JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

FACULTY OF MECHANICAL ENGINEERING

MANUFACTURING SYSTEM ENGINEERING CHAIR

Evaluation of Mechanical Properties Aluminum Alloy 7050 with Glass Particels reinforced Metal Matrix Composites

A Research Submitted to the School of Graduate Studies of Jimma University in Partial Fulfillment of the Requirements for the Degree of Masters of Science in Manufacturing System Engineering

By

Yalew Tamene

January,2022
Jimma, Ethiopia

JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

FACULTY OF MECHANICAL ENGINEERING

MANUFACTURING SYSTEM ENGINEERING CHAIR

Evaluation of Mechanical Properties Aluminum Alloy 7050 with Glass Particels reinforced Metal Matrix Composites

A Research Submitted to the School of Graduate Studies of Jimma University in Partial Fulfillment of the Requirements for the Degree of Masters of Science in Manufacturing System Engineering

By

Yalew Tamene

Advisor: Dr. Anil Kumar

Co-Advisor: Dr. Olu Emmanuel Femi

January,2022
Jimma, Ethiopia

DECLARATION

This MSc. thesis entitled "***Evaluation of Mechanical Properties Aluminum alloy 7050 with Glass Particulates reinforced Metal Matrix Composites***" is the result of my effort and has not been previously included in a thesis, exposition, or report submitted to this university or any other institution for the degree, diploma or another requirement, excluding where due acknowledgment and reference is made. It is submitted to the Faculty of Mechanical Engineering, Jimma Institute of Technology, in partial fulfillment of the requirement for the award of masters of sciences in manufacturing system engineering.

Student

YalewTamene ______________________ ______________________

Signature Date

Approval sheet

As a member of the Examination Board of the final Master of Science open defense, we certify that we read and evaluated the thesis prepared by yalewtamene entitled as "***Evaluation of Mechanical Properties Aluminum alloy 7050 with Glass Particulates reinforced Metal Matrix Composites***" we recommend that it could be accepted as a fulfilling the thesis requirement for the Degree if Master of science in Mechanical engineering (Manufacturing System Engineering).

Dr. Anil Kumar D. Anil K January 15, 2022

Advisor Signature Date

Dr. Olu Emmanuel Femi ________ January 15, 2022

Co-Advisor Signature Date

Dr. BesufekadFetene ________ ________

External examiner Signature Date

Dr. Nagaraj Ashok ________ ________

Internal examiner Signature Date

Hana Beyene ________ ________

Chairperson Signature Date

ACKNOWLEDGMENTS

First of all, I would like to express my heartiest gratitude to my advisor Dr. Anil Kumar (Asst.prof.) for his guidanceand willingness despite, gratefully acknowledge my co-advisor Dr. Olu Emmanuel Femi for his continuous supervision coordination throughout the duration which has a vital role in the achievement of this study.

Mr. Wendimu Fanta. and Mr. Eyule Abate was, faculty dean and program coordinator, respectively, of the faculty of mechanical engineering. For their long-lasting cooperation of giving information and writing a formal letter of request to different institutes for laboratory work with best wishes. Also, I would like to pass my appreciation to Mr. Balewgize Amare for his support during my research work.

Mr. Hane Beyene, chairperson of manufacturing system engineering, for his full-time genuine guidance and inspiration.

Mr. Mitiku and Mrs. Nigat, Lab technicians at the faculty of mechanical engineering, for their steadfast honest support during my experimental work.

JIT, Material science engineering staff, and lab technicians for their thankful cooperation during this study laboratory work.

ABSTRACT

Composite materials are continuously developed with the time being due to the necessity of human civilization and therefore advancement of each material in its highest classes is the best research necessity.Aluminum-based composites reinforcement in continuous/discontinuous fibers, whisker, or particulates; reinforced whit particles have received considerable attention because of their superior mechanical properties over monolithic aluminum matrix. Different composites with micros-sized reinforcements have become radical progress for composites because they have different strengthening mechanisms as compared to that in composites with micro-sized reinforcements. Therefore different properties can be predictable from the micros-size particulate reinforced composites.

Properties of aluminum matrix composites (AMCs) can be customized to the demands of automotive and different industrial applications by appropriate combinations of the matrix, reinforcement, and processing routes. This work focuses on the fabrication of aluminum alloy 7050 matrix composites (AMCs) reinforced with 4%,6%, and 8 wt% glass particels of 0.225mm, using the stir casting method route. The mechanical properties of the fabricated aluminum matrix composites were analyzed. The mechanical properties like hardness and tensile strength of the unreinforced alloy and composites have been measured. The mechanical properties like hardness and tensile strength have improved with the increase in the weight percentage of glass particulates in the aluminum matrix.

Keywords:Aluminum Matrix Composites, Glass particl, Stir casting method.

Table of Contents

List of Tables

List of Figure

List of Abbreviation and Symbols

Al Aluminum

AMCs Aluminum matrix composites

ASTM American society of testing materials

CMComposite material

CMC Ceramic matrix composite

FCM Fiber composite material

MMCsMetal matrix composites

RHMRockwell hardens method

PAMCsParticulate Reinforced AMCs

PMC polymer matrix material

SC Stir casting

UTM universal testing machine

XRD X-ray diffraction,

CHAPTER ONE

1. INTRODUCTION

Nowadays, scientists and researchers are searching for strong, stiff, light weight and cheap materials. Because of this composite materials are becoming more preferable to other materials. Due to this, the concept of composite materials has a great impact on the upcoming advanced technologies and it has a great role in the advancement of many technology areas i.e. furniture, automotive, aerospace structural engineering, etc.

The present study will focus on the evaluation of aluminum matrix composite with glass particles reinforced by the stir casting method andconducting an experimental investigation ofmechanical performances forautomotive and different applications. This chapter stated a general introduction of the research with a brief background of the study. It also includes the objective of this paper, and the scope of the work.

The term composite broadly refers to a material system that is composed of a discrete constituent reinforcement distributed in a continuous phase matrix and which derives its distinguishing characteristics from the properties of its constituents, from the geometry and architecture of the constituents, and the properties of the boundaries interfaces between different constituents[1].The Composite material is prepared by mixing two or more similar and dissimilar elements to make the resulting material have superior properties from its parental materials. There are two parts of composite material, matrix and reinforcing phase. We can reinforce in several phases, in the form of fibers, sheets, or particles. It is bounded in the other materials called the matrix phase. Metal, ceramic, non-metal, and polymer materials can be used as reinforcing elements and matrix material in the development of composites [2].The properties of composite materials depend to a large extent on the properties of their constituent materials, their distribution, and their interactions. In addition to the properties of the composite material, it is also defined according to some parameters, namely the influence of the size, shape, and percentage, and the geometric orientation of the reinforcing material on the strength of the main components[3].

Composite materials are classified according to the type of matrix and reinforcement. The composite material is divided into polymer matrix composites (PMC), metal matrix composites (MMC), and Ceramic Matrix Composite (CMC) based on the type of matrix. According to the type of Reinforced materials, composite materials include particle-reinforced composite materials, short-fiber composite materials (Whiskers), and continuous fiber composite materials (sheets). The reinforcement material can be organic fibers, metal fibers, ceramic fibers, and particles. The material of the matrix can bePolymers, metals and their alloys, glass, glass ceramics, ceramics. Usually, the strength of onematrix is much smaller than the matrix of the fiber reinforcement[4].Figure.1 shows the structure of the composite materials.

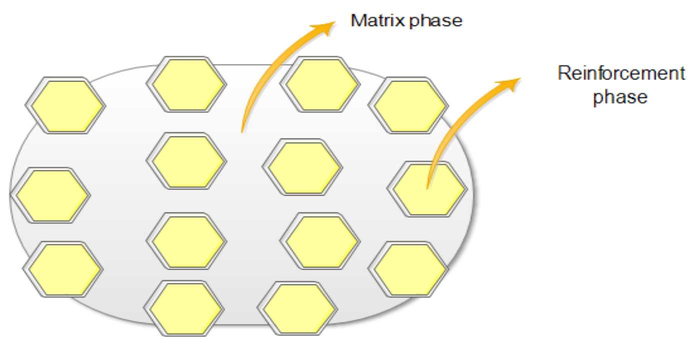

Figure 1.1Structure of composite material

Developed composite materials with enhanced properties. Because of their distinctive characteristics and superior quality compared with basic materials, they have received widespread attention in many fields such as aerospace, automotive, military, and other manufacturing industries[5].

The combination of the most important properties of the matrix and the reinforcing material is a significant advantage obtained through the production of composite materials. High-strength materials are manufactured through combination without affecting the excellent ductility and density of the alloy. The possibility of adding high-strength particles as a reinforcing agent also helps to overcome any shortcomings of the matrix material[6].

According to reports, adding reinforcing materials to the aluminum matrix can increase the tensile strength, compressive strength, impact strength, and hardness of the composite material. Generally, the wear resistance of AMC is also higher than that of unreinforced aluminum or aluminum alloy[7]. Various materials are used as reinforcement materials for the manufacture of AMC. They can be used in the form of particles, whiskers, short fibers, and continuous fibers. Compared with other types, particle enhancers have better isentropic properties, enabling them to be evenly distributed in the matrix phase[8].

Composite materials have been identified as potential substitutes for traditional materials, but there are still some obstacles in the research and development of composite materials. The key goal of composite material production is to improve material properties, which depends on many factors, such as manufacturing routes, process parameters, constituent materials, and ingredients. The appropriate materials and manufacturing methods and the best process parameters must be selected to achieve the required performance. A wide range of manufacturing technologies has been explored for MMC, including liquid and solid methods[9].Figure 2 showsgenerally introducesthe Classification of composite materials based on reinforcement and matrix types.

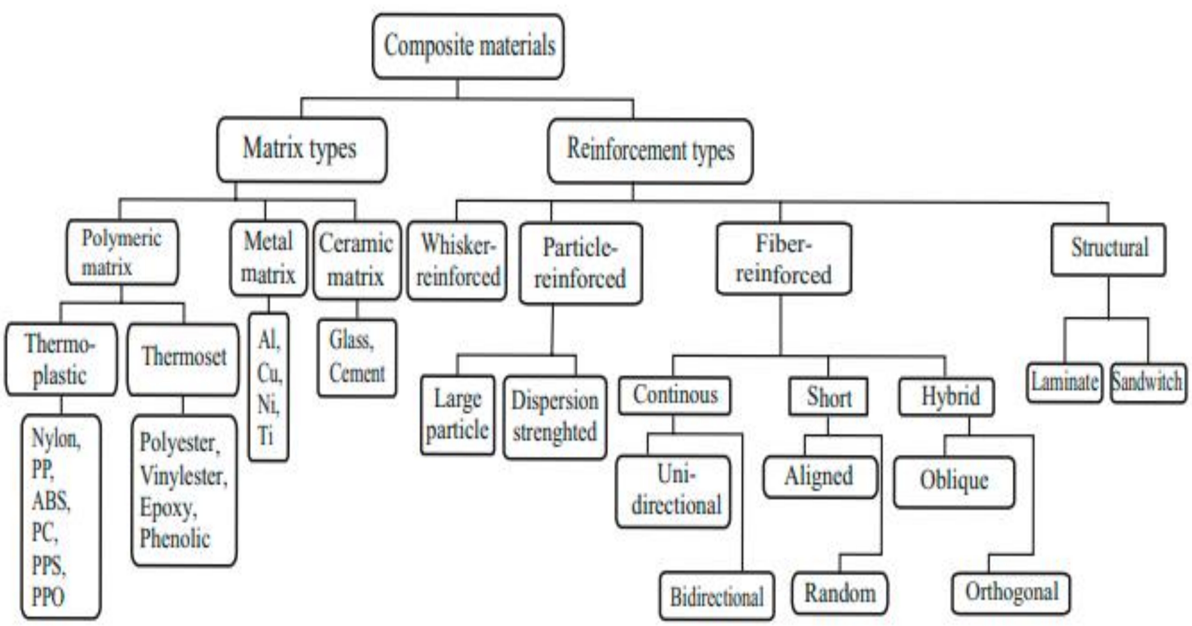

Figure 1.2Classification of composite materials based on reinforcement and matrix types [10]

1.1. Matrix materials

Therefore, they are the first choice in the manufacture of aluminum matrix composites (AMC), and due to their superior tribological properties, they are mainly used in the manufacture of automotive parts. Ceramic, synthetic, industrial waste, and agricultural waste reinforcement particles with micron or nanometer sizes can be effectively mixed with the matrix material to produce aluminum matrix composites (AMC)[11].

Aluminum alloys are the main non-ferrous metals used in various applications because they have a wealth of desirable material properties. As a result of extensive research, many aluminum alloys have been created to improve specific required material properties. Composite materials are multi-phase materials composed of a matrix and reinforcements, which were developed to meet the growing demand for attractive engineering materials. Generally, composite materials have excellent thermal properties and excellent mechanical properties, including higher strength, hardness, fracture toughness, and better wear resistance and corrosion resistance.These advantageous properties have led to an increase in the use of composite materials in industrial applications[12].

Aluminum-based composite materials (AMC) are based on pure aluminum or its alloys. Due to their remarkable mechanical, material, and tribological properties, they are increasingly used in industrial applications. This led to the development of aluminum matrix composites based on various possible aluminum alloys, combined with various reinforcement materials to achieve specific desired properties. AMC can be manufactured by a variety of methods depending on its end-use. Since the 1930s, aluminum alloy has been the material of choice for the production of automotive parts[13].

1.2. Reinforcement materials

Glass is a solid that has non-crystalline materials the structure of glass is amorphous and exhibits a glass conversion when heated to the liquid state. Soda, soda, and lime are the main ingredient in glass production, but several other chemicals can add to the mixture to achieve certain properties that make it one of the most flexible engineering materials out there. Glass can be made by combining several minerals at very high temperatures. Quartz sand itself can be melted into glass, but the achievable temperature is about 1700. The addition of sodium carbonate (Na^2CO_3), known as soda, to make a mixture of 75% silica (SiO^2) and 25% sodium oxide (Na2O) lowers the melting temperature to about 800 ° C. However, a glass of this composition is soluble in water and is referred to as a water glass. Glasses can be engineered to meet almost any requirement for many special applications. Fiber-reinforced glass and glass-ceramic matrix[14].

To develop sustainable metal matrix composites, it is important to manufacture reinforcement ata low cost. The large numbers of glasses are available from the recycling activity of industrial wastes lead to new applications. Glass disposal can be recycled as particulate reinforcement in metal matrix composite with the development of new materials such as low-cost composite[15].

1.3. Background of the study

People have been making composite materials for thousands of years. The first uses of composite materials began with Egyptians and Mesopotamian settlers. Around 1500 BC an early example is adobe bricks. Mud can be dried in a brick mold to make a building material. It's strong when you try to squeeze it (it has good compressive strength), but it breaks pretty easily if you bend it (it has poor tensile strength). Straw seems very strong when you try to stretch it, but you can crumple it up easily. By mixing the mud and straw, it is possible to make bricks that are both crush and tear-resistant and make excellent building blocks[16].

Show in figure 3 the first modern composite material was fiberglass. It is still widely used today on boat hulls, sports equipment, building panels, and many car bodies. The matrix is plastic and the reinforcement is glass that has been made into fine threads and often woven into a kind of fabric. The glass is very strong on its own, but it is brittle and breaks when bent sharply. The plastic matrix holds the glass fibers together and protects them from damage by distributing the forces acting on them. The main advantages of composite materials are their high strength and rigidity combined with low density compared to bulk materials, which results in a weight reduction in the finished part. The industrial need for good materials with low weight, excellent properties, and low cost prompted scientists to research composites[17].

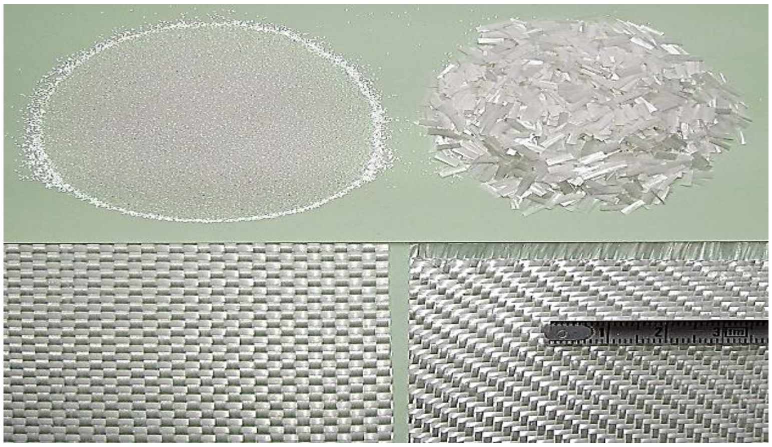

Figure 1.3 Glass reinforcements to be used in the creation of fiberglass[18].

Industrial technology is growing very quickly and the demand for materials is increasing. Conventional monolithic materials have limitations in achieving a good combination of strength, stiffness, toughness, and density. To overcome these shortcomings and meet the ever-increasing demands of modern technologies, composites are the most promising materials. The main advantages of composite materials are their high strength and rigidity combined with low density compared to bulk materials, which enables weight reduction in the finished part. The industrial need for good materials with lightweight, excellent properties, and low cost has led scientists to research composites[19].

Aluminum metal matrix composites significantly improved the mechanical properties compared to the unreinforced aluminum alloys[20].Applications of Aluminum-based MMCs have increased in recent years as engineering materials.Al7050 alloy is a very interesting material because of its mechanical properties, namely, low density, high strength, moderate ductility, and toughness. Due to these properties, the alloy is mainly used for highly stressed structural parts. This material has a wide range of applications such as aircraft fittings, gears, and shafts, fuse parts, meter shafts and gears, missile parts, regulating valve parts, worm gears, keys, and various other parts of commercial aircraft and aerospace vehicles [21].

Aluminum metal matrix composites (AMCS) have an advance from their attractiveness in automotive applications to the fundamental attributes of the aluminum alloy, namely: specific weight, specific strength, high elasticity under shock loads, and toughness at very low temperatures, formability, and high conductivity. With alloying and compositing, these attributes are enhanced and the major shortcoming of the base aluminum metal strength is improved extremely[1].

The role of the reinforcement in a composite material is fundamentally one of increasing the mechanical properties of the neat resin system. Among the various discontinuous reinforcements used, ceramic reinforcement will create many strong and hard phases in the aluminum matrix which will give good wear resistance compared to pure metals.Alsoglass particulate is one of the most inexpensive materials. It is high strength but brittle and has low-density reinforcement. Inthe corporation of glass, particles reduce the cost and density of aluminum and its alloys[15].

Many researchers had suggested that fabricating aluminum alloy-based composites through the liquid metallurgy method is economically feasible. The Stir casting technique is extensively low cost and economical process, easy procedure, and gives uniform mixing of different compositions of metal constituents, minimum moisture level, good adhesion, and negligible elemental reactions among the particles, and the base material aluminum matrix is a more challenging one because of their interfacial contact area when compared to the other reinforcement materials[22].

1.4. Statement of the problem

Now day's Industrial technology is growing at a very rapid rate and there is an increasing need for materials.With the advanced engineering materials for various engineering applications goes on increasing. To meet such demands aluminum metal matrix composite is one of the reliable sources. Composite material is one of the reliable solutions for such requirements. In composites, materials are combined in such a way as to enable us to make better use of their parent material while minimizing to some extent the effects of their deficiencies. The simple term 'composites' indicates the combinations of two or more materials to improve the properties. In the past few years, materials development has shifted from massive to composite materials for adjusting to the global need for reduced weight, low cost, quality, and high performance in structural materials. The driving force for the utilization of aluminum metal matrix composites (AMCs) in areas of aerospace and automotive industries include performance, economic and environmental benefits.

Aluminum 7050 is added to glass particles to improve the mechanical property of metal matrix composites through the stir casting method. Aluminum increases the tensile strength and hardening, but the composition can be adjusted to strength requirements.

In this project, composite material prepared from glass particles and aluminum base metal is to be investigated. The glass particles with a size of 0.225 millimeter at different compositions of 4%, 6%, and 8% by weight have been cast under the stir casting method. To investigate the optimum ratio of composition, the resulting composite matrix's mechanical properties need to be investigated exhaustively. From experimental results, comparisons with pure materials as well as with required mechanical properties for specific applications for automobile parts will be done to conclude the new proposed composite materials preferred use in the field.

1.5. Objective

This thesis has a general objective and specific objectives as in the following,

1.1.1. General objective

The main goal of this masters research is developing and characterizing aluminum metal matrix composites with reinforced glass particles evaluated mechanical propertiesispuer Aliminum alloy 7050 and aluminum matrix composites(Al7050).

1.1.2. Specific objective

1) To develop metal matrix composite material by using aluminum 7050 as reinforcement with glass particles through the stir casting method.
2) To characterize the mechanical performance of the developed aluminum metal matrix composites through experimental investigations.
3) To optimize the composition ratio of the glass particles of 0.225 mm for better mechanical properties at three proposed ratios of 4%, 6%, and 8%
4) To investigate the effect of the stir casting method on the glass particles.
5) To compare the results that are obtained from the experimental results with universal tensile strength, hardness tested, and X-ray diffractionanalysis.

1.6. Scope of the research

The scope of this research will include;

- Developing metal matrix composite material using Al7050 as reinforcement and glass particles through the stir casting process
- Conducting mechanical tests like a tensile test and hardening test
- Performing comparison on the mechanical performance of Al7050 metal matrix composites prepared using the stir casting method
- X-ray diffraction analysis will be done to compare the results obtained from the pure Al7050 alloy and aluminum matrix composites with glass particles.

2. LITERATURE REVIEW

In this chapter, the summary of the literature surveyed duringthis research has been presented. This survey of the literature is expected toprovide the background information and thus to select the objectives of thepresent investigation. A treatise on aluminum metal matrix composites (AMMCs) andparticulate-filled AMMCs has been given illustrating the previous researchfindings. A brief research history on Al7050 alloy metal matrix composites is also provided with stir casting methods. In short, this thesis embraces various aspects of aluminum matrixcomposites with a glass reference to their physical and mechanical characteristics. This chapter thus includes reviews of availableresearch reports organized in subsections.

2.1. Summary composite material

Composite materials are one of the material types that are used in a large number of applications. Comprised are two or more materials in the form of chemical, physical or dissimilar phases that are to be combined to obtain better property. Composite materials produce significant properties different from that of the individual alloys. In composites, materials or phases were combined to enable us to sustain better use of composite materials [23].

Composite materials are classified according to the type of matrix material present in it. They are categorized into three major types as metal matrix composites (MMCs), ceramic matrix composites (CMCs), and polymer matrix composites (PMCs). Metal matrix composites are the most widely used type of composites in industrial applications, because of their various advantages relative to the other matrix materials [19].

Composite martial factors that affect composite characteristics comprise the geometry of reinforcement, the shape of the discontinuous phase, distribution of concentration, the orientation of reinforcement, and volume fraction. Concentration determines the input of the single constituent and influences composite characteristics [4].

2.2. Constitutes Of Composite Material

Composite material is materials that differ from others are it is made from a macro scale combination of the reinforcement and matrix material.Reinforcement and matrix are several factors that influence the selection of the processing method, which include the type of reinforcement and matrix, their mechanical and thermal properties, and the amount of microstructural reliability desired. The type of reinforcement variation of reinforcement in the matrix, and interaction of matrixwith reinforcement play a very important role in determining the final properties of the composite.Composites are generally classified in Polymer Matrix Composites,Metal Matrix Composites, and Ceramic Matrix Composites[24]. Figure 1 showsthe classification of these three major composite groups stating they're the majority familiar reinforcement architecture and the materials regularly engaged.

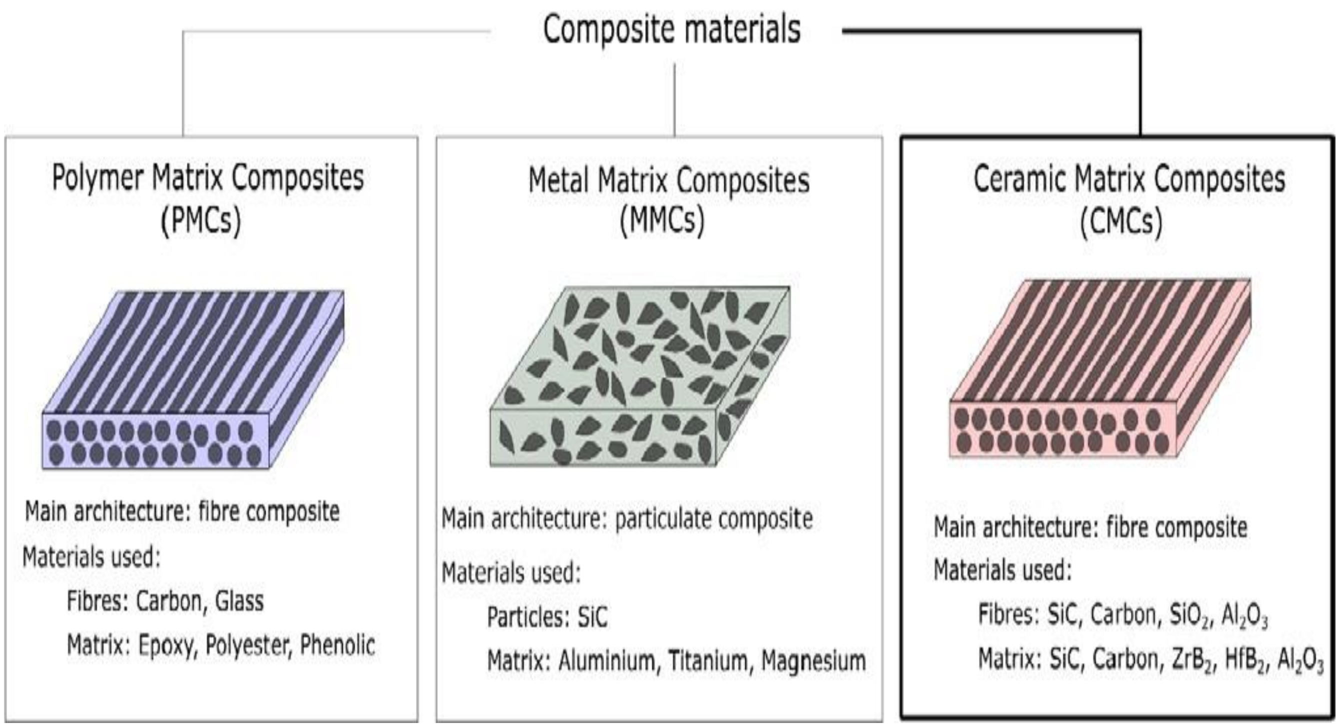

Figure 2.1 Classification of the composite materials depending on the nature of the matrix major reinforcing architectures and materials used[25].

2.3. Metal matrix composites (MMCs)

Metal Matrix Composites are broadly familiar as advanced materials. Matrix material composites of metal matrix composites (MMCs) are by strength low density metallic. Such because aluminum, titanium, and copper reinforcement with particulate or fibers of a can ceramics like carbides and oxides & or it could be metallic. Reinforcement contributes a small number of percentages to around 50% of the total volume of the composite material [26].

The automobile and aerospace industries are the majority broadly used in aluminum-based metal matrix composites.Reinforcement compounds such as $Al_2O^3$and SiC are mixed without the complexity and effectively in molten aluminum to complete the majority of required properties like higher strength, superior stiffness, reduced density, controlled thermal increase, andbetter wear resistance [27].

Metal matrix composite (MMC) is better than conventional materials in terms of improvement. Such as

- High Toughness and impact properties.
- High electrical and thermal conductivities.
- Excellent antifriction anti-abrasion, damping.
- Excellent machinability properties.
- Reduced wear, anti-sizing.
- Lighter in weight.
- Good strength and Specific stiffness.
- High Strength.
- Low Density etc.

2.3.1. Polymer matrix composites (PMCs)

Polymers are low density and good chemical resistant matrices that are suitable are generally used composite, from obtainable composites. PMCs are composed of thermoplastics matrix dispersed reinforcement with glass, carbon, metal fibers [28].

Polymer composite composites (PMCs) proffer a broad variety of properties. a few of them be good strength, outstanding impact, all over cost-effective processes of production and tooling, exceptional chemical and corrosion resistance, obtainable at low-cost chemical inertness, and good mechanical properties. The application of polymer matrix composites is generally in aircraft and sports equipment[29].

2.3.2. Ceramic matrix composites (CMCs)

Ceramic matrix composite (CMC) is mostly used in high-temperature applications and where the environmental attack is an issue. Ceramic matrix composite type of ceramics generally composed of carbon, silicon carbide, aluminum oxide fibers surrounded in ceramic matrix structure [30].

The ceramic matrix can be reinforced through ceramics, glasses,metals, and polymer matrices. Ceramic-based matrix materials have outstandinghigh melting points, superior compressive strength, corrosion resistance, and strength at high temperatures.is the common choice for high-temperature applications such aspistons, different car parts, and rotors into gas-turbine parts[31].

This survey just reported on the machinability of polymer matrix composites and ceramic matrix composites. In the specific field of reinforced ceramics, a review was the researcher written focusing on the manufacturability and machining of particulate ceramics[32].

Ceramic matrix composites are classified depending on the nature of the ceramic matrix: oxide for example SiO2, Al_2O^3, Non-oxide ceramic matrix composites are at this time the popularly used materials appropriate to their mechanical strength at high temperatures release, especially SiC-based CMCs which arebranded material selection for great applications such as aero-engines [33].

2.4. Aluminum metal matrix composites (AMMCs)

Study on Aluminum alloys is the predominant nonferrous metal used in various applications due to their plentiful desirable material properties. As a result of the extensive studies conducted, numerous alloys of aluminum have been created to improve the specific required material properties. Composites are multiphase materials that consist of matrix and reinforcement, which were developed to fulfill the ever-increasing demand for attractive engineering materials.

Generally, aluminum metal composites exhibit excellent thermal properties and outstanding mechanical characteristics, These advantageous characteristics led to the increased use of composite materials in industrial applications[12].

This paper reviews recent studies on the aluminum metal matrix composites existing and advanced processing techniques. The major disadvantages of metal matrix composites are the relatively high cost of fabrication and the reinforcement materials. some major advantages of aluminum matrix composites compared to unreinforced materials are as follows[22].

- Low density
- Low coefficient of thermal expansion
- Higher service temperature
- Higher elastic modulus
- Increased strength
- Improved stiffness
- Improved wear and abrasive resistance
- High electrical and thermal conductivity
- High vacuum environmental resistance
- Improved damping capabilities
- Increase in creep resistance at higher temperatures
- Increase in fatigue strength
- Improvement of thermal shock resistance
- Minimum ductility.

For instance, in the automotive industry, aluminum matrix composites (AMCs) are typically used for pistons, cylinders, brakes, and power transfer system elements. Moreover, it is believed that aluminum matrix composites (AMCs) offer potential as a substitute for monolithic materials, including aluminum alloys, ferrous alloys, titanium alloys, and polymer-based composites, in several applications [34].

In addition to its broad applications in aircraft, aluminum is also widely used in the modern automotive industry. In vehicles, aluminum and its alloys are used to manufacture various parts, such as the car body, engine blocks, braking mechanism, etc, due to their lightweight, high strength, and good corrosion resistance. However, compared to pure aluminum and various unreinforced aluminum alloys [35].

2.5. Classification of aluminum metal matrix composites

Classification of aluminum metal matrix composites there are three main types of AMMCs be able to be classified according to this reinforcement; particulate reinforced, short fiber orwhiskersreinforcementandContinuous-fiber or sheet reinforced MMCs possess higher stiffness and strength because of continuous filaments.Several types of discontinuous and particulate reinforced MMCs have been fabricated composite materials have some engineering advantages of good strength, greater stiffness, and superior dimensional stability than unreinforced aluminum alloys[36].

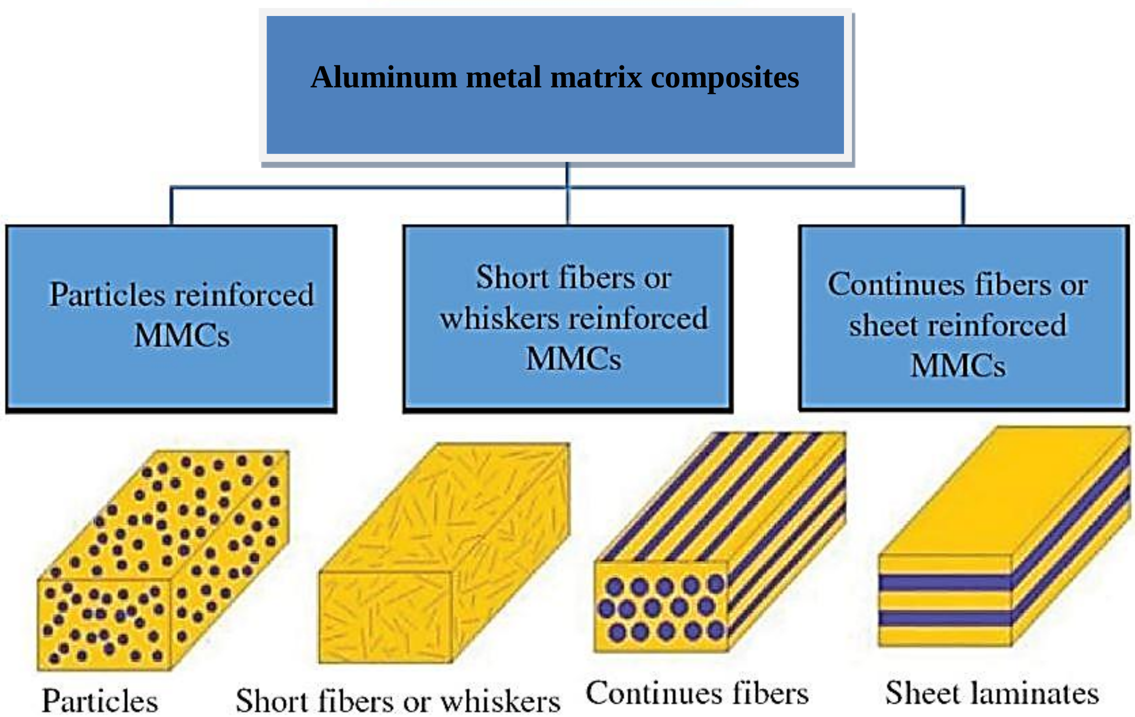

Figure 2.2 Type of reinforcement[36].

2.5.1. Particulate Reinforced AMCs (PAMCs)

In recent years, particulate reinforced metal matrix composites have attracted the thought of several researchers, designers, and engineers as promising highly developed engineering and structural materials for automotive and different applications. Particles use for reinforcing contain glasses andceramics such as small mineral particles, particles such as amorphous, and aluminum materials, particles metal matrix composites present isotropic properties with an increase in strength and stiffness compared to unreinforced materials.General Ceramic reinforcement is usually carbides or oxides (SiC or Al_2O_3) and there in quantity fraction less than 30% when used for wear resistance and structural applications [37].

The particle shapes,theparticle sizes, the particle positions and,the particle contents in the composites, intowhichtheparticle-matrix interfaceareas are well-retainedandtheyadditionalaffect the mechanicalbehavior of soft particles inforced MMC[38].Nanoparticles contain high surface energy and higher specific surface areas; hence, mechanical property improves compare to micro-size particle-reinforced aluminum metal matrix composites AMCs[39].

2.5.2. Whisker or Short Fibre-Reinforced AMCs (SFAMCs)

fiber reinforced metal matrix composites which have either continuous or discontinuous fiber reinforcements, the reinforcement be able to be in the form of whiskers which include the size of length to diameter ratio can go up to 200and the diameter approximately in the range of 0.1up to 0.5 mm[40].

Theseproperties include resulted in a greater than before interest in fiber-reinforced metal matrix composites so many advantages improving mechanical properties. improved specific strength, improved specific stiffness, improved wear resistance, improved damping capabilities, and improved resistance to corrosion[41].

The recent work concern not only the manufacturing process of the aluminum-based composites material reinforced with discontinuous glass fiber randomly oriented amongst the matrix except as well the search of the influence of the glass fiber adding together to the matrix on basic mechanical and physical properties of the composite obtained by two different methods. Such composites are not usually used in current technology and what is more, the scientific research is relatively limited[42].

The presentation of the fiber composite depends greatly on thetransfer of load involving the matrix and the fiber composites. The debondingshear strength of the fiber-matrix interface can be resolute quantitatively through the use of a single fiber drive-out test. In addition, thisexperiment can be used to obtain qualitative information on the boundary.A notch technique is the basis of a single fiber force out the testand it was developed primarily by Marshall to investigatethe ceramic-metal composites (CMCs)[43].

2.5.3. Continuous-fibre-reinforced MMCs

There are two types of fiber-reinforced composites, continuous and discontinuous fiber-reinforced composites. Frequently, fibers can be defined as particles with an aspect ratio diameter and length ratio, the diameter greater than 10:1 and length greater than 100 μm.Continuous fibers have length exceptionally a lot larger than their cross-sectional area; but not it will be considered a discontinuous or short fiber. The property of this type of composite is strongly affected by fiber length, in general, increasing fiber length leads to development in the elastic modulus and the strength of the composites. Continuous fiber-reinforced composites are often fabricated to be there a multi-layered stack; each layer can have a particular fiber orientation. Such a heap is called a laminar composite or laminated stack [44].

Study on fibers such once carbon and glass be abundant and renewable, lightweight,hightoughness and through low density. Fibers such ascarbon and glass can be used as a replacement for conventionalreinforcement materials in composites for applications that require high strength to weight ratio. Carbon andglass fiber has been imperative fabric in engineering production outstanding to their luster mechanical properties. The interfacial attachment strength has to be there satisfactory for the load to be transferred from the matrix to the fibers if the composite is stronger than the unreinforced matrix [45].

In fiber-reinforced composite materials, the dispersed phase ofsynthetic fibers such as glass, carbon, basalt, and Kevlarin a composite structure revealed enhanced material properties such as high strength, stiffness, and resistance to chemicals, temperature, and wear [46].

2.6. Aluminum metal matrix composites mechanical property

The mechanical properties are very important for anymaterial with the application of load, which determine tensile strengths and compressive strengths are the maximumstresses attained before fracture under tensile and compressiveloading,

Studied aluminum matrix composites the fabrication and mechanical properties of aluminum boron carbide composites. The aluminum alloy-boron carbide composites were fabricated by liquid metallurgy techniques with different particulate weight fractions (2.5, 5, and 7.5%).The researcher was experimental that homogeneous distribution of the boron carbide reinforcement particles in the matrix phase,with scanningelectron microscope to conclude the hardness of the composite material increased andthe matrix phase with increasing the amount of the boron carbide[47].

Investigation of the mechanical strength of Al6061 alloy metal matrix composites with different percentages of glass particle andfour types of micrometers size with stir casting method. Tensile strength and hardness have improved with the increase in the weight percentage of glass particles in the aluminum matrix composites. The strength of the aluminum matrix composite might be influenced by the disruption generated in the matrix, the sharing of reinforcement in the matrix, the interface bond between matrixreinforcement, and the grain size of the aluminum matrix composites. [1].

Study on mechanical properties of al7050 aluminum reinforced particles with graphite content and indirect that there is reduced in hardness with increasing graphite content. The study of mechanical property is due to the increasing brittle natural history of graphite particles, which without difficulty tends the composites to be unsuccessful in the brittle method [48].

Investigated on aluminum metal matrix composite Al7075composite with SiC particulates different weight was increased with the addition of 2.5% and 7.5% SiC. The stir casting process maintains the consistent distribution of Al 7075 alloy with SiC/Al_2O^3 reinforced composites in clearly better form to the base of Al 7070 alloy. The distribution of SiC /Al_2O^3 particles in the Al 7075 matrix improves the microhardness of the matrix material[49].

Investigated wear behavior of Al7050 aluminum matrix composites with reinforced SiC by three different weight percentages and using three process parameters such as sliding velocity. SiC composition and sliding distance three different were optimized during Taguchi investigation. The sliding velocity be thegreater part influencing the limit on the wear rate and the optimal percentage of SiC was suggested as 6%. The microstructure study previous to the wear test shows the uniform distribution of SiC particles in the Al7050 composite. except, in attendance is an increase in wear rate due to an increase in the percentage of reinforcement due to the poor stir casting process of Al7050 aluminum matrix composites[50].

Investigation on metal matrix composites with glass particles is in use in the two ranges of glass particles μmandwith the four different percentages. Methods of stir casting stirring speed were fixed. The outcome indicated that the tensile strength and hardness be higher for the chilled metal matrix composites (MMCs) than for the matrix alloy[51].

Examination Al7050 aluminum matrix composites with graphene compressed SiC nanoparticles use extensively increased that tensile strength when compared to SiC, reinforced composites.Al7050 aluminum alloy is the first fondness in the productions. Al7050 is a high-strength and less-weight aluminum alloy usually used in automotiveand aerospace industries because of its excellent mechanical properties[52].

Investigation Ceramic reinforced aluminum matrix composite materials are acknowledged for their weight volume and good strength, corrosion resistance performance, and better tribological properties, for which they are replacing their attractive alloys in the field of automobile and aerospace engineering applications[53].

Studied the outcome of glass particulates on the mechanical properties of Al6061 aluminum matrix composites. The mechanical properties and microstructure of the fabricated aluminum matrix composites were analyzed. The mechanical properties approximating tensile strengthand hardness of the unreinforced alloy and composites have been evaluated. The tensile strength of the composites increased with glass particulates up to 9%[15].

Investigations on the outcome of silicon carbide on the mechanical properties of LM6 alloy matrix composites. Hardness tests and Tensile properties studies were conducted to classify the hardness and tensile strength of the as shine metal matrix composites. The investigational outcome reveals that the hardness and tensile properties of the as-cast composites increase with the increasing weight ratio of Sic particulates in the matrix metal[54].

Study the hardness value of the aluminum matrix composites reinforced with a weight of percentage 10% of SiC particles and different mass fractions of mica particles. The outcomes indicated that the determined hardness value is achieved with 3% mica particles when that the hardness value of the composites spirits on reducing. He also recommended that the low strength and hardness of a composite is promising for respectable machining characteristics[55].

Fabrication on stainless steel particulate reinforcement with a size of around 40 μm with Al6082 aluminum matrix. Practically comparable process parameters were practical to kind the composite with the stainless steel particulate reinforcement method. Outcomes of ductility tests and tensile strength remained higher than the matrix only, and now, the tensile test outcome value was lower than the previous examination that it could be due to the combined volume fraction of the reinforcement, one limited to 18%of volumes.Additionally, the ductility of the composite was betteras a resultthan stainless steel particles outcome are highly ductile as compared to the generallyused ceramic reinforcement particles[56].

investigated on aluminum alloy 7050 was experiential the semi-solid state of the aluminum alloy 7050 and it was observed that its ductility and strength are high close to the solidus temperature and reduce considerably with decreasing solid fraction. The most important driving force after the development of most of the aluminum matrix composites is to accomplish improved mechanical properties[57].

Found that tensile properties of the aluminum matrix reinforced with graphene encapsulated SiC nanoparticles have significantly increased when compared to SiC reinforced composites. 7xxx series aluminum alloy are most preferred in military and civil services especially 7050 aluminum alloy is the first preference in the industries. AA7050 is a high-strength and less-weight aluminum alloy mostly used in aerospace and automotive industries because of its outstanding mechanical properties[52]

A study on aluminum matrix composites reinforced with graphene content and observed that increasing the graphene content added by 1% into aluminum matrix composites decreased the hardness values significantly. Aluminum matrix composites with graphene content with difficult to distribute the reinforcement equally into the matrix and thus a decrease in mechanical properties of composites were experimental. Brinell hardness tested outcome shows that the hardness of the composite decreases with increasing graphene content. The highest strength of Al7050 was obtained through duplex aging at different successive temperature conditions [58].

Fabrication aluminum metal matrix composites with different percentages of reinforcement were mixed from 0 up to 12 wt.% in a gap of 3%. The average size of particles is 50 μm. Stir casting Stirring speed was kept at 200 rpm for a duration time 10 min. outcome recommended that the density increased from 2.69 up to 2.75 g/cm^3, porosity increased from 0.37 up to 1.43%, micro-hardness increased from 49.5 up to 93.5 Vickers hardness numbers, tensile strength increased from 161.5 to 210 MPaand macro-hardness increased from 31.6 to 58 by Brinell hardness number [59].

Study onAl6063 alloy metal matrix composites reinforced with SiC particles three different sizes interconnect and weight fractions of silicon carbide particles upto 20% by stir casting method. The microstructure and mechanical properties of the arranged specimens are investigated experimentally. Starting the results it shows that hardness and tensile strength of the composites increased, with decreasing size and increasing weight fraction of the SiCparticles[60].

sturdy aluminum alloy since a base on reinforced with different reinforcements (Al2O3, SiC, MgO) of 50 μm correspondingly. Since the outcome, it shows that adding together these reinforcements increases mechanical properties, and SiC is the most effective strengthening particulates[61].

2.7. Liquid state stirs casting method

Fabrication processes used for different MMCs depend on parameters such as type and composition of matrix and reinforcement martial, wet ability and uniform distribution of reinforcing particle in the base matrix, and production cost. According to the operational conditions, the fabrication processes of aluminum-based composites have been categorized into two types which are liquid-state fabrication and solid-state fabrication processes [62].

Stir castingmethod of composite fabrication, the thermodynamics of combining reinforcement the particles into the molten metal must be measured carefully. Then, the wet ability of particle reinforcing in the molten materials to in these methods is the main challenge in casting methods. The current method of fabrication is relatively supportive to achieve this stir casting method[63].

The researcher conducted a single fabrication stir casting process pass and listed cluster sizes and locations within the cross-section. According to the researcher, on the advancing side, clusters in the center and on the retreating side are different in size due to differences in material flow and stirring achievement. Nevertheless, the researcher does not propose a preparation to do away with these unattractive defects[64].

Study on aluminum matrix composites stirs casting different the stirring speed was diverse at three variation rpm and the also three different stirring times varied after the adding of Sic. improved distribution of particles and hardness was observed at 600 rpm with 10 min stirring time. The property similar to tensile strength and hardness property of aluminum alloy with glass composites through stir casting methods followed by cryogenically cooled copper chills be studied [65]

Fabrication on aluminum matrix composites by Mechanical Stir casting stirring was performed at 600 rpm for a duration time 10 up to15 min. the outcome indicated that micro-hardness increased with increasing the percentage of SiC particles in the composites. It is observed that the tensile strength assessment of the composites originally increases as the volume of SiC increases 10% and after that tends to decrease for 15% SiCparticlesinsertion. A356 aluminum alloy reinforced with a weight of percentage 7wt.% micro size composites fabricated throughout stir casting methods[66].

Investigation on performance of stir cast methods Al_2O^3 aluminum matrix composites with SiC reinforced. The effect showed that the composite materials explain improved physical andmechanical properties,such as lowcoefficient of thermal increase as low, high ultimate tensile strength, high impact strength, and hardness. The composite materials can be useful as potential lightweightmaterials in automobile components[67].

Fabrication of Al7050 with TiB2 composites with the rut filling process by fabrication stirs casting methods. The reinforcement particles are around 1 μm in diameter, which is a large amount smaller than the B4C particles 10 μm used[68].

Investigation on A356 aluminum alloy composites stir casting Stirring was complete for 10 min at a speed of 500 rpm. The outcomeindicated to the hybrid composite material has maximum hardness and metal matrix composites with mica have the least hardness. Tensile behavior of A356 matrix composites reinforced with TiB2 nano-particles maximum size 20 nm and the smallest micro maximum size 5 μm particles was investigated [69].

2.8. The Knowledge Gap in Earlier Investigations

This literature review on particulate reinforced aluminum matrix composites revealsthe following knowledge gap in the earlier investigations, based on which theobjectives of the present research work have been set.

Includes definition and theories related to this study several studies are explored to determine the factor that significantly affects the strength of composite material. This recommendation, related to maximizing and optimizing various composite parameters is presented below.

Throughout developing aluminum alloy reinforced composite material, the main consideration is its mechanical performance that depends on many factors. Such as martial types and their strength, particles size, particles orientation in the composite and the number of particles in the composite (weight fraction),

Though much work has been reported on various composites characteristics of aluminum and its alloys, comparatively less has been reported on the glass particles performance of aluminum matrix composite.

3. METHODOLOGY

3.1. Materials and Equipment

The following table summarizes the lists of materials and machinery used to accomplish the research.

Table 3.1 Required Materials.

Item name	Specification	Used for
Types of equipment:		
Electric Furnace	Temperature range 1200°C	preheat the glass particles
Diesel furnace	Temperature range 1600°C	Molting aluminum matrix
Stirring mechanism (indigenous design modification)	Range of speed 500 rpm	Mixing matrix and reinforcement
Casting facilitates	Helmet and faces shield	Safety equipment
Machining	Lathe machine and power hacksaw	Preparation Specimen
Sieve	Laboratory sieve 0.225 mm	Majoring particles size
Weighing system	Digital mass balance	Wight percentage of particles
Thermocouple	Temperature was recorded	Molten temperature
Raw materials:		
Aluminum ingot	Al 7050 alloy	Matrix material
Glass	Soda-lime silica glass	Reinforcement material
Sand	Casting	Preparation to mold

3.1.1. Reinforcement Material

Reinforced materials are generally discontinuous, stronger, and harder than matrix materials. The main function of these reinforcing materials is to improve the mechanical and physical properties of composite materials. Used for soda-lime-silica glass, the glass family includes many glass components used to decorate tableware, accessories, and windows. The composition of soda-lime quartz glass accounts for nearly 90% of the world's manufactured glass. Glass particles are one of the cheapest and low-density reinforcement materials. The addition of glass particles reduces the cost and density of aluminum and its alloys.

Table 3.2 Chemical Composition of soda-lime glass for window[70].

Type of Glass	**Approximate Composition (%)**	**Substances**
Soda -Lime Glass	72	SiO_2
	14	Na_2O
	10	CaO
	2	MgO
	1	Al_2O_3
	0.03	K_2O
	0.02	TiO_2
	0.1	Fe_2O_3

Table 3.3 Mechanical Properties of (soda-lime) glass and historic masonry[71].

Mechanical Properties	**Glass**	**Historic masonry**
young's Modulus GPa	50-70	2.55*
	2520**	2250*
Density Kg/m3	0.22**	0.19*
Poisson's ratio -	200	28**
Compressive strength MPa	6-20	3**
Tensile strength MPa	9.5**	6.3**
Thermal exp. coeff. $10^{6/}C°$		

3.1.2. Preparation of reinforcement material

Preparation of reinforcement with a soda-lime glass window was manually crushed by hammer to achieve coarse glass. Then the coarse glass was powdered after being crushed with Planetary Balls Mill Machine. Finally, the powder glass was sieved by Sieving Machine with 0.225 mm to the expected size.

Figure 3.1 preparation reinforcement materials

3.1.3. Preparation of Matrix materials

The matrix used in the present study was aluminum 7050 alloy. Because of its superior properties like high strength at subzero temperatures. However, their strength can be reduced at high temperatures It has high toughness, strong mechanical strength, and good stress corrosion cracking resistance.

Table 3.4Chemical Composition of the aluminum 7050 alloys[72].

Element	**Content (%)**
Aluminum, Al	87.3 – 90.3
Zinc, Z	5.7 – 6.7
Copper, Cu	2.0 – 2.6
Magnesium, Mg	1.9 – 2.6
Zirconium, Zr	0.08 – 0.15
Iron, Fe	≤ 0.15
Silicon, Si	≤ 0.12
Mangnese, Mn	≤ 0.10
Titanium, Ti	≤ 0.06
Chromium, Cr	≤ 0.04

Table 3.5 Mechanical Properties of aluminum 7075 alloys[72].

Properties	**Values**	**Unit**
Ultimate Tensile Strength	524	MPa
Tensile Yield Strength	469	MPa
Elongation at Break	11	%
Modulus of Elasticity	71.6	GPa
Poisson’s Ratio	0.33	
Hardness, Rockewell A	51.6	BHN
Hardness, Rockwell B	84	BNH
Density	2.6-2.8	gms/cm^3
Melting Point	494	°C

Figure 3.2 Figure Aluminum 7050 ingots

3.2. Experimental Methods

This chapter deals with the detailed experimental procedure carried out in the present investigation. Describes the materials used for the fabrication of the aluminum metal matrix composites and methods in employment to take out this study. Itpresents the particulars of the tests related to the physical and mechanical characterization of the prepared aluminum metal matrix composites.

This studyuses Al7050 alloy of materials, with reinforcement, glass, mold, and testing equipment. These materials used during composite preparation and the experimental investigation are presented below.

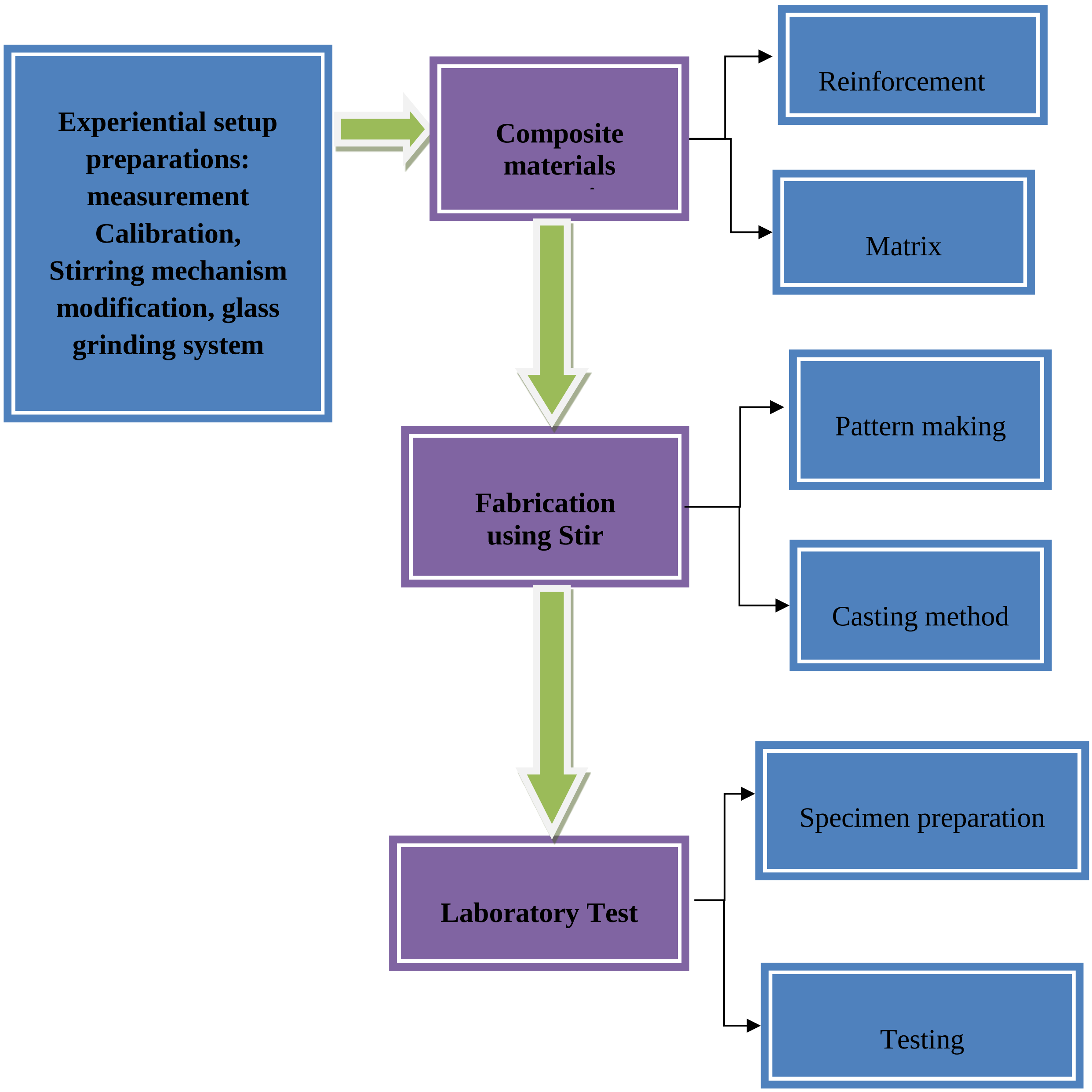

Figure 3.3 Flow chart representing experimental procedures

3.2.1. Preparation of the composites

The materials tested were metal matrix composites based on aluminum alloy 7050 and glass particles. The Al7050 and glass composites were prepared by the vortex method. The soda-lime glass particulates contents used for the preparation of the composites were 4%, 6%, and 8%the weight percentage. With stir casting method a mechanical stainless-steel simple paddle blond types. With rotated at a speed of stirring is500 rpm to create the required vortex. The glass particles were preheated upto 500°C.The molten metal was then poured into permanent molds for casting.The matrix and composites would be prepared by liquidmetallurgy technique through the process of stir casting method. The matrix prepared by box type treatment furnace was used to preheat the glass particulates. The aluminum 7050 alloy composites were prepared by the liquid state metallurgy technique. The furnace used for the preparation of the composite isfundamentally an electrical single-phase with a diesel furnace of a capacity of 3 up to 5kg. The furnace isfitted with a crucible at its center and the furnace can be tilted in a horizontalaxis. A box-type furnace was used to preheat the glass particulates to a 500C temperature. And introduced into the molten aluminum alloy melt. Aluminumalloy melt was melting temperature of 775°C and maintained at thattemperature. A stirring casting stainless steel simple paddle blade type’s impeller stirrer was usedto stir the molten metal to create a vortex. The stirrer was 3up –to5 minute’s rotated at a speed of 500 rpm and a vortex was created in the melt of aluminum and glass particles, the depth of stirring depends on the size of composites malt. After that prepare the metal mold standard STM of the size of Specimen.then molten aluminum was then poured into metal molds for casting.

Figure 3.5 Electric resistance furnace.

Figure 3.6 Diesel furnace Figure stirrer blade assembly.

3.2.2. Preheating of the composites

Use a muffle furnace to preheat the glass particles to a temperature of 500°C and keep it at that temperature until it is introduced into the aluminum alloy melt. To reduce the temperature gradient between the molten aluminum and the glass reinforcement material, improve the wetting ability and reduce the difference in surface energy between the matrix and the reinforcement material, it is necessary to preheat the reinforcement material.

Figure 3.7 preheating glass particles

3.2.3. Casting of aluminum metal matrix

Identified amounts of the 7050 aluminum alloy it is depending on weight percentage. The covering 0.4% glass and 0.96% aluminum alloy ingots. These cleaned ingots immediately charged into the crucible of the furnace for melting.

The melting point of aluminum alloy 7050 is 494 °C.The melt was superheated to a temperature of 800°C and maintained at that temperature. Thetemperature was recorded using a chrome-alum thermocouple. A stainless-steel impeller was used to stir the molten metal and create a vortex. The impeller used for stirring was of a centrifugal type with simply passedblades welded at 45°inclination and 180°radius apart. The stirrer was rotated at a speed of 500 rpm and avortex was created in the melt. The depth to which the impeller was immersed was 60% of the height of the molten metal from the surface of the melt. Then the reinforcement namely glass particulate, which was preheated in the box type furnace, Stirring was continued until interface interactions between the glass particulate and the aluminum matrix promotes wetting bout 3-5 minutes and at superheat temperature, then this time enables the glass particulate to be distributed matrix the in the developed the aluminum matrix composite.

Figure 3.8 casting of aluminum ingot.

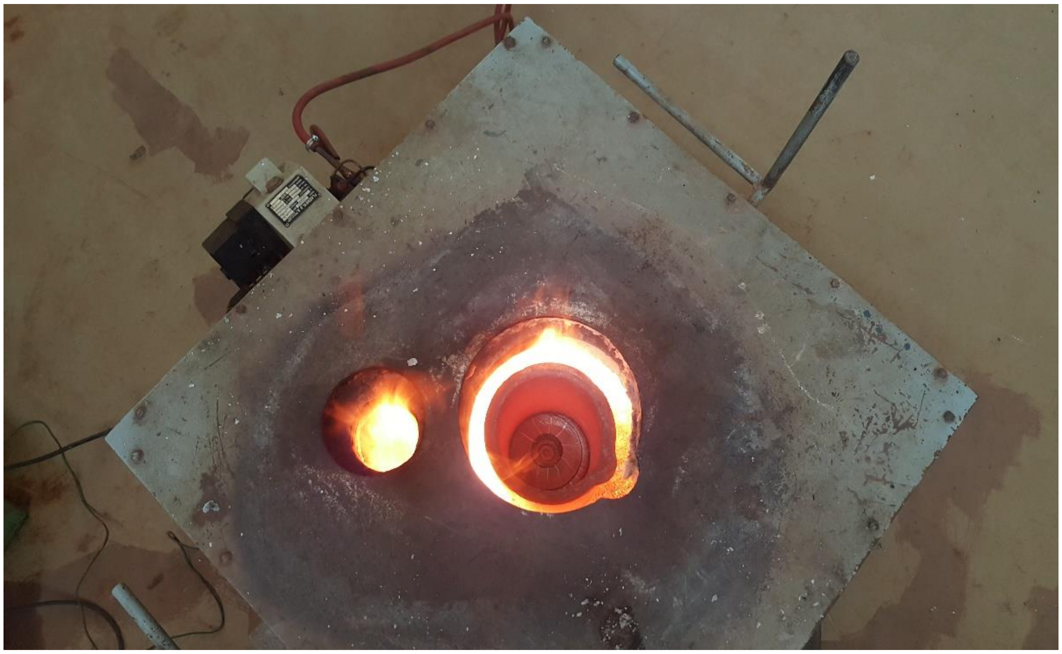

Figure 3.9 Molten aluminum

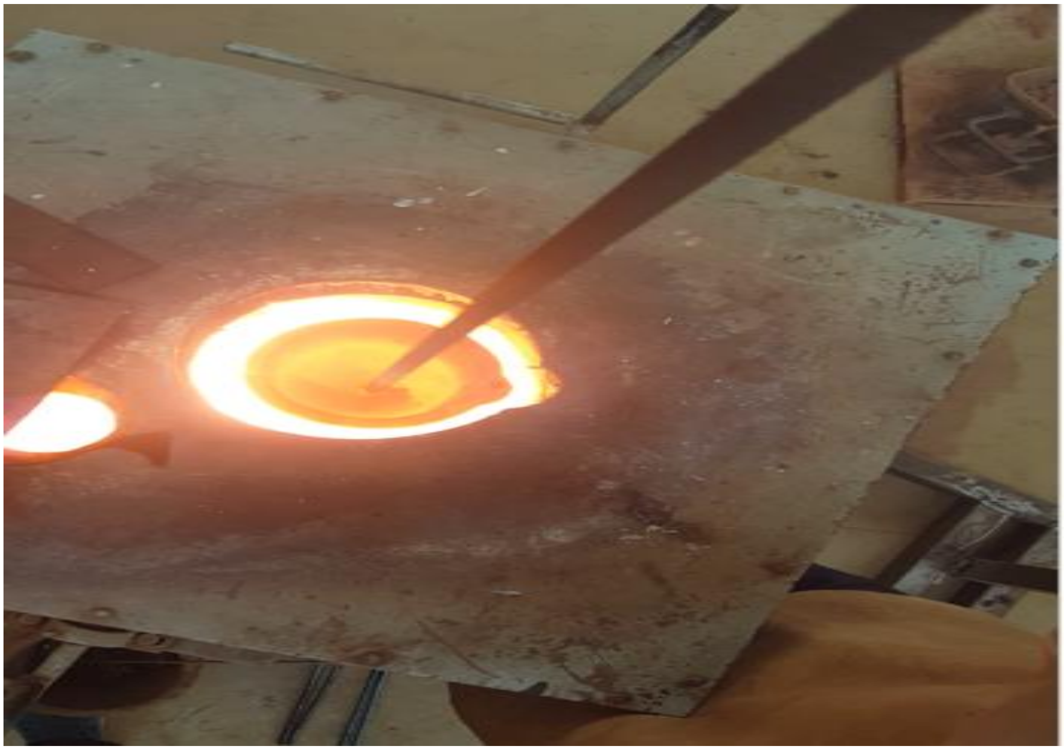

Figure 3.10Stiring aluminum matrix and glass particles.

3.3. Parameter of the stir casting process for aluminum matrix composites (AMCs)

3.3.1 Reinforcement size

The size of the reinforcement and significant role in obtaining uniform dispersion of the distribution in the stir casting. The strength is inversely proportional to the reinforce size it is if the reinforce size decreases the strength increases. reports indicate that it would be difficult to disperse a large volume percentage of flake type mica particles in aluminum melts whereas distribution such as particles, it is said that glass particles, which are amorphous materials, will be dispersed in the aluminum melt in a certain amount, but it is not simple. In this study, 0.225 mm spherical particles were used. Since the dispersion used in this study is granular, only 4% of glass particles can be dispersed in the aluminum melt at most. More than some, it will result in the rejection of particles from the molten melt, which can be seen from the output of the casting.

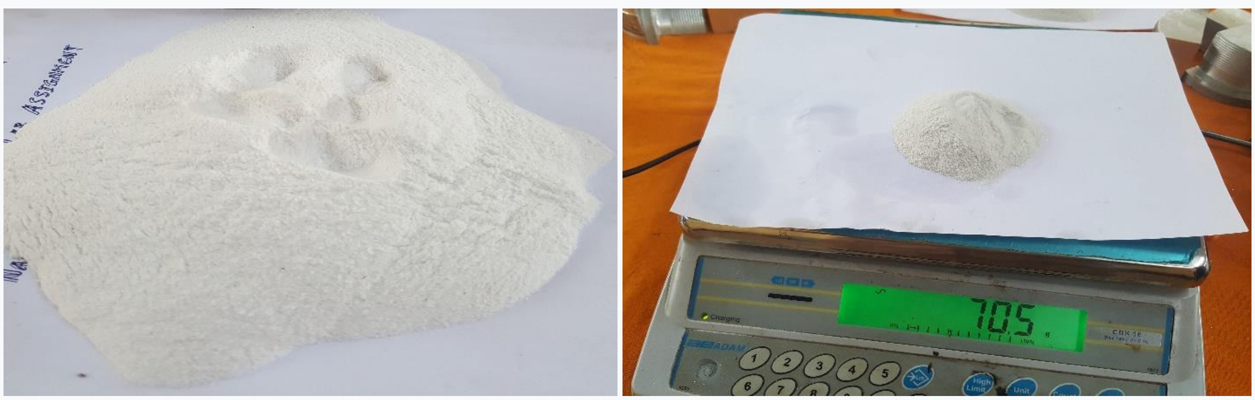

Figure 3.11 Wight percentage of particles.

3.3.2. Preheating temperature of glass particles

The glass particles are preheated to a temperature of 500°C for 5 minutes. It was observed that after the pre-heat treatment, the dispersion was more uniform, and the casting was also found to be intact with a smaller porosity. This is expected because preheating the glass particles to a temperature of 500°C will partially remove the gas-absorbing layer on the surface of the particles. However, the gas layer adsorbed on the surface can also be removed by vacuum treatment. In addition, the pre-heat treatment reduces the cooling of the melt, It is found that the optimal preheating temperature of the glass particles is 500°C, and the preheating reduces the surface energy difference of the reinforcing phase.

3.3.3. Stirrer blade shape and design

The mixing blades used are made of stainless steel to prevent the alloy and stainless steel from reacting at high temperatures. The impeller used for stirring is a centrifugal impeller, and the simple channel blades are welded together with an inclination angle of 45° and a radius of 180°. The vortex on the surface of the melt is necessary to disperse the particles in the molten aluminum. Stirring the molten metal at a higher speed will produce a stronger vortex, but at very high speeds, there is a danger of air entrainment. Therefore, the optimum speed of 500 rpm was reached by standardizing the stirring speed.

3.3.4. Stirring time

The mixing time is another key parameter in the mixing and casting process. By increasing the mixing time, the tensile strength of the composite material is significantly improved because the reinforcement in the matrix of the composite material is evenly distributed. The stirring time is the actual duration of time the particles are held.in the melt. In other words, it is the duration just after the glass particles are introduced into the melt and just before the solidification of the composite melt in the mold is complete. At this point, it was found that the best residence time was between 3-5 minutes. When the residence time was increased by more than 5 minutes, separation of the glass particles was found. When the residence time is short (less than 4 minutes), the particle distribution in the casting is not uniform, and some pores will appear in the composite material.

3.3.5. Melting temperature

The melting temperature process of composite materials is very important. With the increase of the stirring and holding time, any increase in the casting temperature will reduce the viscosity of the aluminum malt, which also stimulates the bonding performance between the reinforcing material and the matrix. The melting point of 7050 aluminum alloy is 494°C. The melt was overheated to a temperature of 800°C and kept at that temperature. A chromium-aluminum-nickel thermocouple was used to record the temperature. The stainless steel impeller or stirrer the molten metal and generates a vortex. The material enters the melt, thereby contaminating the melt. The impeller used for mixing is a centrifugal impeller, and the two blades are welded together at an inclination angle of 45°degrees and a distance of 180 °degrees.The agitator rotates at a speed of

500 rpm, creating a vortex in the melt. The immersion depth of the impeller is 60% of the height of the molten metal from the surface of the melt. Then the reinforcement material preheated to 500°C in the muffle furnace is introduced into the vortex

Figure 3.12 Molten temperature.

Rate of 5 minutes. Stirring was continued until interface interactions between particulate and the matrix promotes wetting. Poured into the preheated metallic dies. The cooled castings in the form of cylindrical bars of diameter 20 mm and length 200 mm were removed from the dies by loosening the clamps. A similar approach was adopted for all the other compositions and corresponding castings were obtained, throughout the investigation, the composites were prepared by superheating the molten metal at 775°C to facilitate degassing, mixing, and easy flow of molten metal. The melting point of aluminum alloy 7050 is 494°C and hence the melt was super heated to a temperature of 800°C and the drop in temperature was estimated to be 775°C by the time it was poured into thepermanent mold.

Figure 3.13 stir glass particles.

3.3.6. Pouring Temperature

Throughout the research process, composite materials were prepared by keeping molten metal at 800°C to promote the easy flow of molten metal. The melting point of 7050 aluminum alloy is 494°C, so overheating the melt to a temperature of 800°C, it is estimated that the temperature dropped by 20°C when poured into the permanent mold. However, since the viscosity of the melt is low at high temperatures and the yield is found to be low, the increase in the holding temperature causes the floating of glass particles.

Figure purr

Figure 3.14 Purring aluminum composites.

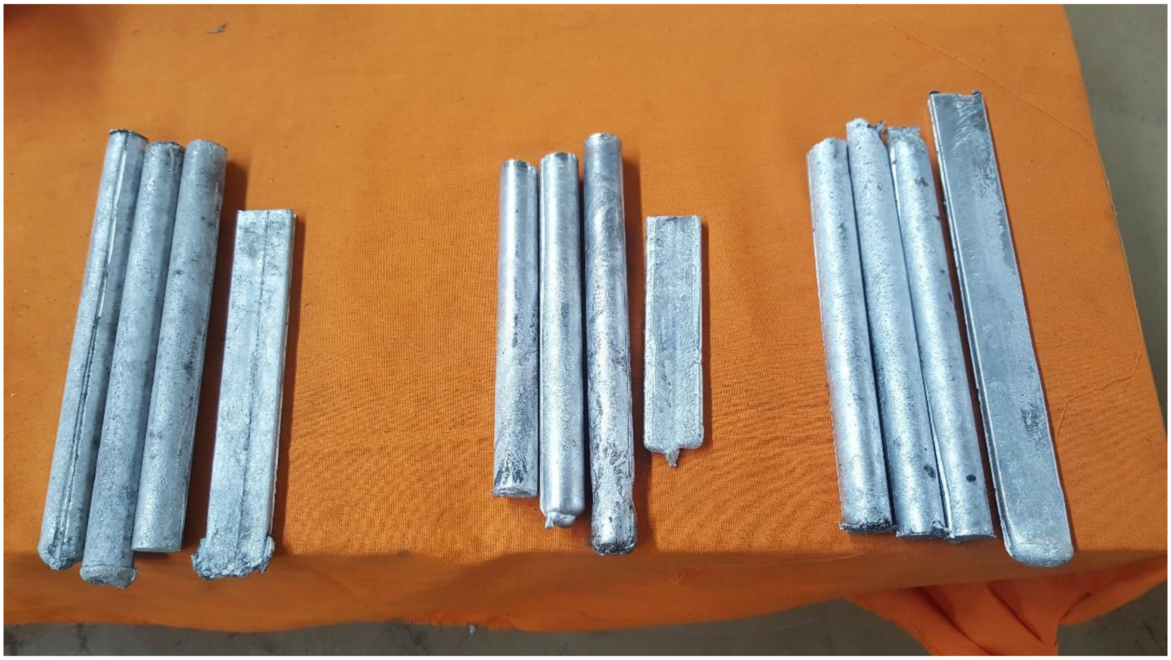

Figure 3.15 Aluminum composite materials.

3.4. Sample preparation

3.4.1. Tensile specimen

The tensile properties indicate how the material reacts to applied tensile loads. A tensile test is a basic mechanical test in which a carefully prepared sample is loaded in a very controlled manner while the applied load and elongation of the sample are measured over a distance. Various tensile properties of the cast and heat-treated composites, namely tensile strength, ductility, yield strength, and modulus of elasticity, were evaluated using a universal testing machine (UTM). The ultimate tensile strength tests were performed according to ASTM E8 standards. The ductility of the samples was rated as a percentage elongation. The yield strength of the samples was given in MPa. The testing specimen's total numbers 9 on three specimens were selected for each composition and average values of tensile strength, ductility, yield point, and modulus of elasticity were given.

The geometry of the specimen is shown in Figure 1. Tensile specimens and all diameters were taken in a longitudinal section parallel to the rolling direction. The result of the tensile test shows the ultimate (fracture) and yield point of the material. The final testing of the specimen is shown in figure 3.17. Tensile test was validated using a 200 KN servo-hydraulic computer interface to a universal test machine. The test setup is shown in the figure 3.18. Attached extensometers allow the reading of both real and technical stress and strain data.

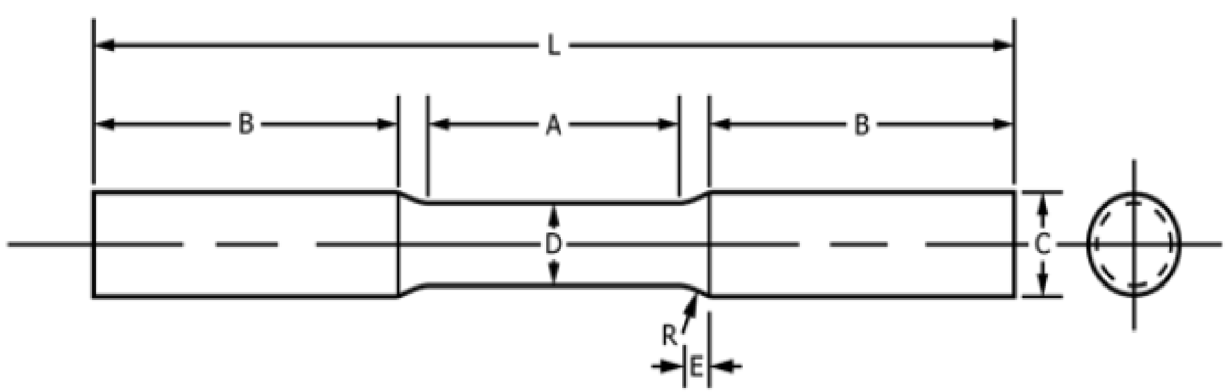

Figure 3.16 Test Specimens with Gauge Length Four times the Diameter [E8]

Table 3.6 The dimensions of the tensile test specimen.

D = *diameter*	= 12 mm
B = *Length of end section*	= 64 mm
A = *length of reduced parallel section*	= 64 mm
R = *Radius of fillet*	= 8 mm
L = *Overall length*	= 180 mm
E = *length of fillet*	= 2.mm
C = *diameter of end section*	= 18 mm

Figure 3.17 Tensile tests specimen.

Figure 3.18 servo-hydraulic computer interfaces to a universal test machine.

3.4.2. Hardness specimen

Hardness tests are a measure of the confrontation of material to limit the plastic surface deformation to a small area. The static pitting test was the behavior in the present study to investigate the hardness of the specimen at which a ball indenter is pressed into the specimen to be tested. The ratio of the numbers of all test forces to the area or depth of the dimples provides the determination of the hardness. The hardness of the samples was measured with a Rockwell hardness testershown in Figure 3.19.

Figure 3.19 Hardness specimen.

The hardness tests are consistently performed on the test sample made according to ASTM E10 standards. A ball indenter of 2.5 mm in diameter was used, and a load of 100 kg was applied over 5 seconds to the samples of 10 mm in thickness and 25 mm in width. The red dial on scale B is used for measuring the ridingshown in Figure 3.20.

Figure 3.20 Rockwell hardens measuring.

The test values were recorded on both samples at different locations to circumvent the achievable property of particle separation. The hardness is determined by taking the represented distance of the dimple and the result of calculating the Brinell hardness method (BHM) by dividing the applied load, the surface area of the dimple, Since the accuracy of the Brinell hardness test can be strongly influenced by the surface finish of the workpiece, the surface of the workpiece was polished so that the impression was defined clearly enough to allow accurate measurement.

3.4.3. X-ray diffraction (XRD)

X-ray diffraction patterns are more than impressive used to phase analysis method performed observe through you. We will see how x-rays are used to determine the crystal lattice structure of crystalline solids whether they be ionic, covalent, molecular, or metallic. The X-ray diffraction test was carried out using a pattern artist of science X-ray. Diffract meter with a rotating stage and goniometry in 2Ө configuration.

The testing sample for X-ray diffraction testing was prepared by specimens 15*15 mm cutting by hacks. Showing in figure 3.21 X-ray diffraction machine and spacemen.

Figure 3.21 X-ray diffraction machine and spacemen.

4. RESULTS AND DISCUSSION

In this investigation of Al7050alloy aluminum matrix composites with soda-limen glass, particle reinforcement is fabricated using stir-casting methods. The production of the composites is acceptedout by adding 4%, 6%, and 8% weight percentage of micro particulates in the size range of 225 nm.The resulting aluminum matrix composites are appropriately machined and tested for their mechanical properties and carburization. This section presents and discusses the results of the testing of the developed Al 7050 alloy matrix composites.

4.1.Mechanical properties of Al 7050 alloy matrix composites

4.1.1. Tensile strength test

Tensile tests are used for evaluating the yield tensile strength, ultimate tensile strength and ductility. The aluminum matrix composites experimental testing results the stress-strain curves for Al7050 matrix and reinforced with 4, 6, and 8wt% soda-lime glass particles, The tensile strength test was used to measure the mechanical performance of the matrix and composites. The Al7050 alloy matrix composites secular rods were machined to tensile testing specimens with a diameter of 16 mm and a gauge length of 30mm.The ultimate tensile strength, regularly reduced to tensile strength (TS) or ultimate strength, is the maximum stress that an aluminum matrix composites materials can survive while existence stretched or pulled before necking. This is after the specimen cross-section starts to significantly contract.

Table 4.1 Mechanical Properties of Al7050 alloy matrix composites containing varying amounts of glass particles.

Glass particleswt%	Ultimate tensile strength (MPa)	Young's Modulus(MPa)	Elongation ofA(%)
0%	90 MPa	68 MPa	5%
4%	95 MPa	70 MPa	5.2%
6%	120 MPa	106 MPa	5.4%
8%	135 MPa	120 MPa	6.1%

4.1.2. **Ultimate tensile strength**

The mechanical properties of Al7050 alloy matrix composites with glass particles reinforcement are shown in Table 4. Showing in graph 4.1 isthe effect of glass particles reinforcement contented on the ultimate tensile strength (UTS) of aluminum matrix composites particulate reinforcement. The effect of glass reinforcement weight percentage on the universal tensile strength (UTS) of aluminum matrix composites. As the glass particles' weight percentage increases, the ultimate tensile strength of the aluminum matrix composite increase monotonically by significant amounts. The ultimate tensile strength result increased from 68MPa to 135MPa. The point, by way of the glass weight percentage, is increased from 4% to 8%, the ultimate tensile strength increases by around 20%. This increase in ultimate tensile strength can be due to the glass particulates acting as barriers to disarticulations.

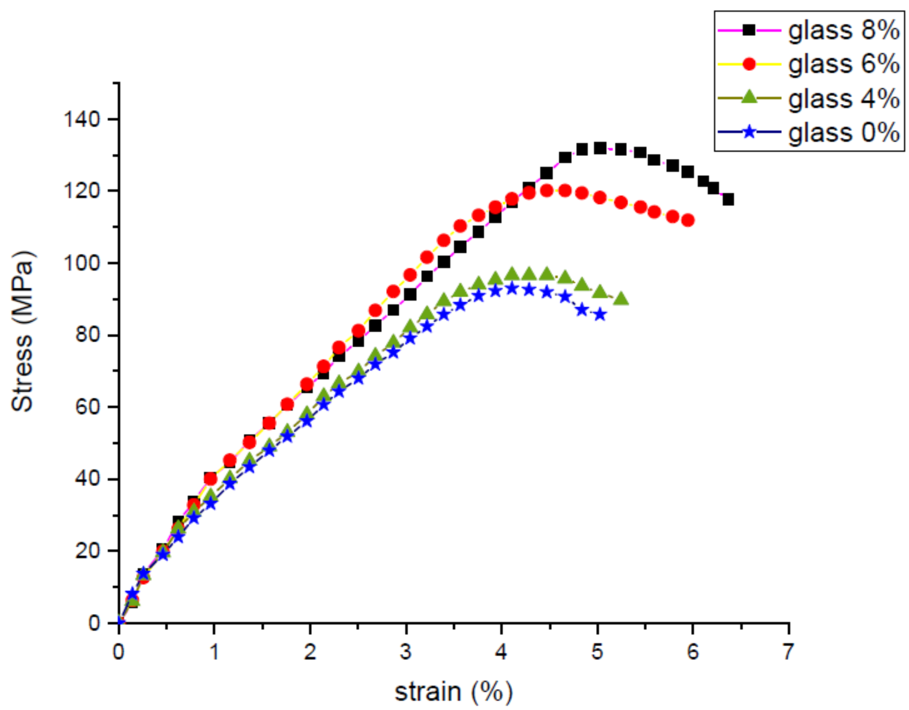

Figure 4.1Ultimatetensile strength of soda-lime glass-reinforced Al7050 composites.

4.1.3. **Young's Modulus**

The showing in graph 4.2 effect of glass particles weight percentage on DeYoung's Modulus of Al7050 alloy matrix composites with glass particulate composites. Theeffect of glass particles weight percentage on Young's modulus of Al7050 alloy matrix composites. As in the case of ductility, ultimate tensile strength (UTS), and compressive strength defined above, it can be seen that as the glass particles weight percentage increases, Young's modulus of the composite material increases monotonically by significant amounts. As the glass particulate content is increased from 4% to 8%, Young's modulus increases by about 20% when compared to the base alloy. The increase in young's modulus is from 70 MPa to 120MPa, an observed increase in strength of20% when compared to the base aluminum alloy.

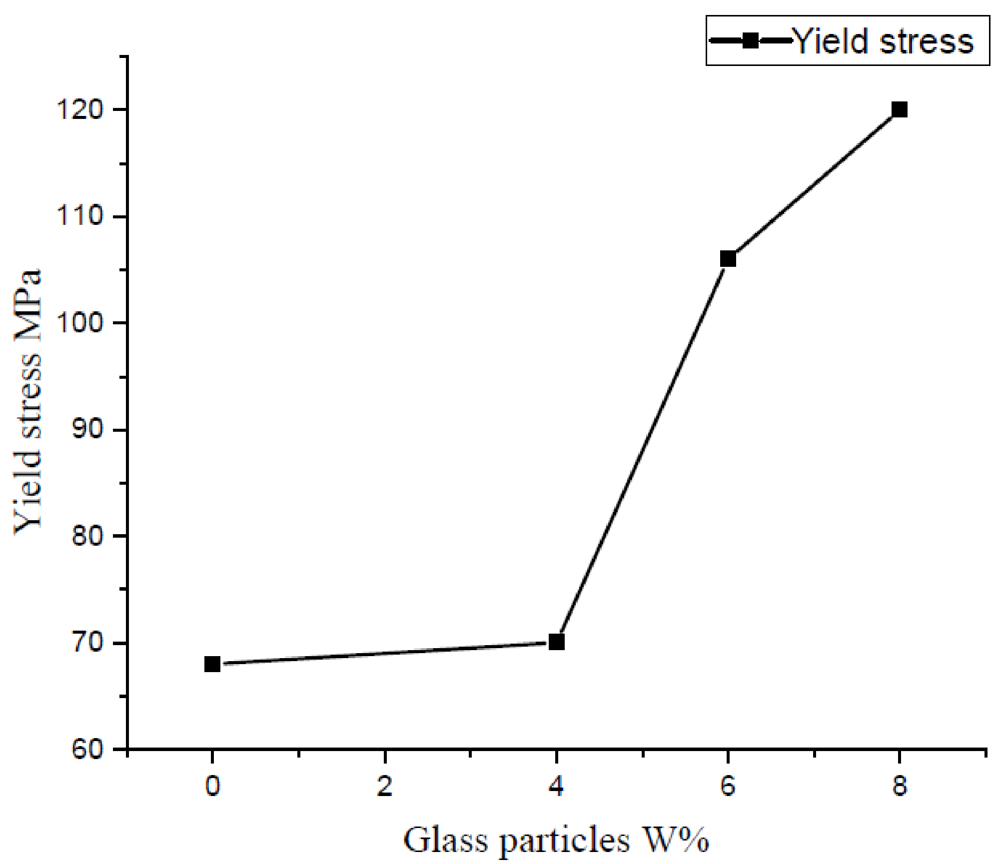

Figure 4.2 Young modulus of soda-lime glass-reinforced Al7050 composites.

4.1.4. Ductility

The showing in graph 4.3 the effect of glass particles weight percentage on the ductility of Al7050 matrix composites. When 8% by weight percentage of glass particles reinforcement to the Al7050 alloy the ductility of due to the presence of hard dispersions, but on successive addition of glass particles weight percentage, an increase in ductility is aluminum matrix composites. As the glass particles increases, the ductility of the aluminum matrix composites composite increases monotonically by important amounts. In detail, as the glass particles' weight prestige is increased from 4% to 8% the ductility increases by about 5%. This considerable increase in ductility is due to the glass particles additions, He concluded that the properties of the hard glass particles control the mechanical properties of the composite. In addition, the strong bonding load of the matrix interface is transferred to the reinforced material which exhibits improved composite strength.

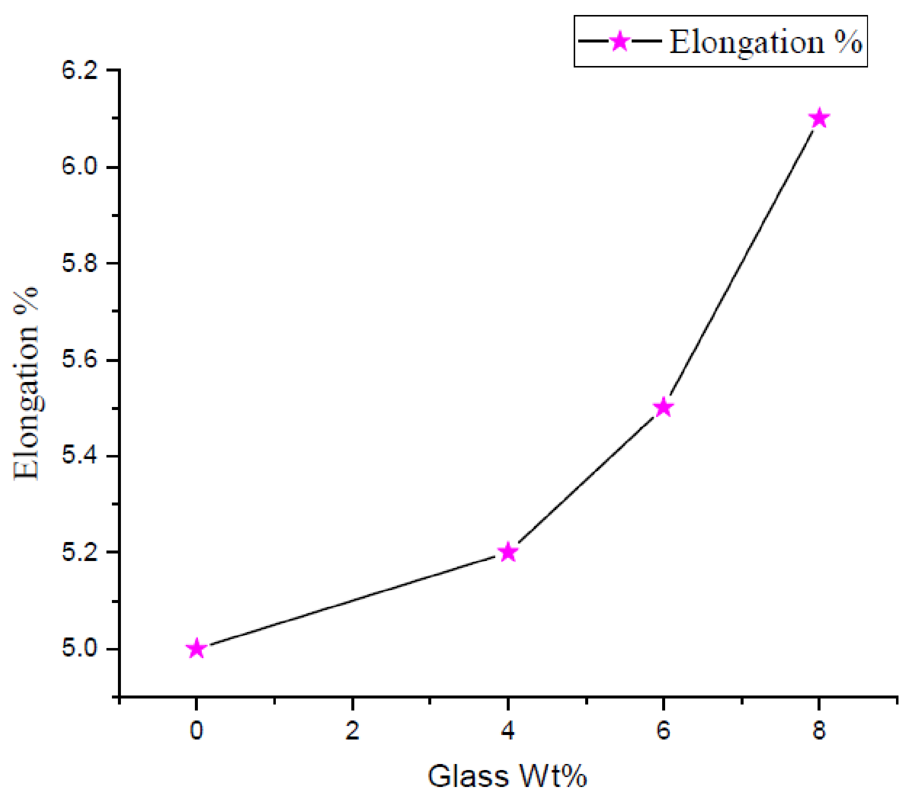

Figure 4.3 Ductility of soda-lime glassreinforced Al7050 composites.

4.1.5. Hardness Test

Hardness tester for hardness measurement. The surface to be tested generally requires a was carried out with 400, 600, and 1000 grit sandpaper. The load on the Rockwell hardness tester was 100 kg with a dwell time of 5 seconds for each sample. For the hardness test, samples were prepared according to the specification required for the Rockwell hardness test 10 mm x 20 mm x 25 mm. four measurements were taken with a standard distance of approximately 0.5 mm from each well for reliable results. The diamond indenter is used for the accuracy of results. The highest measured value is 87.9 KN. This confirms the increase in the hardness value. The hardness value was increased by adding glass particles with an aluminum matrix. During composite production, the reinforcement strengthens the aluminum matrix and the unique hardness property of glass particles is transferred to the sample. Aluminum matrix composites hardness outcome observed for the test specimens results in Table 4.1 below. On the other hand, it shows the effect of the number of glass particles on Rockwell hardness. A significant increase in the hardness of the AA 7050 matrix can be observed with glass particles. The hardness of the composites was higher than that of the pure aluminum alloy, as the hardness increases with an increasing amount of glass particles.

Table 4.2 Hardness results of Al7050 composites.

Sl.no	Composites	Rates				Average Hardness results
1	Al 7050 alloy	65	66.6	64.3	70	66.7 KN
2	Al 7050 alloy+ glass 4%	69.4	70.8	73.8	74	72 KN
3	Al 7050 alloy+ glass 6%	81.4	84	84.5	85.5	84 KN
4	Al 7050 alloy+ glass 8%	87.4	91.4	87	86	87.9kN

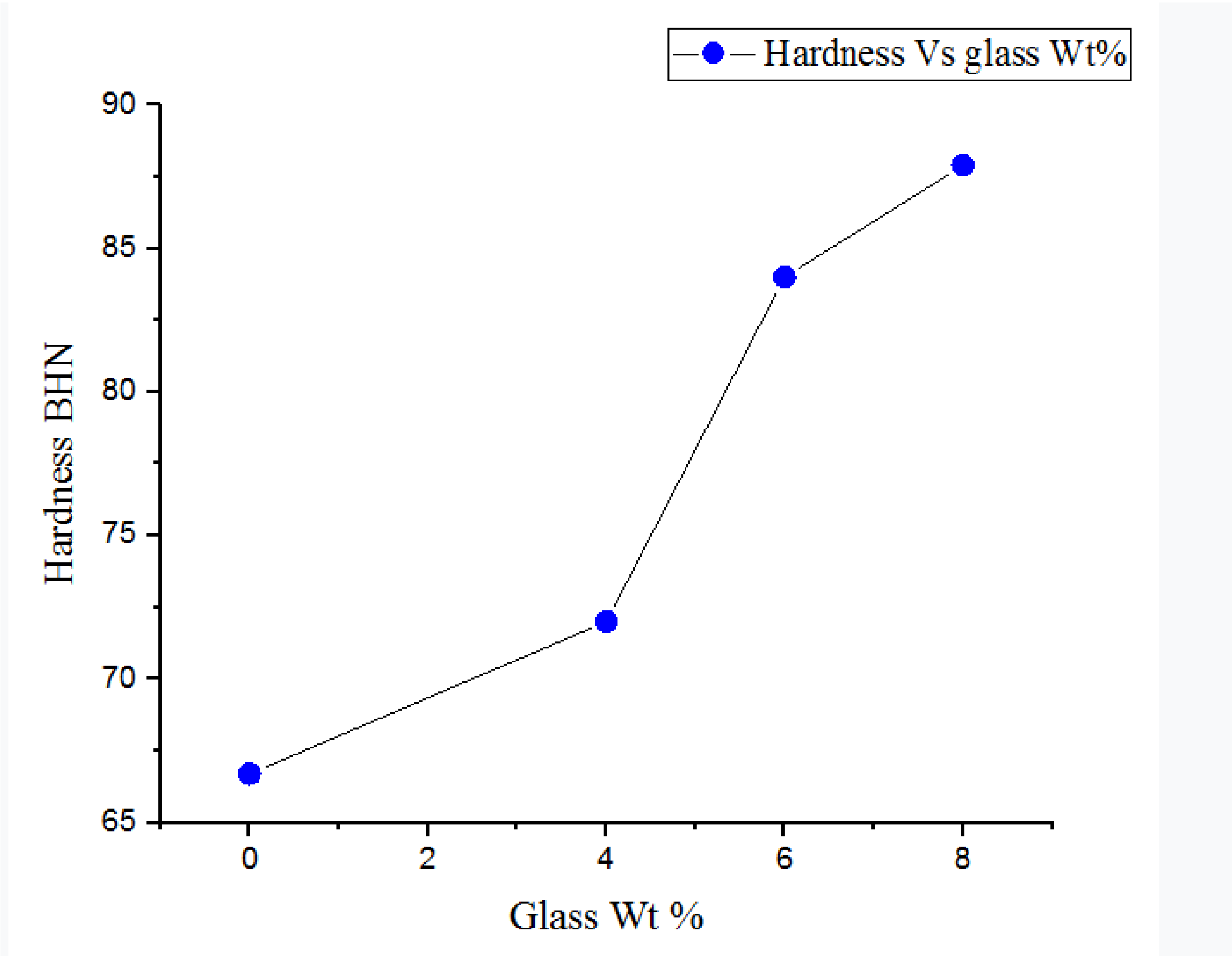

Figure 4.4 Hardens asa function of glass content.

The development in Brunel hardness was qualified to the uniform dispersion of glass particles reinforcement Throughout the Al7050 alloy aluminum matrix composites (AMCs). In addition, the presence of hard glass reinforcement in the soft Al 7050 alloy matrix enhances the general hardness of the matrix material.

Desiccation of aluminum matrix composites with glass particles. It is the outcome is that hardness increases with the increasing Wight percentage of glass particles. The greatest results remained found for the stir casting Al7050 alloy with glass particles composite which contains 8 Wight percentages of glass particles. Al7050 alloy matrix composite displayed the outcome of results higher hardness values than the other composites as well as the pure Al7050 alloy matrix composites material in the present investigation. The outcome results in a development in BHN

25%were experiential. It is supposed that glass particles are harder than Al7050alloy, the characteristic property of hardness is rendered to the soft matrix.

Finally, from the results of mechanical properties, it is attributed that the properties of hard glass particles control the mechanical properties of the composite. Also, the strong interface bonding load from the matrix is transferred to the reinforced material exhibiting enhanced strength of composites.

4.2.Effect of Stir-Casting ParametersAl 7050 alloy matrix composites

4.2.1. Effect of Temperature of the molten metal

With the other parameters renaming favorable for aluminum matrix composites casting. General observation of the temperature of the molten both showed an important effect on wet ability and porosity of the casting. The dispersion of glass particles was found to improve at higher holding temperatures this may be attributed. Firstly to the increase in the fluidity of the melt Secondly to a decrease in the surface free energy this, in turn, improved the wet ability of the melt by decreasing the contact angle between glass particles and the aluminum liquid metal. The porosity of the composites increases with the increases in holding temperature due to the dissolution of more dissolved gases in the melt.

It was found that the heat-treated particles could be easily interlocked and dispersed into the melt. If the holding temperature of the molt was maintained at a temperature higher than 770ºC.However. If the pouring is done 800 ºC particles get enough time to see at the bottom of the mold before solidification.The stir casting method, the temperature of 775ºC is suggested to geta superior hardness outcome. The most select temperature of 825ºC is recommended. Such aluminum matrix compositesat an elevated temperature of 825ºC are used to improve the fluidity of flow for obtaining a good casting[58].

4.2.2. Effect of stirring

The effect of stirring mostly depends on the time stirring the distribution on the glass particles.General observations short stirring time of 3 minutes resulted in the agglomeration of the glass particles. After the completion of glass additions giving a proper stirring time, the glass particles were dispersed evenly throughout the structure.

4.3.XRD Analysis of Al 7050 alloy matrix composites

X-ray diffraction is one of the important phase analysis methods achieved in the aluminum matrix composites to determine the reaction between the Al7050 alloy matrix and glass reinforcement. The showing in figure 4.5 shows the typical X-ray diffraction pattern for Al7050 alloy matrix composites with glass particles reinforcement. The machine model isXRD-7000 and using the scanning speed 0.02o/min, target material Cu that corresponds to the wavelength of 1.54 Angstrom and the recording done in the range of 2 thetas from 10 to 80 degrees, to determine the reaction between the alloy and ceramic component. In Aluminum alloy(as obtained), the diffraction peaks are observed at 34.82, 38.66, 40.28, 44.74, 58.3, 65.5, 69.62, and 78.3 among these some are the peaks due to Aluminum alloy and the rest are corresponding to other alloying elements like Mg and Silicon or their compounds. The glass-reinforced aluminum alloy pattern shows that there is a more amorphous phase in the sample and the peaks observed at 34.82, 38.88, 40.48, 44.74, 65.5, and 78.54are assigned in the diagram.

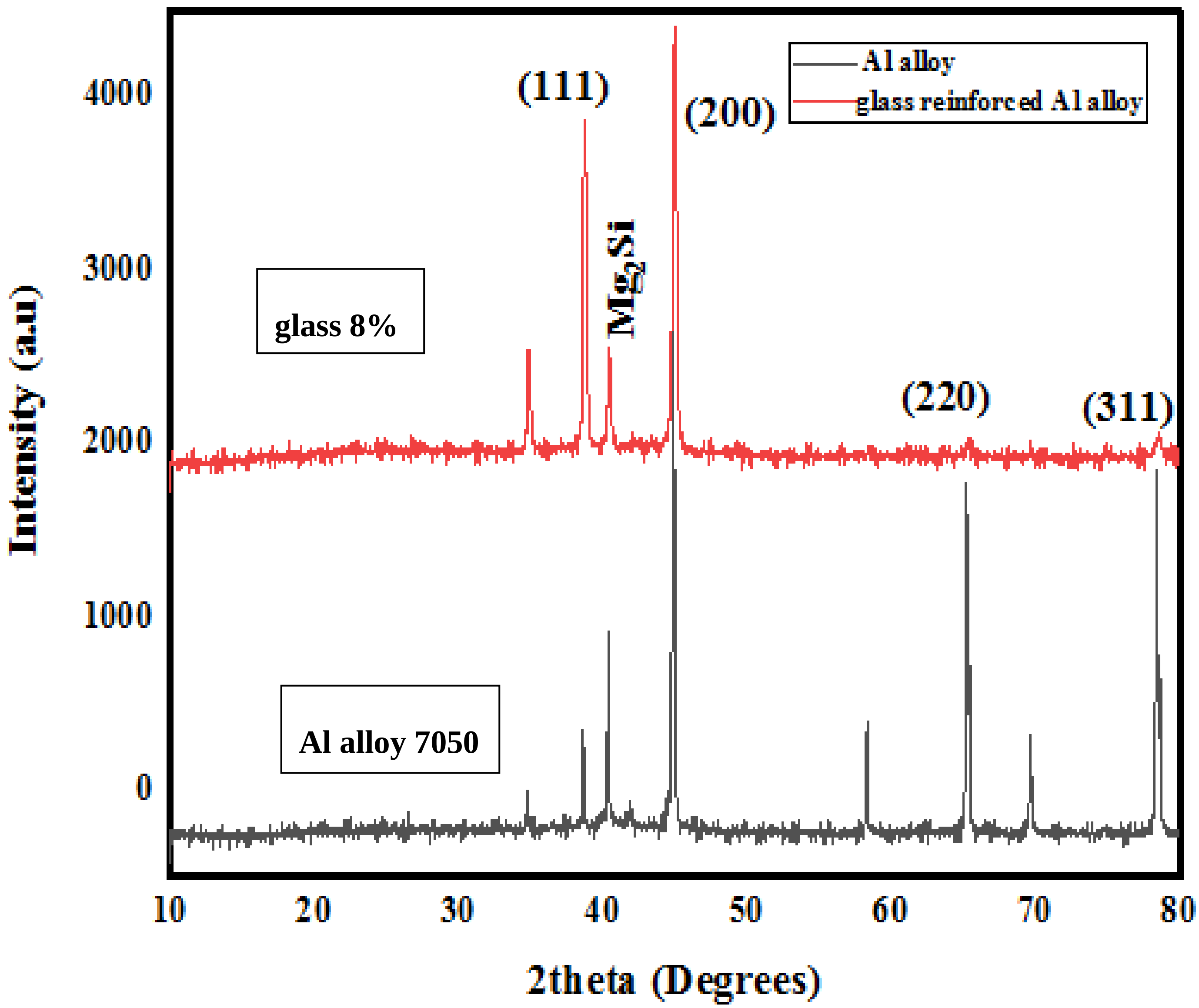

Figure 4.5 XRD image of soda-lime glass-reinforced aluminum 7050 composites.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

The conclusions drawn from the present investigation of aluminum alloy 7050 was reinforced with ceramic composites produced by the stir casting method with different weight percentages 4%, 6%, and 8wt% of glass particles the 0.225 mm, mechanical properties were calculated. From this research approach following results were obtained.

- Aluminum matrix composites have been successfully fabricated by the stir casting method with a quite uniform distribution of glass particles.
- Dispersion of glass particles in aluminum matrix composites improves the hardiness of the matrix material.
- It appears from this study that UTS and yield strength trend starts to increase with the increase in the weight percentage of glass particles in the matrix.
- The hardiness increases after the increases of glass particles in the matrix.
- XRD results showed the presence of glass particles in the alloy matrix. The oxide phases like glass etc. have dispersed uniformly throughout the MMC thus strengthening the resulting composite.
- Stir casting process. Stirrer design and position Stirrer speed and time particle-preheating temperature particle incorporation rate etc. are the important process parameters.

5.2 Recommendations for future study

From the conclusion of this research, the following recommendation is made for further studies in the future.

- Manufacturing technique was used to develop aluminum matrix composites. By using another manufacturing method,
- Study on effects of glass particles size on the mechanical performance of aluminum matrix composites concerning the different sizes.
- Study on the effect of the stirring time and stirring speed on aluminum matrix composites with glass particles.
- To improve the strength of the AMCs for the advanced works, further research works must be done on the improvement of the UTS.
- For future work one can make an experiment to get a better result on hybrid aluminum metal matrix composite reinforced with glass and other materials.

REFERENCES

[1] Surappa M.K., "Aluminium Matrix Composites: Challenges and Opportunities // Sadhana. Department of Metallurgy, Indian Institute of Science, Bangalore 560 012, India," *S¯ adhan¯ a*, vol. 28, no. 1–2, pp. 319–334, 2003.

[2] A. VRamesh, E. Paul, and S. K. Ali, "Comparitive Study of the Mechanical Properties of Alkali Treated and Untreated Sugarcane Bagasse Fiber Reinforced Composite Material," *Int. Res. J. Eng. Technol.*, pp. 413–420, 2018, [Online]. Available: www.irjet.net.

[3] H. G. Prashantha Kumar and M. Anthony Xavior, "Graphene reinforced metal matrix composite (GRMMC): A review," *Procedia Eng.*, vol. 97, pp. 1033–1040, 2014, doi: 10.1016/j.proeng.2014.12.381.

[4] S. P. Hannula, P. Lintula, P. Lintunen, and T. Lindroos, "Processing and properties of metal matrix composites synthesized by SHS," *Mater. Sci. Forum*, vol. 426–432, no. 3, pp. 1971–1978, 2003, doi: 10.4028/www.scientific.net/msf.426-432.1971.

[5] S. T. Mavhungu, E. T. Akinlabi, M. A. Onitiri, and F. M. Varachia, "Aluminum Matrix Composites for Industrial Use: Advances and Trends," *Procedia Manuf.*, vol. 7, pp. 178–182, 2017, doi: 10.1016/j.promfg.2016.12.045.

[6] J. Joel and M. Anthony Xavior, "Aluminium Alloy Composites and its Machinability studies; A Review," *Mater. Today Proc.*, vol. 5, no. 5, pp. 13556–13562, 2018, doi: 10.1016/j.matpr.2018.02.351.

[7] A. Awasthi, N. Panwar, A. S. Wadhwa, and A. Chauhan, "Mechanical Characterization of hybrid aluminium Composite-A review," *Mater. Today Proc.*, vol. 5, no. 14, pp. 27840–27844, 2018, doi: 10.1016/j.matpr.2018.10.021.

[8] H. Kala, K. K. S. Mer, and S. Kumar, "A Review on Mechanical and Tribological Behaviors of Stir Cast Aluminum Matrix Composites.," *Procedia Mater. Sci.*, vol. 6, no. Icmpc, pp. 1951–1960, 2014, doi: 10.1016/j.mspro.2014.07.229.

[9] N. Panwar and A. Chauhan, "Fabrication methods of particulate reinforced Aluminium metal matrix composite-A review," *Mater. Today Proc.*, vol. 5, no. 2, pp. 5933–5939, 2018, doi: 10.1016/j.matpr.2017.12.194.

[10] P. Priyanka, A. Dixit, and H. S. Mali, "High-Strength Hybrid Textile Composites with Carbon, Kevlar, and E-Glass Fibers for Impact-Resistant Structures. A Review.," *Mech. Compos. Mater.*, vol. 53, no. 5, pp. 685–704, 2017, doi: 10.1007/s11029-017-9696-2.

[11] P. D. Srivyas and M. S. Charoo, "Role of Reinforcements on the Mechanical and Tribological Behavior of Aluminum Metal Matrix Composites - A Review," *Mater. Today Proc.*, vol. 5, no. 9, pp. 20041–20053, 2018, doi: 10.1016/j.matpr.2018.06.371.

[12] A. Abdudeen, A. H. I. Mourad, J. A. Qudeiri, and A. Ziout, "Evaluation of characteristics of A390 - SiCp squeeze cast and gravity cast composites," *2020 Adv. Sci. Eng. Technol. Int. Conf. ASET 2020*, 2020, doi: 10.1109/ASET48392.2020.9118349.

[13] U. Pandey, R. Purohit, P. Agarwal, and S. Kumar Singh, "Study of Fabrication, Testing and Characterization of Al/TiC Metal Matrix Composites through different Processing Techniques," *Mater. Today Proc.*, vol. 5, no. 2, pp. 4106–4117, 2018, doi: 10.1016/j.matpr.2017.11.671.

[14] G. A. Duvuna, A. Ayuba, Y. I. Zhigilla, and Y. I. Tashiwa, "An investigation on the chemical and physical properties of gada and muvur silica sand for glass making," *Niger. J. Technol.*, vol. 38, no. 4, p. 871, 2019, doi: 10.4314/njt.v38i4.8.

[15] M. K. Yc and U. Shankar, "Evaluation of Mechanical Properties of Aluminum Alloy 6061-Glass Particulates reinforced Metal Matrix Composites," *Int. J. Mod. Eng. Res. (IJMER*, vol. 2, no. 5, pp. 3207–3209, 2012.

[16] M. Haghshenas, "Metal–Matrix Composites," *Ref. Modul. Mater. Sci. Mater. Eng.*, no. October 2015, pp. 0–28, 2016, doi: 10.1016/b978-0-12-803581-8.03950-3.

[17] M. Haghshenas, "Metal–Matrix Composites," *Ref. Modul. Mater. Sci. Mater. Eng.*, pp. 1–28, 2016, doi: 10.1016/b978-0-12-803581-8.03950-3.

[18] E. Martynova and H. Cebulla, *Glass fibers*. Elsevier Ltd., 2018.

[19] A. K. Sharma, R. Bhandari, A. Aherwar, R. Rimašauskiene, and C. Pinca-Bretotean, "A study of advancement in application opportunities of aluminum metal matrix composites," *Mater. Today Proc.*, vol. 26, no. March, pp. 2419–2424, 2020, doi: 10.1016/j.matpr.2020.02.516.

[20] B. V. Ramnath *et al.*, "Aluminium metal matrix composites - A review," *Rev. Adv. Mater. Sci.*, vol. 38, no. 1, pp. 55–60, 2014.

[21] S. Venkatesan and M. Anthony Xavior, "Investigation of aluminum (Al7050) metal matrix composites reinforced with graphene nanoparticles using stir casting process," *Int. J. Appl. Eng. Res.*, vol. 10, no. 15, pp. 35778–35783, 2015.

[22] B. G. Narasimha, V. M. Krishna, and A. M. Xavior, "A review on processing of particulate metal matrix composites and its properties," *Int. J. Appl. Eng. Res.*, vol. 8, no. 6, pp. 647–666, 2013.

[23] A. Sommers, Q. Wang, X. Han, C. T'Joen, Y. Park, and A. Jacobi, "Ceramics and ceramic matrix composites for heat exchangers in advanced thermal systems-A review," *Appl.*

Therm. Eng., vol. 30, no. 11–12, pp. 1277–1291, 2010, doi: 10.1016/j.applthermaleng.2010.02.018.

[24] M. Bagci and H. Imrek, "Application of Taguchi method on optimization of testing parameters for erosion of glass fiber reinforced epoxy composite materials," *Mater. Des.*, vol. 46, pp. 706–712, 2013, doi: 10.1016/j.matdes.2012.11.024.

[25] O. Gavalda Diaz, G. Garcia Luna, Z. Liao, and D. Axinte, "The new challenges of machining Ceramic Matrix Composites (CMCs): Review of surface integrity," *Int. J. Mach. Tools Manuf.*, vol. 139, pp. 24–36, 2019, doi: 10.1016/j.ijmachtools.2019.01.003.

[26] C. S. Kim, K. Cho, M. H. Manjili, and M. Nezafati, "Mechanical performance of particulate-reinforced Al metal-matrix composites (MMCs) and Al metal-matrix nano-composites (MMNCs)," *J. Mater. Sci.*, vol. 52, no. 23, pp. 13319–13349, 2017, doi: 10.1007/s10853-017-1378-x.

[27] P. V. Reddy, G. S. Kumar, D. M. Krishnudu, and H. R. Rao, "Mechanical and Wear Performances of Aluminium-Based Metal Matrix Composites: A Review," *J. Bio- Tribo-Corrosion*, vol. 6, no. 3, pp. 1–16, 2020, doi: 10.1007/s40735-020-00379-2.

[28] R. Kumar, M. I. Ul Haq, A. Raina, and A. Anand, "Industrial applications of natural fibre-reinforced polymer composites–challenges and opportunities," *Int. J. Sustain. Eng.*, vol. 12, no. 3, pp. 212–220, 2019, doi: 10.1080/19397038.2018.1538267.

[29] M. Y. Lyu and T. G. Choi, "Research trends in polymer materials for use in lightweight vehicles," *Int. J. Precis. Eng. Manuf.*, vol. 16, no. 1, pp. 213–220, 2015, doi: 10.1007/s12541-015-0029-x.

[30] C. Zhang, *Understanding the wear and tribological properties of ceramic matrix composites*. Woodhead Publishing Limited, 2014.

[31] D. K. Rajak, D. D. Pagar, R. Kumar, and C. I. Pruncu, "Recent progress of reinforcement materials: A comprehensive overview of composite materials," *J. Mater. Res. Technol.*, vol. 8, no. 6, pp. 6354–6374, 2019, doi: 10.1016/j.jmrt.2019.09.068.

[32] M. S. Rayat, S. S. Gill, R. Singh, and L. Sharma, "Fabrication and machining of ceramic composites — A review on current scenario," *Mater. Manuf. Process.*, vol. 32, no. 13, pp. 1451–1474, 2017, doi: 10.1080/10426914.2017.1279301.

[33] M. H. Yang L., "Ceramic additive manufacturing: A review of current status and challenges," *Proc. 28th Annu. Int. Solid Free. Fabr. Symp. 2017 An Addit. Manuf. Conf. August 7-9, 2017, Univ. Texas Austin, Austin, Texas, USA*, no. v. 1, pp. 652–679, 2017, [Online]. Available: https://books.google.com.tr/books?id=B9fIswEACAAJ.

[34] Q. Han, R. Setchi, and B. L. Karihaloo, "Challenges and Opportunities in the Additive Layer Manufacturing of Al-Al 2 O 3 Nanocomposites," *J. Innov. Impact*, pp. 389–399, 2015.

[35] A. Kurşun, E. Bayraktar, and H. M. Enginsoy, "Experimental and numerical study of alumina reinforced aluminum matrix composites: Processing, microstructural aspects and properties," *Compos. Part B Eng.*, vol. 90, pp. 302–314, 2016, doi: 10.1016/j.compositesb.2016.01.006.

[36] J. M. Mistry and P. P. Gohil, "Research review of diversified reinforcement on aluminum metal matrix composites: Fabrication processes and mechanical characterization," *Sci. Eng. Compos. Mater.*, vol. 25, no. 4, pp. 633–647, 2018, doi: 10.1515/secm-2016-0278.

[37] S. Sivananthan, K. Ravi, and S. J. Samuel, "Effect of SiC particles reinforcement on mechanical properties of aluminium 6061 alloy processed using stir casting route," *Mater. Today Proc.*, vol. 21, no. xxxx, pp. 968–970, 2020, doi: 10.1016/j.matpr.2019.09.068.

[38] R. P. Of *et al.*, "P - - s cno," no. August, pp. 20–25, 2017.

[39] S. Veličković *et al.*, "Parametric optimization of the aluminium nanocomposites wear rate," *J. Brazilian Soc. Mech. Sci. Eng.*, vol. 41, no. 1, 2019, doi: 10.1007/s40430-018-1531-8.

[40] S. Bahl, "Fiber reinforced metal matrix composites - A review," *Mater. Today Proc.*, vol. 39, no. xxxx, pp. 317–323, 2020, doi: 10.1016/j.matpr.2020.07.423.

[41] D. K. Rajak, D. D. Pagar, P. L. Menezes, and E. Linul, "Fiber-reinforced polymer composites: Manufacturing, properties, and applications," *Polymers (Basel).*, vol. 11, no. 10, 2019, doi: 10.3390/polym11101667.

[42] C. Hu and Q. H. Qin, "Advances in fused deposition modeling of discontinuous fiber/polymer composites," *Curr. Opin. Solid State Mater. Sci.*, vol. 24, no. 5, p. 100867, 2020, doi: 10.1016/j.cossms.2020.100867.

[43] S. Zhang *et al.*, "Carbon Nanotube Reinforced Strong Carbon Matrix Composites," *ACS Nano*, vol. 14, no. 8, pp. 9282–9319, 2020, doi: 10.1021/acsnano.0c03268.

[44] X. W. Yin, L. F. Cheng, L. T. Zhang, N. Travitzky, and P. Greil, "Fibre-reinforced multifunctional SiC matrix composite materials," *Int. Mater. Rev.*, vol. 62, no. 3, pp. 117–172, 2017, doi: 10.1080/09506608.2016.1213939.

[45] C. Elanchezhian, B. V. Ramnath, and J. Hemalatha, "Mechanical Behaviour of Glass and Carbon Fibre Reinforced Composites at Varying Strain Rates and Temperatures," *Procedia Mater. Sci.*, vol. 6, no. Icmpc, pp. 1405–1418, 2014, doi: 10.1016/j.mspro.2014.07.120.

[46] D. C. Davis, J. W. Wilkerson, J. Zhu, and D. O. O. Ayewah, "Improvements in mechanical properties of a carbon fiber epoxy composite using nanotube science and technology," *Compos. Struct.*, vol. 92, no. 11, pp. 2653–2662, 2010, doi: 10.1016/j.compstruct.2010.03.019.

[47] R. S.R. and P. G., "Fabrication and Mechanical Properties of Aluminium-Boron Carbide Composites," *Int. J. Mater. Biomater. Appl.*, vol. 2, no. 3, pp. 15–18, 2012, [Online].

Available: http://urpjournals.com/tocjnls/19_12v2i3_1.pdf.

[48] A. Baradeswaran and A. E. Perumal, “Wear and mechanical characteristics of Al 7075/graphite composites,” *Compos. Part B Eng.*, vol. 56, no. August, pp. 472–476, 2014, doi: 10.1016/j.compositesb.2013.08.073.

[49] B. Rajeswari, K. S. Amirthagadeswaran, and K. Ramya, “Microstructural studies of aluminium 7075- Silicon carbide- alumina metal matrix composite,” *Adv. Mater. Res.*, vol. 984–985, pp. 194–199, 2014, doi: 10.4028/www.scientific.net/AMR.984-985.194.

[50] T. Sathish and S. Karthick, “Wear behaviour analysis on aluminium alloy 7050 with reinforced SiC through taguchi approach,” *J. Mater. Res. Technol.*, vol. 9, no. 3, pp. 3481–3487, 2020, doi: 10.1016/j.jmrt.2020.01.085.

[51] T. P. D. Rajan, R. M. Pillai, B. C. Pai, K. G. Satyanarayana, and P. K. Rohatgi, “Fabrication and characterisation of Al-7Si-0.35Mg/fly ash metal matrix composites processed by different stir casting routes,” *Compos. Sci. Technol.*, vol. 67, no. 15–16, pp. 3369–3377, 2007, doi: 10.1016/j.compscitech.2007.03.028.

[52] A. Fadavi Boostani *et al.*, “Enhanced tensile properties of aluminium matrix composites reinforced with graphene encapsulated SiC nanoparticles,” *Compos. Part A Appl. Sci. Manuf.*, vol. 68, pp. 155–163, 2015, doi: 10.1016/j.compositesa.2014.10.010.

[53] K. K. Alaneme, E. A. Okotete, A. V. Fajemisin, and M. O. Bodunrin, “Applicability of metallic reinforcements for mechanical performance enhancement in metal matrix composites: a review,” *Arab J. Basic Appl. Sci.*, vol. 26, no. 1, pp. 311–330, 2019, doi: 10.1080/25765299.2019.1628689.

[54] A. Jailani and S. M. Tajuddin, “Mechanical properties of stirred SiC reinforced aluminium alloy: Stir casting with different composition of SiC, blade angle and stirring speed,” *Adv. Mater. Res.*, vol. 622, pp. 1335–1339, 2013, doi: 10.4028/www.scientific.net/AMR.622-623.1335.

[55] T. Rajmohan, K. Palanikumar, and S. Ranganathan, “Evaluation of mechanical and wear properties of hybrid aluminium matrix composites,” *Trans. Nonferrous Met. Soc. China (English Ed.*, vol. 23, no. 9, pp. 2509–2517, 2013, doi: 10.1016/S1003-6326(13)62762-4.

[56] S. Selvakumar, I. Dinaharan, R. Palanivel, and B. G. Babu, “Development of stainless steel particulate reinforced AA6082 aluminum matrix composites with enhanced ductility using friction stir processing,” *Mater. Sci. Eng. A*, vol. 685, pp. 317–326, 2017, doi: 10.1016/j.msea.2017.01.022.

[57] Q. ling Bai, H. xiang Li, Q. Du, J. shan Zhang, and L. zhong Zhuang, “Mechanical properties and constitutive behaviors of as-cast 7050 aluminum alloy from room temperature to above the solidus temperature,” *Int. J. Miner. Metall. Mater.*, vol. 23, no. 8, pp. 949–958, 2016, doi: 10.1007/s12613-016-1311-3.

[58] S. Venkatesan and M. A. Xavior, “Characterization on aluminum alloy 7050 metal matrix composite reinforced with graphene nanoparticles,” *Procedia Manuf.*, vol. 30, pp. 120–127, 2019, doi: 10.1016/j.promfg.2019.02.018.

[59] Yashpal, Sumankant, C. S. Jawalkar, A. S. Verma, and N. M. Suri, “Fabrication of Aluminium Metal Matrix Composites with Particulate Reinforcement: A Review,” *Mater. Today Proc.*, vol. 4, no. 2, pp. 2927–2936, 2017, doi: 10.1016/j.matpr.2017.02.174.

[60] K. L. Meena, D. A. Manna, D. S.S. Banwait, and D. Jaswanti, “An Analysis of Mechanical Properties of the Developed Al/SiC-MMC’s,” *Am. J. Mech. Eng.*, vol. 1, no. 1, pp. 14–19, 2013, doi: 10.12691/ajme-1-1-3.

[61] S. D. Al-Shobaki, “Jordan journal of mechanical and industrial engineering.,” *Jordan J. Mech. Ind. Eng.*, vol. 5, no. 3, pp. 267–272, 2007, [Online]. Available: https://pure.uniten.edu.my/en/publications/drag-reduction-in-a-wing-model-using-a-bird-feather-like-winglet.

[62] U. Pandey, R. Purohit, P. Agarwal, S. K. Dhakad, and R. S. Rana, “Effect of TiC particles on the mechanical properties of aluminium alloy metal matrix composites (MMCs),” *Mater. Today Proc.*, vol. 4, no. 4, pp. 5452–5460, 2017, doi: 10.1016/j.matpr.2017.05.057.

[63] P. Kittali, J. Satheesh, G. Anil Kumar, and T. Madhusudhan, “A Review on Effects of Reinforcements on Mechanical and Tribological behavior of Aluminum based Metal matrix composites,” *Int. Res. J. Eng. Technol.*, pp. 2–7, 2016, [Online]. Available: www.irjet.net.

[64] H. G. Rana, V. J. Badheka, and A. Kumar, “Fabrication of Al7075 / B4C Surface Composite by Novel Friction Stir Processing (FSP) and Investigation on Wear Properties,” *Procedia Technol.*, vol. 23, pp. 519–528, 2016, doi: 10.1016/j.protcy.2016.03.058.

[65] K. H. W. Seah and J. Hemanth, “Cryogenic effects during casting on the wear behavior of aluminum-alloy/glass MMCs,” *Compos. Part A Appl. Sci. Manuf.*, vol. 38, no. 5, pp. 1395–1402, 2007, doi: 10.1016/j.compositesa.2006.09.007.

[66] K. M. Sree Manu, K. Sreeraj, T. P. D. Rajan, R. M. Shereema, B. C. Pai, and B. Arun, “Structure and properties of modified compocast microsilica reinforced aluminum matrix composite,” *Mater. Des.*, vol. 88, pp. 294–301, 2015, doi: 10.1016/j.matdes.2015.08.110.

[67] C.-A. Review, A. Manimaran, and M. Venkatasudhahar, “EXPERIMENTAL INVESTIGATION ON SINGLE AND DUAL REINFORCEMENT IN ALUMINUM METAL MATRIX COMPOSITES MANUFACTURED BY STIR Abhimanyu Mallick,” no. 03, pp. 48–52.

[68] N. Gangil, S. Maheshwari, E. A. Nasr, A. M. El-Tamimi, M. A. El-Meligy, and A. N. Siddiquee, “Another approach to characterize particle distribution during surface composite fabrication using friction stir processing,” *Metals (Basel).*, vol. 8, no. 8, pp. 1–14, 2018, doi: 10.3390/met8080568.

[69] M. Karbalaei Akbari, H. R. Baharvandi, and K. Shirvanimoghaddam, “Tensile and fracture behavior of nano/micro TiB2 particle reinforced casting A356 aluminum alloy composites,” *Mater. Des.*, vol. 66, no. PA, pp. 150–161, 2015, doi: 10.1016/j.matdes.2014.10.048.

[70] S. B. Jamaludin, J. Hadipramana, M. F. M. Wahid, K. Hussin, and A. Rahmat, “Microstructure and interface analysis of glass particulate reinforced aluminum matrix composite,” *Adv. Mater. Res.*, vol. 795, pp. 578–581, 2013, doi: 10.4028/www.scientific.net/AMR.795.578.

[71] F. Oikonomopoulou, F. A. Veer, T. Bristogianni, C. Groot, R. Nijsse, and K. Karron, “Restoring and structurally reinforcing historic monuments by glass,” *Insights Innov. Struct. Eng. Mech. Comput. - Proc. 6th Int. Conf. Struct. Eng. Mech. Comput. SEMC 2016*, no. December 2018, pp. 1668–1673, 2016, doi: 10.1201/9781315641645-275.

[72] AZO Materials, “Aluminium / Aluminum 7050 Alloy (UNS A97050),” *AZO Mater.*, pp. 1–2, 2012, [Online]. Available: https://www.azom.com/article.aspx?ArticleID=6650.

APPENDIX

Appendix A. Matrix material specification

	HIBRET MANUFACTURING AND MACHINE BUILDING INDUSTRY	DOC. No.HMMBI HMMBI/ / SPI/LB/-02	
	Chemical composition Laboratory Test Result Form	Issue No. 01	Page 1 of 1

Date: 10/04/11

Requested by: JIMMA UNIVERSITY

Sample type: ALUMINUM

Purpose: IDENTIFICATION

S/N	Sample Name	Chemical composition												
		Si	Fe	Cu	Mn	Mg	Zn	Ni	Cr	Pb	Sn	V	Al	CSN
1	small	0.35	0.63	0.22	0.42	1.39	6.18	0.016	0.071	0.028	0.016	0.011	90.6	Aluminur
2	Large UK	13.34	0.41	0.25	0.30	0.034	0.036	0.005	0.013	0.005	0.012	0.0087	85.3	Aluminur Alloy

Prepared by: Diribe
Sign:
Date: 10/04/11

Checked by: Saba
Sign:
Date: 10/04/11

Approved by:
Sign:
Date: 10/04/2011

Appendix B. Tensile speciments test results

የኢትዮጵያ የተስማሚነት ምዘና ድርጅት
Ethiopian Conformity Assessment Enterprise

ቁጥር (No) 2/8/16-2/2120/2020
ቀን (Date) 01 SEP 2020

To: Yalew Tamene
Jimma

On your request date August 28, 2020 you have requested for the analysis on Aluminum Composite.

Accordingly, the analysis is completed as per your request and hence you find the report attached here with.

Regards,

Solomon Mulunberhan
Customer Service, Manager

Enc: 3 Page of test reports MTR/0915-0917/13

CC. ECAE

- Customer's Service
  Addis Ababa

ወደ ላቀ ብቃት የሚያደርስ!
Moving you forward!

Head Quarters
House No: New:
Woreda 6, Bole Sub-city
P.O.Box: 11145
Addis Ababa, Ethiopia
Tel: +251 (0)11 647 0193-Ex 140,122
Fax: +251 (0)11 645 9720
Fax: +251 (0)11 667 0245
Email: info-cp@eca-e..com
(Complain Handling)
Web site: www.eca-e.com
Bank Account
Commercial bank of Ethiopia (CBE)
megenagna bracnh
Account no 1000005054366
Tin no 0020245227

Director General office
Tel: +251 (0)11 869 5041
Fax: +251 (0)11 667 0245
Email: info-dg@eca-e.com

Customer Services
Tel: +251 (0)11 651 6468
Tel: +251 (0)11 896 0258
Fax: +251 (0)11 667 0249
Email: info-cs@eca-e.com
Certification Services
Tel: +251 (0)11 651 8205
Email: info-cd@eca-e.com
Fax: +251 (0)11 645 9308
Inspection Services
Tel: +251 (0)11 8960261
Email: info-id@eca-e.com

Testing Laboratory Services
Tel: +251 (0)11 667 0246
Email: info-tld@eca-e.com

Corporate Communication
Tel: +251 (0)11 646 0683
Email: info-ce@eca-e.com

Finance and Supplies
Tel: +251 (0)11 869 5044

Admin. Human Res.Dev.
Tel: +251 (0)11 896 0263

****

Addis Ababa Branch
Tel: +251 (0)11 6517988
Email:addisababa-br@eca-e.com

Central Branch (Adama)
Tel: +251 (0) 22 111 2278
Fax: +251 (0)22 112 8066
Email: adama-br@eca-e.com

Southern Branch (Hawassa)
Tel: +251 (0) 46 221 4732
Fax: +251 (0)46 220 4488
Email: hawassa.br@eca-e.com

North Western Branch (Bahir Dar)
Tel: +251 (0) 58 220 0724
Fax: +251 (0)58 220 0724
Email: bahirdar-br@eca-e.com

North Eastern Branch (Dessie)
Tel: +251 (0) 33 111 1664
Fax: +251 (0)33 111 9069
Email: dessie-br@eca-e.com

Eastern Branch (Dira Dawa)
Tel: +251 (0) 25 111 3159
Fax: +251 (0)25 112 1426
Email: drodawa-br@eca-e.com

Northern Branch (Mekle)
Tel: +251 (0) 34 440 6280
Fax: +251 (0)34 440 6280
Email: mekele-br@eca-e.com

Western Branch (Jimma)
Tel: +251 (0) 47 111 0432
Fax: +251 (0)47 111 7020
Email: jimma-br@eca-e.com

ECAE ኢትምድ	የኢትዮጵያ የተስማሚነት ምዘና ድርጅት Ethiopian Conformity Assessment Enterprise	Document No. TLD/F7.08-1 Copy No: - Rev No: 0
Title:	TEST REPORT ይህ የናሙና ፍተሻ ሪፖርት እንጂ ሰርተፍኬት አይደለም	Page No: 1 of 1 Effective Date: 19 Aug 19

Name and address of client: Yalew Tamene, Jimma
Tel: +251-945-05-27-04
Fax: -
E-mail: -
Date sample Received: 28/08/2020
Client Sample code: G5

Type of sample: Aluminum composite
Laboratory Designation Number: 12352030

Test Report No: MTR/0915/13
Test Order No: -
Reported date: 28/08/2020
Date of sampling: Not specified
Place of sampling: Not Specified
Sampled and submitted by: Client
Date tested: 28/08/2020
Method Specification: Not specified

S/N	Characteristics tested	Test Method / Specification	Ser No.	Standard Requirements			Test result	Comment
				Min	Nom	Max		
1.	Tensile strength Rm (mpa)	As per client's agreement	1	-	-	-	91	-
			2	-	-	-	90	-
			3				88	

Remark

1 This test report relates only to the specific sample product which has been tested by ECAE testing laboratory.

Test report authorized by, Name Habtamu Mihert, Position Analyst III, Sign.

☒ 11145 ☎ 011 6 51-64-68, Fax. 011 6 45-97-20, E-mail info-cs@eca-e.com Web site: www.eca-e.com
BOLE SUBCITY, WOREDA 6, ADDIS ABABA, ETHIOPIA

ECAE ኢተምድ	የኢትዮጵያ የተስማሚነት ምዘና ድርጅት Ethiopian Conformity Assessment Enterprise	Document No. TLD/F7.08-1	
		Copy No: -	Rev No: 0
Title:	TEST REPORT ይህ የናሙና ፍተሻ ሪፖርት እንጂ ሰርተፍኬት አይደለም	Page No: 1 of 1	Effective Date: 19 Aug 19

Name and address of client:	Yalew Tamene, Jimma	Test Report No:	MTR/0916/13
Tel:	+251-945-05-27-04	Test Order No:	-
Fax:	-	Reported date:	28/08/2020
E-mail:	-	Date of sampling	Not specified
Date sample Received:	28/08/2020	Place of sampling:	Not Specified
Client Sample code:	G4	Sampled and submitted by:	Client
Type of sample:	Aluminum composite	Date tested:	28/08/2020
Laboratory Designation Number:	12352031	Method Specification:	Not specified

S/N	Characteristics tested	Test Method / Specification	Ser No.	Standard Requirements			Test result	Comment
				Min	Nom	Max		
1.	Tensile strength Rm (mpa)	As per client's agreement	1	-	-	-	113	-
			2	-	-	-	109	-
			3				120	

Remark

1 This test report relates only to the specific sample product which has been tested by ECAE testing laboratory.

Test report authorized by, Name Habtamu Mihert, Position Analyst III, Sign.

✉ 11145 ☎ 011 6 51-64-68, Fax. 011 6 45-97-20, E-mail info-cs@eca-e.com Web site: www.eca-e.com
BOLE SUBCITY, WOREDA 6, ADDIS ABABA, ETHIOPIA

Name and address of client:	Yalew Tamene, Jimma	Test Report No:	MTR/0917/13
Tel:	+251-945-05-27-04	Test Order No:	-
Fax:	-	Reported date:	28/08/2020
E-mail:	-	Date of sampling	Not specified
Date sample Received:	28/08/2020	Place of sampling:	Not Specified
Client Sample code:	G6	Sampled and submitted by:	Client
Type of sample:	Aluminum composite	Date tested:	28/08/2020
Laboratory Designation Number:	12352032	Method Specification:	Not specified

S/N	Characteristics tested	Test Method / Specification	Ser No.	Standard Requirements			Test result	Comment
				Min	Nom	Max		
1.	Tensile strength Rm (mpa)	As per client's agreement	1	-	-	-	136	-
			2	-	-	-	120	-
			3				125	

Remark

1 This test report relates only to the specific sample product which has been tested by ECAE testing laboratory.

Test report authorized by, Name Habtamu Mihert, Position Analyst III, Sign.