EFFECT OF PROPERTIES OF SILICON CARBIDE AND RUBBER POWDER ON ADDITION OF GLASS FIBRE AND EPOXY RESIN COMPOSITES

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CERTIFICATE

This is to certify that the Project Report entitled "**EFFECT OF PROPERTIES OF SILICON CARBIDE AND RUBBER POWDER ON ADDITION OF GLASS FIBRE AND EPOXY RESIN COMPOSITES**" being submitted by SADU LALITH KIRAN (317126520112), PACHILLA GOUTHAM (317126520103), KILLARI RAJ KUMAR (317126520086), OMMI LAKSHMI DURGA PRASAD (317126520102), MAMIDI PAVAN KUMAR (318126520L17) in partial fulfillments for the award of degree of **BACHELOR OF TECHNOLOGY** in **MECHANICAL ENGINEERING, ANITS**. It is the work of bona-fide, carried out under the guidance and supervision of **MR.S.PHANI KUMAR**, Assistant Professor, Department Of Mechanical Engineering, ANITS during the academic year of 2017-2021.

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ABSTRACT

With the concept of eco-materials in mind,this paper deals with the review of previous research in the mechanical properties of fiber reinforced composites.Many fibres fabricatd from thermosetting polymers reinforced with synthetic fibres which have high mechanical properties when compared with natural fibre.The present study is an attempt to know the change in mechanical properties of the metal powders when they are reinforced with glass fiber and epoxy composites.Epoxy composite is choosen based on its application and ease of manufacturing techniques.

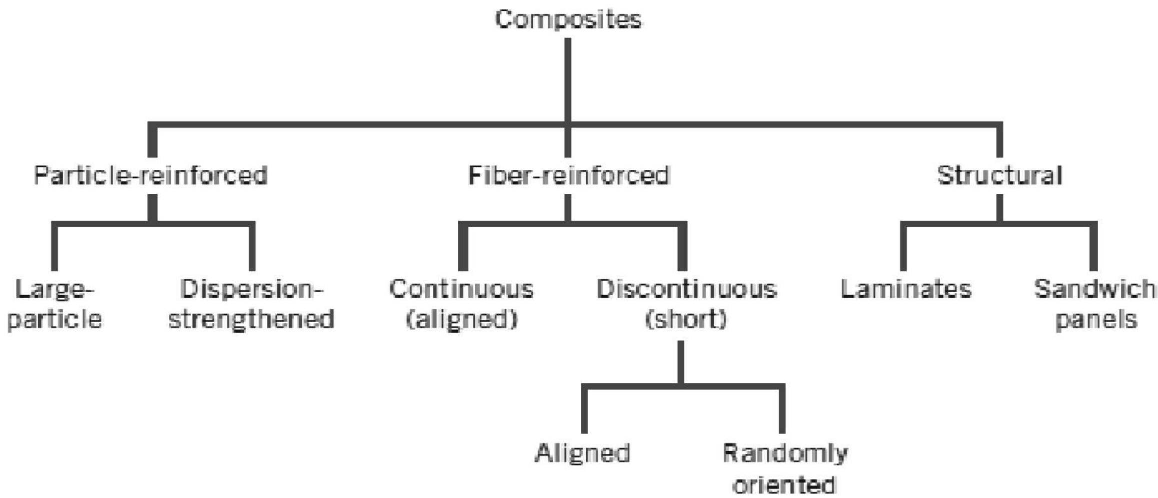
1.INTRODUCTION

INTRODUCTION

1.1 Introduction of Composite Materials

A composite material is made by combining two or more materials are together to create a superior, unique material properties, minimizes their weakness and chemically distinct phases. A composite material is heterogeneous at a microscopic scale but statistically homogeneous at macroscopic scale. The composite materials have significantly different properties.

The composites materials can be naturally or artificially made materials. There are many researches for new materials which will satisfy the specific requirements for various applications like aerospace, marine, industrial, structural, electrical, house-hold, etc. It is impossible of any material to fulfill all properties. Hence, newer materials are developed for more required properties. Composites are used in place of metals because they are equally strong but much lighter.



1.1.1 Types of composite materials

These three types of matrix produce three common types of composites:

Polymer matrix composites (PMCs):

Polymer matrix composites are comprised of a variety of short or continuous fibers bound together by an organic polymer matrix. The advantage of PMCs is their light weight coupled with high stiffness and strength along the direction of the reinforcement. This combination is the basis of their usefulness in aircraft, automobiles, and other moving structures. Other desirable properties include superior corrosion and fatigue resistance compared to metals. Because the matrix decomposes at high temperatures, however, current PMCs are limited to service temperatures below about 600° F (316° C). PMCs are oriented generally fibers, whiskers, particulates, fabric.

Metal-matrix composites (MMCs):

In metal matrix composites use silicon carbide fibers embedded in a matrix made from an alloy of aluminium and magnesium, but other matrix materials such as titanium, copper, and irons are increasingly being used. Typical applications of MMCs include bicycles, golf clubs, and missile guidance systems. A metal matrix composite (MMC) is composite material with at least two constituent parts, one being a metal necessarily, the other material may be a different metal or another material, such as a ceramic or organic. When at least three materials are present, it is called a hybrid composite.

Ceramic-matrix composites (CMCs)

The ceramic matrix makes them particularly suitable for use in lightweight, high-temperature components, such as parts for airplane jet engines .Ceramic matrix composites (CMC) are produced from ceramic fibers embedded in a ceramic matrix. Various ceramic materials, oxide or non-oxide, are used for the fibers and the matrix. Also a large variety of fiber structures is available. So properties of CMC can be adapted to special construction tasks. They are especially valuable for components with demanding thermal and mechanical requirements.

1.1.2 Different forms of composites

Unidirectional Lamina: It is basic form of continuous fiber composites. A lamina is also called by ply or layer. Fibers are in same direction. Orthotropic in nature with different properties in principal material directions

Woven fabrics: Examples of woven fabric are clothes, baskets, hats, etc. Flexible fibers such as glass, carbon, aramid can be woven in to cloth fabric, can be impregnated with a matrix material.

1.2 Introduction of Hybrid Composite Material

Incorporation of two or more fibers within a single matrix is known as hybridization and the resulting material referred to as hybrid composite materials. Glass fibers are the most commonly used reinforcement, carbon and boron fibers are highly expensive and their use only in aero space applications. Different types of hybrid constructions are available as mixed fiber tows, mixed fiber ply, individual fiber ply, sandwich and Reinforced with rods or webs.

By using hybrid composite materials reduce cost, high specific modulus, strength, and corrosion resistance. In many cases hybrid composite materials shows excellent thermal stability. It is generally accepted that the properties of hybrid composites are controlled by factors such as nature of the matrix length and relative composition of the reinforcements, fiber interfaces.

The use of two or more fibers allows the combination of desired properties from the fibers. For example, combination of aramid and carbon fibers gives excellent tensile properties of aramid and compressive properties of carbon fibers. Further, the aramid fibers are less expensive as compared to carbon fibers.

1.3 Introduction of Glass Fiber

Glass fibers are the most common of all reinforcing fibers for Polymeric Matrix Composites (PMC). The principle advantages of glass fibers are low cost, high tensile strength, high chemical resistance, and excellent insulating properties. The disadvantages are relatively low tensile modulus and high density (among the commercial fibers), sensitivity to abrasion during handling (i.e frequently decreases its tensile strength), relatively low fatigue resistance, and high hardness (which causes excessive wear on moulding dies and cutting tools). The fibers have low modulus but significantly higher stiffness. Individual filaments are small in diameters, isotropic and very flexible as the diameter is small. The glass fibers come in variety of forms based on silica which is combined with other elements to create specialty glass.

1.3.1 Types of glass fibers and their key features are as follows:

E glass - high strength and high resistivity.

S_2 glass - high strength, modulus and stability under extreme temperature and corrosive environment.

R glass -enhanced mechanical properties.

C glass - resists corrosion in an acid environment.

D glass - good dielectric properties.

1.3.2 Continuous fibers:

If the fibers used in a composite are very long and unbroken or cut then it forms a continuous fiber composite. A composite, thus formed using continuous fiber is called as fibrous composite. The fibrous composite is the most widely used form of composite.

1.3.3 Short/chopped fibers:

The fibers are chopped into small pieces when used in fabricating a composite. A composite with short fibers as reinforcements is called as short fiber composite.

1.3.4 Applications of glass fiber:

Storage tanks, house hold, piping system, traffic lights, Helicopter rotor blades, surf boards, rowing shells

1.3.5 Applications of Fiber Reinforced Plastics

Many fiber-reinforced composite materials offer a combination of strength and modulus that are either comparable to or better than many traditional metallic materials. Because of their low specific gravity, the strength-weight ratio, and modulus-weight ratios, these composite materials are markedly superior to those of metallic materials. In addition, fatigue strength weight ratio as well as fatigue damage tolerance of many composite laminates is excellent. For these reasons fiber-reinforced composites have emerged as a major class of structural material and are either used or being considered as Substitutions for metals in many weight-critical components in aerospace,automotive and other industries.

Traditional structural materials, such as steel and aluminium alloys, are considered isotropic since they exhibit nearly equal properties irrespective of direction of measurement. In general the properties of fiber-reinforced composite depend strongly on direction of measurement. For example the tensile strength and modulus of unidirectional oriented fiber-reinforced laminate are higher when these properties are measured in the longitudinal direction of fibers. At any other angle of measurement, these properties are lower. The minimum value is observed at 90° to the longitudinal direction, similar angular dependence is observed for other physical and mechanical properties, such as coefficient of thermal expansion, thermal conductivity and impact strength.

In addition to directional dependence of properties, there are a number of other differences between structural metals and fiber-reinforced composite. For example, metals in general exhibit yielding and plastic deformation. Most fiber reinforced composites are elastic in their tensile stress-strain characteristics. However, the heterogeneous nature of these materials provides mechanisms for higher energy absorption on a microscopic scale comparable to yielding process.

Coefficient of thermal expansion of many fiber-reinforced composites is much

lower than those metals. As a result composite structures may exhibit a better dimensional stability over a wide temperature range.

Another unique characteristic of many fiber-reinforced composites is their higher internal damping. This leads to better vibration energy absorption within the material, resulting in reduced transmission f noise and vibrations to neighbouring structures.

Many common materials including iron, copper, nickel, carbon and boron have directionally dependent properties, with the directional dependence being due to the strengths of the inter atomic and intermolecular bonds. The bonds are stronger in some directions than in others, and the material unit is very stiff and exhibits considerable strength in direction of the stronger bond. Unfortunately the favourable properties found in one direction usually come at the expense of the properties in other direction, In directions perpendicular to the stiff and strong direction, the material is much softer and weaker. Other properties like electrical conductivity and heat conduction can also be directionally dependent.

Fibers have significant length, so they can be easily aligned in one direction to provide selective reinforcement within another material. A fiber contains many units in its length, and thus it has a greater chance of having an imperfection as a result fiber is weaker than a whisker. The strength property of fibers is a random variable. Testing 10,000 fibers would result in 10,000 different strength values. Obviously one can use such {aw strength data to form a probability distribution of the strength. The average strength and the scatter of the strength become important quantities in describing the properties of fiber.

The major structural applications of fiber-reinforced composites ate spacecraft, automotive components, sporting goods, marine engineering, military and commercial aircrafts.

Applications of fiber-reinforced composites in the automotive industries can be classified into three groups: body components, chassis components, and engine components. The hood, door panels etc. are some of the exterior body components, which are made up of composite materials. The radiator supports, bumper reinforced beams and doorframes are some of the interior components made up of composite materials.

Reinforced composite have been also found very well in chemical industry due to their corrosive resistance, low maintenance cost, chemical resistance and cheaper than conventional non corrosive materials like stainless steel.

Over the last few years, fiber-reinforced polymer composites have experienced a substantial usage in the sporting goods industry. The sporting goods like Tennis rockets, Racket balls, Golf club shafts, Fishing rods, Bicycle frames, Snow and water skis, Ski poles, pole vault poles, Hockey sticks, sail boats and kayaks, Oars, Paddles, Canoe hulls,surfboards, arrows, archery bows, javelins, helmets etc., are made of fiber-reinforced polymer composite.

Composite materials occupied considerable area in building industry for making parts like corrugated sheets, windows, swimming pool, cladding the columns and exterior Walls etc., high performance fiber composites will go a long way in the equipment industry. fiber reinforced plastics have proved effective in bulkheads, blower housings, base pans and enclosure of air cooler, computer duplicating machines etc.

2.LITERATURE REVIEW

LITERATURE REVIEW

2.1 Introduction

A brief study on papers related to composite materials, fillers, mechanical properties, Tribological characteristics and Taguchi method. Many authors gave different ideas related to their works on glass fiber reinforced composite materials. The different papers reviewed are listed below:

Basavarajappa et al [1] have done their project using the optimization technique Taguchi and perform to acquire data in a controlled way. An orthogonal array and analysis of variance (ANOVA) was employed to investigate the influence of process parameters on the wear in composite materials. Based on Taguchi approach, the experimentation provides an orderly way to collect, analyses, and interpret data. Incorporation of the silicon carbide particles in the polymer matrix as a secondary Reinforcement increases the wear resistance of composite material. Applied load is the wear factor that has the highest physical as well as statistical influence on the wear of composite material.

Suresha et al [2] carried out experimentation to study the influence of two inorganic fillers of SiC particles and graphite on wear of the glass fabric reinforced epoxy composites. They reported that the increase of load and sliding velocity results higher wear loss. The coefficients of frictional values are increasing with increase of load and sliding velocities. By investigation, the Graphite filled glass fiber composite has lower coefficient of friction. Silicon carbide and Graphite filled composites exhibits maximum wear resistance. Inclusion of Graphite and silicon carbide filler particles in Glass fiber composite reduces friction and gives better wear resistance properties.

Manikandan1 et al [3] Conducted experimentation to study the influence of fly ash fillers on mechanical and tribological properties of woven jute fiber reinforced polymer hybrid composite. Composites were prepared using hand layup method with weight percentage of fly ash as filler material. Inclusion of Filler percentage increases hardness and wear resistance properties but decreases the tensile strength of composite material decreases.

BharatAdmile et al [4] Performed experimentation on metal matrix composites which plays a vital role in tribological industries because of their inherent properties like high strength to weight ratio, low wear rate. Matrix material LM25 which is commercially available has advantage of lighter weight & major silicon content of alloy may helps to improve castability. ANOVA was used to determine the design parameters significantly influencing the wear rate (response). By the analysis applied load was most significant parameter having the highest statistical influence on the dry sliding wear of composites compared to sliding velocity and sliding distance.

SudeepDeshpande et al [5] investigated about sliding wear characteristics of epoxy composites. They reported that the addition of bone powder in hybrid fiber reinforced epoxy composites decreases the wear rate of composite. They are also studied about S/N ratio.

Sandhyarani Biswas et al [6] determined the physical and mechanical properties of bamboo fiber reinforced epoxy Composites. Composites were fabricated using short bamboo fiber at different weight percentages and observed that few properties increases significantly with respect to fiber loading, properties like void fraction increases with the increase in fiber loading. To reduce the void fraction, improve hardness and other mechanical properties and so silicon carbide filler is added in bamboo fiber reinforced epoxy composites resulting increases hardness, tensile strength and flexural strength.

Mukul Kant Paliwal et al [7] Carried out studies on Composites materials which are extensively used in almost all aspects of their most attractive properties are the high strength-to-weight ratio. Composite materials also have some problems such as fiber fracture, matrix cracking and delaminating. Matrix cracks and fiber fractures play an important role in laminates under tensile load. Materials added to the matrix help improving operating properties of a composite. To investigate the tensile strength of glass fiber and epoxy resin based composite with $CaCO_3$ as filler. E-glass/epoxy composites were manufactured to fabricate the specimens, by using Hand lay-up technique.

Hemanth et al [8] Studied on glass fibers which plays an important role in thermoplastic based composites, as they shows good balance between properties and costs. Polymer based composites is very common in situations where combinations of good properties are required. Such properties are not obtained with a single polymer. Strengthening of polymers along with fibers and fillers in varies proportions exhibit immense possibilities of producing materials with variable properties. By investigation hybrid composites are lower tensile strength and strain with increase in filler content, Polyoxymethylene composites better tensile, flexural, modulus properties. Composites filled with short glass/carbon fiber, silicon carbide and Aluminium oxide composites, exhibited improved flexure strength and modulus.

Sakthivel et al [9] Carried out studies on the natural fiber which has advantages like low density, appropriate stiffness, mechanical properties with high disposability and renewability. Banana fibers are one of the natural fiber it is recycling and biodegradable. Banana fibers are good reinforcement in polypropylene resin. The properties of the composites are strongly influenced by the fiber length. The hybrids composite has move out of and have the potential reinforcement material for composites and thus gain attraction by many researchers. Natural fiber and glass fiber hybrid composites were fabricated by using epoxy resin combination of hand lay-up method and cold press method. Banana fibers are Chemical treatment like NAOH will increases the flexural strength of the fiber and removes the moisture content of the fiber.

Ganesha et al [10] describes the development and mechanical characterization of new polymer Composites consisting of glass fiber reinforcement, epoxy resin and filler materials as cerium oxide. In Composite materials different variety of filler inclusions added organic and inorganic. The matrix material a medium viscosity epoxy resin (LAPOX L-12) and polyamine hardener (K-6) curing at room temperature, these matrix provide good resistance and adhesive properties to alkalis. By the investigation tensile strength and flexural strength of composite material is enhance with inclusion of cerium oxide.

Chandru et al [11] Performed studies on polymer composites. In their study, vinyl Ester is a resin produced by the esterification (The process of converting an acid into an alkyl) of an epoxy resin with an unsaturated mono carboxylic acid. It can be used as an alternative to polyester and epoxy materials in matrix or composite materials, where its characteristics, strengths, and bulk cost intermediate between polyester and epoxy. Vinyl ester has lower resin than polyester and epoxy. The vinyl ester resin used as general purpose resin. The resin combines, the strength properties of epoxy resins and ease of processing of unsaturated polyester resins. It is outstanding long-term performance at elevated temperatures and under stress conditions. But in general epoxy resin gives better results and easily available then vinyl ester.

Mohan et al [12] Carried out studies on Polymer matrix composites are plays important role in Tribological applications due to possibility of tailoring their properties with special fillers improve their performance. The addition of ceramics such (silicon carbide, aluminium oxide, titanium oxide etc.) as within the matrix then increases the friction coefficient and reduces the wear loss. Glass fibers enhance the toughness of the matrix silicon carbide shows high hardness, thermal stability and low chemical reactivity, leading to superior friction properties over normal glass fiber reinforced composite. The enhancement on the wear resistance of silicon carbide filled glass-epoxy composite is associated with less fiber matrix loss.

2.2 Summary of work

From the literature survey, many authors have identified the mechanical, damping and tribological properties of glass fiber reinforced composites by altering the filler materials. Therefore, in this work alternative filler materials are selected to improve both damping and mechanical strength of the composite by incorporation of Sic and rubber powder particles as filler materials. The behaviour of the composite is examined for mechanical and damping properties of the material. The better configuration of materials can be used for aerospace and automobile industries.

3.FABRICATION OF GLASS FIBER REINFORCED POLYMER COMPOSITES

FABRICATION OF GLASS FIBER REINFORCED POLYMER COMPOSITES

3.1 INTRODUCTION

The materials that are used in fabrication of the GFRP composite and the process that was followed are discussed in this chapter.

3.2Materials Required for Fabrication of GFRP Composites

- Glass Fiber
- Epoxy Resin
- Silicon Carbide
- Rubber Powder

3.2.1 Introduction of Epoxy Resin

Epoxy resins are polymeric or semi-polymeric materials, and as such rarely exist as pure substances, since variable chain length results from the polymerization reaction used to produce them. High purity grades can be produced for certain applications, e.g. using a distillation purification process. One downside of high purity liquid grades is their tendency to form crystalline solids due to their highly regular structure, which require melting to enable processing.

The applications for epoxy-based materials are extensive and include coatings, adhesives and composite materials such as those using carbon fiber and fiber glass reinforcements (although polyester, vinyl ester, and other thermosetting resins are also used for glass-reinforced plastic). The chemistry of epoxies and the range of commercially available variations allow cure polymers to be produced with a very broad range of properties. In general, epoxies are known for their excellent adhesion, chemical and heat resistance, good-to-excellent mechanical properties and very good electrical insulating properties. Many properties of epoxies can be modified (for example silver-filled epoxies with good electrical conductivity are available, although epoxies are typically electrically insulating). Variations offering high thermal insulation, or thermal conductivity combined with high electrical resistance for electronics applications, are available.

3.2.2 Hardener

Hardener is high viscous liquid material, mixed with resin in suitable proportion during the process of preparation of composites which helps in the solidification of the wet, smooth composite. It is used to harden the smooth composite hence it is called as hardener.

3.2.3 Catalyst

Catalysis is the increase in the rate of a chemical reaction due to the participation of an additional substance called a catalyst. With a catalyst, reactions occur faster and require less activation energy. Because catalysts are not consumed in the catalyzed reaction, they can continue to catalyze the reaction of further quantities of reactant. Often only tiny amounts are required.

Catalysts are substances that increase the rate of a reaction by providing a low energy "shortcut" from reactants to products. In some cases, reactions occur so slowly that without a catalyst, they are of little value. Nearly all reactions that occur in living cells require catalysts called enzymes- without them, life would be impossible. There are two important classes of catalysts: homogenous catalysts like enzymes and aqueous ions that are uniformly mixed with the reactants and heterogeneous catalysts that provide a surface that holds and reconfigures the reactants in a way that is favourable for reaction.

3.2.4 Silicon Carbide

Silicon carbide is composed of tetrahedra of carbon and silicon atoms with strong bonds in the crystal lattice. This produces a very hard and strong material. Silicon carbide is not attacked by any acids or alkalis or molten salts up to 800°C. In air, SiC forms a protective silicon oxide coating at 1200°C and is able to be used up to 1600°C. The high thermal conductivity coupled with low thermal expansion and high strength give this material exceptional thermal shock resistant qualities. Silicon carbide ceramics with little or no grain boundary impurities maintain their strength to very high temperatures, approaching 1600°C with no strength loss. Chemical purity, resistance to chemical attack at temperature, and strength retention at high temperatures has made this material very popular as wafer tray supports and paddles in semiconductor furnaces. The electrical conduction of the material has lead to its use in resistance heating elements for electric furnaces, and as a key component in thermistors (temperature variable resistors) and in varistors (voltage variable resistors). Silicon Carbide is the only chemical compound of carbon and silicon. It was originally produce by a high temperature electro-chemical reaction of sand and carbon. Silicon carbide is an excellent abrasive and has been produced and made into grinding wheels and other abrasive products for over one hundred years. Today the material has been developed into a high quality technical grade ceramic with very good properties (High strength, Low thermal expansion, high thermal conductivity, high hardness, excellent thermal shock resistance, superior chemical inertness).

It is used in abrasives, refractories, ceramics, and numerous high-performance applications. The material can also be made an electrical conduct and has applications in resistance heating, flame igniters and electronic components. Structural and wear applications are constantly developing.

3.3 Introduction to Fabrication Processes

3.3.1 Wet/Hand Lay-Up

The fibers are first put in place in the mould. The fibers can be in the form of woven, knitted, stitched or bonded fabrics. Then the resin is impregnated. The impregnation of resin is done by using rollers, brushes or a nip-roller type impregnator. The impregnation helps in forcing the resin inside the fabric. The laminates fabricated by this process are then cured under standard atmospheric conditions. The materials that can be used have, in general, no restrictions. One can use combination of resins like epoxy, polyester, vinyl ester, phenolic and any fiber material. Fig 3.1 shows the simple hand layup technique.

Advantages of Hand Lay up

- The process results in low cost tooling with the use of room-temperature cure resins.
- The process is simple to use.
- Any combination of fibers and matrix materials are used.
- Higher fiber contents and longer fiber as compared to other processes.

Disadvantages

- Since the process is worked by hands, there are safety and hazard considerations.
- The resin needs to be less viscous so that it can be easily worked by hands.
- The quality of the final product is highly skill dependent of the labour.
- Uniform distribution of resin inside the fabric is not possible. It leads to voids in the laminates.
- Possibility of diluting the contents.

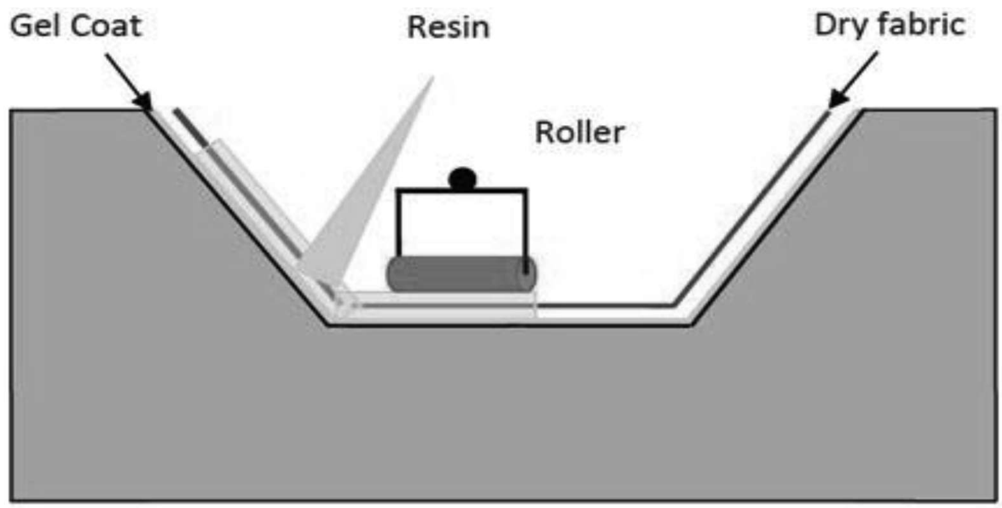


Fig 3.1 Hand Lay-up Technique

3.3.2 Pultrusion

It is a continuous process in which composites in the form of fibers and fabrics are pulled through a bath of liquid resin. Then the fibers wetted with resin are pulled through a heated die. The die plays important roles like completing the impregnation and controlling the resin. Further, the material is cured to its final shape. The die shape used in this process is nothing the replica of the final product. Finally, the finished product is cut to length. The resins like epoxy, polyester, vinyl ester and phenolic can be used with any fibers.

3.3.3 Vacuum Bagging

This is basically an extension of the wet lay-up process described above where pressure is applied to the laminate once laid-up in order to improve its consolidation. This is achieved by sealing a plastic film over the wet laid-up laminate and onto the tool. The air under the bag is extracted by a vacuum pump and thus up to one atmosphere of pressure can be applied to the laminate to consolidate it.

3.3.4 Centrifugal Casting

In this process the chopped fibers and the resin is sent under pressure to the cylindrical moulding. The moulding is rotating. Due to centrifugal action, the mixture of resin and chopped fibers get deposited on wall of the moulding. Thus, the mixture gets the final form of the product.

3.3.5 Filament Winding

This process is an automated process. This process is used in the fabrication of components or structures made with flexible fibers. This process is primarily used for hollow, generally circular or oval sectioned components. Fiber tows are passed through a resin bath before being wound onto a mandrel in a variety of orientations, controlled by the fiber feeding mechanism, and rate of rotation of the mandrel. The wound component is then cured in an oven or autoclave. It can use resins like epoxy, polyester, vinyl ester and phenolic along with any fiber. The fiber can be directly from creel, non-woven or stitched into a fabric form.

3.3.6 Applications of composite materials

- **Aerospace:** Aircraft, spacecraft, satellites, space telescopes, space shuttle, space station, missiles, and booster's rockets, helicopters (due to high specific strength and stiffness) fatigue life, dimensional stability.
- **Missile:** Rocket motor cases, Nozzles, aerodynamic fairings etc.
- **Launch vehicle:** Inter stage structure, High temperature nozzles, and control surfaces etc.
- **Composite railway carriers:** Bodies of railway bogeys, seats, doors, gear case, pantographs etc.
- **Sports equipments:** Tennis rockets, golf clubs, base-ball bats, helmets etc.
- **Automotive:** Drive shafts, fan blades, clutch plates, gaskets, engine parts etc.
- **Industrial:** conveyer belts, hoses, tear and puncture resistant fabrics, ropes, cables etc.
- **Medical:** Wheel chairs, crutches, Hip joints, surgical equipments etc.
- **Electronic:** chips in electronic computing devices, electronic packaging materials etc.
- **Marine:** ship hulls, masts, hydrofoils, hovercrafts, propellers etc.
- **Military:** Helmets, bullet proof vests, impact resistant vehicles, portable bridges etc.
- **Miscellaneous:** Paints and coatings, adhesives, industrial tooling, petroleum and petrochemical etc.

3.4 Fabrication of Composites by Hand lay-up technique

This chapter describes about the method of fabrication and various tests that are to b conducted Hand lay-up technique is the simplest and oldest open molding method of composite fabrication process. In this work, Silicon carbide, rubber powder of different weight percentages given in Table 3.1 are mixed with epoxy resin, hardener and fiber reinforcements. The thickness of the composite sheet to be fabricated is controlled by the layers placed on the mould. After the preparation of composite sheets, the work pieces are cured for 24 to 48 hrs so that work pieces will get hard as shown in Fig 3.1. After this, the specimens were cut according to ASTM standards using cutting machine as shown in Fig3.2 and finished the composite material with Emory paper as shown in Fig 3.4. The designations of work pieces are shown in Table 3.1.

Table 3.1. Material Selection

Material	**Sample S1**	**Sample S2**	**Sample S3**	**Sample S4**
GF	38%	38%	38%	38%
Epoxy Resin	48%	51%	55%	59%
SiC	4.5%	3%	2%	1%
Rubber Powder	9.5%	8%	5 %	2%
Total	100%	100%	100%	100%

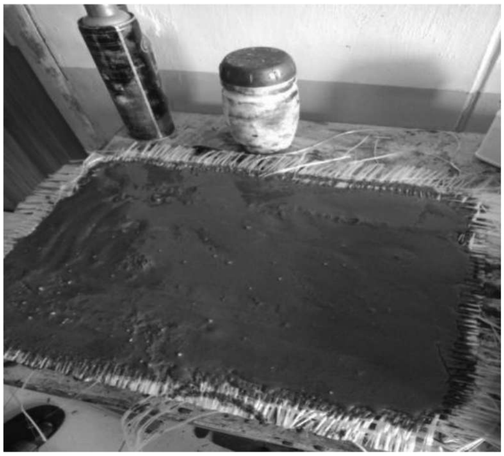


Fig 3.2 Fabrication by hand lay-up method

Fig 3.3 Solidified composite sheets after curing 48 hours at room temperature

The remaining scrap after cutting is as shown in the figure 3.4

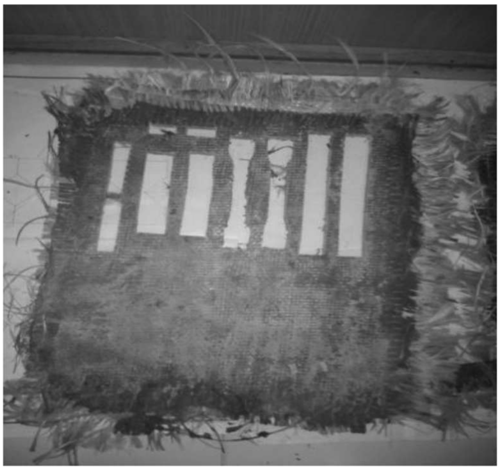


Figure 3.4 Remaining Scrap after cutting

4.TENSILE BEHAVIOUR OF GFRP COMPOSITES

TENSILE BEHAVIOUR OF GFRP COMPOSITES

4.1 INTRODUCTION

In this chapter the tensile behaviour of different samples of GFRP composites are presented .The Tensile test was carried out on computerised UTM ,as per ASTM standards.The four specimens were subjected to tensile test and their values were reported.

4.2 Equipment for Tensile Testing

A computerised UTM is used to find the tensile properties of the composites.Universal Testing Machine which is available in electronic and computerized functioning. This machine is used to test the tensile and compressive properties of material. The reason Universal Testing machine is named so because it can perform all the tests right from compression, bending to tension and examine the material in all mechanical properties.Operation of the universal testing machine is by hydraulic transmission of load from the test specimen to a separately housed load indicator. The system is ideal since it replaces transmission of load : through levers and knife edges ,which are prone to wear and damage due to shock on rupture of test pieces. Load is applied by a hydrostatically lubricated ram. Main cylinder pressure is transmitted to the cylinder of the pendulum dynamometer system housed in the control panel. The cylinder of the dynamometer is also of self - lubricating design. The load transmitted to the cylinder of the dynamometer is transferred through a leverage to the pendulum. Displacement of the pendulum actuates the rack and pinion mechanism which operates the load indicator pointer and the autographic recorder. The deflection of the pendulum represent the absolute load applied on the test specimen. Return movement of the pendulum is effectively damped to absorb energy in the event of sudden breakage of the specimen

4.3Method of tensile testing

The Composite material used in the current study consists of glass fibre, epoxy resin as matrix and silicon carbide and rubber powder as filler materials in different weight percentages .Tensile test is the basic important test to evaluate the strength of any material. The machine is equipped with advanced load cell technology for faster testing and reduction of inertia errors. Tensile test is performed based on ASTMD638-02a standard of (Type1) shown in fig 4.2(C). The specimens before test and after test are indicated in fig 4.2(a) and fig 4.2(b).

Fig 4.1 Tensile Testing Machine

Table 4.1 Technical specifications for computerized version universal testing machine

MODEL	**TUE-C-600**
Measuring capacity (KN)	600
Measuring Range (KN)	0-600
Least count (KN)	0.06
Resolution of piston movement(mm)	0.1
Overall dimensions approx(mm)	2200 × 800 × 2400
Weight approx..(kg)	3100
Distance between columns(mm)	600

Piston stroke(mm)	250
Power supply	3 phase 415v 50HZ AC
Total H.P	2.5
Pair of compression plate diameter(mm)	120
Tension test jaws for flat specimen thickness(mm)	0-30
Tension test jaws for Maximum width of flat specimen(mm)	70

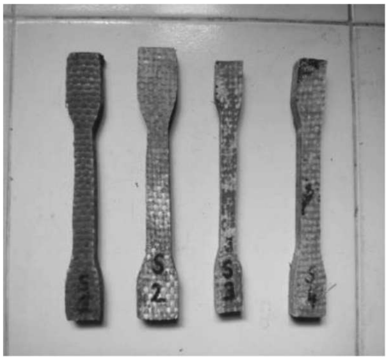


Fig 4.2(a) Specimens before testing

Fig 4.2(b) Specimens after testing

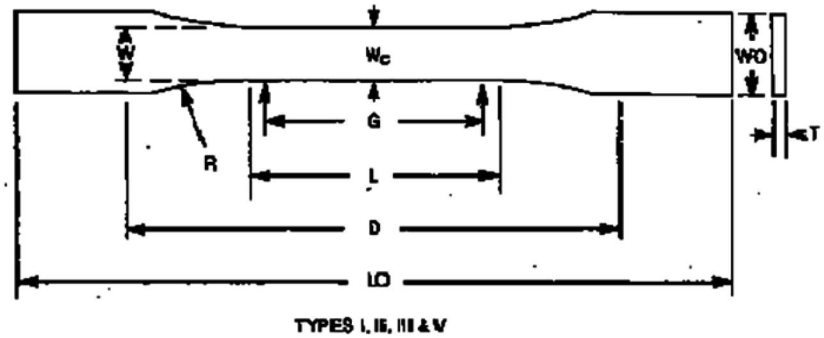


Fig 4.2 (c) Tensile test specimen as per ASTM standard

The notations used in Fig 4.1 (c) are indicated with the dimensions Lo – Overall length 165(6.5) mm,

D- Distance between grips 115(4.5) mm, L- Length of narrow section 57 (2.25) mm, G- Gauge length 50(2) mm, R- Radius of fillet 76(3.0) mm, Wo- Width overall 19

(0.75) mm, Wc- Width of narrow section 13(0.50) mm, T – Thickness of the specimen 10 (0.50) mm.

Initially, the specimens are fixed between two clamping jaws firmly and loaded gradually with incremental load until failure takes place. The values of deformation against each load value are noted and tabulated. The breaking load for each specimen is noted and ultimate tensile strength values of all the samples with varying surface treatments are calculated.

4.4 Analysis of tensile test result:

Type of composite	Maximum load (KN)	Load at break (KN)	Ultimate tensile strength(Mpa)
S1	8.968	8.01	44.84
S2	9.129	7.06	45.65
S3	10.304	10.17	51.52
S4	14.571	14.09	72.86

Table4.2. Ultimate tensile strength values of all specimens

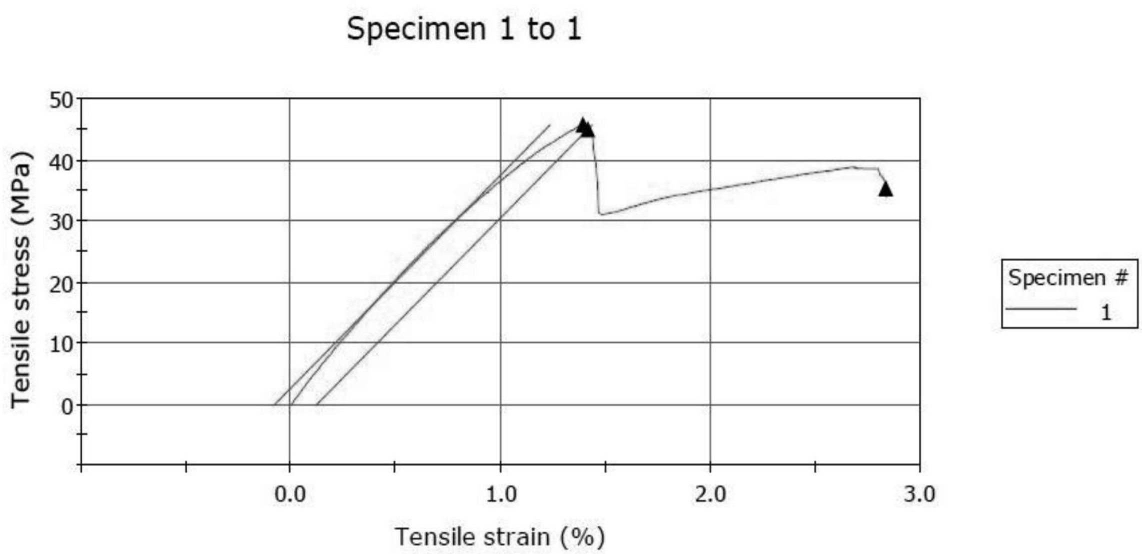


Fig 4.3 Tensile Stress vs strain for sample S1

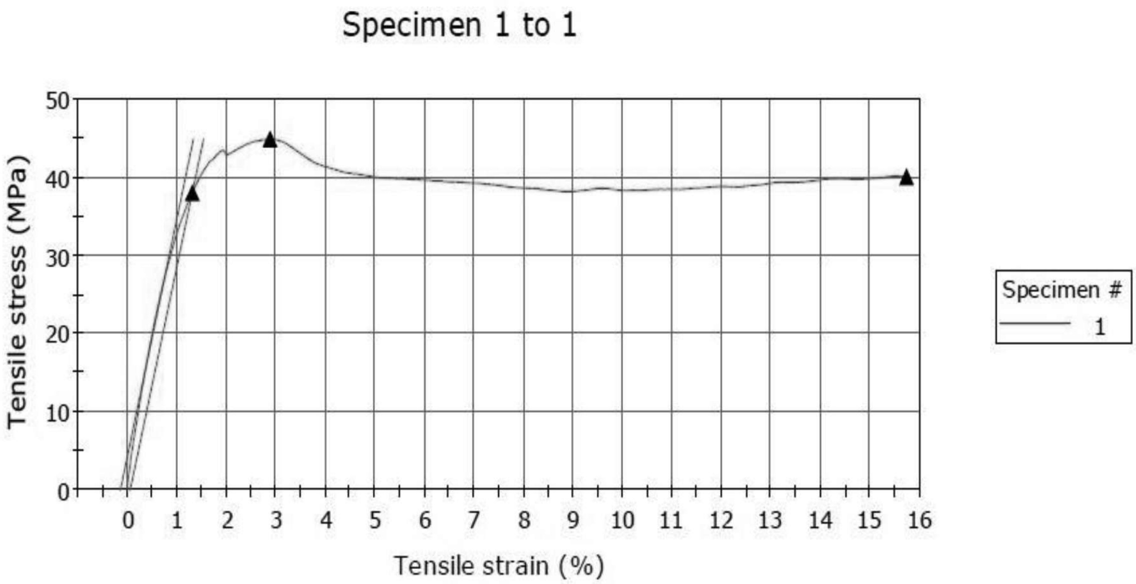


Fig.4.4 Stress vs strain for sample S2

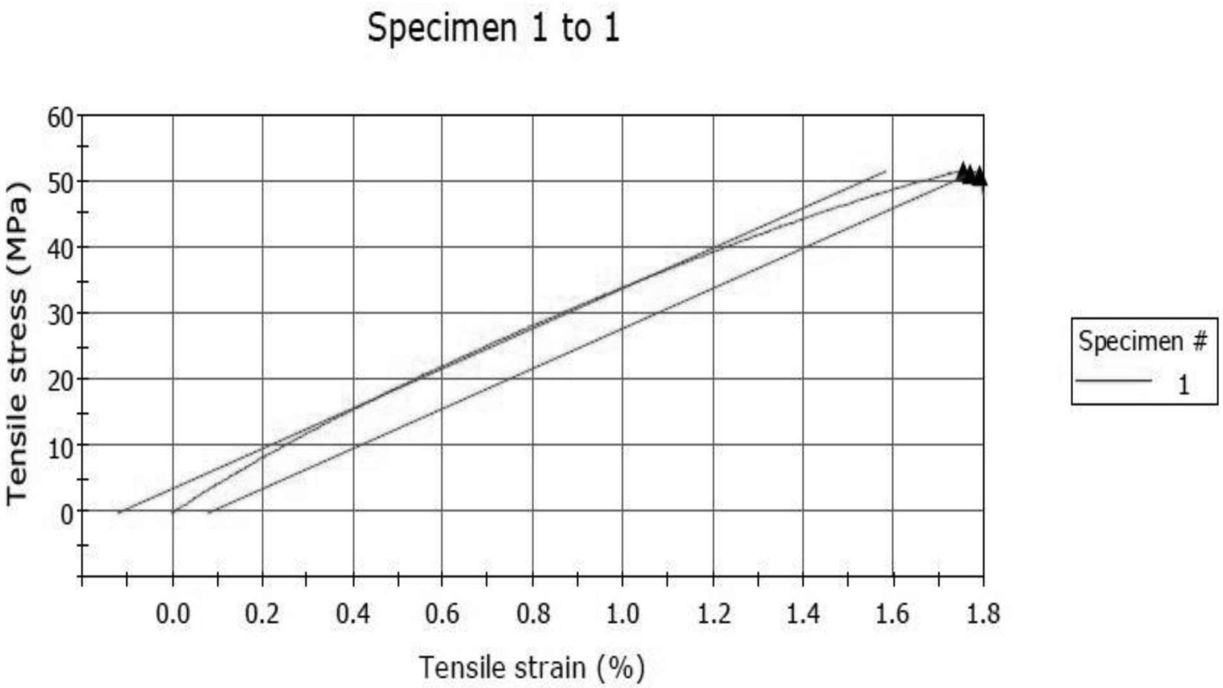


Fig. 4.5 Stress vs strain for sample S3

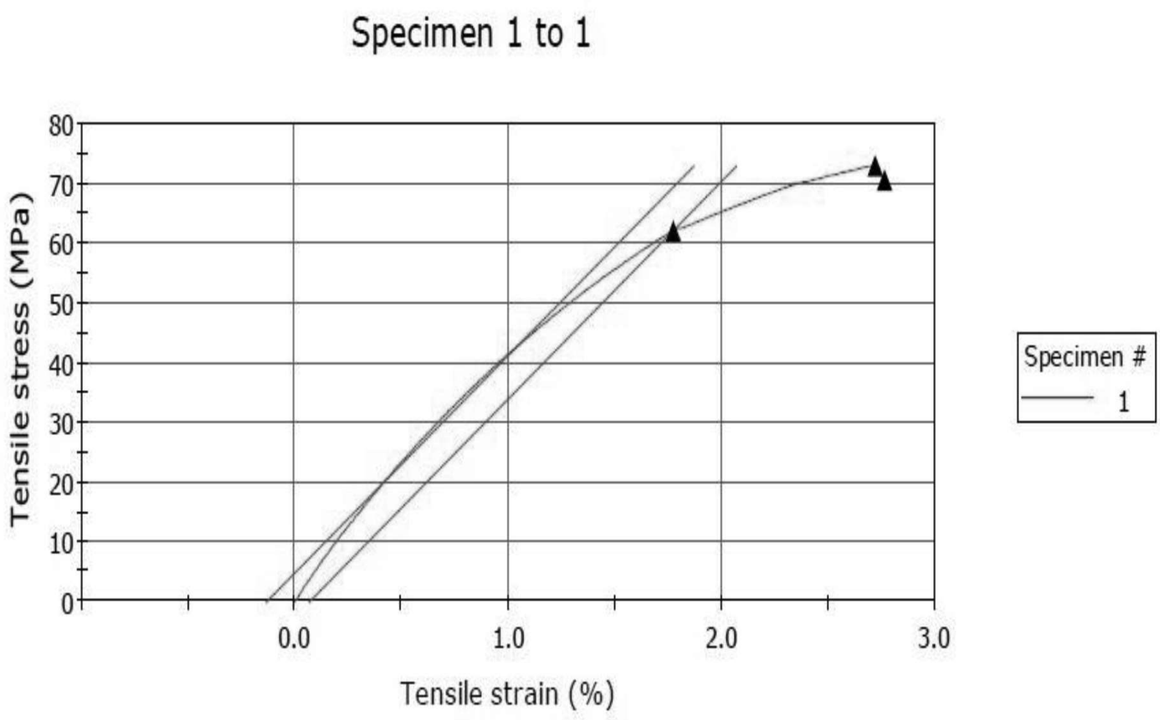


Fig. 4.6 Stress vs strain for sample S4

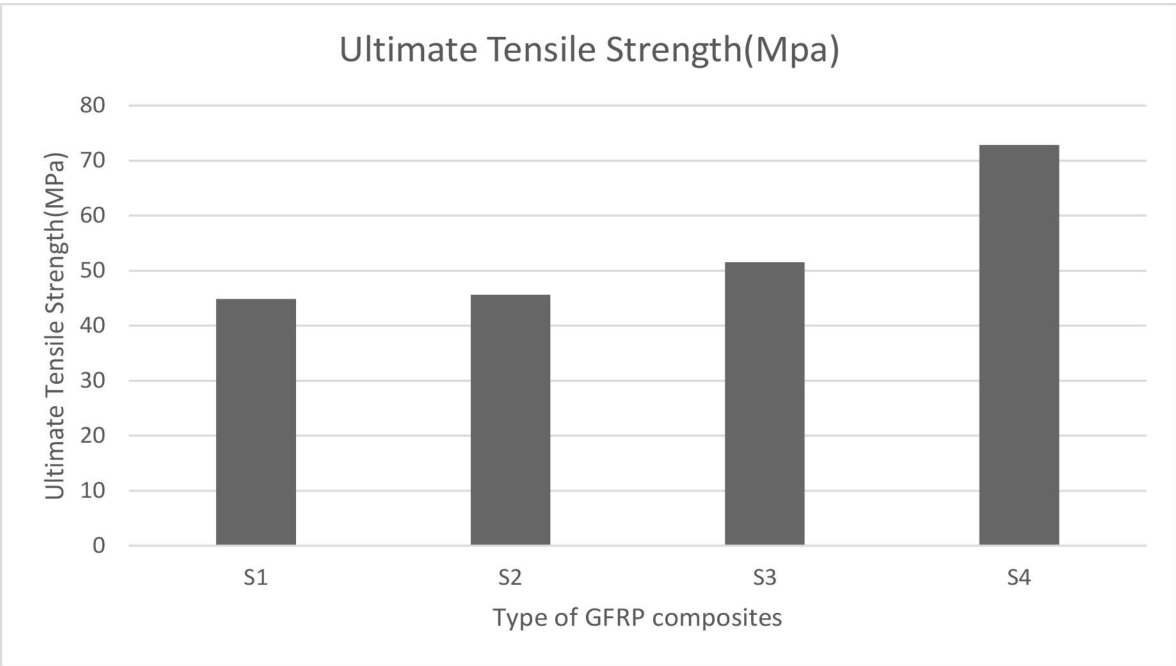


Fig.4.7 Variation tensile Strength for different weight percentages of fillers

This sample specimen S4 with selected ingredients can sustain more load and can extend its application in usage in glass fiber reinforced composites in aerospace and automobile industries, The main reason to have better tensile properties for the sample specimen S4 is the selection of ingredients. The load carried by the specimen is taken initially by the fiber and transmitted to the ingredients. Another reason to have better ultimate tensile strength value is mainly due to incorporation silicon carbide. This material can easily sustain the load acting on the entire composite

5.FLEXURAL BEHAVIOUR OF GFRP COMPOSITES

FLEXURAL BEHAVIOUR OF GFRP COMPOSITES

5.1 INTRODUCTION

In this chapter the flexural behaviour of different samples of Glass fiber reinforced plastics with different compositions is presented.The flexural test was carried out on computerised UTM ,as per the ASTM standards.The test specimens are prepared as per ASTM D790(125×3.2×12.7)mm.The four specimens were subjected to flexural test and their values were reported.

5.2Equipment for Flexural testing

A 10 ton capacity computerised UTM was used for conducting flexural test. The instrument is equipped with integrated computer compatible software in order to display various graphical results. And a special three point loading attachment is provided for conducting flexural test.

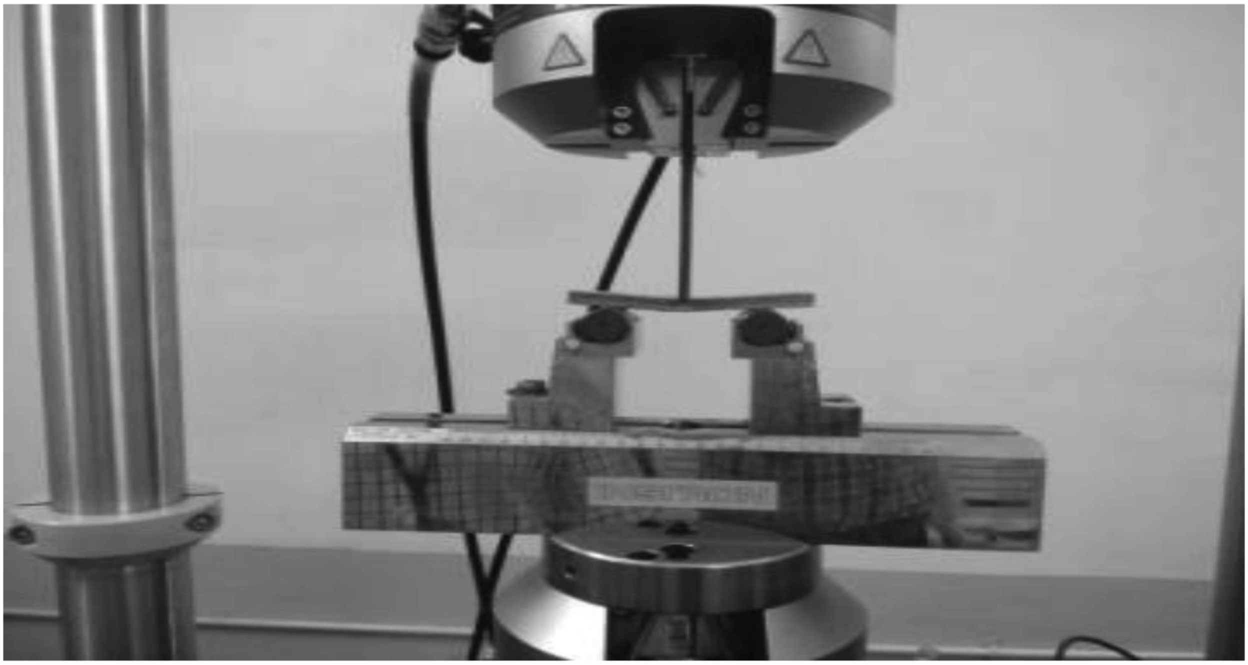


Fig5.1 Flexural test apparatus

5.3Methods of Flexural testing

There are three basic methods which cover the determination of flexural properties of the polymer.

Method 1

It is basically a three point loading, utilizing centre loading on a simply supported beam. A bar of rectangular cross section rests on two supports and is loaded by means of a loading nose at the centre. The maximum axial fiber stress occurs on a line under the loading nose.

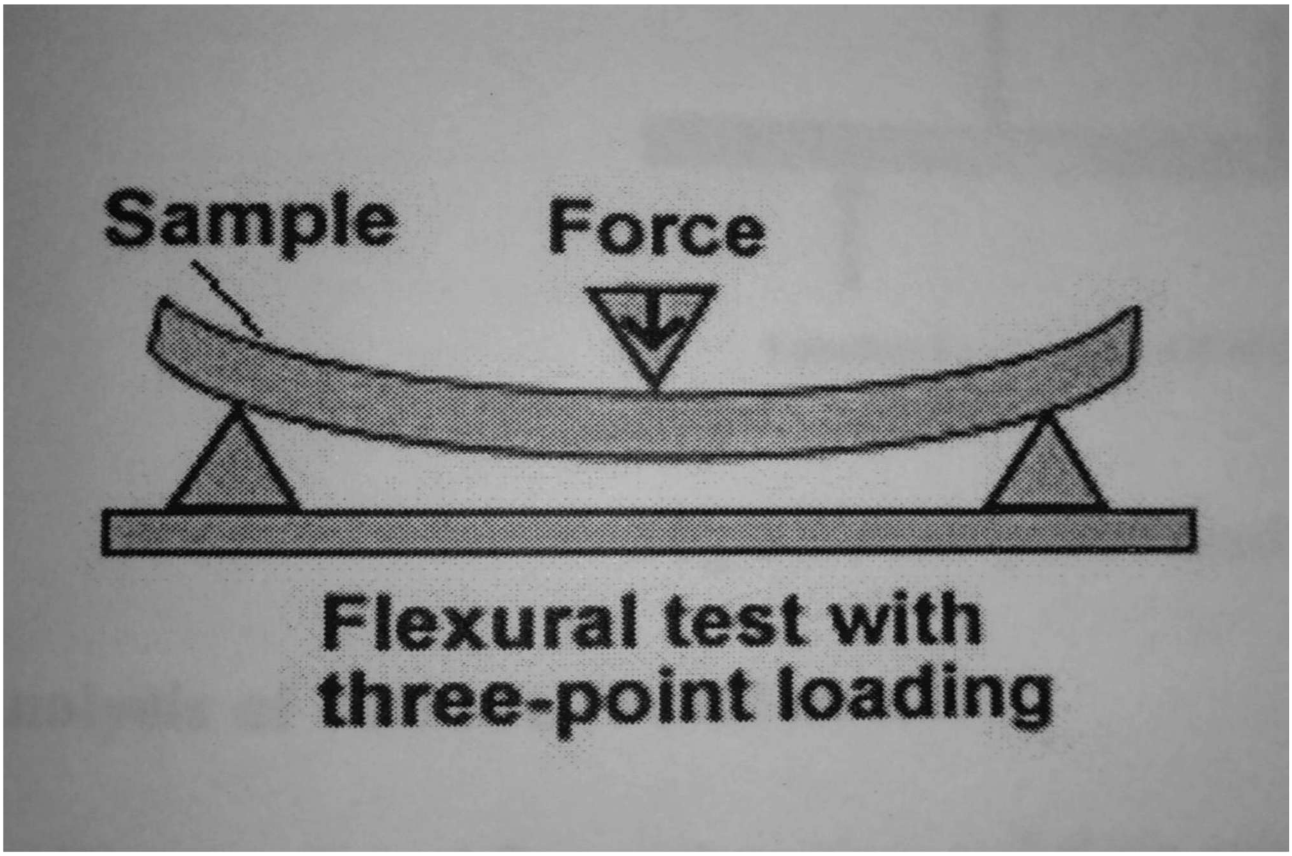


Fig.5.2 Three Point Bending

Method 2

In this method a four point loading system is utilized .Two load points equally spaced from their adjacent supporting points, with a distance between loading points equal to one third of the support span. In this test, the bar lies on a two points each at an equivalent distance from the adjacent support points.

Either method can be used for conducting the experiment. Method 1 is used for materials that break at relatively at low loads. Method 2 is used particularly for those materials that undergo large deflections during testing. Standard test method, ASTM D790, for flexural properties of reinforced polymer composites has been used to test the Composites. Table 5.1 indicating the maximum bending load and maximum bending stress.

Flexural test is performed on all specimens by mounting a three point bending load fixture, shown in fig 5.1. The sample to be tested is placed on the two end supports and a concentrated load is applied at the centre of the specimen. This test determines the maximum amount of load carried by the specimen under bending load. The samples before testing and after testing are shown in fig 5.3(a) and fig 5.3(b).

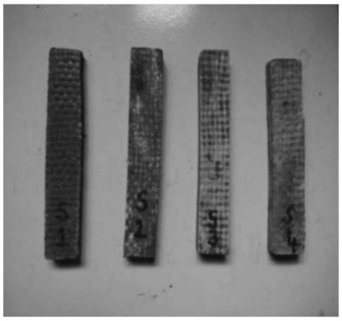


Fig 5.3(a) Specimens before testing

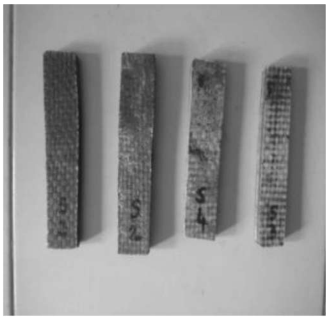


Fig 5.3 (b) Specimens after testing

5.4 Analysis of tensile test results

Type of composite	Load at max Flexure load (KN)	Flexural stress at max flexural load (Mpa)
S1	1.261	60.8
S2	0.942	51.0
S3	2.247	122.43
S4	3.095	168.0

Table 5.1. Flexural strength values for all samples

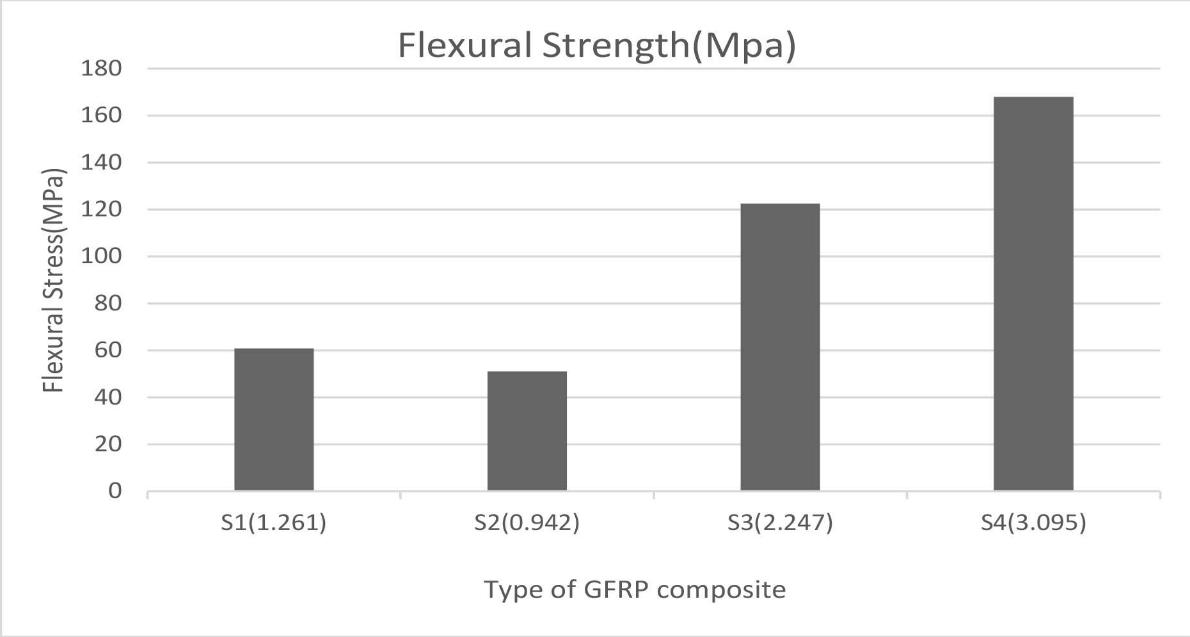


Fig. 5.4 Variation of Flexural Strength with varying percentage of fillers

From Fig5.4, it was observed that, sample S4 with along with remaining ingredients can sustain more bending load (i.e 3.095KN) and possess high flexural strength value (i.e 168.0 MPa) compared to remaining formulations of the material. This sample specimen S4 with selected ingredients can sustain more bending load and can extend its application in fabrication of brake friction material. The main reason to have better flexural properties for the sample specimen S4 is the selection of better ingredients The load carried by the specimen is initially transmitted to the fiber and then it is transmitted to the ingredients. The rubber powder particle present in the composite is mainly responsible for sustaining more bending load acting on the composite.

6.COMPRESSIVE BEHAVIOUR OF GFRP COMPOSITES

COMPRESSION BEHAVIOUR OF GFRP COMPOSITES

6.1 INTRODUCTION

In this chapter the Compressive behaviour of GFRP composites with different compositions is presented.The compression test is carried out on computerised Universal Testing Machine(UTM).The four specimens are subjected to Compression test and their values were reported.

The equipment and the method for the compression testing are discussed in the sections6.2 and6.3 respectively.The results of experimental investigation for compression behaviour are analysed and compared in section 6.4

6.2 Equipment for Compressive Testing

Compression test is conducted as per ASTM D3410 standards specimen cut in to $140\times 12.7 \times 3\ mm$.Compressive test is conducted on computerized universal testing machine in a similar way as tensile test, but the direction of loading is reversed. Component subjected to a compressive force as shown in Fig 6.1 does not deform uniformly. If the material is plastic instead of brittle, it bulges at its mid-section. In this test stress rises rapidly near the end of the test due to an increase in area of the specimen.

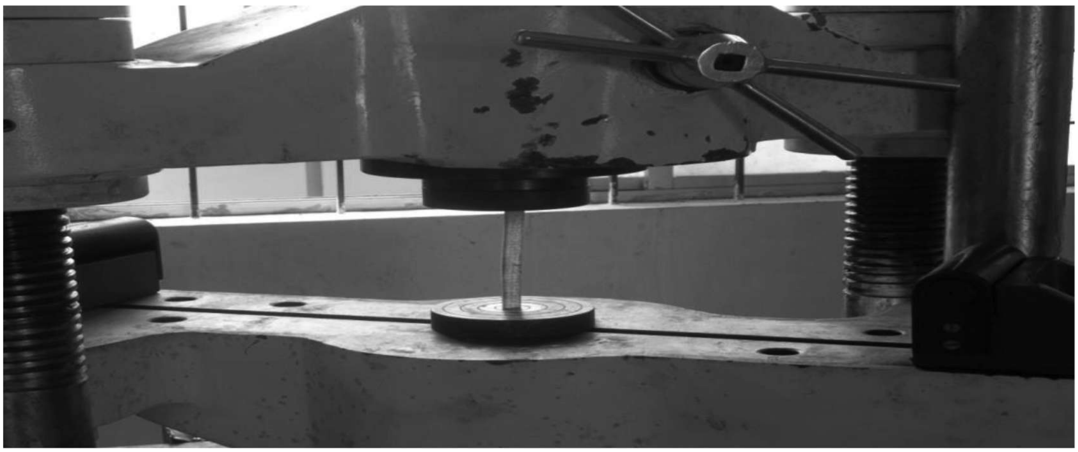


Fig 6.1 Compression Test Rig

6.3 Test Procedure

The specimen is placed between two compressive rams parallel to the surface. The specimen is then compressed at a uniform rate. The maximum load is recorded along with stress-strain data .The tests were conducted at room temperature of 25°C and 50%,respectively in the laboratory atmosphere .The results are recorded for further analysis and comparison of compression strength among various samples of GFRP composites.

6.4 Analysis of Compression Test Results

Analysis of the results obtained from Compression tests of different samples of GFRP Composites are presented in this section. Compression strength of various composites are calculated from using the following relations

Compression Strength=Maximum load(N)/Cross sectional area

Type of composite	Maximum load (KN)	Load at break (KN)	Ultimate compressive strength(Mpa)
S1	600	134.94	511.13
S2	600	100.50	380.68
S3	600	206.91	783.75
S4	600	268.41	1016.70

Table 6.1 Ultimate tensile strength values of all specimens

Load Vs. Elongation

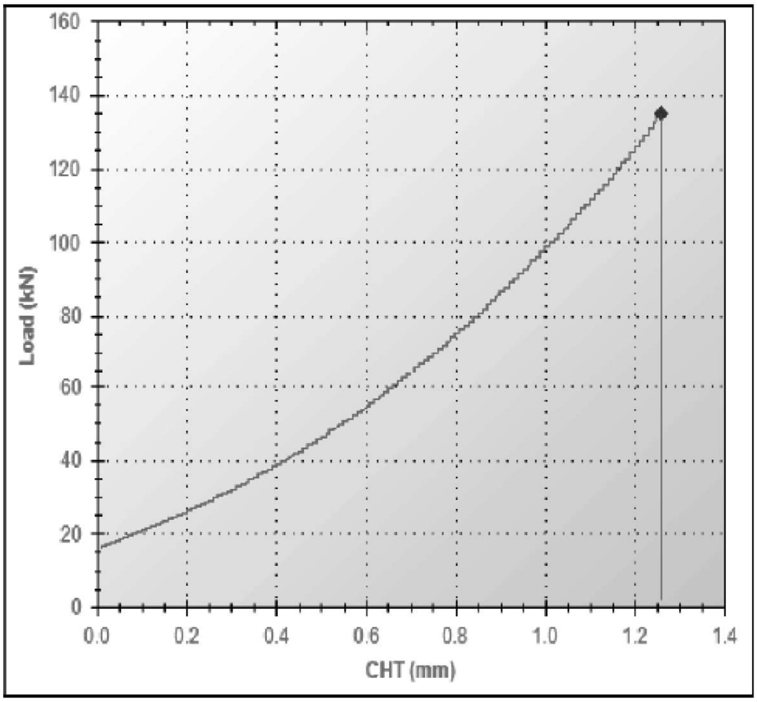


Fig. 6.2 Load Vs Elongation for sample S1

Load Vs. Elongation

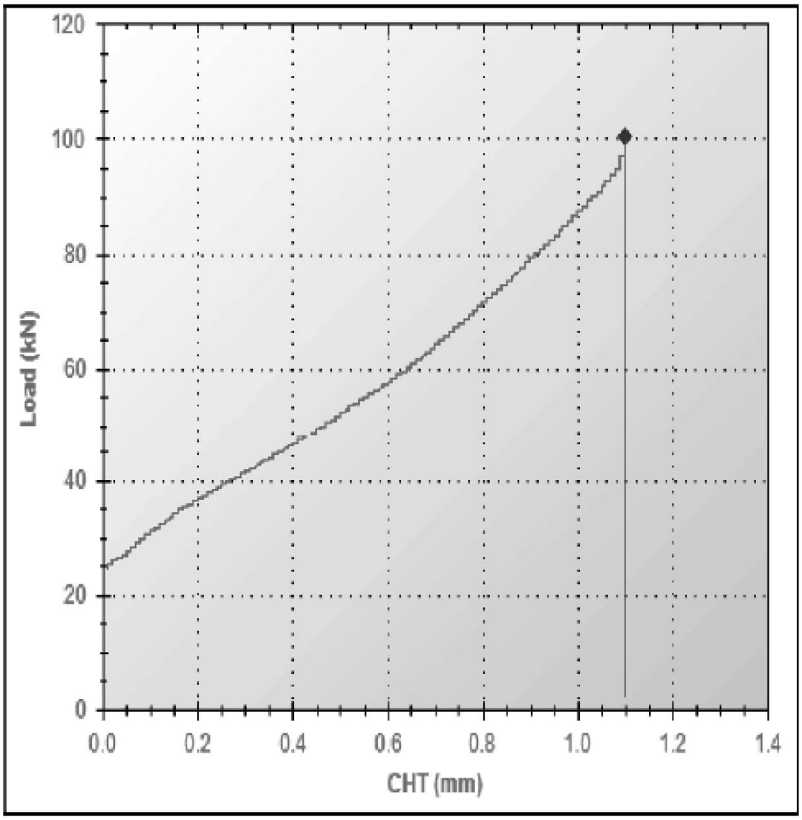


Fig. 6.3 Load Vs Elongation for sample S2

Load Vs. Elongation

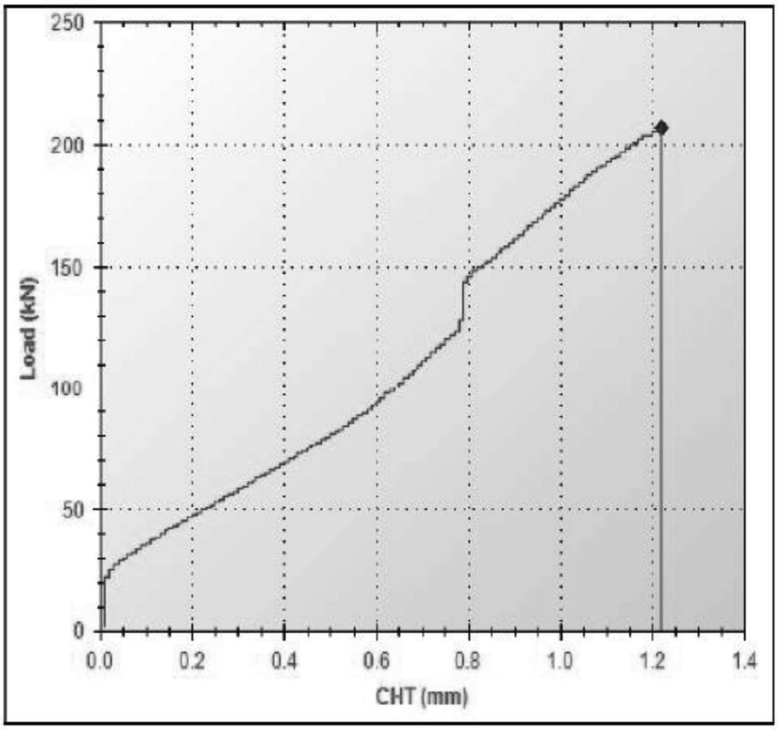


Fig. 6.4 Load Vs Elongation for sample S3

Load Vs. Elongation

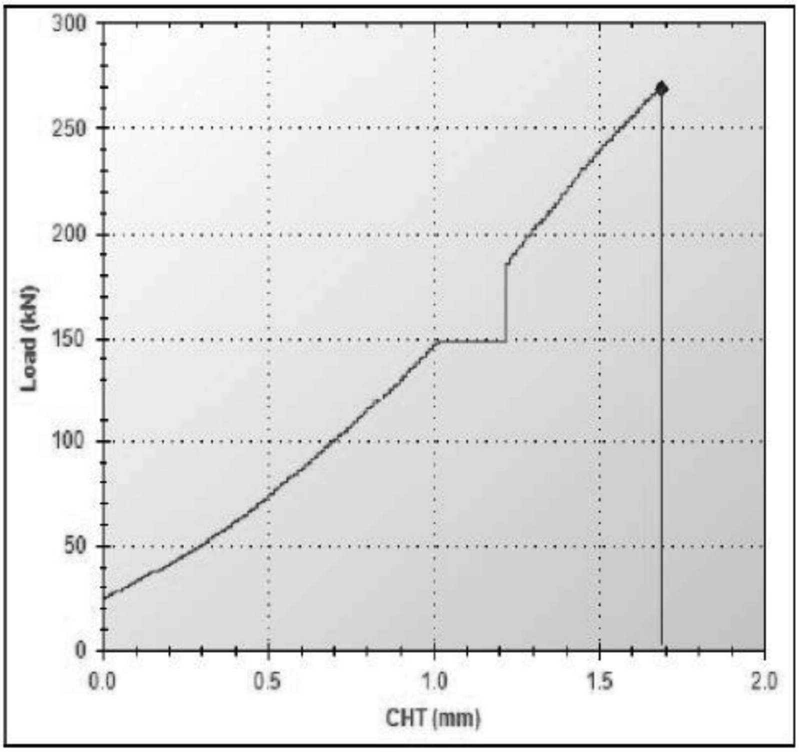


Fig. 6.5 Load Vs Elongation for sample S4

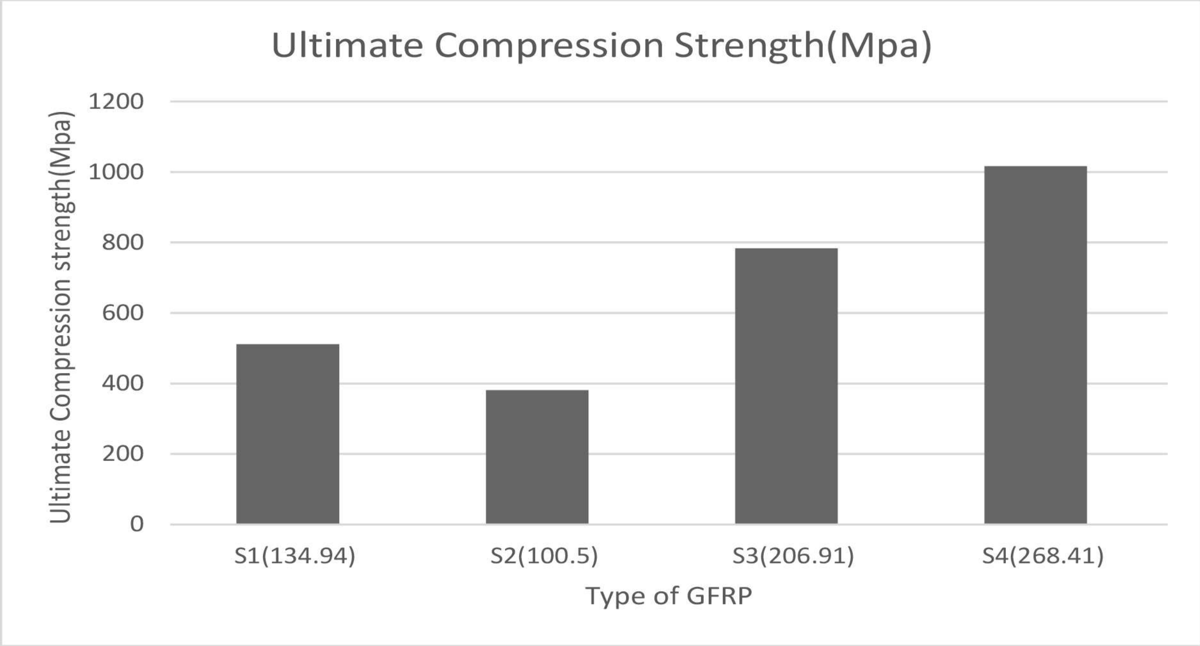


Fig.6.6 Variation of Compressive Strength with varying percentage of fillers

From the above bar chart it was observed that sample S4 is better when compared to samples. The maximum compression strength of SampleS4 is 1016.7Mpa which is recorded as the highest compression strength among remaining samples.

7.HARDNESS OF GFRP COMPOSITES

HARDNESS OF GFRP COMPOSITES

7.1 INTRODUCTION

In this chapter, hardness of different samples of GFRP composites are presented. Hardness test is conducted as per ASTM D2240 standards specimen cut in to 30× 30mm.The ability of material to resist indentation or penetration is called hardness.

The equipment and method for hardness testing are discussed in sections 7.2 and 7.3. In section 7.3.1 the analysis on the experimental investigations for the hardness of various samples of GFRP composites are presented.

7.2 Equipment for Hardness testing

Brinell hardness testing machine was used to find the hardness of GFRP composites. The brinell hardness testing machine is shown in Fig 7.1. The brinell test consists of indenting the surface of the composite material by a hardened steel ball under a load.

Fig7.1Hardness Testing Machine

7.3 Method for hardness testing

The load is applied by a lever system and the specimen is placed on stage with its ground face upwards. The height of the specimen can be raised by hand wheel so that the specimen is brought into contact with the indenter which is forced into the specimen by the specified load. The formulation of brinell hardness number can be obtained from the relation.

Table 7.1 Experimentation specifications of Brinell's Hardness Tester

Ball diameter,mm	Load, kg	Material
10	250	plastics

The time of loading the indentor is important and it should allow equilibrium to be attained. The time of loading is 30 seconds for non-ferrous materials. The brinell test should be performed on smooth flat specimen from whom dirt and scale have been cleaned. The brinell test is simple to conduct and hardness number may be correlated with ultimate tensile strength.

Table 7.2 Technical specifications of Hardness Test Rig

MODEL	**AKB-3000**
Load Range(kgf)	In steps of 250-3000
Optical microscope	25×Magnification
Impression depth gauge(mm)	Dial gauge diameter 80 L.C 0.01
Drive	An electric motor of 0.33 Hg flange
Maximum test height(mm)	410
Depth of throat(mm)	200
Maximum depth of spindle base(mm)	180
Gross weight of machine(kg)	450approx
Size of Base(mm)	670 × 370
Height of machine(mm)	1125
Main supply	400/440V, 3Phase, 50 HZ
Oil used for hydraulic system	Avalon 58 or servo system 32-15liters

7.3.1 Calculation and Analysis of Brinell hardness number

Brinell hardness number $$BHN= \frac{Load}{curved\ surface\ area\ of\ indentation}$$

$$BHN = \frac{2P}{\pi D(D-\sqrt{D^2-d^2})}$$

Brinell hardness number for bare material $$BHN = \frac{2\times 250}{\pi\times 10(10-\sqrt{10^2-6.5^2})}$$

$$= 6.629 Kgf/mm^2$$

Brinell hardness number for S1 material BHN =19.06 Kgf/mm^2

Brinell hardness number for S2 material BHN =14.87 Kgf/mm^2

Brinell hardness number for S3 material BHN =13.56 Kgf/mm^2

Brinell hardness number for S4 material BHN =16.37 Kgf/mm^2

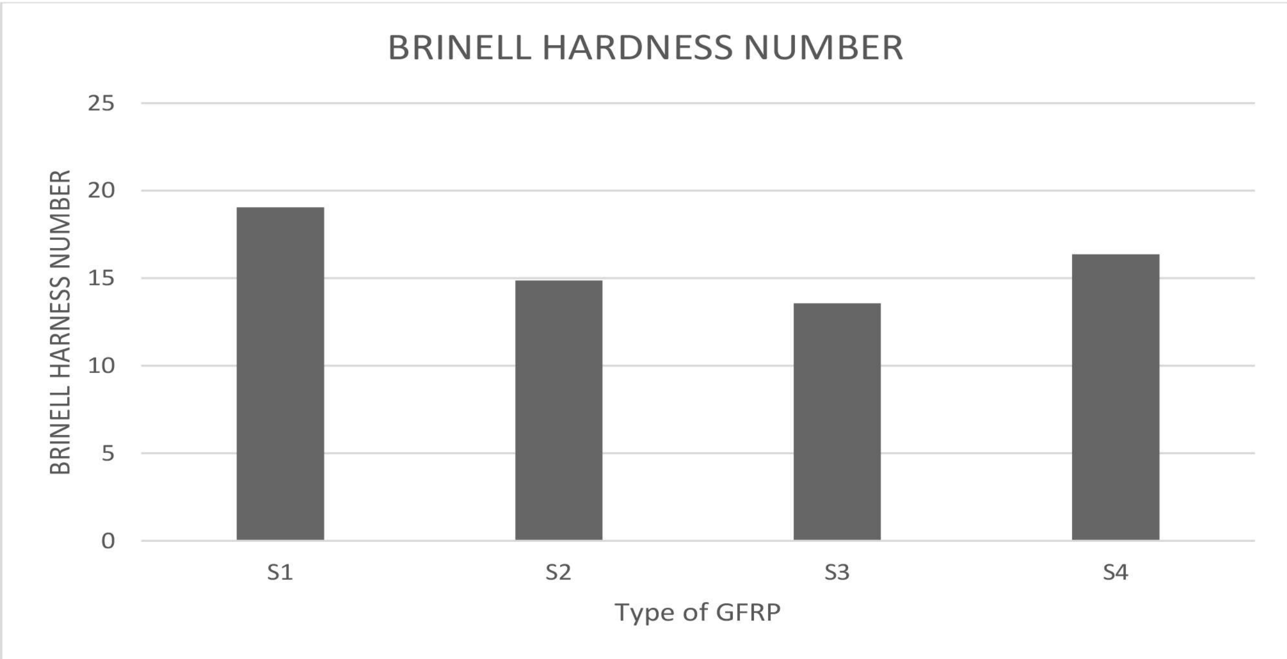


Fig7.2 Variation of Hardness with varying percentage of fillers

From the above bar graph it has been observed that sample S1 exhibits more hardness when compared to other samples .The maximum value of Brinell Hardness number is 19.06 Kgf/mm^2 which was recorded as highest among remaining samples.

8.IMPACT BEHAVIOUR OF GFRP COMPOSITES

IMPACT BEHAVIOUR OF GFRP COMPOSITES

8.1 INTRODUCTION

In this chapter the impact behaviour of different samples of GFRP composites is presented. The Impact test was carried out on Izod Impact testing machine, as per the ASTM standards. The test specimens are prepared as per ASTM D256 (64X12X4) mm. The four specimens were subjected to Impact test and their values were reported.

The equipment and the method for impact testing are discussed in the sections 8.2 and 8.3 respectively. In section 8.4, the analysis on the results of the experimental investigations for the impact strength various samples of glass fibre reinforced polymer resin matrix composites of different weight ratios is presented.

8.2 Equipment for Impact Testing

An analog Izod impact tester is used to find the impact strength of glass fibre reinforced polymer resin matrix composite specimens. The equipment has four working ranges of impact strength and they are 0-2.71 J,0-5.42 J, 0-10.84 J and 0-21.68 J, with a minimum resolution on each scale of 0.02 J, 0.05 J, 0.1 J and 0.2 J respectively.

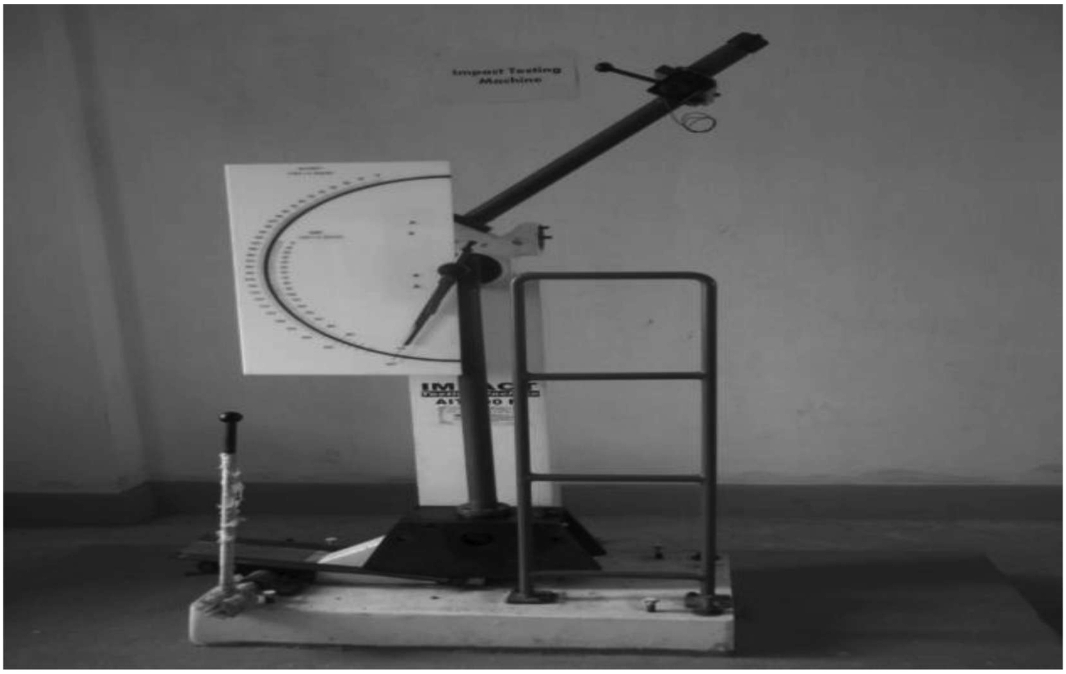


Fig 8.1 Impact Test Machine

Four scales and the corresponding four hammers are provided for all the above working ranges. The four hammers are designated as R1, R2, R3 and R4 respectively.

8.3 Method of impact testing

Impact test is conducted as per ASTM D256 standards specimen cut in to $64\times 12.7 \times 5\ mm$ .The behaviour of material under dynamic loading may sometimes differ markedly from their behaviour under static or gradually increasing loads. The capacity of material to withstand such blows (impact or shock loads) without fracture is called impact strength. The material with high toughness will generally exhibit greater impact strength. Static tests are unsuitable for determining the impact strength. Dynamic tests have been developed to establish impact resistance by using a notched specimen. The impact testing machine is shown in Fig 8.1. The specimen is held in an anvil and is broken by a single blow of the pendulum, which falls from a fixed height (h1). After breaking the specimen the pendulum continues to swing on the other side through a height(h2), if the weight of the hammer is W, then the energy delivered to the specimen to break it is W(h1-h2). The pendulum type impact machine is provided with scales and pointer, and scales are usually calibrated to read energy required to break the specimen in KJ.

It is obvious that the initial energy, Wh1 must be greater than that required to break the specimen. Correction for the energy losses due to machine friction and air resistance on the pendulum may be made by repeating the experiment without placing a specimen on the anvil and with indicator set at zero. The energy lost in friction, E_f may be computed. The actual energy absorbed is given by equation

$$E_a=E-E_f$$

The small amount of energy lost in friction may be neglected in commercial testing.

After calculating the energy required to break the specimen, the impact strength can be found by the formula,

$$\text{Impact strength} = \frac{Energy\ in\ fracture}{cross-section\ area\ at\ notch}$$

.

Table 8.1 Technical specifications of impact tester

MODEL	AIT-300
Maximum Impact Energy of pendulum(joules)	300
Minimum Value of scale graduation(joules)	2
Weight of the machine(kg)	250
Distance between supports(mm)	40
Angle of test piece support	78° to80°
Angle of inclination of supports	0°
Radius of supports(mm)	1-1.5
Maximum width of striker(mm)	18
Angle of striking edge	$30^0 \pm 1^0$
Radius of curvature striking edge(mm)	2-2.5
Pendulum drop angle	140°
Effective weight of pendulum(kg)	22.35
Suitable for specimen size(mm)	$10 \times 10 \times 55$

8.4 Calculation and Analysis of Impact Strength

Impact strength = $\frac{Energy\ in\ fracture}{cross-section\ area\ at\ notch}$

Actual Energy observed in Fracture of bare material E_a=E-E_f

E_a=18-11=7

Cross-section area at notch in Fracture of bare material A=14×5=70

Impact strength of Bare material = $\frac{7}{70}$ =0.1 J/mm^2

Impact strength of S1 material =0.128 J/mm^2

Impact strength of S2 material =0.1428 J/mm^2

Impact strength of S3 material =0.1714 J/mm^2

Impact strength of S4 material =0.2 J/mm^2

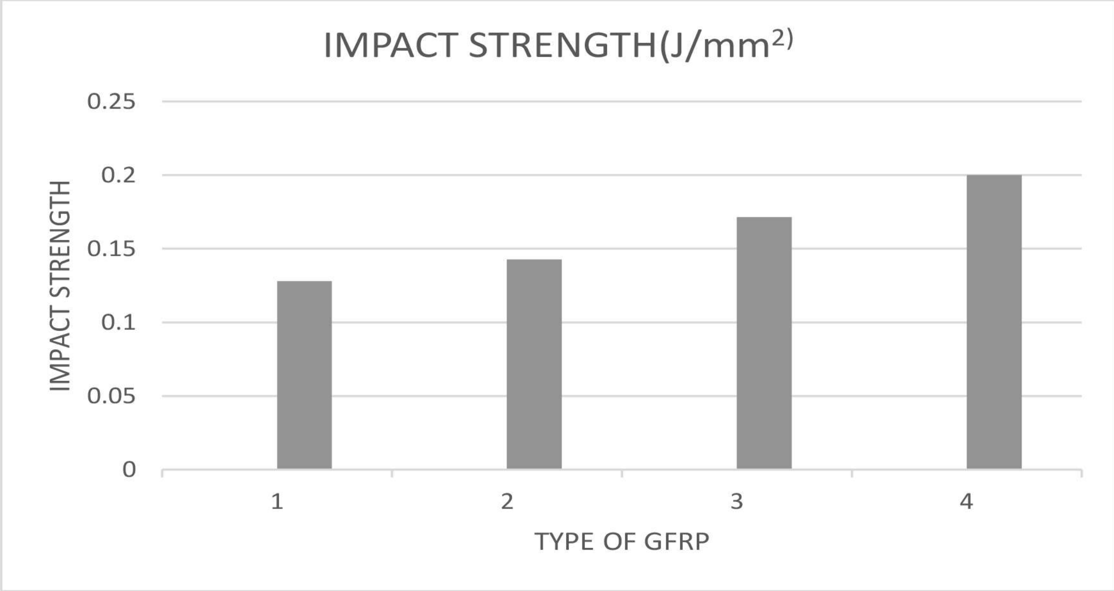


Fig.8.2 Variation of Impact Strength with varying percentage of fillers

From the above bar chart it is clearly understood that the impact strength of the sample s4 is more when compared to the other samples. Hence Impact strength of sample S4 ranges from 16.6%to56.25% greater than the remaining composites of different compositions.

9.SURFACE ROUGHNESS ANALYSIS

Surface Roughness of GFRP Composites

9.1 Introduction

With the more precise demands of modern engineering products, the control of surface texture together with dimensional accuracy has become more important. It has been investigated that the surface texture greatly influences the functioning of the machined parts. The properties such as appearance, corrosion resistance, wear resistance, fatigue resistance, lubrication are influenced by the surface texture .Surface finish of the composite varies for different compositions of filler materials. . Whatever may be the manufacturing process used, it is not possible to produce perfectly smooth surface. The imperfections and irregularities are bound to occur.

Surface roughness test was conducted on four Specimens and there values were reported.The manufactured surface always departs from the absolute perfection to some extent.

9.2 Equipment and method for surface Roughness Testing:

Remove any oil or dust on the measurement target's surface. If the measurement direction is not indicated, position the target so that the measurement direction will give the maximum parameters in the height direction (Ra, Rz). The stylus probe is kept on cleaned surface just touching the surface.Stylus is set to move through some distance and Ra value is shown in apparatus. Repeat this trials for three times on each sample.

Fig9.1 Surface Finish Tester

9.3 Analysis of surface roughness measurements:

Average of all the trials are taken for each sample.This is shown as avg.Ra in column5 of Table9.1

Type of GFRP	Ra1	Ra2	Ra3	Avg.Ra
S1	8.409	11.063	55.931	25.13
S2	9.191	13.241	71.71	31.38
S3	12.48	18.32	91.09	40.63
S4	11.40	15.08	82.33	36.27

Table9.1 Different Ra values for different samples.

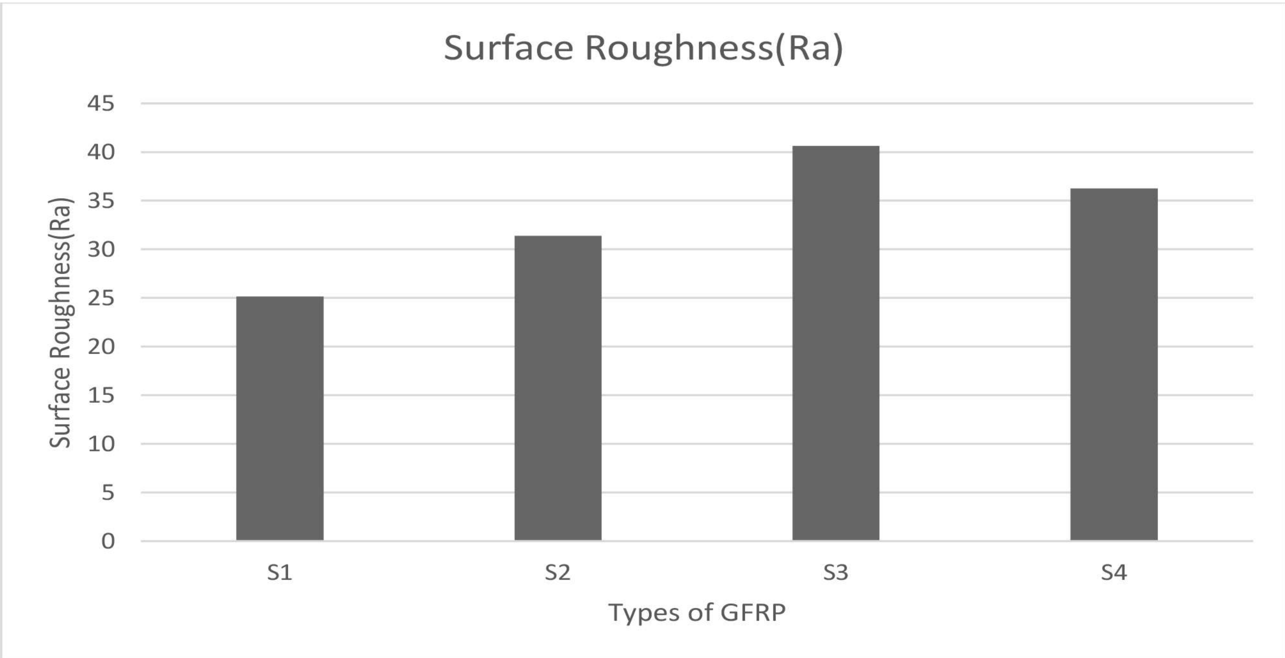


Fig 9.2Grpah Showing various Ra values of different GFRPs

From thefig.9.2 it has been observed that S3 sample has highest Ra vale which implies that it exhibits high surface roughness among all the samples.

10.CONCLUSION

CONCLUSION

10.1 Introduction

Glass fiber reinforced composite materials are fabricated by varying the content of filler materials such as Rubber powder and Silicon carbide. Four different formulations of composite sheets are fabricated. Experimental investigation on tensile,flexural,compression and Impact behaviour of Glass fibre reinforced polymer composites with different weight percentages of filler materials have been carried out in the present research work.All the tests are conducted as per ASTM standards.The results obtained from these tests are compared in $5^{th}, 6^{th}, 7^{th}, 8^{th}$ chapters.Critical observations of the present study are highlighted in this chapter.

10.2 Conclusions from Results

The results obtained from different tests are presented as per the order discussed in this report i.e.,Tensile,Compression,Flexural,Impact results.

10.2.1 The Conclusion drawn from the Tensile test results are:

- The maximum Tensile Strength is obtained for sample S4 among all samples
- It was observed that the sample sheet S4 better tensile properties than compared to remaining samples.
- It was observed that the tensile strength is increasing from sample S1 to S4

10.2.2 The Conclusions drawn from the flexural test results are:

- The maximum flexural strength is obtained for sample S4 among all the different samples.
- It was observed that flexure strength decreased on going from S1 to S2 and then again increased from S2 to S3 and S4.

10.2.3 The Conclusions drawn from the Compression test results are:

- The Maximum Compression strength is obtained for sample S4 among all the different filler weight percentage samples.
- It was observed that compressive strength is decreased on going from S1 to S2 and then started increasing from S2 to S3 and S4**.**

10.2.4 The Conclusions drawn from the Impact Test Results are:

- The highest impact strength was observed for the sample S4.
- The variation of Impact strength is minute with linearly increasing from samples S1 to S4.

10.2.5 The Conclusions drawn from Hardness Test Results are:

- The highest Brinell hardness number is observed for sample S1

TABLE 10.1 Comparison of strengths for different filler percentages

Type of GFRP samples	Surface Roughness(Ra)	Tensile Strength (Mpa)	Flexural Strength (Mpa)	Compression Strength (Mpa)	Impact Strength (joules/mm^2)	Brinell's Hardness number
S1	25.13	44.84	60.8	511.13	0.128	**19.06**
S2	31.38	45.65	51.0	380.68	0.1428	14.87
S3	40.63	51.52	122.43	783.75	0.1714	13.56
S4	36.27	**72.86**	**168.0**	**1016.70**	**0.2**	16.37

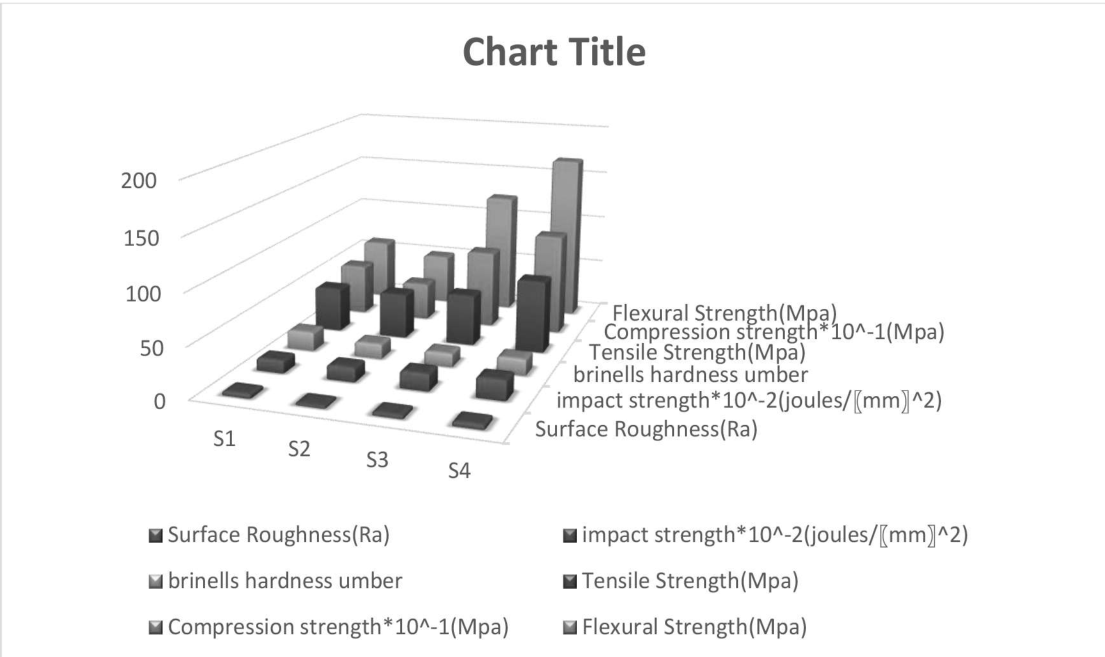


Fig.11.1 Graphical representation for different percentages of filler materials

The mechanical properties and thermogravimetric analysis is performed on all the samples of composite sheets. Based on mechanical property results, it was observed that sample sheet S4 with the selected ingredients possess higher ultimate tensile, compressive and flexural strength value compared to remaining formulations of materials. It was also observed that, the Brinell hardness number for the sample S1 is having highest hardness. Impact test results re

veal that, the sample specimen S 4 possesses high impact energy compared to remaining formulations. Thermal analysis is also performed on all the samples of fabricated composite sheets to check maximum temperature withstanding capability. It was observed that the sample specimen S4 is having high temperature with standing capability and low weight loss with increase in temperature compared to remaining formulations of the material.

Therefore, based on the Mechanical and thermal tests it was observed that, sample specimen S4 possess better values compared to other material configurations. The main reason to have better mechanical and thermal properties is the selection of ingredients like Silicon carbide and rubber powder for improving mechanical and damping properties of the composite. This material combination S4 can extend its usage in the field of aerospace and automobile industries.

Scope for future work

Damping properties of the composites can be analyzed by using FFT analyser. The bonding strength behaviour of the composite can be examined in detail by studying the inter laminar cohesive force attraction between all the ingredients by observing SEM and bonding behaviour.

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