber volumes.[21]

T. Rajmohan examined the characteristics of synthetic and hybrid aluminum matrix reinforced by small sic particles, and the synthesis method prepares copper-oxide (CuO) nanoparticles. The primary powder mixture for setting the fixed weight (wt.) and different wtc is an element of nano-copper oxide reinforcement that is irregularly cool. Later, the compact green is sinned during the electric muffin furnace. Microstructure and mechanical characteristics such as tensile strength, subtle hardness and composite density are investigated. A scanning microscope (SEM), X-ray diffraction (XRD) and Atomic Force Mgnifier (AFM) were examined for sample microstructure. The results show that the risein nano-copper weight increases mechanical properties.[22]

2.2. Literature review for application

Jérôme PORA was investigate that the use of aluminium matrix composite in the field of aerospace sector for producing of airbus A380. The A380 will also be the primary aircraft to possess a central wing box composed of CFRP (plastic reinforced with carbon fiber). Finally, the dimensions of the components of the A380 will generate the possibility of designing enormous composite components, reducing assembly prices and increasing the amount of materials to be produced, movingA380 one step additional within the development by airbus of composite applications on airframes.[23]

E. Salernitano was investigated the appliance of composite material within the field of medical specialty application. In medical specialty sector Composite materials are employed in clinical practice to restore anterior and posterior teeth. Internal fixation devices are quickly established within the body to carry along the bone fragments and promote healing. The utilization of composite materials in artificial joints may be a promising research field.[24]

M ADrewry Use the composite material to create a wind turbine. They were constantly looked after, usually populated and manually operated to a large extent. We were introduced into the culture and were designed to replace other components regularly. During the examination, NDT control strategies were used to examine the rotor blades. The injury analysis in most towers shows that this is done under a medium intensity wind, and fatigue failure is also the reason. A wireless system with a little oscillation circuit for the detection of carbon / epoxy composites is planned during this study.[25]

Conclusion of literature review

After reading all the review we tend to conclude that aluminium matrix composite are employed in different field for the producing of various kind of product that is use in future life.

The different properties of aluminium matrix composite are varying as per use of various composition of material. Some material increase their mechanical property like tensile strength, Compressive strength, strength, hardness and thermal characteristics.

The MMC of aluminium are utilized in totally different sector because of their property like low density, high strength. In the field of aerospace aluminium matrix play animportant in the production of various a part of aircraft.

It was additionally found that the foremost of the research work has been carried out on improvement of some parameter like wear strength, fracture strength, etc. by the addition of various reinforcement.

The use of this kind material is increase day to day. These materials have high strength, high temperature at less weight/ rarity. It uses in several sector like medical part, aerospace, wind mills and additionally in automobile sector.

2.3 Objectives of present work

- Development of composite aluminum matrix with stir casting..
- Test their mechanical, thermal property like strength, hardness, toughness, density.
- Experimental modeling and optimization of method parameters.

Chapter 3

Testing Equipment

3.1 Universal Testing Machine (UTM)

A universal testing machine (UTM), together called comprehensive analyzer, For the inspection of each material tensile and compressive nature, a definition of material inspection machine or material inspection shall be used. Universal measuring machines are designed for various materials, components and frames. The bulk of UTM versions are versatile and can be customized to meet customer needs.

Generic processing machines can accommodate many different types of materials such as metal and fine concrete objects, lightweight materials such as rubber or textiles. This range applies equally to universal testing machines for almost all manufacturing industries.

UTM may serve as a multifaceted and valuable research tool for the assessment of materials ' physical characteristics, including tensile strength, elasticity, rigidity, production volume, elastic and plastic deformation, revolving strain and strict hard materials. Different Universal Machine Testing models have various loads, lower than 5 kN and more than 2000 kN. Work can also be carried out in the controlled environment. It is achieved in a lab or a laboratory by installing a universal check unit.

3.1.1 Principle of operation

Through transferring liquid load from the test sample to an individual load sensor, the system works. The hydraulic system is suitable because it replaces the load transmissible through the lever and knife tips, which are susceptible to damage and tear due to shock of the check components.

Traditionally, load is supplied with lubricated ram. The dynamometer pendulum mechanism moves the central gas pressure to the cylinder in the control panel. The ring is also self-lubricating. The load is transmitted to the pendulum via the liver system.

The pendulum displacement is based on the load-indicator and the autograph pinion and pinion system. The deflection of the pendulum reflects the full load added.

In the case of abrupt fracturing of a specimen, the pendulum reversal moment dampens the absorbed force.

3.1.2 Unit of UTM

UTM consist two main units, via the loading unit and the controlling unit.

3.1.1.1 Loading Unit

The charging machine has a strong base in the center of which the maincylinders and pistons are mounted. A rigid framework consisting of the lower table and of the higher unrefined head and hence two straight columns is connected by ball and socket joint with the current piston. A group of screwed columns connected to the foundation move through the central nozzles to protect the unrefined head beneath. This unrefined head moves up or down when a gear motor fitted to the base rotates the screwed columns. Each unrefined head has a slot in the center inserted into a pair of racked jaws. Such jaws are pushed by the rotating handle up or down.

3.1.1.2 Control Panel

The control panel is made up of the hydraulic power unit, the control devices, the load measuring device and a monitor.

I. The Hydraulic Power Unit

A reciprocal type of pump, which contains a set of submersibilities which ensures the continuous flow of non-spring oil into the main cylinder for smooth sampling. Hydraulic lines are specially designed to modify them for numerous functions. The reciprocal type is a pump driven by an electric motor and a sump for the hydraulic oil.

II. The Load Measuring Unit

The load estimation unit is typically a dynamometer pendulum unit. There is a small cylindrical piston in the same oil pressure with the main piston. The spindle liver also deflects a single pendulum associated with this small piston according to the sample load and spinal ratio. This deflection is sent to load points that show the test load on the dial. The machine's general accuracy depends on the precision of itsestimating function.

III. Control Device

They include electrical control equipment, hydraulic control equipment and loading equipment.

The electric power gadgets are in the shape of four switches on the left side of the board. The top and bottom push buttons are designed for moving all the bottom head. A onand off option for two hydraulic siphons is necessary.

The hydraulic control devices A few control levers are mounted on the table or control board. The right mechanism for power is the inlet valve. The oil flows back when this valve is close and the hydraulic system is on. The valve is opened by the continuous non-pulsed flow of oil in the principal cylinders. Return valve is the left power mechanism.If the valve is near and the hydraulic mechanism is triggered, the piston pushes upward the oil injected into the tank.

The load indicating devices That loading point is called the floating dial in the range behind the loading signal dial. When the range modification handle is activated, the previous move is set to the chosen range. At any step, the load on the sample is shown through the load pointer, displaying the button, pushing the load forward and going along with the dummy. This tests how real (hardness) it is (extension) and how disrespectful (ducile modulus).

Test on UTM

A UTM is a great multi-use device in the research and development laboratoryor the QC team.

1. **Tensile Test:** Fix a piece on both sides and drag it to break. It is estimated how difficult (hard), how long (extension), and how difficult (elastic coefficient).

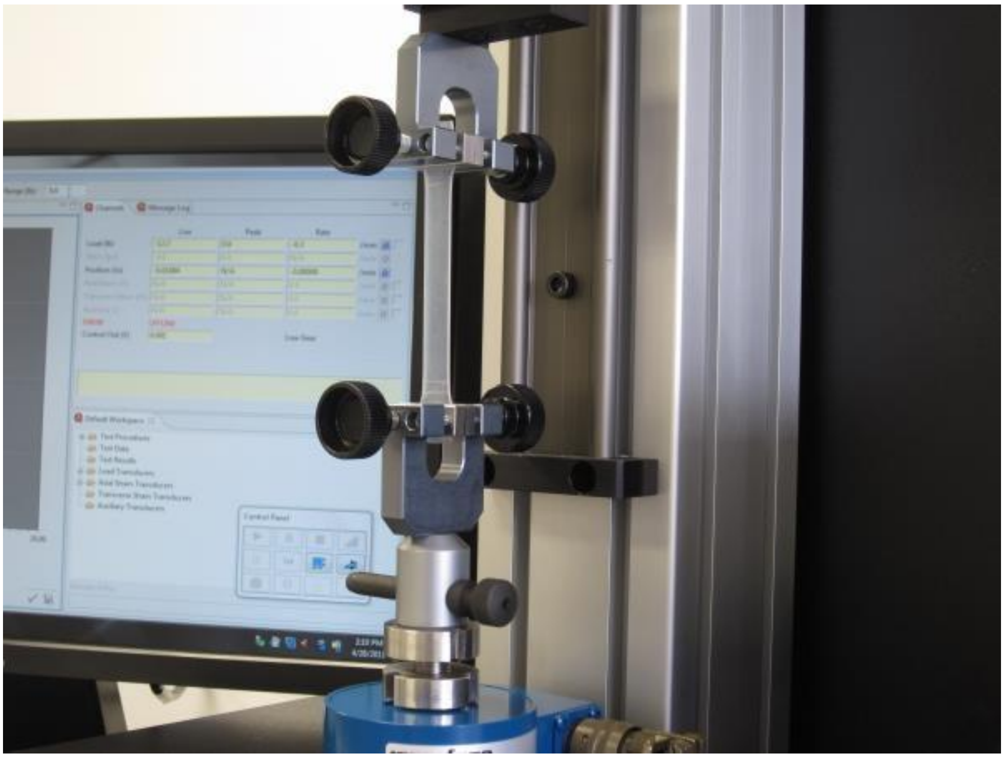


Fig. 3.1: ADMET Testing Machine performing a tensile test.

2. **Compression Test:** Just the reverse of a tensile check. This is when you compact an item between two layers before you exceed a certain weight or distance or the substance splits. The normal pre-break calculation (compressive force) is the highest assisted power or load or weight displacement through displacement.
3. **Bend Test:** This is a compression measure, with up to two supports each end representing the duration of the material. There is nothing underneath it to support the middle. You move in the center of the material immediately from top to bottom; the substance breaks down in a given distance. This testmeasures the strength and the hardness of the material in the flexor (flexuralmodule).

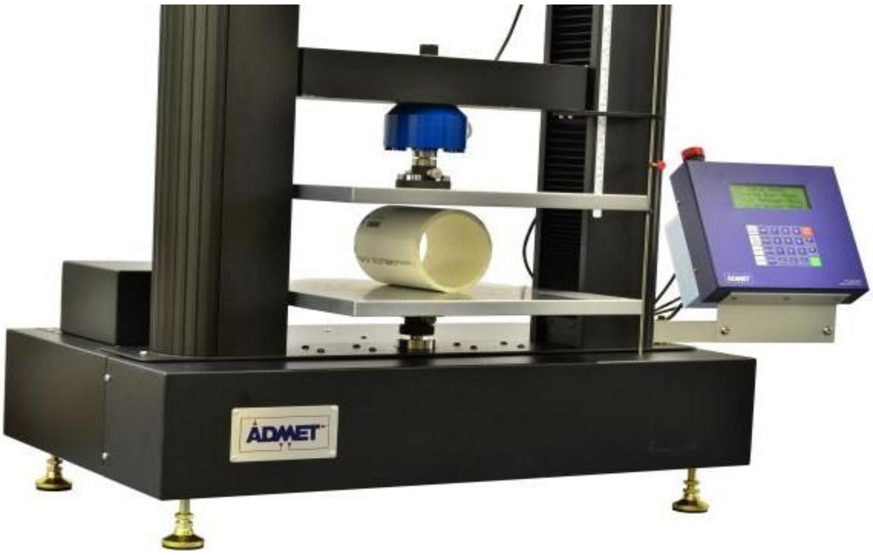


Fig. 3.2: Compression Test.

Fig. 3.3: Bend Test being performed.

3.2 Hardness Tester

The hardness of Rockwell is enough for analysts to measure the hardness of metals and their compounds as a smooth, round, unpredictable form in these parts. These devices are designed and assembled in a manner that allows users to use component calculation on computers as weight and height. These computers are operated manually, easy to plan and easy to operate. The Rockwell and Rockwell chal calculations require indentation (precious stones or balls) compulsions at, for example, the exterior surface of a testmaterial in two phases to determine the indentation depth by the test force and, accordingly, by an additional test strength.

The Brianel test is the measurement of the indentation diameter with a given test force to fasten the hard ball to the surface of the test piece and evaluate the number of salted stiffnesses.

Some important types of hardness testing machine are

3.2.1 Digital Motorised Rockwell Hardness Testing Machines are suitable for testing the hardness of metals and testing of all types of alloys. This motorized system is used to implement and remove major loads. To display high-value-high-value signals, larger, more sophisticated 7-segment displays are used.

The nominal load is determined by the LED bar graph. It can be operated manually in case of motor failure. Machines are providing enough error codes for smooth operation. Three ways to operate Machine Vis Motorized automatic mode, motorized mode, and manual indicator are guided in linear effect so that small jobs can be tested.

3.2.2 Vickers cum Brinell hardness testersis Suitable for assessing a wide range of products. Rigid goods, including rigid stainless steel, thin metal bars and hard boxing, can be used as well because the test is extremely small. These machines are available in different models that are very precise but easy to operate. There is a load selection push-button system. The cycle and penetration of the forecasting device begins. The handle is removed and the specifically exposed impact / diameter is impacted. The user can use an optimized optical system to calculate the impact directly on the computer with a micrograduate sample.

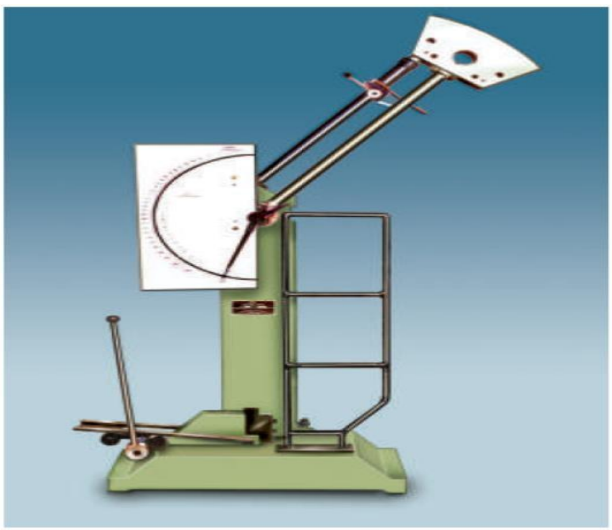


Fig. 3.4 Digital Motorised Rockwell Testing Machines **Fig. 3.5 Vickers cum Brinell hardness hardness testers.**

3.3 Impact Testing Machine

Pendulum effect testing machine applies to the pendulum against the antioxidant effect. Two tests will be done by the change in the starting position of this machine, lower for the upper one for the bunk and another for the ezod test. When the pendulum moves out of its position, the pendulum swings down all the way to break the sample and absorbs energy before testing before breaking the sample and is read from the maximum position of the indicator on the dial scale. A joint support for the ezod and perforated test, for fitting in the pendulum, is a joint support of Envilles and two strikers on the basis of the machine. The change from one attacker to another is achieved only by fixing a new attacker in his place. Fig. 3.6 Impact testing machine

3.3.1 Charpy Test

The Charpy test part rests on the support of alloy steel, rigidly placed on the basof the machine by the Allen Screw. The Charpy test piece rests on the support of an alloy steel, which is rigidly placed on the base of the machine by the Allen Screw. The end connector is quickly and accurately accommodated to find the test piece centrally between the supports.

3.3.2 Izod Test

The Izod test is clamped vertically in an Izod pad installed on the machine's base. A mechanical vertical groove in accordance with the size of the test piece is supported. The front cinch piece and the Allen screw allow the test piece to be clamped in the right height with the support of the Izod setting indicator.

3.4 Density Meter

Density meters are a device that estimates the density, otherwise known as the densometer. The density is determined by the mass ratio (m / v). The density unit is kg / m3.

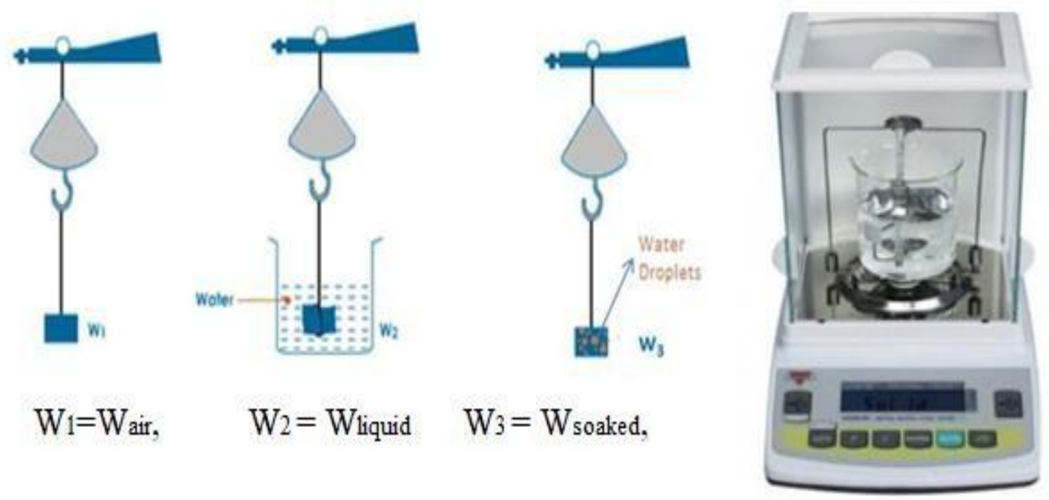


Figure 3.7: (a) Experimental setup for density measurement (b) Density measurement kit.

3.4.1 Wet bits and dry sections of the sample can be measured by several meters of density. The abundance of all fluids in the sample is found in the wet part. The actual gravity of a substance is not determined by a density meter directly. A different density meter can nevertheless be used. The density of the opposite sample is known as special gravity with the reference density. Normal amount of water relation. Diameter meters come in many different shapes.

3.4.2 Gravitic

To calculate the density of gravity, gravitational density meters use the theory of gravity. A flexible hose is employed to see changes in weight. Calculation of load 2 can be done using the theory of beam deflection of the holes of the cord.

Displacement is calculated with a high accuracy laser displacement. The deflection of the micron scale can be browsed with density meters. Small weight shifts are shown onit graph. The entire quantity is measured by gravity. It implies that the sample size must be measured.

3.4.3 Coriolis

3.4.4 Density meter of Coriolis, also known as an inertial flow meter or mass flow meter, works on a thin vibration of a wall tube. The small bar rotates around the center axis. If there is no mass in the block segment, the tube is still unused.

3.4.5 But once the density in the Bent segment has reduced. This rotation causes sectional changes, resulting in a resonant frequency of thin-walled tubules. Therefore the resonant frequency is directly affected by the density. If high flow rate is constant, high density media have a great effect on coriolis.

3.4.6 Nuclear

The atomic density meter works on the principle of gamma ray measurement. Gamma radiation is released from a plant. This source is typically Cesium-137 (half- life:~30 years). Radiation can be seen by a scalinator.

The emission is light. The number of light is counted. The atomic intensity of the gamma ray is confined to the meter radius. The sample size may be a very linear column that is blurred.

3.5 Wear testing

A pin-on-disk laboratory wear testing machine was used to evaluate the abrasive wear of composites. The two-body wear-testing system was selected because it can offer high voltage and low-speed surroundings with minimum variables that can be controlled easily for every test.

Fig displays a design sketch of a pin-on-disk typical wear device. There are two forms of pins in the disk wear testing machine. A running axis and chuck are used in a sort ofnormal system to keep the curved disk so as to enable pin measurements against a curved disk sample using a pin scan with the sample controlled. Keep attachments. Keeping attachments. Disable fittings. A second system type loads the spinning pin around the disk center against the static disk. In any case, the device to be carried on the disk is a loop containing multiple trackers on the same track.

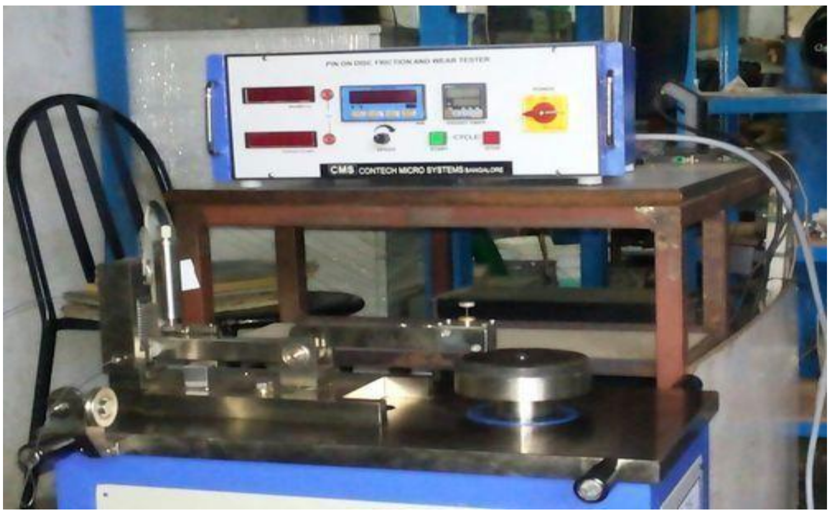


Fig. 3.8: Pin on Disc Wear testing machine.

The machine can have a frictional force measurement device, such as a load cell, which enables the coefficient of friction to be measured. A variable speed engine that maintains the constant speed (61% rating full load engine speed) under load. The engine should be rotated to avoid the noise from impacting thecheck. Usually the spinning speed is between 0,3 and 3 rad / s (60 to 600 r / min). The machine will be equipped with a revolution counter or equivalent, recording the number of disk revolutions and the ability to turn off the machine after the pre-selected revolution. A stable sample holder is connected to a lever arm with a swivel in a standard device.

The addition of weight as the loading optionproduces proportional test strength in proportion to weight mass. Ideally, the hand pivot wear should be placed in the contact aircraft to prevent external loading forces due to sliding friction. During the test, the pin holder and hand should be designed adequately to reduce the vibration speed. Wear system instruments which measure linear measures to achieve 2.5 microns or better wear sensitivity. Any balances used to measure mass loss of the test sample are 0.1 mg or better, and fewer conditions of wear may require more sensitivity. The frequency is 0.26-10 m / sec, with a disk rotation Speed: 100-2000 rpm. This machine's full usual load power is 200 N. Can use a 3-12 mm diagonal / diameter specimen pin. Wear Track This machine's diameter is 0-140 mm.

Chapter 4

Development of FeAl MMC

4.1 Introduction

This chapter describes the manufacturing steps taken in the current project. The rawmaterials required to produce the MMC specimen are supplied with their characteristics and composition. Images illustrate details of each step of manufacturing Al / Fe / WC MMC with special compositions.

4.2 Material for fabrication

In the development of aluminium MMC different type of material are used to improve their property. In the present work for the development of aluminium MMC iron aluminides (FeAl) are used as a base metal. In this iron aluminides iron and aluminium are mixed in equal portion and tungsten carbide used as reinforcement. The compositions of different metal are different for the development of Aluminium MMCs.

Aluminium alloy Aluminium 6063-T6 (In solid plate), Iron in the form of powder (-325 Mesh) and tungsten carbide (-325 mesh) used as a reinforcement.

Aluminium alloy Aluminium 6063-T6 plate was obtained from Vijay PrakashGupta & Sons, New Delhi, India. The WC particles from UNITED WOLFRAM Surat Gujarat India and iron powder from Gangotri Inorganic Pvt. Ltd Ahmedabad Gujarat India.

Fig 4.2 Iron powder 325 mesh

4.2.1 Aluminium Alloy

The aluminium used for the development of iron aluminides is Aluminium 6063-T6 and they have following compositions

- Magnesium (Mg) 0.45 - 0.90
- Silicon (Si) 0.20 - 0.60
- Iron (Fe) 0.0 - 0.35
- Others (Total) 0.0 - 0.20
- Chromium (Cr) 0.0 - 0.10
- Copper (Cu) 0.0 - 0.10
- Titanium (Ti) 0.0 - 0.10
- Manganese (Mn) 0.0 - 0.10
- Zinc (Zn) 0.0 - 0.10
- Aluminium (Al) Balance Purchased slabs were of size 26cm×6cm×1cm each.
  Aluminium alloy 6063T6 has following properties
- Tensile strength 214 MPa
- Young‘s modulus 70GPa

- Density 2.7 g/cm^3
- Melting point 655^{0}C
- Hardness Vickers 83 HV
- Excellent corrosion resistance.
- Very good weldability.
- Good machinability.
- High specific strength (Tensile strength/density).
- High specific stiffness (Elastic modulus/density).

4.2.2 Iron powder

Fine Iron powder is of particle size 325 meshes (44µm).Its hardness on mohs scale is 4 and on brinell hardness scale is 600 MPa.It has a Young's modulus of approximately 211 GPa. Its density is 7.874 g/cm^3. Iron has high melting point 1538^{0}C.

4.2.3 Tungsten carbide powder

Fine WC powder has been used with 5µm particle size. Tungsten carbide is extremely hard with a Mohs rating of about 9 and a Vicker ranking of about 2600. It has a Young modulus of about 530-700 GPa. It has 15.7 g / cm3 mass. Low melting point of tungsten carbide is2700oC. Tungsten carbide powder contains 0.02 to 0.09 percent oxygen and 0.06 to 0.08 percent free carbon.

Fig. 4.3: Tungsten carbide powder.

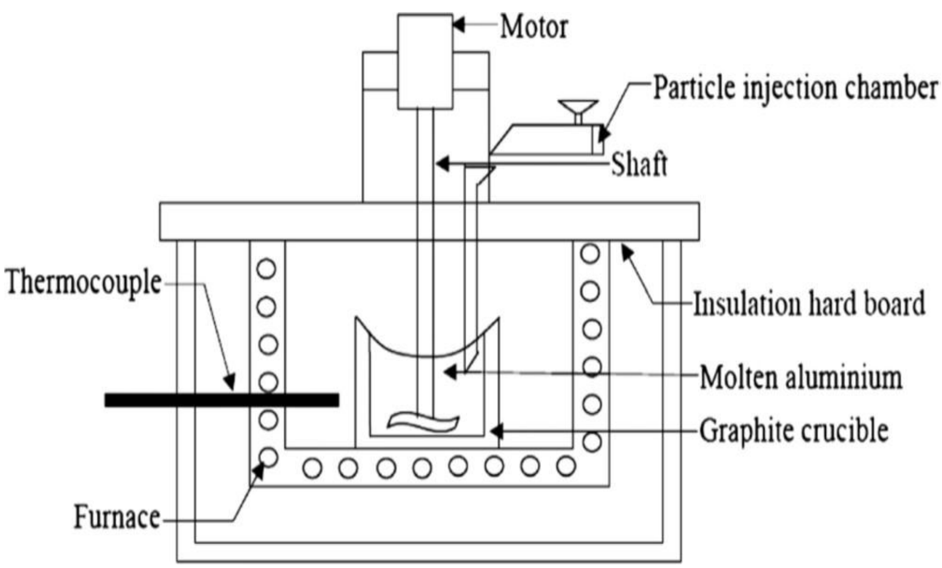
4.2.4 Composite Specimen Fabrication

The main task was to produce composite material. Our primary goal is to enhance the physical and mechanical properties by correctly combining the framework with the metal matrix. Different road intrusion techniques, spray coagulation, casting and powder metallurgy methods for the construction of al-based MMC are available. The method of spray deposition of the aluminum metal matrix helps to improve material overall and a low dissociation property but this method becomes costly and difficult to obtain the net form. Powder metallurgy involved problems including rough interfacial relations, isolation, aggregation of clusterings, etc., because this is performed at low temperatures and it is a costly process. TheCasting Process is the most flexible process for constructing composites with metal matrix for various reasons, which include a wide variety of reinforcements in the matrix. The rigidity, indirect strength and compression power of composites are increased significantly.

4.3 Stir-casting

Casting removal is also classified as a "semi-solid metal casting" or a "composting" and strengthens the advantages of casting and forging. The SSM is rendered between fluid and rigid metal pressures at a temperature.

When an electric current (preferably a strong conductor) passes through a device, heat is dissipated because of mechanical resistance. This phenomenon provides a good, clean and easily controlled source of heat and is commonly used in heating and industrial applications. The person or function can be electrically heated by focusing a fluid heater or oven "indirectly." The object can also be used as a heater or resistance alone to generate internal heat.[26-30,30-26]



4.3.1 Principles

Fig 4.4 A typical stir casting setup.

If the driver resistor (OHMS) is R and the current I (AMPS), T (compress) moves through it once, heat production (H) is: H= I2RT(Joule).

The driver is referred to as a radiator or a heating element. Heat technology is usable up to a maximum effective temperature of 2000oC. But the whole series and all kinds of atmospheres have no content. Each material has its most useful temperature in a given environment.

4.3.2 Casting methods

4.3.2.1 Mould temperature

The use of metal die creates considerable grinding relative to cast cement, but the temperature of the mould is of auxiliary significance to the production of structures. Its main importance lies in the degree to which the die is preheated. Expansion decreases casting risk. For nonferrous castings For nonferrous castings, the molding temperature should not be too low or too high. The mold thickness should not be less than 25 mm, and the casting size and weight decrease.

4.3.2.2 Mold Coatings

Different types of surface compounds are used. The source of the painting is themetal mold spraying. Coating is designed to reduce container heat transfer. Defects including shrinking and breaking of metal molds can be reversed and life can be improved. Through adjusting the thickness of the sheet, the function of coating and reinforcement can be modified to the optimal value of a specific alloy. The coating is an aluminum alloy mixture of silicate and graphite in water.

4.3.2.3 Mold Life

The casting of metals is under thermal stress due to continuous operation. This can lead to mold failure. The amount of stress depends on the thickness of the mold andthe layer of the coating, both of which influence production rates. The decrease in cast iron mold is rapid compared to steel mold. The following features describe mustard castings:

- The content of the spread phase is limited (usually no more than 30 vol%)
- Distribution of the phase spread across the entire matrix is not completely

homogeneous:

- There are local clusters of dispersed particles (fiber).
- Gravitational separation of the phase spanning due to the difference in the densityof the spread and matrix phase can be.
- The technique is relatively simple and low cost.

4.3.3 Stir Casting Setup

It consists of the following components:

I. Furnaces

II. Control Room

III. Stirrerassemblies

IV. Thermocouple

V. Motor

I. **Furnaces**: The furnace has the following components:

II. **Electric Furnace Frame:** It is made of light steel sheet.

Fig. 4.5: Electric furnace frame with insulating materials.

- **Insulating material:** It is made of asbestos thin sheets and refractive bricks.
- **Heat wire:** The heat wire used is the KANTHAL wire, which can withstand temperatures up to 14000^0C.
- **Crucible:** Crucible containers that heat the metal and dump it into the casting mould. The mold material should have a high melting point, high strength and heat should be a very good driver for a low heat loss. Many materials such as silicone carbide, caststeel and graphite are available for this purpose. The silicone carbide sinker is best suitedto our

needs, although the cost is high and can not be tolerated. Here we have taken a graphite tubing to meet our goals because the melting temperature is around 2700 ° C, away from our working temperature. The crucible is produced in the form of the cylinder with a smaller diameter, so that the upper section remains a cylindrium, although the lower section takes the form of the hemisphere. A handle is mounted on the side of the induction in the forge, and it is put in a hot cell during the heated injection of hot metal. It supports the high temperature and the number of modern laboratory processes with the productionof metal, glass and pigments.

Graphite crucible has been used. The following dimensions are

Fig. 4.6: Graphite Crucible.

Exterior dimensions = 145 mm Inner dimension = 117 mm Exterior Height = 165mm Inside depth = 150 mm

III. Control Room

A control room is defined as a meeting of systematic and standard arrangements of motor controllers such as two or more components; overload relay; Connected disconnect switch; And related wires, terminal block, pilot light push button station, selector switch, timer, switch and control relay with circuit breaker and related control device with similar components. It controls the temperature inside the furnace and displays the temperature inside the furnace. Electricity is provided to the furnace through the control panel. The control panel receives power from the main connection.

Fig 4.7 Control panel

IV. Stirrer Assembly

For the MMC building process, the need to phase the expansion of ceramic particles (WC) in solid metal must be combined. For the mixing of ceramic particles in liquid metal, the mixture needs to be stirred well. A stimulant is therefore required that can withstand high temperatures and does not affect the overall purity. The stir is made of a steel rod with a fan-connected front graphite. It is driven by a 1⁄2 HP AC engine and rotates about 400 rpm. The stimulant is inserted vertically into approximately one third of its height crush following the addition of ceramic particles.

Here we have included ways to remove external media that can be attached from the oven to the top at any stage.

Stirrer assembly consists of the following components:

- Stirrer stand: It is made of steel.
- Stirrer rod: It is made of stainless steel.
- Stirrer: It is made of stainless steel.

V. Thermocouple

The temperature sensing devices used to measurethe temperature are thermocouples. They are highly efficient, reliable, highly sensitive and inexpensive. Here we use a thermocouple for copper stabilizer. The temperature of the liquid metal must be known at all points, which is why the use of thermocouples is used. The thermocouple that is used here are the Iron-Constant and Chromel-Alumel (K-Type).

Fig 4.8 Stirrer assembly

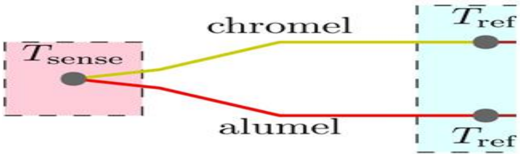


Fig. 4.9: Thermocouple_circuit_K-type.

VI. Motor

A universal AC motor is used for the rotating of stirrer for the mixing of iron (Fe) and tungsten carbide (WC) in the molten aluminium. The motor has rated capacity of ½ HP with the rotation speed around 400 rpm.

Fig. 4.10: Universal motor.

4.3.4 Melting of matrix material

After procuring matrix material, the Aluminium alloy 6063 T6 was cut in small bars of size 125mmX 70mm X 13mm, with power hacksaw, to be easily placed in the crucible for melting. For melting, electricity was turned on and the material was placed in crucible in the furnace. Since the electric furnace has been used for melting of composite, so after two hours the temperature inside the furnace reached 750℃, which was shown on the control panel display and measured by thermocouple. At this 750℃ temperature, the matrix material was melted.

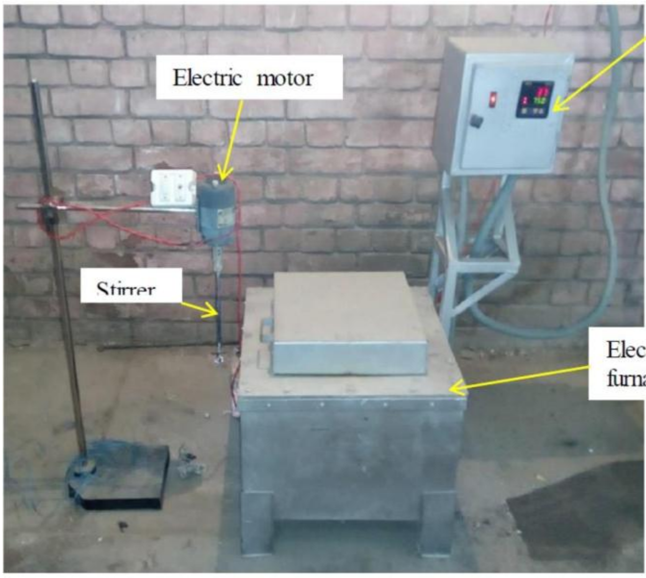


Fig. 4.11: Complete stir casting setup.

4.3.5 Mixing of Reinforcements

Reinforcements is manually combined with the aid of mechanical stirrer in the molten matrix. The first iron powders of 44µm size are mixed in molten metal and heatup. Then tungsten carbide powder of 5µm size is mixed as reinforcement in molten metal. In the mixing process, the first stimulant was molten and the motor was turned on. After this, the reinforcement was sprinkled in the molten matrix.

4.3.6 Stirring of molten mixture

After sprinkling of reinforcements in molten matrix, mixture of matrix and reinforcements were stirred by mechanical stirrer at 1550°C temperature, at 400 rpm, for10 minutes.

Fig. 4.12: Stirring of Reinforcements in molten composite.

4.4 Specimen Preparation

4.4.1 Sand Casting

4.4.2 The casting technique, often referred to as sand-shaped cast, may be distinguished by the use of sand due to the mold. The term ' sand casting' can also be verified with an object using the sand casting method. Sand castings are produced in specialist factories known as foundries. Sand casting produces over 70ths of all metal casts. Sand moulds in stainless steel factories are comparatively low and sufficiently refractory to be used. In addition to the oil, the sand is combined with agood binding agent (usually clay). The mixture is humidified to increase the soil strength and physical characteristics and to mold it, usually with water, but usuallywith other substances. The sand is usually found in a system or in mold boxes that are known as a bottle. The mould cavities ' logical door system is created by compacting sand around models or patterns or sculpted in the sand.

4.4.3 Pattern making

While casting, a template is a copy of the component to be produced, the normal preparing of the cavity in which liquefied content is poured throughout the castingprocess. A sand casting design is also made of wood, metal, plastics or other substitute materials. Models are built to exacting building standards and will last for a reasonable period of time, in keeping with the regular grade of the product, because they provide again and again an appropriate dimensional casting. In this study, mahogany wood is used for the sand casting pattern. And she saw the various sizes.

4.4.4 Preparation of sand moulds

Sand moulds are temporary in nature; a replacement mould should be shaped every time for individual casting. First, moulding sand was prepared. For this, sand, soil, and ash were filtered with sieve-mesh 2mm. Green sand was prepared by mixing sand, soil, ash and some water. This sand mixture was properly kneaded and water was added till binding initiates. The mold is made up of two parts in a mold box which helps to remove the pattern. Cores require bigger strength to carry their kind throughout pouring. Mould designs includes a gating system which a design to carry molten metal smoothly to all part of the mould the gating system typically includes a sprue, gates, runners and risers. After preparation of the mould, it was kept for one day to get dry and to get set properly.

4.4.5 Pouring of molten composite

After preparing sand moulds, in days advance to melting, molten composite was poured in the mould cavities in red melt condition manually with tong. After pouring molten composite, composite gets solidify in sand mould cavity itself within an hour. After solidification of composite, sand mould was collapsed and thus we get solidified composite.

Chapter 5 Experimental procedure and Results

5 Experimental procedure

This chapter describe the testing performed on the specimen for the calculating of different mechanical properties. This chapter contain tensile testing, compressive testing, hardness testing, impact testing, and torsion testing and density measurement.

5.1 Tensile testing

Tensile testing is utilized to give data that will be utilized in structure computations or to show that the material consents to the necessities of suitable details - so it can be either quantitative or qualitative test. Tensile strength of the specimen is measured by tensile testing. In this research tensile testing is carried out on universal testing machine.

The test is done by applying the continuous growing uni-axial load by holding the ends of the standardized test piece, properly prepared in a tensile test machine and then on failure. As per ASTM standard the size of test piece is based on the following relation

L0 = k√A0

Where L0 = Original gauge length of sample within minimum diameter (m) k = constant (value of k varies from 5 to 6)

A0 = Original cross-sectional area at gauge length (m2)

Test pieces are standardised in order that results are reproducible and comparable as shownin Fig 5.1.

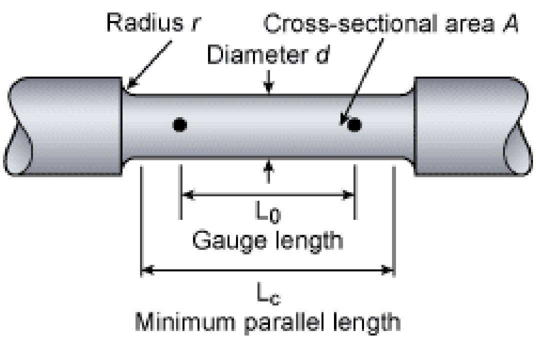


Fig. 5.1: Standard shape tensile specimen.

A uniformly increasing load applies to the sample. As the load increase, the sampleis initially expanded extensively. Upon moving forward, the sample goes beyond the elastic limit when the sample starts the neck at some points. The lower width of the samplewill decrease under the force of the load and in the end the fracture will develop when the test is completed.

The applied stress is directly proportional to the stress induced. The end of this linear portion is the yield point of the material over which the material begins to deform, and if the sample breaks if strength applies beyond the limit. The stress is called yield strength at the elastic limit. The maximum stress before the fracture is known in a material

In present experiment the tensile test are conducted on aluminium MMCs.

Following formulas are used.$\sigma = P/A_0$

$e = (L_f - L_0)/L_0 = (A_0 - A_f)/A_0$

σ_u = maximum load /cross-sectional area

Table 1: Tensile strength of specimen at different % of Reinforcement.

S No.	Specimen composition (% weight)			Tensile strength (MPa)			
	Al	Fe	WC	Test 1	Test 2	Test 3	Average
1.	50	50	0	315	317	320	317
2.	49.5	49.5	1	302	307	311	307
3.	49	49	2	295	298	301	298
4.	48.5	48.5	3	285	289	293	289

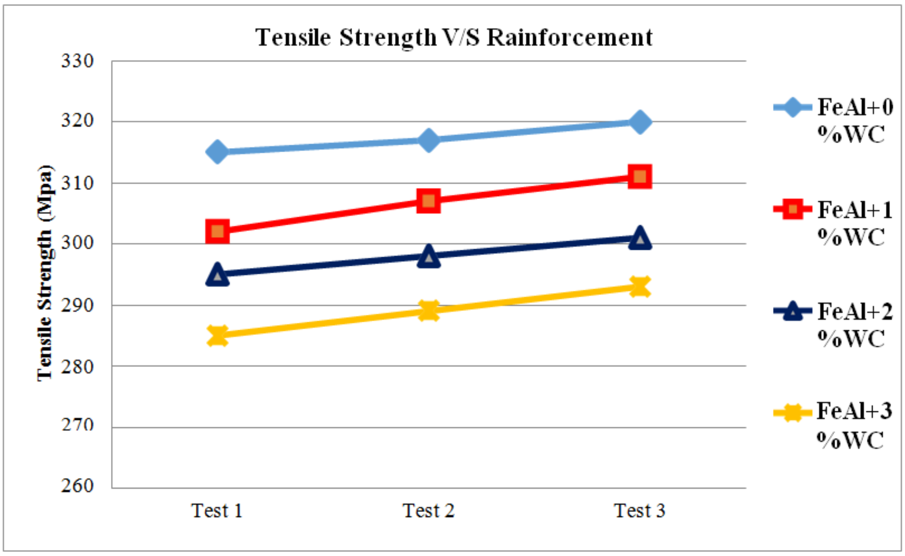


Fig. 5.2: Tensile strength of specimen at different % of Reinforcement.

5.2 Compressive testing

Specimen compressive strength is measured through compressive testing. Compressive quality testing, mechanical tests that estimate the highest measure of compressive weight before a material breaks. The test component, typically in the form of a triangle, prism, or ring, is compressed by an applied load step by step among the plates of a compression testing machine. Compressive testing is conducted on universal testing machines in this research.

The test is done by applying the continuous growing uni-axial load by holding the ends of the standardized test piece, properly prepared in a tensile test machine and then on failure.

In present study the compressive test are conducted on aluminium MMCs. Following formulas are used.

$\sigma = P/A0$

$e = (Lf-L0)/L0 = (A0 - Af)/A0$

σu = maximum load /cross-sectional area

Table 2: Compressive strength of specimen at different % of Reinforcement.

S No.	Specimen composition (% weight)			Compressive Strength (MPa)			
	Al	Fe	WC	Test 1	Test 2	Test 3	Average
1.	50	50	0	180	190	197	189
2.	49.5	49.5	1	220	229	238	229
3.	49	49	2	290	303	317	303
4.	48.5	48.5	3	400	409	417	409

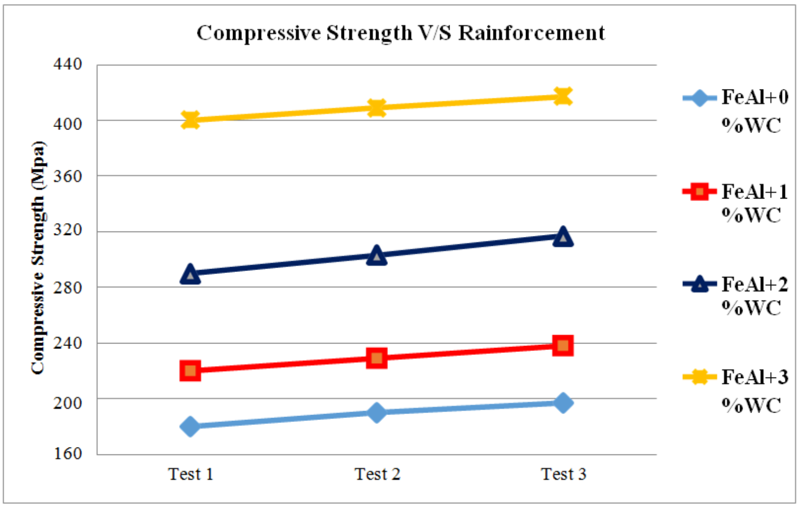


Fig. 5.3: Compressive strength of specimen at different % of Reinforcement.

5.3 Impact test

The effect test is, of course, the most widely used method for demonstrating stability of sensitive behavior in the transfer of substances. The impact test is performed by placing a V-nose sample on the test machine. The charpy specimen is usually 10 mmx 10 mm square and has a 2 mm grade of 45 o V with a 0.25 mm root radius. The sample is divided by a heavy pendulum released from a known height. The pendulum approaches the height after fracturing the control rim, which decreases when strength in the fracture is lost. The energy expended by the fracture can be measured by understanding the pendulum mass and the discrepancy between its first and last heights.

Table 3: Fracture Toughness of specimen at different % of Reinforcement.

S No.	Specimen composition (% weight)			Toughness			
	Al	Fe	WC	Test 1	Test 2	Test 3	Average
1.	50	50	0	90	93	95	93
2.	49.5	49.5	1	97	99	103	100
3.	49	49	2	107	110	112	110
4.	48.5	48.5	3	119	122	125	122

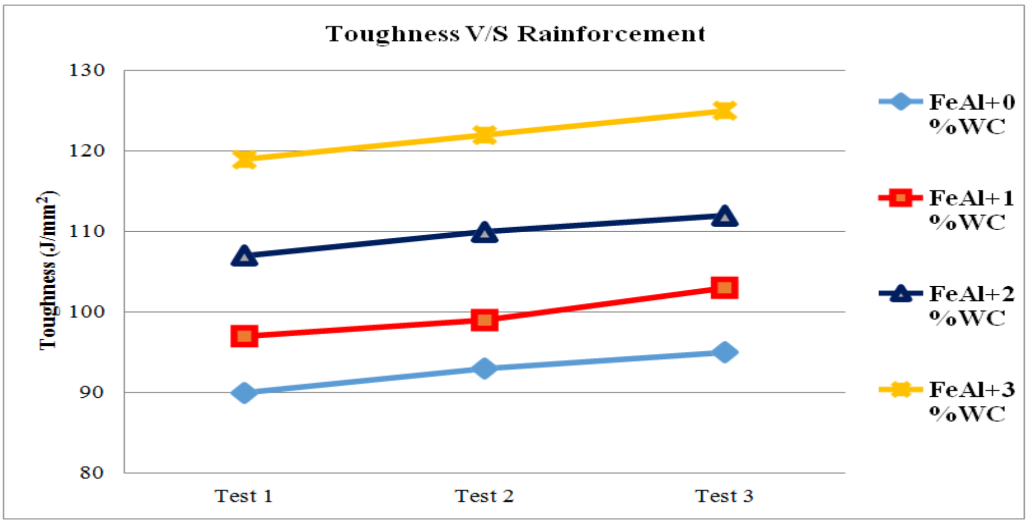
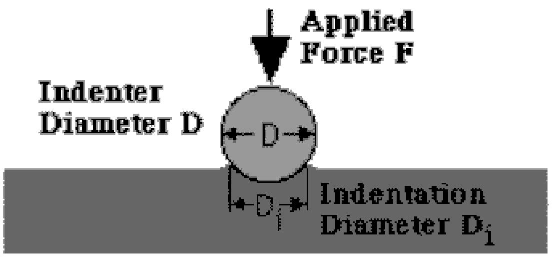


Fig. 5.4: Fracture Toughness of specimen at different % of Reinforcement.

5.4 Brinell hardness test

The hardness test method Brinell consists of a 10 mm diameter carbide ball, which is subjected to a load of 300 kg. For 3 sec, the full load is applied. With an occasionally powerful lens, the diameter of the indentation left inside the test material is measured. The amount of the Brinell brace is the load ratio added to the indentation area.



$$BHN = \frac{F}{\frac{\pi}{2} D \cdot \left(D - \sqrt{D^2 - D_i^2}\right)}$$

Table 4: Hardness of specimen at different % of Reinforcement.

S No.	Specimen composition (% weight)			Hardness (HV)			
	Al	Fe	WC	Test 1	Test 2	Test 3	Average
1.	50	50	0	290	294	299	294
2.	49.5	49.5	1	380	390	400	390
3.	49	49	2	490	496	502	496
4.	48.5	48.5	3	594	606	617	606

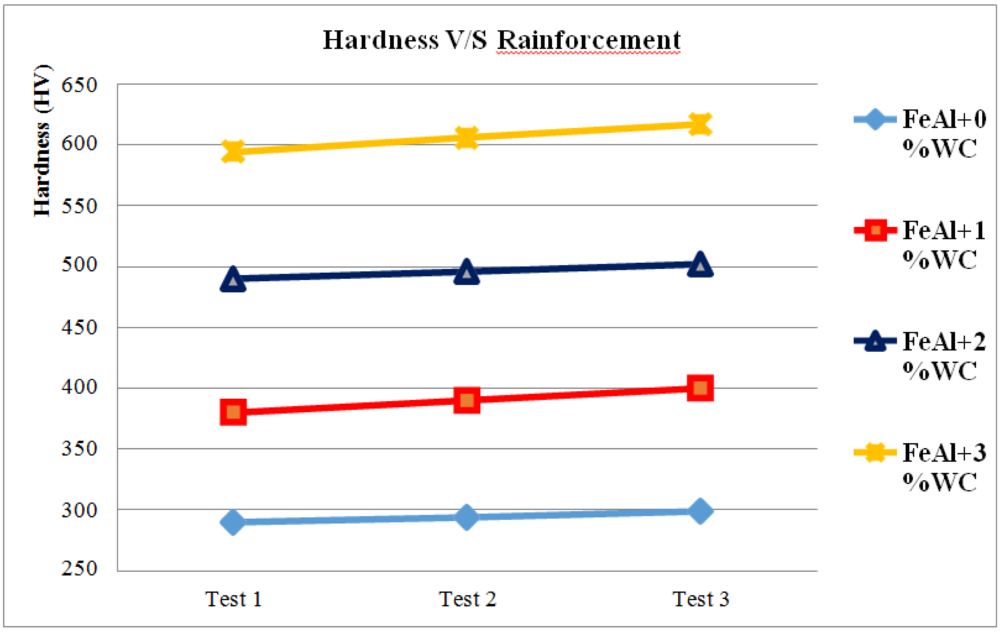


Fig. 5.5: Hardness of specimen at different % of Reinforcement.

5.5 Density measurement

The density of the different samples was calculated by the Archimedes theory. Due to several problem measuring density due to interconnected and disconnected pores in samples, the accurate density of sintered samples is very difficult to measure. Fluid fills the intertwined pores and influences density determination. There were three weight actions to mitigate this error: air weight or dry weight (wair); liquid or dipped (liquid) sample weight; and air sample weight after a long-term ingestion or soaked weight (wsoaked). The solvent used is water (µl=1.0 gm / cc). The sample density is calculated with the following formula for each sample, using the three weights obtained.

The density of different samples was determined using Archimedes' principle. Density measurement has many errors due to the presence of embedded and disconnected holes in the sample, because the precise density of sintered samples is difficult to measure. The liquid gets in the embedded cavity and affects the density measurement. To reduce this error, three weight measurements were taken weight in air or dry weight (Wair), weight of the sample dipped in liquid or dipped weight (Wliquid), and weight of the sample in air after soaking in liquid for a long time or soaked weight (Wsoaked). The liquid used in this process is distilled water (ρliquid =1.0 gm/cc). Density of the sample is determined form the three weights taken for each sample using the following formula.

ρc = $Wair$x $\rho liquid/(Wsoaked - Wliquid)$ … (1)Where,

ρc= Density of the composite, gm/cc Weight of the sample in air W1=Wair, gm

Weight of the sample in liquid W2 = Wliquid, gm

Weight of the sample soaked in liquid for a long time W3 = Wsoaked, gm

Table 5: Density of specimen at different % of Reinforcement.

S No.	Specimen composition (% weight)			Density (g/cm^3)				
	Al	**Fe**	**WC**	**Test 1**	**Test 2**	**Test 3**	**Test 4**	**Test 5**
1.	50	50	0	5.23	5.26	5.28	5.28	5.29
2.	49.5	49.5	1	5.39	5.41	5.41	5.43	5.30
3.	49	49	2	5.47	5.51	5.49	5.50	5.49
4.	48.5	48.5	3	5.55	5.58	5.57	5.59	5.61

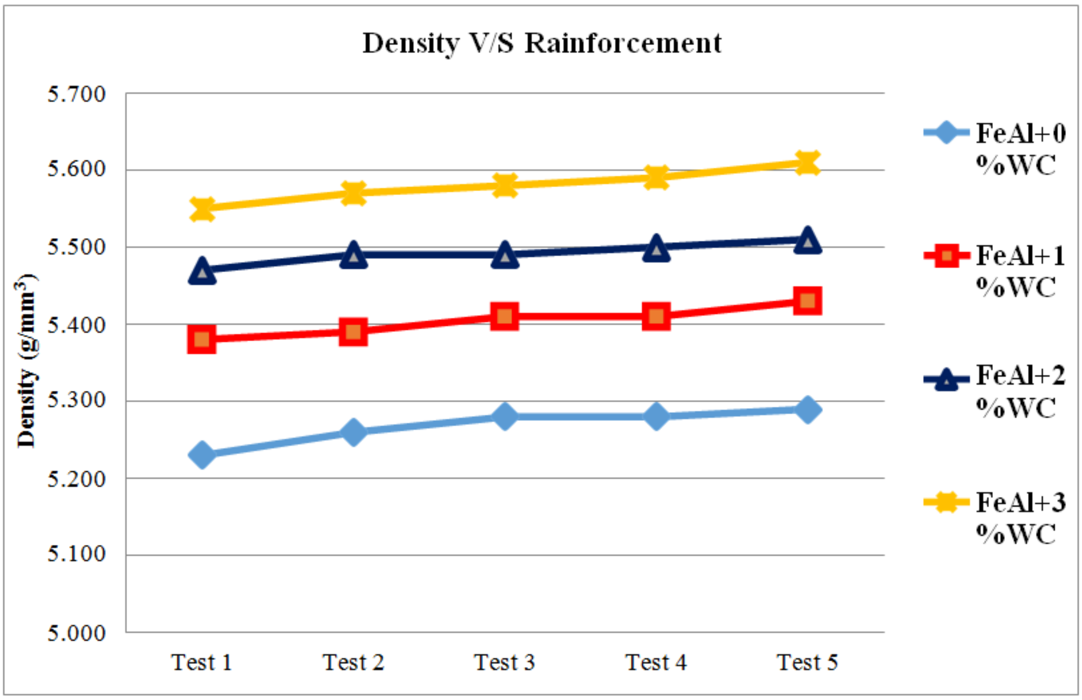


Fig. 5.5: Density of specimen at different % of Reinforcement.

5.6 Wear testing

The wear test on the pin on the disk wear test machine is performed. The pin sample was 12 mm in diameter and the acceptable length was 30 mm. The rotating diskhas a diameter of

90 mm and the electric motor has variable speeds. The sample was horizontally moved to the curved drum by an electric motor, as shown in the photo. The load was applied by adding charges at the end of the side.

The pin was placed against the counter face of a 60 mm spinning disk in wear track diameter. The pin has been fitted with a dead weight loading system against the tape. For all specimens under normal loads of 100N and a sliding speed of approximately 1 m / s the wear test was carried out.

Wear tests were conducted at a cumulative sliding distance of about 30 m under similar conditions as discussed earlier.

Prior to inspection, the sample pin surfaces were slided sandpaper (120 grain size) to ensure effective contact between the fresh, flat surface and the disk. Before and after each test, the samples and wear track were weighed (up to 0,0001 gm. with a microbalance).

In this experiment, the following parameters were requiring to conduct this test:

1. Load
2. Speed
3. Distance

To order to quantify the relative wear intensity of combosites, mass loss of reference material was used. The relative wear intensity of a material has been described as a large loss of test material to similar conditions for large-scale failure of reference test content.

The wear rate was calculated by the using the following equation:

$$Ws = \frac{\Delta m}{\rho L F N}$$

Where, ˙Ws is the wear rate mm3/mN, Δm is the mass loss of test specimen during abrasion test of N revolutions, ρ the density of test material, g cm−3. L is the total sliding distance, m and FN the normal force on the pin, N. Wear testing was performed 5 times on each specimen and the results were averaged. The coefficient of variation of the 5 tests was selected to be less than 5%. Any result with coefficient of variation value of higher than this was discarded. The error in the wear testing of the materials was estimated using the formula proposed by Pollard.

$$\sigma = \sqrt{\frac{1}{n-1}\sum_{n=1}^{n}(mi-\overline{m})2}$$

Where, σ is the standard deviation from the arithmetic mean.

The reproducibility of the mass loss from the wear test was examined using the reference material. Five tests were carried out on WC–Fe50Al50 composites. A normal force of 100 N, corresponding to 0.884 MPa pressure on the wearing surface of the pin,was applied to the specimen at a sliding speed of approximately 1 m/s. Fresh 120-grit silicon carbide paper (nominal particle size of 120µm; hardness 24.0 GPa; fracture toughness 2.5MPam1/2 was used to abrade the material in each test.

WC-3% Fe50Al50 composite were found to exhibit comparable rates of mass loss per unit sliding distance, and wear rates to that of the reference material (Tables 6 and 7).

The average mass loss and mass loss per unit sliding distance (mg/m) of WC-3% Fe50Al50 composites are shown in Table 6, in addition to those of the WC–10 vol. % Co reference material. The hardest composite in the group of materials tested

Table 6: Wear rate of WC-FeAl composite.

S No.	Specimen composition (% weight)			Path length (m)	Mass Loss (mg)	Mass loss per unit length
	Al	Fe	WC			
1.	50	50	0	30.144	45.88	1.5220
2.	49.5	49.5	1	30.144	42.77	1.4188
3.	49	49	2	30.144	40.78	1.3528
4.	48.5	48.5	3	30.144	36.83	1.2218

Table 7: Wear rate of WC-FeAl composite with hardness.

S No.	Specimen composition (% weight)			Density (gm/cm^3)	Hardness (HV)	Wear rate (mm^3/N-m)
	Al	Fe	WC			
1.	50	50	0	5.268	309	2.903
2.	49.5	49.5	1	5.388	411	2.646
3.	49	49	2	5.492	522	2.475
4.	48.5	48.5	3	5.580	637	2.200

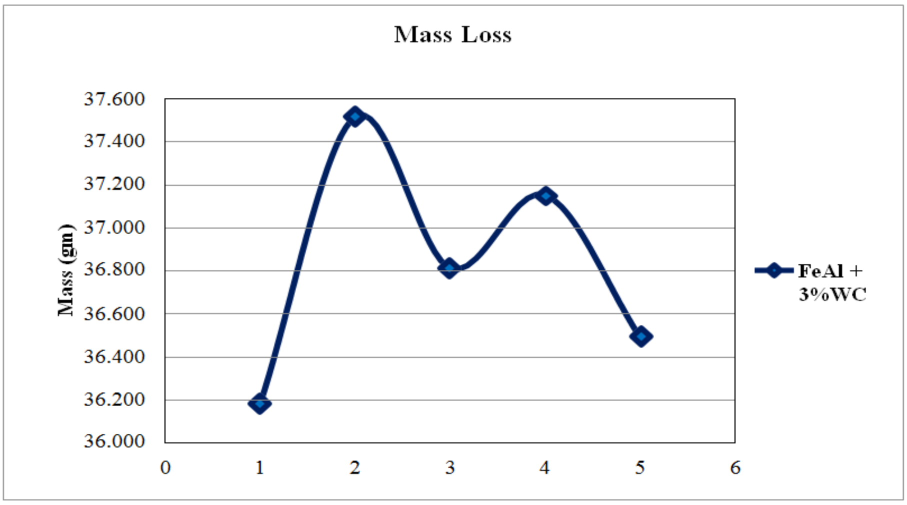


Fig. 5.6: Mass losses from 5 test of specimen of WC 3% FeAl.

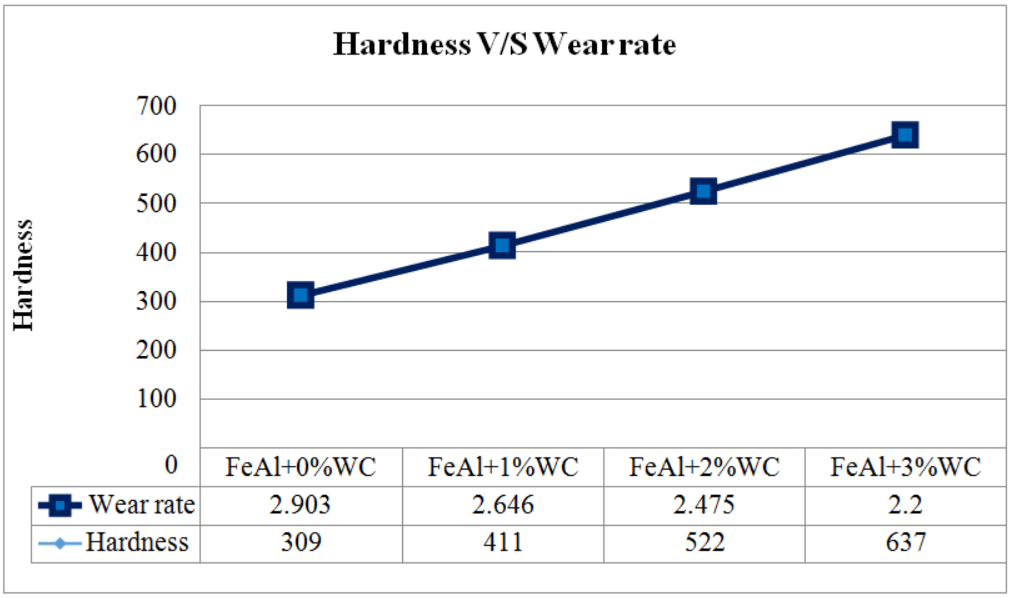


Fig. 5.7: Specific wear rate of composites plotted as a function of hardness.

CHAPTER 6 DISCUSSION AND CONCLUSION

6.1 Conclusion

From the present investigation the following conclusions can be drawn.

- WC- FeAl composite was developed successfully by stir casting method.
- After developing the MMC's testing their mechanical properties.
- In this investigation make an effort to develop new material which fulfils the need of present requirement.
- New developed material WC-FeAl has light weight as compare to other conventional material. The density of this composite material is less so it is useful for motor cars, bike

etc. Low density of metal composite makes it very useful in different sector application.

- This material has high strength as compared to other conventional material which is present at this time in our daily life/uses. This material has low weight to strength ratio as compared to other. In this investigation it is tested that as well as WC increase their tensile strength decrease but compressive strength increase. When WC is zero in FeAl material, compressive strength is 189MPa but as per increase percentage of WC in FeAl compressive strength increase. At 3% of WC compressive strength of composite is 409MPa.
- The hardness of this composite increase as per increase of reinforcement in the present material FeAl. The hardness of the present metal is 309 on Vickers hardness. As increase the percentage of reinforcement (3%) in present material hardness goes to 637 HV.
- Wear testing done on this composite and find that as the percentage of reinforcement increase the wear rate of the material is decrease. The wear rate ofthe present material is 2.903 mm^3/N-m. When the percentage of reinforcement goes to 3% the wear rate is decrease to 2.20 mm^3/N-m.
- Due to low wear rate it is very usefull as a raw material for part of aerocraft, automobile etc. where high wear resistance required.
- A disadvantage in this developed material that In addition of WC as a reinforcement in Iron aluminide (FeAl) their tensile strength decrease. Due to low tensile strength it can't use in tension.

6.2 Scope for Further Research

- Iron aluminide (FeAl) is one of the most essential aluminum in the scientific community. FeAl can be used to boost wear and strength in other soft and ductile metal composites including copper-based composites. Such composites can be used in numerous applications in vehicles and aerospace.
- In the development of MMCs, further aluminide effects such as Fe3Al, Ni3Al and NiAl can also be examined.
- The composite can also study the properties of high temperatures.
- Effect of addition of specific enhancements like SiC, TiC, TaC and Cr3C2 to Iron Aluminium (FeAl) on the formation of MMCs could also be observed.

6.3 Application of this material

This material has low density, high strength and low wear rate. Thus this material ishaving following uses

- Light weight composite material is used in the production of part of automotivebody.
- It is a light weight composite material and have low wear rate at 3% of WC. Thus itis useful to make the part of aircraft, space jet etc.
- Due to high compressive strength it is use as a base of a machine.

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