

**FABRICATION AND MECHANICAL PROPERTIES OF Al_2O_3
COATED GLASS FIBER REINFORCED STYRENE-ETHYLENE-
BUTYLENE-STYRENE POLYMER COMPOSITES:
EFFECT OF Al_2O_3 COATING ON MECHANICAL STRENGTH**

A THESIS

Submitted by

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **S.PRAGATHEESH (REG . NO. 40590008)** who carried out the project entitled “**Fabrication and Mechanical Properties of Al₂O₃ coated Glass fiber reinforced styrene-ethylene-butylene-styrene polymer composites: Effect of Al₂O₃ coating on mechanical strength**” under my supervision from **NOVEMBER 2021 TO MARCH 2022**

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I **S. PRAGATHEESH (Reg. No. 40590008)** hereby declare that the Project Report entitled “Fabrication and Mechanical Properties of Al_2O_3 coated Glass fiber reinforced styrene-ethylene-butylene-styrene polymer composites: Effect of Al_2O_3 coating on mechanical strength” done by me under the guidance of **Dr. S. Ravichandran M.Sc., M.Phil., Ph.D.**, is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

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ABSTRACT

FRP is very dynamic material, building it the good option for every kind of infrastructure. This paper demonstrates the improvement and mechanical properties of hybrid composite along with glass fiber, SEBS and aluminum oxide (Al_2O_3) particles reinforced with epoxy resin. And, the SEBS which is mixed with the Toluene solvent and Al_2O_3 is typically combined with Epoxy matrix. Pasting taken glass fibers are laminated with thermal compression molding method. Further, the mechanical characterization has been finished through tensile test. It has been absorbed that, the addition of Al_2O_3 into the GFRP composite improves the mechanical properties of pressure and stress properties in Composite Technology Center, IIT-M. The consequences were optimized the usage of the desirability characteristic approach, and tested through an affirmation test. The specimens were characterized by different techniques such as Tensile strength test, FTIR test and Water absorption test.

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LIST OF SYMBOLS

%	-	Percentage
°C	-	Degree Celcius
°F	-	Fahrenheit
™	-	Trade Mark
K	-	Kelvin
nPa	-	Gigapascal
MPa	-	Megapascal
Ωm	-	Ohm-meter
g/cm ³	-	grams per cubic centimeter
g/mol	-	Grams per Mole
W/mk	-	Watts per meter-Kelvin
F/A	-	Force per unit Area
psi	-	Pounds per square inch

LIST OF ABBREVIATIONS

Al ₂ O ₃	-	Aluminum Oxide
BMC	-	Bulk Molding Compounds
CCC	-	Carbon - Carbon Composite
CFRP	-	Carbon Fiber Reinforced Polymer
CMC	-	Ceramic Matrix Composite
EP	-	Epoxy
GFRP	-	Glass Fiber Reinforced Polymer
H ₂ O	-	Water
Fe	-	Iron
FRP	-	Fiber Reinforced Polymer
FTIR	-	Fourier Transform Infrared
IIT-M	-	Indian Institute of Technology - Madras
LY 556	-	Epoxy
MMC	-	Metal Matrix Composite
PC	-	Poly-Carbonate
PMC	-	Polymer Matrix Composite
PP	-	Polypropylene
PVD	-	Physical Vapour Deposition
SBS	-	Styrene-Butadiene-Styrene
SEBS	-	Styrene-Ethylene-Butylene-Styrene
SMC	-	Sheet Molding Compounds
SO ₄	-	Sulphate
TNT	-	Trinitrotoluene
TPE	-	Thermoplastic Elastomer
UP	-	Unsaturated Polyester
US	-	United States

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Composites can be determined as an amalgamation of two or more substances (with markedly non-identical physical or chemical properties) that occurs in finer properties than those of the individual substances. These prominent materials are becoming a mandatory part of present day's modern substances due to their major advantages such as less weight, big fatigue strength, rust free and quick assembling. They are widely used as ingredients in airframe structures construction, spacecraft manufacturing for home construction and auto-electronic packing for medical devices. The normal variation between the polymer blends and the composites is that blends are single phase system get by amalgamation of two or more components, while composites are polyphase system consisting of two or more components, usually composed of polymeric and non-polymeric component. The main important materials are used in our daily life are trees, porcelain, glass fibers, ceramics, limestone and so on. Miraculously, the most primary polymer composite materials that occurs in nature and these are called natural composites. Mammalian connective is one of the most developed polymer composite materials known to human with collagen, fibrous protein as a reinforcement material. It acts as both hard and soft connective tissues.

The components keep holds a nature within the composite. That is, they work together, but they do not dissolve or fully integrate. These individual components work together to provide the mechanical strength required for the composite, which is a composite substance called a substance made from several different parts of two or more different phases, such as a matrix and a dispersed phase, and has aggregate properties that are significantly distinct from the aggregate properties of the component. Matrix phase is the primary phase, which has continuous properties. The matrix phase is generally not hard and ductile and it is weaker than the secondary phase. However, the secondary phase is the dispersed phase.

Consequently, it is occasionally called the reinforcing phase. The most usual or predominantly artificial composites were construction bricks formed by merged straw and mud.

1.2 HISTORY OF COMPOSTIES

The periods B.C. opening remarks of the type of composite material used in day-to-day application appears. The first confidential work of the composite materials is earned in Mesopotamia. These primeval group created plywood in 3400 BC by laminate some wood strips at some distinct angles. In the middle of the periods from 2181 to 2055 BC. The Egyptians made masks by used the cardboard and hemp fiber layers or papyrus layers extremely saturated in plaster. The times 1500 BC Mesopotamians and Egyptians constructors, designers and craftsmen improved boats, mud bricks and pottery by the help of straw. Approximately 25 BC, concrete and recognized different types of mortars and lime reported by The Ten Books on Architecture. Beautifully, studies have shown that the cement described is similar in some ways better to the Portland cement.

Since primeval times, constructors, craftsmen, engineers, and manufacturers has continued to develop composite materials into a wider range of substances for high complex applications.

Around 1200 AD the first bows are done by composite materials invented by Mongols made by combining of bamboo, wood, cattle tendon, bone, silk, and horn merged by natural pine resin. This powerful, small, highly accurate bow was the most dreaded weapon on the planet until effective firearms were invented in the 14th century.

From 1870s to 1890s, the chemical revolution switched the development of composites. The New synthetic resin was converted from a liquid matter to a solid matter in a crosslinked subatomic structure by using this process called as polymerization. During synthetic resins included Bakelite, Melamine, and Celluloid.

During 1900s, advances in chemistry led to the advancement of plastics. Components such as polyester, vinyl, phenol, and polystyrene, was made and component was needed to give them rigidity and strength.

Poly-oxy-benzyl-methylene-glycol-anhydride, or more commonly known as

Bakelite, was developed in 1907 by New York chemist Leo Baekeland. A removal of phenol with formaldehyde, the first plastics called as Bakelite created from synthetic materials that formed thermosetting phenol formaldehyde resin, which component that heat-resistant and non-conductivity properties made it a widely used composite material in industrial and consumer products, with radio, electrical insulators and phone housings, children's toys, jewellery, pipe rods, and kitchenware. Present days collection of Bakelite's "Retro" appeals.

The period 1993, as a sign that recognized the importance of Bakelite as the first synthetic plastic, the US chemical society pointed Bakelite a National Historical Chemical Landmark.

In 1930s, recognized as the most successful decade for the composites material industry, saw the improvement of resins that are still used present day. In 1935, the first glass fiber was introduced by Owens Corning and launched the production of FRP (fiber reinforced polymer). An unsaturated polyester resin was patented in 1936. Now a days, due to their healing properties, un-saturated polyester resins are the currently dominant choice for resins production. The other high performance resin systems become available such as epoxy resins from 1938.

The demands of World War II drove the industries of FRP to production from research. Chemists have learned that in addition to their high strength properties, glass fiber composites are clear to radio frequencies. This has led to the adaptation of composite materials for radar domes and other electronic machine.

Although not deployed or commercialized until the end of World War II, the first commercial-grade boat hulls were developed during this decade.

By 1947, all mixed-body cars had been prototyped and tested, with the 1953 Corvette being developed. It was molded into a metal die matched with a resin-impregnated fiberglass blank to create this classic car. The origin of the automobile age has given rise to several new molding methods. There are two methods for molding, Sheet Molding Compounds (SMC) compression molding and Bulk Molding Compounds (BMC), have become the dominant molding forms for the automotive industries and other industries.

In the early 1950s, manufacturing innovation continued with the development of drawing, vacuum packing, and filament winding of large-scale. This composite material still in use present applications. Pultrusion is used in the production of linear substances such as stairs and moldings. In 1960s, Filament windings are an

example of aerospace composites. It served as the keystone of the largescale rocket engines that fueled space disquisition of space.

Carbon fiber was patented for the first time in 1961 and commercialized a few years later. Carbon fibers has improved thermosetting parts of weight ratios with stiffness, for use in more applications such as automobiles, aerospace, sportswear, and goods for consumers. In 1960s, the marine market was the huge consumer of composites.

The Metropolitan Composite Market has been improved for the next 20 years. The New ultrahigh molecular poly-ethylene combined with the other developed fibers provided in aircraft ingredients, structural and private armor, sports equipment, medical and other applications. In 1970, the automotive market is surpassing the marine on the automobile market today. In 1970, Mar Bal began to create customizable switches for multiple applications, including electric switches, motor assemblies, small devices and electric switches. Due to this modest start, Marl Cream has grown into the most built-in thermosetting solution of composite providers today. Until mid-1990, composite has been more common in major production and construction. The composite material of the thermosetting composition was a common component within the device, construction, electricity appliances and transplantation industry, while replacing graphics of traditional substances such as metal and engineering thermoplastic plastics. Consumer and industrial markets have seen the growth of everyday complexes. Currently, roots and normal use are currently examples of the composite materials of the application, including handle and handle, garbage system, electric infrastructure, pole hardware, electrical remittance, and insulators. In the mid-2000s, composite materials inspected by 787 Dream Liner for continued development of high strength and hard applications and finishing technologies such as Thermital TM and PVD.

1.3 CLASSIFICATION OF COMPOSITES

Based upon the material of the matrix substrate, composites can be categorized into MMC (Metal-Matrix Composite), CMC (Cerami-Matrix Composite) and PMC (Polymer-Matrix Composite).

MMC (Metal-Matrix Composite) consisting of a metal matrix (aluminum, iron, magnesium, cobalt, and copper) and ceramic (carbide and oxide) or a metal

dispersed ceramic (molybdenum, tungsten, and lead). CMC (Ceramic-Matrix Composite) consist of a matrix of ceramic and embedded fibers of another ceramic substances (dispersed-phase). PMC (Polymer Matrix Composite) consisting of a thermosetting to matrix (UP (Unsaturated Polyester) and EP (Epoxy)) or thermoplastic (PC (Poly-Carbonate), Poly-Vinyl-Chloride, Nylon, Poly-Styrene) and fiber substrates glass, carbon, steel or integrated kevlar (dispersed-phase).

Based on the structure of reinforcing materials, composites can be categorized into Particulate composites (particles made), Fibrous composites (fibers made) and Laminate composites (laminates made).

Particulate composite consists of a matrix strengthen by a granular dispersion phase. It consists of two categories, such that, first one is composite materials with arbitrary grain orientation. And second one is composite materials with have preferential grain orientation. The dispersed phase of these substances categorized into two, that is platelets of dimensional flat (flakes) and arranged parallel to each other.

Fibrous composites are categorized into two types, such that, Short-fiber reinforced composite materials and Long-fiber reinforced composite materials. The first one, Short-fiber reinforced composites, consisting of a matrix strengthened by dispersed phase-reinforced substrate in the form of metallic fibers (100 diameter > length). Then, it consists of two categories that composite materials consists of random fiber orientation and composite materials consist of preferred fiber orientation. And the second one, Long-fiber reinforced composites, consisting of a dispersed phase-enhanced substrate in the form of continuous fibers. Then, it consists of two categories that One-way fiber orientation and Two-way fiber orientation (weaving).

Laminate composite materials that when a fiber strengthened composite is made up of many layers consist of distinct fiber inclination it is called an angle ply (multi-layer) composite material.

1.4 LIST OF POLYMER MATRIX COMPOSITE

The PMC (Polymer Matrix Composite) is classified into, GFRP (Glass-Fiber Reinforced Plastic) composite, CFRP (Carbon-Fiber Reinforced Polymer) composite, Aramid-Fiber (aromatic polyamide) Reinforced Polymer composite, MMC (Metal

Matrix Composite), CMC (Ceramic Matrix Composite), CCC (Carbon-Carbon Composite), Hybrid Composite and Structural Composite.

GFRP – Glass-Fiber Reinforced Plastic Composite, Consists of glass fibers in a polymer matrix. It is produced in the largest quantity. glass is widely used as a reinforced substance, such that easily attracted into the molten state from fibers, economical manufacture and easily available, a wide range of complex manufacturing techniques are available, composite materials have more specific strength can be obtained, and when merged with a polymer matrix composite, it exhibits chemical inertness, making the composite material useful in a variety of harsh atmosphere. The following are the list of GFRP applications, plastic pipes, automobiles, marine motors, bodies of marine, storage containers, industrial fabricating, transportation hubs, etc.,

CFRP (Carbon-Fiber Reinforced Polymer) are composite substances of materials that depend on carbon fibers, and polymers provide cohesive matrices to guard and maintain sealing and provide several reinforcements. Carbon fibers are very distinct from the most commonly usage metals that are commonly provided material for these automobile applications. These has been designed to achieve large cuts that metal can not be achieved. Since, the component material is artificially, these characteristics and performance may be adapted to be used by various direction, length, strength and total amount of reinforced fibers and polymer matrix composite. The biggest disadvantage is too expensive to produce fibers and low bandwidths that can make ingredients. The total time it takes to put the fibers into the mold, introduce the polymer and solidify the pins is a several times. Widely used in sport games and entertainment equipment, incandescent rocket engines, military and commercial vehicles, helicopters, and other aircrafts.

Aramid-Fiber Reinforced Polymer Composites, that are preferred due to their excellent strength-to-weight ratio. In chemistry, this group of substances is called as poly-para-phenylene tetra-phthalimide. The two most casual aramid substances Nomex and Kevlar. Hard molecules are arranged along the fiber axis. These fibers with high longitudinal tensile strength and modulus. However, it is comparatively weak to compression mold. In addition, aramid is highly resistant to creep and fatigue failure. More stable at high temperature (-200°C to 200°C). In chemistry, they are easily broken down by strong acids and bases. The following are the list of applications, that Bulletproof vests, ropes, materials for sports, bags for missile,

automobile switches and lever gaskets, etc.,

MMC (Metal Matrix Composite) is a ductile metal matrix. In addition, strength can improve stiffness, wear resistance, creep resistance and stability of dimension. Here, some advantages of Metal Matrix Composite over Polymer Matrix Composite include huge operating temperature, nonflammability, and resistance for degradation with organic liquids.

CMC (Ceramic-Matrix Composite), here, particles, fibers, or whiskers with the inherent strength of ceramics are enclosed in the matrix of other ceramics. This develops the internal mechanical properties such that toughness resulting from the attraction of propagating rifts with substances of dispersed phase.

CCC (Carbon-Carbon Composites), that are carbon fibers laminated matrix composite. They have very high with tensile strength and Moduli, that are held at temperatures above 2000 °C. The major benefits of CCC are high stability and relatively high scratch strength. These are extremely stable to temperature shocks. Apart from being expensive, their main disadvantage is that they are prone to oxidation at high temperatures. The Carbon-Carbon Composite finds application in rocket engines, aircraft frictional substances and huge performance vehicles, hot press dies to mould, gas turbine engine materials, and ablation shields for new automobiles.

Hybrid Composite Material is simply merge of carbon fiber and glass fiber. First, the carbon fiber fails, then the glass fiber and matrix take over the load. Classical applications of this material are sporting goods and matrices. Hybrid Composites are classified into four types, the first one is Inter-ply hybrids (replacement of similar matrix plates of distinct fibers), the second one is Inter-ply hybrids (including each plate with two or more types of fiber systems) the third one is Inter-ply – Intra-ply (amalgamation of both) and the last one is Super Hybrid.

Structural Composite materials are divided into two categories Sandwich panel and laminated composite material. Sandwich Panels, these consist of a surface separated by two strong external sheets or a core of less density material or less rigidity and strengthened. Laminated Composite Materials are a multi-wafer mode. Laminas, also known as plies or layers, are very thin, ranging from 0.01 to 0.1 cm thickness. They are joined or glued together to make a laminate of the wanted thickness. The number of layers of laminate can be hardly any to tens.

1.5 TYPES OF FIBER

Fibers are classified into two categories, which one is a natural fiber acquired from natural place of origin. For example, wool, cotton, silk, etc., and another one is man-made fibers which are called synthetic fiber. For example, nylon, rayon, acrylic, etc.,

These man-made fibers are synthesized from polymers made of molecules small. The materials help to create those fibers receives from raw materials such that petrochemicals or chemicals derived from petroleum. These substances are chemicalized from synthesis process that binds two nearby carbon atoms. Different chemical materials are provided to produce varied categories of synthetic fibers.

1.6 TYPES OF SYNTHETIC FIBER

Rayon-Rayon is polymerized from wood pulp. Rayon is also called as silk because it resembles a disease. Rayon is coated in many distinct colors and it is very low-priced than silk. Nylon-Nylon was the first commercialized synthetic fiber and it is combination of water, air and coal. It's durability and its lamination that same as silk. Polyester-Polyester, it is the one of the most popular artificial synthetic fiber. It is composed of a loop unit of a chemical called an ester. It is broadly used to manufacture clothes. Acrylic-Acrylic is a man-made fiber that is called fake or synthetic or artificial wool in the view of the fact that same as wool. Acrylic is low-cost than natural fiber and it can be coated a variety of colors. This reason makes acrylic famous alongside when compared to other fibers.

1.7 CHARACTERISTICS OF SYNTHETIC FIBER

Synthetic fiber is low-priced than natural fibers, strengthened than natural fibers, and it is more durable than natural fibers, are easy to clean and maintain, and it also fabrics are made from synthetic fibers are dry in less time.

1.8 POLYMER COMPOSITE MATERIALS

Polymer composites materials are multiphase materials that exhibits symbiotic

mechanical properties that cannot be attained with a single substance in which a reinforcing agent is combined with a polymer matrix.

1.9 COMPONENTS OF POLYMER COMPOSITES

Modern Composite materials typically consist of two categories, such as one fibers and other matrices. Fibers are usually glass, but every so often Kevlar, Carbon fiber or Polyethylene. The substrate is typically a thermoset of epoxy, polyamide or poly-di-cyclo-pentadiene. Fibers are sub-merged in the matrix to make it strengthened material. Fiber reinforced composites consists of two functions. One is Strong and another one is lite. They are frequently stronger than normal steel, but weigh much less, which means that composite materials can be provided to make cars lighter and therefore more saving fuel energy. This also means they are less polluting.

1.10 ADVANTAGES OF FRP COMPOSITES

High Durability Metals such as aluminum or steel are utilized in the building sector to provide high power in all every places. High strength in the construction of structures using composites provides a prolonged service life and minimal keeping up. Natural fiber composite material is used as an excellent insulation material. It is provided on the buildings as doors, windows of buildings to defend them from bad weather. This is because composite materials based on natural fibers, it's not conduct heat or cold well. Lightweight Composite material is not only with good strength, but also with lightweight. As a result, composites can be used in both aircraft design and the automobile industry. Composite has excellent corrosion resistance and toughness. It can absorb anything and resist weather damage. In Chemistry, composite materials have good chemical resistance. It can the ability to resist to all temperatures and weather. Composite materials are always stable in dimension. Their shape and size do not change with the time or temperature or weather. On the flip side, wooden material contracts and expands with changes in temperature. As a result, because the composite material has very good properties that can be used at any situation, air wings use it so that the size and shape of the wing does not change in cold or hot weather. Composite material is non-conductive.

This means that the composite material cannot conduct electricity. Due to these properties, composite materials are used in the manufacture of electric poles and printed circuit boards. Sometimes, when a composite material requires electrical conductivity, it is very easy to translate that property into a conductive material. Composites are non-magnetic and are the only reason why they are used as reinforcements in cabinet and table construction, around electronics, and in hospitals for concrete wall and floor construction. Transparent Radar Composite materials are provided to manufacture radar equipment, whereas composite materials are used in radars for ground or air transmission.

1.11 APPLICATIONS OF FRP COMPOSITES

Some major applications of FRP are Aerospace, automotive and construction applications. Consumer Goods, Energy, Protective Equipment, Marine Infrastructure.

1.12 SCOPE OF PRESENT WOEK

Current Scope of Work, when developing a comprehensive infrastructure idea, it is major key to consider the overall project as well as the time required for each phase of the procedure. Clearly, saving time renders to cost savings, but don't want to surrender standard for plan. FRP is the perfect balance to deliver the quality you need while saving precious production strength and time. FRP is a perfect component for provide in virtually any infrastructure ideas, making it extremely dynamic, making it a valuable option for all categories of infrastructure existing roads, pedestrian and walkway bridges, pavement cantilever, railway platform, embankment frameworks, storage cisterns and tubes, and foot-stairs, and railings, etc.,

CHAPTER 2

LITERATURE SURVEY

Nayak, Ramesh Kumar, and Bankim Chandra Ray. "Water absorption, residual mechanical and thermal properties of hydrothermally conditioned nano- Al_2O_3 enhanced glass fiber reinforced polymer composites." *Polymer Bulletin* 74.10 (2017): 4175-4194. The purpose of this study was to nano- Al_2O_3 coated GFRP composites in hydrothermal environment. And the investigation about tests the effect filler concentration on water absorption of nano- Al_2O_3 , then mechanical properties of GFRP nano-composites treated by hydrothermally. May have taken also tensile strength and XRD test.

Nayak, Ramesh K., Alina Dash, and B. C. Ray. "Effect of epoxy modifiers ($\text{Al}_2\text{O}_3/\text{SiO}_2/\text{TiO}_2$) on mechanical performance of epoxy/glass fiber hybrid composites." *Procedia materials science* 6 (2014): 1359-1364. The purpose of this study has changed the epoxy resin by the materials such as Al_2O_3 , SiO_2 and TiO_2 in glass fiber to develop the mechanical properties. And it is confirmed by SEM analysis test.

Wang, Zhi, et al. "Effect of micro- Al_2O_3 contents on mechanical property of carbon fiber reinforced epoxy matrix composites." *Composites Part B: Engineering* 91 (2016): 392-398. The purpose of this study used Al_2O_3 on carbon fiber surface area by the effect of integrating and perfectly investigated about the mechanical properties in carbon fiber reinforced polymer composites.

Iglesias, J. G., et al. "Effect of glass fiber surface treatments on mechanical strength of epoxy based composite materials." *Journal of colloid and interface science* 250.1 (2002): 251-260. The purpose to study this paper that observed the influence of varied amino-silanes glass fiber coatings on the epoxy-based composite substances.

Reddy, S. Pichi, et al. "Tensile and flexural strength of glass fiber epoxy

composites." *International Conference on Advanced Materials and manufacturing Technologies (AMMT)*. 2014. The purpose of this study that the impact of fly ash material to flexural strength and tensile strength of glass fiber epoxy materials are observed.

McCarthy, D. N., et al. "The effect of dispersion on the increased relative permittivity of TiO₂/SEBS composites." *Journal of Physics D: Applied Physics* 42.14 (2009): 145406. The purpose of this study that investigated the impact of particle size of composite materials of rutile poly-(SEBS).

Spriggs, R. M., J. B. Mitchell, and T. Vasilos. "Mechanical properties of pure, dense aluminum oxide as a function of temperature and grain size." *Journal of the American Ceramic Society* 47.7 (1964): 323-327. The purpose of this study for find the transverse bend strength and elastic modulus of pure, dense aluminum oxide particles.

CHAPTER 3

AIM AND SCOPE OF THE PRESENT INVESTIGATION

The aim of this project to provide a material for automotive with good mechanical strength and less weight that observed by tensile strength. The automobile polymer composite materials market is assumed to grow at a CAGR of 4% or higher during the forecast period. One of the basic market drivers is the notable increase in the use of plastics in automobile construction. The market also benefits from the increasing adoption of battery vehicles in countries such as Europe, China and North America. However, the slowdown in the global automobile factory is assumed to slow down the automobile polymer composite materials market due to lower demand. It is estimated that the Asia-Pacific region dominates the market, with the biggest expenditure coming from countries such as India, China, Japan and South Korea. However, Africa is growing beyond the small scale and should see better growth over the forecast period.

CHAPTER 4

SELECTION OF MATERIALS AND EXPERIMENTAL METHOD

4.1 Al_2O_3 (ALUMINUM OXIDE)

Al_2O_3 is an inorganic chemical reagent whose compound name is aluminum oxide. I bought it from Nice Chemical. Al_2O_3 has a molecular weight of 101.96. Its solubility in H_2O (Water) - maximum 0.05%, SO_4 (Sulphate) – maximum 0.05% and Fe (Iron) - maximum 0.02%. The following are the uses of Al_2O_3 exists Filler for varnishes and paints. Dental cement, glass and steel are used as catalysts for organic reactions.

4.2 PROPERTIES AND BENEFITS OF ALUMINUM OXIDE

With extra-ordinary chemical, mechanical and thermal qualities, alumina sets itself apart from many comparable materials by providing equivalent or greater results for low budget manufacturing and fabrication.

The following Properties of aluminum oxide has a boiling point of 2977 degree celcius (5391 degree Fahrenheit, 3250 Kelvin), a melting point of 2072°C (3762° Fahrenheit, 2345 Kelvin), a hardness of 15 Gigapascals - 19 Gigapascals (9 on the Mohs scale), mechanical strength is 300 Megapascals to 630 Megapascals, resistivity is 1012 Ωm to 1013 Ωm , density is 3.95 g/cm³, compressive strength is 2000 Megapascals to 4000 Megapascals, molecular weight is 101.96 g/mol, thermal conductivity is 20 W/mK to 30 W/mK, and the exterior is solid.

Some applications of alumina are medical industries, military and protective equipment's, electrical and electronic industries, gem industries and other factory works.

4.3 EPOXY (LY.556)

Huntsman's Araldite LY 556 is an unmodified, normal viscosity bisphenol-A based epoxy resin. It has good mechanical properties and chemical resistance and can be varied widely with various hardeners and fillers. LY 556 Epoxy has a low propensity to crystallize. Buy from Sakthi Traders in Saidapet, Chennai. Before mixing the components to achieve the exact rate of mixture 2: 1, casually measure out that two Parts of the Epoxy Resin to one part of the hardener before mixing the substances.

4.4 SEBS (STYRENE – ETHYLENE – BUTYLENE - STYRENE)

SEBS is a good thermoplastic elastomer (TPE) that acts like rubber without exposing vulcanization. SEBS is a strong, flexible, warm, ultraviolet resistance and is very easy to handle. It is carried out using a portion and finicky hydrogenation of Styrene – Butadiene - Styrene (SBS) co-polymer that enhances temperature stability, weatherability, and oil resistance, and it's also SEBS steam sterilization. However, hydrogenation make lower mechanical properties and it's also increasing polymeric expenses.

SEBS elastomers are frequently combined with other polymer materials to improve their production and performance. They are provided as effective modifiers for engineering thermo-plastics and as plasticizers/hardeners for transparent Polypropylene (PP). Frequently, oils and fillers are joined to reduce costs and to additionally alter properties. Major applications include melt pressure sensitive adhesives, toys, shoe soles and TPE modified bitumen materials for slating and fabricating applications.

4.5 GLASS-FIBER SHEETS

Fiberglass (or fiberglass) is a material made up of many extremely fine glass fibers. Glass fibers have almost the same mechanical properties as compared to other fibers such as polymer materials and carbon fibres. While compared to carbon fiber, not as stiff, it is low cost and remarkably low brittle when worked in composite materials. Glass fibers are provided as polymer materials reinforcement in several areas such as aero-space field, automotive, marine field, sporting goods and recreational goods, building works and civil engineering. One of the main benefits of using glass fibers for polymer materials reinforcement is their high performance-to-cost ratio.

4.6 TOLUENE

Rectified Toluene ($C_6H_5CH_3$ or C_7H_8) Colorless liquid from the aromatic group of hydrocarbons of petroleum, obtained by catalytic performing of petroleum napsa containing methyl-cyclo-hexane. Luxury gasoline blend, solvent and chemical

intermediate base for TNT. Toluene is a good flammable substance with a 4.4 degree Celsius of flash point. Toluene and these products containing it may make explosive mixtures with smoke at room temperature. Toluene is an understandable, colorless substance with a characteristic odor. Toluene obtains from naturally in the tolu plant and the crude oil. It is also manufactured when producing the gasoline and other fuels from the producing coke and the crude oil. Toluene is provided in the manufacture of paints, thinner of paints, nail polishes, lacquers, adhesives, and rubbers, as well as in similar printing and tanning synthesis. As a solvent in few paint thinners, some glues, permanent markers and contact cements and toluene sometimes provided as a recreational inhaler and can cause serious neurological damage.

4.7 SYNTHESIS OF FIBER REINFORCED POLYMER COMPOSITE

SEBS is the polystyrene material which is mixed with the solvent named Toluene. Here 10g of SEBS is dissolved in 100 ml toluene for 4 hours which have been in colloidal state. Then 10g of SEBS is added with the solvent since it didn't attain its expected state. In order, attain its expected state 20g of SEBS is dissolved in beaker. And, finally a mixture of 50g SEBS with 250ml of toluene was taken in a beaker.

The glass fibre sheets which weighs 200g for 9 sheets and each has 0.5 mm of thickness. The compositions like Epoxy resin 200 g which is in the ratio of 1:1 with respect to the glass fibre. Similarly, the hardener is 20g and Al_2O_3 is 5g are in the ratio of 1:10 and 1:40 respectively. An Epoxy, hardener and Al_2O_3 is taken in another beaker. Both the beakers are mixed to used it as a bonding agent and strengthening the FRP composites. Pasting taken glass fiber sheets by using this mixed bonding agent. And it was compressed or laminated by Compression Moulding Method in Composite technology centre, IIT-M. Compression moulding is an easy moulding process when compared to others, in which a providing substance is deposited into straighten out, heated mould cavity. The mould is then finished with a top stopper and laminated with huge hydraulic presses in order have the substance contact all region of the mould. The expect heals in the heated mould.

CHAPTER 5

CHARACTERISATION

5.1 TENSILE STRENGTH

Tensile strength, the maximum load a specimen can be withstood absence of damage when the material is extended cleave by its true cross-sectional area. Tensile strength is measured in F/A (Force per unit Area) and is usually indicated in pounds per square inch in the English language system of measurement, frequently shortened to psi. When a tensile strength more than its stress is pulled out, the specimen fully or partly returns to its true size and shape. However, when the stress holds out its tensile strength value, if the material is ductile but has before started plastic flow, it quickly shapes a narrow area called a neck and then collapses.

5.2 FTIR ANALYSIS

FTIR (Fourier Transform Infrared), the favoured infrared spectroscopy method. When infrared radiation passes by way of specimen, any of the radiations are absorbed by the specimen and some travels by way (transmitted). The gesture received at the sensor is a frequency spectrum that represents the molecular "fingerprint" of the specimen. The neatness of infrared spectroscopy stems from the fact that distinct structure of molecules (chemicals) makes dissimilar spectral fingerprints. FTIR envelops a maximum area of benefits in chemicals, specifically for organic compounds and polymers.

5.3 WATER ABSORPTION TEST

Water absorption test is a method that determines the water content of the soil as a proportion of its weight of dry material. Weigh the sample, dry it in the oven, and immediately after cooling, the specimen is weighed again under quality conditions. The specimen is then placed in water, often at 23°C, under admitted conditions for a day otherwise up to equilibrium is established. Absorption rate is determined as the quantity of water sucked by a specimen and is evaluated as the percentage of the

mass of absorbed water to the mass of the dry specimen. Therefore, Water absorption = $[(W_1 - W_2) / W_2] \times 100\%$, where, W_1 is weight of sample after water absorption and W_2 is weight of the sample before water absorption.

CHAPTER 6

RESULT AND DISCUSSION

The stress-strain properties of a SEBS-Epoxy resin with Al_2O_3 are given in Table 6.1. Young's modulus, also known as the tensile modulus or elastic modulus, is a measure of the stiffness of an elastic material and is a quantity used to characterize materials. Young's modulus may have different values depending on the direction of the applied force with respect to the structure. As tensile stress is applied to the composite material, elongation of material takes place. Elongation is inversely proportional to hardness, tensile strength and elastic modulus of the material. A stress-strain curve is drawn to find the ultimate tensile strength and elastic modulus. In general, the stress in a composite material is defined as the change in the internal energy with respect to the strain per unit volume. The flexural strength is one of the important properties for composites mainly used in quantifying structural applications.

Styrene Ethylene Butylene Styrene 50 gm which is combined with the 250 ml of Toluene solvent and it takes several times for dissolve. And, nine sheet of glass fibers was taken and the weight of hole sheets are 200gms. Then, 5 gm of aluminum oxide is mixed with the mixture of 200 gm epoxy matrix and 20 gm of hardener. Epoxy resin was taken by the equal ratio of glass fiber weight and hardener was taken by the 10% of epoxy resin. The two taken solutions are mixed together. Now, the glass fibers are coated and pasted layer by layer, at the mixture of the solution. The pasted materials are laminated by the Thermal Compression molding method through 80°C .

6.1 TENSILE STRENGTH ANALYSIS

The final material was cut by the water cut method, at the size of 30 cm height and 2.7 cm width for tensile strength method in Composite Technology Center, IIT-M. The specimen was fixed into the UTM perfectly, and applied pressure under room temperature. The reading was measured until the material was cracked. And perfectly the graph was drawn by the readings are plotted. Here the sample details and readings are given:

Type of material	Width (mm)	Thickness (mm)	Gauge length	Area (mm ²)	Max. Load (KN)	Tensile Strength (MPa)	Tensile Modulus (GPa)	Failure strain (%)
Glass fiber reinforced SEBS-Al ₂ O ₃	25.1	2.7	50	67.77	5.08	74.95942	17.9	35.4

Table 6.1

Tensile strength, Tensile modulus and failure strain data of Glass fiber reinforced SEBS-Al₂O₃ polymer composites

Disp (mm)	Load (kN)	Strain (mm/mm)	Stress (MPa)
0	0.82	0	12.09975
0.001	0.82	0.00001	12.09975
0.002	0.84	0.00002	12.39486
0.003	0.86	0.00003	12.68998
0.004	0.88	0.00004	12.9851
0.005	0.88	0.00005	12.9851
0.006	0.9	0.00006	13.28021
0.007	0.92	0.00007	13.57533
0.008	0.94	0.00008	13.87044
0.009	0.94	0.00009	13.87044
0.01	0.96	0.0001	14.16556
0.011	0.96	0.00011	14.16556
0.012	0.98	0.00012	14.46068
0.013	1	0.00013	14.75579
0.014	1.02	0.00014	15.05091
0.015	1.04	0.00015	15.34602
0.016	1.04	0.00016	15.34602
0.017	1.06	0.00017	15.64114
0.018	1.06	0.00018	15.64114
0.019	1.08	0.00019	15.93625
0.02	1.1	0.0002	16.23137
0.021	1.1	0.00021	16.23137
0.022	1.12	0.00022	16.52649

0.023	1.14	0.00023	16.8216
0.024	1.14	0.00024	16.8216
0.025	1.16	0.00025	17.11672
0.026	1.18	0.00026	17.41183
0.027	1.18	0.00027	17.41183
0.028	1.2	0.00028	17.70695
0.029	1.24	0.00029	18.29718
0.03	1.24	0.0003	18.29718
0.031	1.26	0.00031	18.5923
0.032	1.26	0.00032	18.5923
0.033	1.28	0.00033	18.88741
0.034	1.28	0.00034	18.88741
0.035	1.28	0.00035	18.88741
0.036	1.32	0.00036	19.47764
0.037	1.32	0.00037	19.47764
0.038	1.34	0.00038	19.77276
0.039	1.34	0.00039	19.77276
0.04	1.36	0.0004	20.06788
0.041	1.38	0.00041	20.36299
0.042	1.38	0.00042	20.36299
0.043	1.38	0.00043	20.36299
0.044	1.42	0.00044	20.95322
0.045	1.42	0.00045	20.95322
0.046	1.44	0.00046	21.24834
0.047	1.46	0.00047	21.54346
0.048	1.46	0.00048	21.54346
0.049	1.46	0.00049	21.54346
0.05	1.48	0.0005	21.83857
0.051	1.48	0.00051	21.83857
0.052	1.5	0.00052	22.13369
0.053	1.52	0.00053	22.4288
0.054	1.52	0.00054	22.4288
0.055	1.54	0.00055	22.72392
0.056	1.56	0.00056	23.01903
0.057	1.58	0.00057	23.31415
0.058	1.58	0.00058	23.31415
0.059	1.58	0.00059	23.31415

0.06	1.6	0.0006	23.60927
0.061	1.62	0.00061	23.90438
0.062	1.64	0.00062	24.1995
0.063	1.66	0.00063	24.49461
0.064	1.66	0.00064	24.49461
0.065	1.68	0.00065	24.78973
0.066	1.68	0.00066	24.78973
0.067	1.7	0.00067	25.08485
0.068	1.72	0.00068	25.37996
0.069	1.72	0.00069	25.37996
0.07	1.74	0.0007	25.67508
0.072	1.76	0.00072	25.97019
0.073	1.78	0.00073	26.26531
0.074	1.78	0.00074	26.26531
0.075	1.78	0.00075	26.26531
0.076	1.82	0.00076	26.85554
0.077	1.82	0.00077	26.85554
0.078	1.84	0.00078	27.15066
0.079	1.86	0.00079	27.44577
0.08	1.86	0.0008	27.44577
0.081	1.88	0.00081	27.74089
0.082	1.88	0.00082	27.74089
0.083	1.9	0.00083	28.036
0.084	1.92	0.00084	28.33112
0.085	1.92	0.00085	28.33112
0.086	1.94	0.00086	28.62624
0.087	1.94	0.00087	28.62624
0.088	1.96	0.00088	28.92135
0.09	2	0.0009	29.51158
0.091	2	0.00091	29.51158
0.092	2.02	0.00092	29.8067
0.093	2.04	0.00093	30.10181
0.094	2.06	0.00094	30.39693
0.095	2.06	0.00095	30.39693
0.096	2.06	0.00096	30.39693
0.097	2.08	0.00097	30.69205
0.098	2.08	0.00098	30.69205

0.099	2.1	0.00099	30.98716
0.1	2.12	0.001	31.28228
0.101	2.12	0.00101	31.28228
0.102	2.14	0.00102	31.57739
0.103	2.14	0.00103	31.57739
0.104	2.16	0.00104	31.87251
0.105	2.18	0.00105	32.16763
0.106	2.18	0.00106	32.16763
0.107	2.18	0.00107	32.16763
0.108	2.22	0.00108	32.75786
0.109	2.22	0.00109	32.75786
0.11	2.24	0.0011	33.05297
0.111	2.26	0.00111	33.34809
0.112	2.26	0.00112	33.34809
0.113	2.26	0.00113	33.34809
0.114	2.28	0.00114	33.6432
0.115	2.3	0.00115	33.93832
0.116	2.32	0.00116	34.23344
0.117	2.32	0.00117	34.23344
0.118	2.34	0.00118	34.52855
0.119	2.34	0.00119	34.52855
0.12	2.36	0.0012	34.82367
0.121	2.38	0.00121	35.11878
0.122	2.38	0.00122	35.11878
0.123	2.4	0.00123	35.4139
0.124	2.42	0.00124	35.70902
0.125	2.42	0.00125	35.70902
0.126	2.44	0.00126	36.00413
0.127	2.44	0.00127	36.00413
0.128	2.46	0.00128	36.29925
0.129	2.48	0.00129	36.59436
0.13	2.48	0.0013	36.59436
0.131	2.5	0.00131	36.88948
0.132	2.52	0.00132	37.18459
0.133	2.52	0.00133	37.18459
0.134	2.54	0.00134	37.47971
0.135	2.54	0.00135	37.47971

0.136	2.56	0.00136	37.77483
0.137	2.58	0.00137	38.06994
0.138	2.58	0.00138	38.06994
0.139	2.6	0.00139	38.36506
0.14	2.62	0.0014	38.66017
0.141	2.62	0.00141	38.66017
0.142	2.64	0.00142	38.95529
0.143	2.64	0.00143	38.95529
0.144	2.66	0.00144	39.25041
0.145	2.68	0.00145	39.54552
0.146	2.68	0.00146	39.54552
0.147	2.68	0.00147	39.54552
0.148	2.72	0.00148	40.13575
0.149	2.72	0.00149	40.13575
0.151	2.74	0.00151	40.43087
0.152	2.76	0.00152	40.72598
0.153	2.78	0.00153	41.0211
0.154	2.78	0.00154	41.0211
0.155	2.8	0.00155	41.31622
0.156	2.82	0.00156	41.61133
0.157	2.84	0.00157	41.90645
0.158	2.84	0.00158	41.90645
0.159	2.86	0.00159	42.20156
0.16	2.86	0.0016	42.20156
0.161	2.88	0.00161	42.49668
0.162	2.88	0.00162	42.49668
0.163	2.9	0.00163	42.7918
0.164	2.9	0.00164	42.7918
0.165	2.92	0.00165	43.08691
0.166	2.94	0.00166	43.38203
0.167	2.94	0.00167	43.38203
0.168	2.96	0.00168	43.67714
0.169	2.98	0.00169	43.97226
0.17	2.98	0.0017	43.97226
0.172	3.02	0.00172	44.56249
0.173	3.02	0.00173	44.56249
0.174	3.04	0.00174	44.85761

0.175	3.04	0.00175	44.85761
0.176	3.06	0.00176	45.15272
0.177	3.06	0.00177	45.15272
0.178	3.08	0.00178	45.44784
0.179	3.08	0.00179	45.44784
0.18	3.1	0.0018	45.74295
0.181	3.12	0.00181	46.03807
0.182	3.12	0.00182	46.03807
0.184	3.16	0.00184	46.6283
0.185	3.16	0.00185	46.6283
0.186	3.16	0.00186	46.6283
0.187	3.18	0.00187	46.92342
0.188	3.2	0.00188	47.21853
0.189	3.22	0.00189	47.51365
0.19	3.22	0.0019	47.51365
0.191	3.24	0.00191	47.80876
0.192	3.26	0.00192	48.10388
0.193	3.26	0.00193	48.10388
0.194	3.26	0.00194	48.10388
0.195	3.28	0.00195	48.399
0.196	3.3	0.00196	48.69411
0.197	3.3	0.00197	48.69411
0.198	3.32	0.00198	48.98923
0.199	3.32	0.00199	48.98923
0.2	3.34	0.002	49.28434
0.201	3.36	0.00201	49.57946
0.202	3.36	0.00202	49.57946
0.203	3.38	0.00203	49.87458
0.204	3.4	0.00204	50.16969
0.205	3.4	0.00205	50.16969
0.206	3.42	0.00206	50.46481
0.208	3.44	0.00208	50.75992
0.209	3.46	0.00209	51.05504
0.21	3.46	0.0021	51.05504
0.211	3.46	0.00211	51.05504
0.212	3.48	0.00212	51.35015
0.213	3.5	0.00213	51.64527

0.214	3.5	0.00214	51.64527
0.216	3.54	0.00216	52.2355
0.217	3.54	0.00217	52.2355
0.218	3.56	0.00218	52.53062
0.219	3.56	0.00219	52.53062
0.22	3.58	0.0022	52.82573
0.221	3.6	0.00221	53.12085
0.222	3.62	0.00222	53.41597
0.223	3.62	0.00223	53.41597
0.224	3.62	0.00224	53.41597
0.225	3.64	0.00225	53.71108
0.226	3.64	0.00226	53.71108
0.227	3.66	0.00227	54.0062
0.228	3.68	0.00228	54.30131
0.229	3.68	0.00229	54.30131
0.231	3.7	0.00231	54.59643
0.232	3.72	0.00232	54.89154
0.233	3.74	0.00233	55.18666
0.234	3.74	0.00234	55.18666
0.235	3.76	0.00235	55.48178
0.236	3.78	0.00236	55.77689
0.237	3.78	0.00237	55.77689
0.238	3.8	0.00238	56.07201
0.239	3.8	0.00239	56.07201
0.24	3.82	0.0024	56.36712
0.241	3.84	0.00241	56.66224
0.242	3.84	0.00242	56.66224
0.243	3.86	0.00243	56.95736
0.244	3.88	0.00244	57.25247
0.245	3.88	0.00245	57.25247
0.246	3.88	0.00246	57.25247
0.247	3.9	0.00247	57.54759
0.248	3.92	0.00248	57.8427
0.249	3.94	0.00249	58.13782
0.25	3.94	0.0025	58.13782
0.251	3.96	0.00251	58.43293
0.252	3.96	0.00252	58.43293

0.253	3.98	0.00253	58.72805
0.255	4	0.00255	59.02317
0.256	4	0.00256	59.02317
0.257	4.04	0.00257	59.6134
0.258	4.04	0.00258	59.6134
0.26	4.06	0.0026	59.90851
0.261	4.08	0.00261	60.20363
0.262	4.08	0.00262	60.20363
0.263	4.1	0.00263	60.49875
0.264	4.12	0.00264	60.79386
0.265	4.12	0.00265	60.79386
0.266	4.12	0.00266	60.79386
0.267	4.14	0.00267	61.08898
0.268	4.16	0.00268	61.38409
0.269	4.16	0.00269	61.38409
0.27	4.18	0.0027	61.67921
0.271	4.18	0.00271	61.67921
0.272	4.2	0.00272	61.97432
0.273	4.22	0.00273	62.26944
0.274	4.22	0.00274	62.26944
0.275	4.24	0.00275	62.56456
0.276	4.24	0.00276	62.56456
0.277	4.26	0.00277	62.85967
0.278	4.28	0.00278	63.15479
0.279	4.28	0.00279	63.15479
0.28	4.28	0.0028	63.15479
0.281	4.3	0.00281	63.4499
0.282	4.32	0.00282	63.74502
0.283	4.32	0.00283	63.74502
0.284	4.34	0.00284	64.04014
0.285	4.36	0.00285	64.33525
0.286	4.36	0.00286	64.33525
0.287	4.38	0.00287	64.63037
0.288	4.4	0.00288	64.92548
0.289	4.4	0.00289	64.92548
0.29	4.4	0.0029	64.92548
0.291	4.42	0.00291	65.2206

0.292	4.44	0.00292	65.51571
0.293	4.46	0.00293	65.81083
0.294	4.44	0.00294	65.51571
0.295	4.44	0.00295	65.51571
0.296	4.46	0.00296	65.81083
0.297	4.48	0.00297	66.10595
0.299	4.5	0.00299	66.40106
0.3	4.52	0.003	66.69618
0.301	4.52	0.00301	66.69618
0.303	4.54	0.00303	66.99129
0.304	4.56	0.00304	67.28641
0.305	4.58	0.00305	67.58153
0.306	4.58	0.00306	67.58153
0.307	4.6	0.00307	67.87664
0.309	4.62	0.00309	68.17176
0.311	4.64	0.00311	68.46687
0.312	4.66	0.00312	68.76199
0.313	4.66	0.00313	68.76199
0.314	4.68	0.00314	69.0571
0.315	4.7	0.00315	69.35222
0.316	4.7	0.00316	69.35222
0.317	4.7	0.00317	69.35222
0.318	4.72	0.00318	69.64734
0.319	4.74	0.00319	69.94245
0.32	4.74	0.0032	69.94245
0.321	4.74	0.00321	69.94245
0.322	4.76	0.00322	70.23757
0.323	4.78	0.00323	70.53268
0.324	4.78	0.00324	70.53268
0.325	4.8	0.00325	70.8278
0.326	4.8	0.00326	70.8278
0.328	4.82	0.00328	71.12292
0.329	4.84	0.00329	71.41803
0.33	4.86	0.0033	71.71315
0.331	4.86	0.00331	71.71315
0.332	4.86	0.00332	71.71315
0.333	4.88	0.00333	72.00826

0.335	4.88	0.00335	72.00826
0.336	4.9	0.00336	72.30338
0.337	4.92	0.00337	72.59849
0.338	4.94	0.00338	72.89361
0.339	4.94	0.00339	72.89361
0.34	4.96	0.0034	73.18873
0.341	4.98	0.00341	73.48384
0.342	4.98	0.00342	73.48384
0.343	4.98	0.00343	73.48384
0.344	5	0.00344	73.77896
0.346	5.02	0.00346	74.07407
0.347	5.02	0.00347	74.07407
0.348	5.04	0.00348	74.36919
0.349	5.04	0.00349	74.36919
0.35	5.06	0.0035	74.66431
0.351	5.06	0.00351	74.66431
0.352	5.06	0.00352	74.66431
0.353	5.08	0.00353	74.95942
0.354	5.08	0.00354	74.95942

Table 6.2

Stress and Strain data of SEBS-GF-Al₂O₃ fiber composites

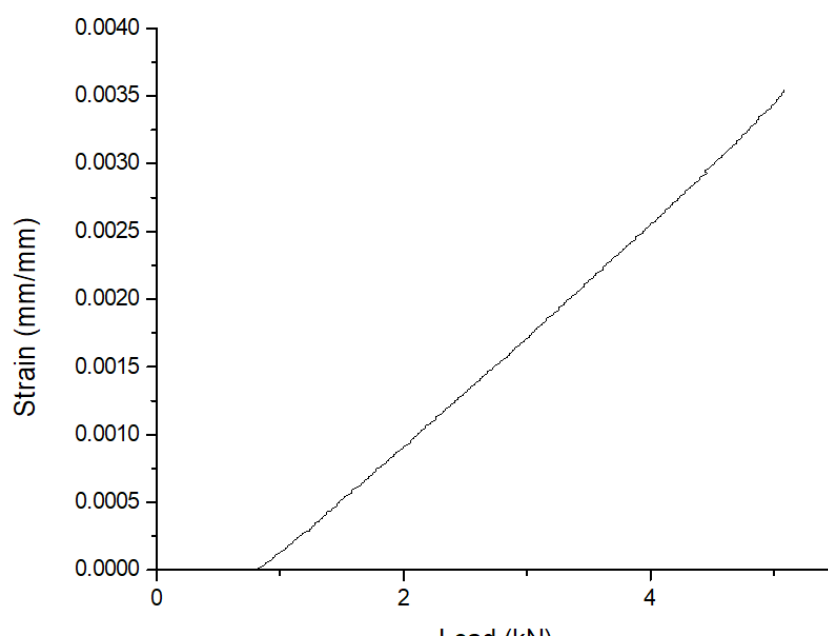


Fig. 6.1

Variation of strain with applied load on SEBS-Al₂O₃ polymer composites

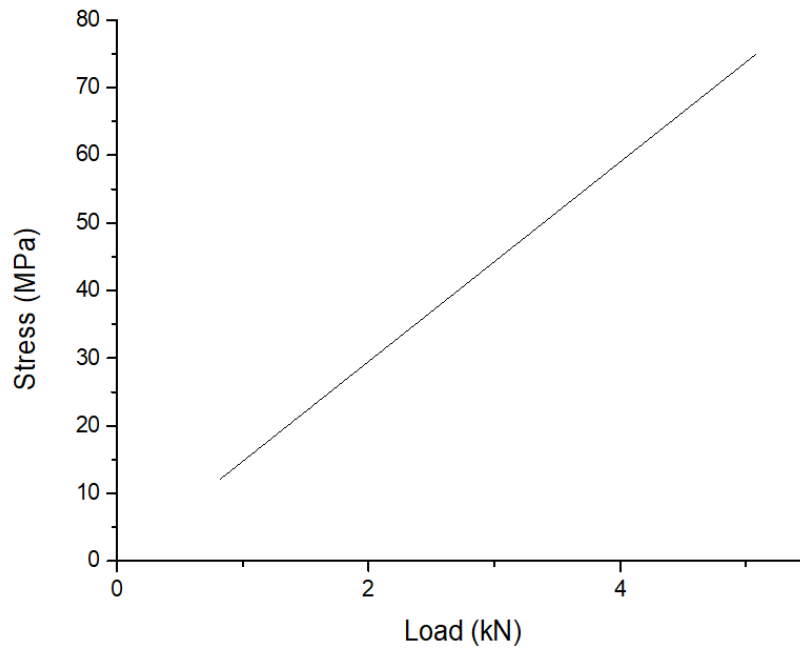


Fig. 6.2

Variation of stress with applied load on SEBS-Al₂O₃ polymer composites

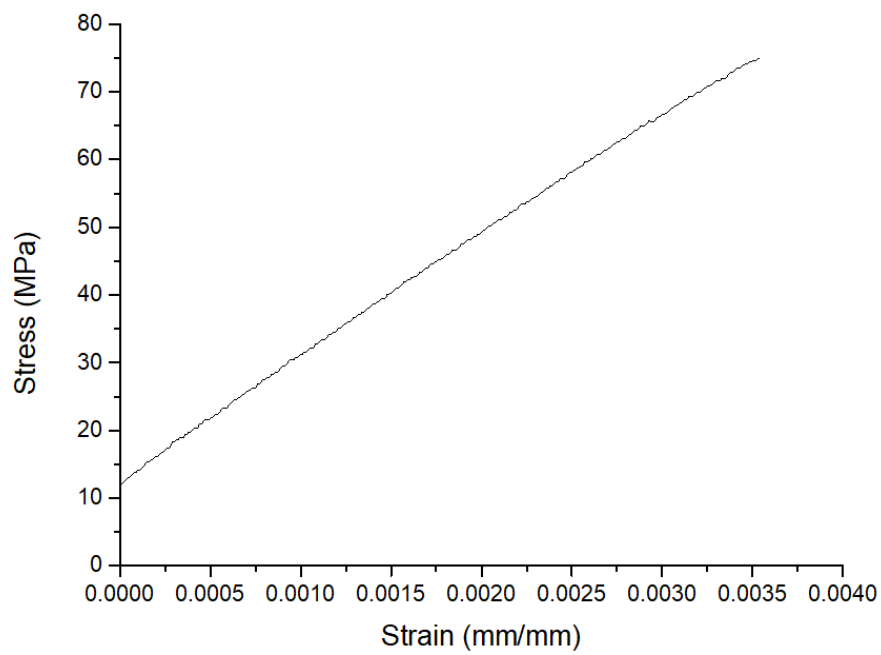


Fig. 6.3

Variation of stress with strain on SEBS-Al₂O₃ polymer composites

Failure mechanism of the polymer composite material is a recent field of study and also one of the important points to discuss in material engineering. Stress-strain analysis the recent ongoing studies in composite materials to find their breaking points. It is found that the failure mechanism depends on the applied stress. Also, the direction of applied stress is relative to the direction of fibre reinforced in the matrix. Hence it is necessary to study the stress component and its analysis of the composite materials. The properties of polymer composites depend on the constituent material, fibre reinforcement, polymer matrix, size of the fibre and its geometry.

Test specimens were taken from the composite sheets. Unidirectional tensile specimens were cut out of the laminates in both fibre and matrix directions according to ASTM D3039. Breaking load of different composites were determined from the stress-strain diagram. Mechanical tests often involve the deformation or breakage of samples of a material called test specimen. The specimen size was 260 mm×24 mm×4mm. The different composite specimen samples were tested in the Universal Testing Machine (UTM) and in each case, the material was allowed to break to find the ultimate tensile strength. For all graphs we see a linear behavior. In the next Figure1-3, we compare the real strain and the experimental data obtained. The variations in the graph are because of the intermittent failure of the fibers and the matrix. Because of the presence of higher number of fibers in the tow, the maximum stress that the test coupon can withstand is relatively higher thus making these test coupons suitable for manufacturing structural components that require higher strength. Composite structures are carefully designed and analyzed by comparing the stress and strains in the structure due to applied loads with permissible limits of stress and strains of the material being used. There are several failure prediction models specially designed for unidirectional composites. The following are some of the failure models/theories that are used. 1) Maximum Stress Theory 2) Maximum Strain Theory 3) Azzi-Tsai-Hill Theory 4) Tsai-Wu Failure Theory. However, the predictions for woven composites made using the above theories were just an approximation. The deformation mainly concentrated near the fracture crack or the

location of possible failure, while the strain far from the fracture crack or the location of possible failure changed a little. It could be seen that the fracture strain of fiber composites was larger than the ultimate average strain of the parallel length region at the same strain rate. In addition, the deviation between them was becoming more obvious due to the strain localization with the tensile processed.

The stress-strain graph of the composite shows a ductile/brittle nature. The effect of strain rate on stress-strain behavior of composite materials measured at room temperature and it shows that the mechanical property of the material strongly depends on the rate of strain. The variation of stress-strain for the glass-reinforced SEBS-polymer doped with Al₂O₃ material is shown in Figure 1-3. When a polymer composite has been subjected to a tensile test, it passes various stages before fracture

This variation of mechanical properties of composites depends mainly on the microstructure and the interface morphology of the polymer matrix and the materials which includes the interfacial bonding, size and spatial distribution of the particles into the polymer matrix. When there is poor bonding interaction between the polymer matrix and particles, the composite becomes brittle as the applied load may not be transferred to the reinforcements.

6.2 WATER ABSORPTION BEHAVIOR AND ITS EFFECT ON THE MECHANICAL PROPERTIES OF FIBRE REINFORCED COMPOSITES

To study the behavior of water absorption of the fibre reinforced composites, water absorption tests were carried out. Composite samples were immersed in a water bath during a time period until the saturation was reached. At different periods of time, the percentage of weight gain was calculated and it was plotted versus square root of water immersion time. As a result, the average value was reported. The difference of weight between the sample in dry conditions and that after water immersion at time was obtained as follows: where is the weight of the sample at time during water immersion and is the weight of the dry sample at initial time. And, it is calculated by the formula, **Water absorption = $[(W_1 - W_2) / W_2] \times 100\%$** .

Water is predominantly absorbed at the fiber interface and matrix. As evident

from Fig. 4 that water content of the composite increased with time and became a constant. It is found that specimens absorbed water is shown in Table 6.3. Let, W_1 be the weight of specimen before immersing them in water. Let W_2 be the weight of specimen after immersing them in water for 1 hr. Let W_3 be the weight of specimen after immersing them in water for 2 hrs.

S. No.	Length of the specimen (cm)	Weight of the specimen before soaked in water (W_1 .g)	Weight of the specimen after soaked in water for 1 hr (W_2 .g)	Weight of the specimen after soaked in water for 2 hrs (W_3 .g)	$W_2/W_1 \times 100\%$	$W_3/W_1 \times 100\%$
1	5	4.16	4.92	4.98	18.27	19.71
2	10	8.40	8.78	8.82	4.52	5
3	15	13.84	14.58	14.68	5.35	6.07

Table 6.3

Data of water absorption test of SEBS-GF- Al_2O_3 reinforced polymer composites

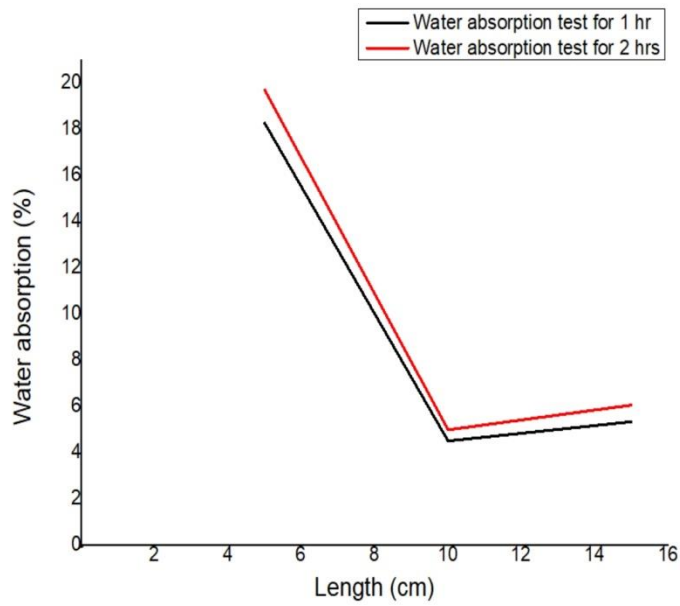


Figure 6.4
Variation of water absorption with different length of SEBS-Al₂O₃ composite laminates

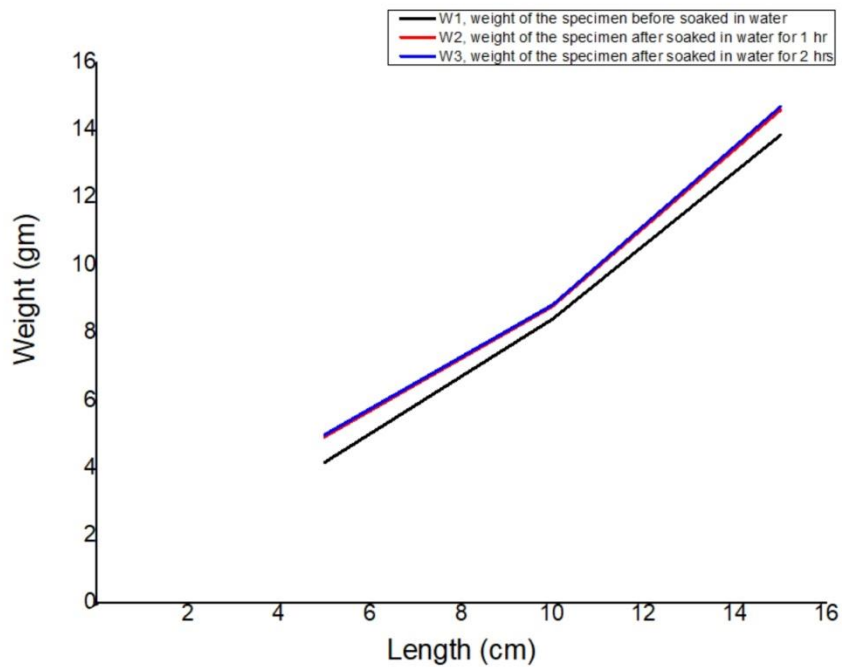


Figure 6.5
Variation of weight of composites with different length of SEBS-

Al₂O₃ composite laminates

The water absorption changes of BFRP laminates were mainly affected by water immersion and hydrolysis of epoxy resin. When the mass gain of epoxy matrix from water immersion was less than the mass loss of epoxy resin due to the hydrolysis, the water absorption of BFRP laminates began to decline. As the degree of hydrolysis of epoxy resin increased, the water absorption of aged BFRP laminates were lower than that without ageing. This abnormal water absorption behavior (i.e., the decline in water absorption after reaching its peak water absorption) was also reported in the other literature.

6.3 FTIR ANALYSIS OF SEBS- Al₂O₃ FIBER REINFORCED COMPOSITES

Infrared spectroscopy has been a workhorse technique for materials analysis. An infrared spectrum represents a absorption peaks which correspond to the frequencies of vibrations between the bonds of the atoms making up the material. Because each different material is a unique combination of atoms, no two compounds produce the exact same infrared spectrum. Therefore, infrared spectroscopy can result in a positive identification of every different kind of material. In addition, the size of the peaks in the spectrum is a direct indication of the amount of material present. With modern software algorithms, infrared is an excellent tool for quantitative analysis.

The chemical bonds in compounds absorb the infrared (IR) energy at given specific wavelengths (frequencies). With the help of FTIR the basic structure of any compound can be obtained with the help of spectral locations of their infrared absorption frequencies. The major advantage of using FTIR spectrometer for providing better sensitivity This capability of FTIR spectroscopy allows rapid analysis of even micro samples to the Nano gram (nano) level in some cases; it makes the FTIR technique unmatched for problem solving tool in organic and inorganic compound analysis.

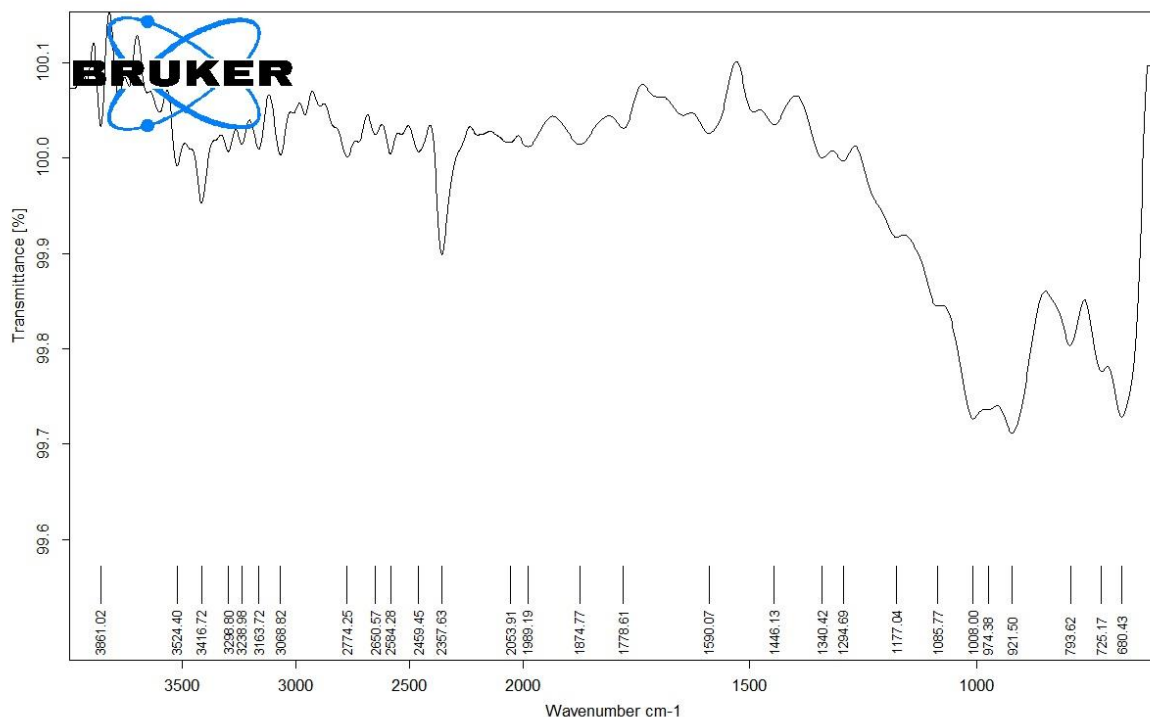


Figure 6.6

FTIR spectroscopic analysis of SEBS-Al₂O₃ GF reinforced polymer composites

From the above graphs we see that presence of peaks in the range of 680 cm^{-1} and 980 cm^{-1} shows the presence of single bonds of C-H, the range of 1000 - 1100, shows the presence of double bonds of C=O, the presence of peak in the range of 2700- 3000 cm^{-1} shows the presence of C-H functional group in composite. Because there is no linear slope in graph between 2500 - 3000, it shows that there is no triple bond functional group is available in the composite. And the peak observed at 3524 cm^{-1} is due to NH bonding. The details of peaks were observed were given in the Table 6.4.

S. No	Wavenumber (cm^{-1})	Vibrational bond analysis
1	3524	NH Stretching
2	3416	Hydroxyl group (-OH) Stretching
3	3068	C-H Stretching
4	2774	C-H Stretching

5	2357	Si-C Stretching
6	1177	C-O Stretching
7	1085	C-O Stretching
8	1008	C-O Stretching
9	974	C-H Plane bending
10	921	Vinyl group (H-C=CH ₂)
11	680	C-H Bending

Table 6.4
FTIR spectroscopic data analysis of SEBS- Al₂O₃ GF reinforced polymer composites.

CHAPTER 7

CONCLUSION

The stress-strain characterization and failure pattern of glass fibre reinforced-SEBS laminates with Al_2O_3 materials under different loading conditions have been investigated. The stress-strain behavior of laminates under different loads is measured until the breaking point. It varies depending on the filler reinforcements. Water absorption test and FTIR analysis is also carried out. The following conclusions were made.

- ❖ SEBS-Glass fiber reinforced polymer composites, doped with Al_2O_3 were synthesized by thermal compression molding method with a thickness of 2.7mm.
- ❖ Tensile properties, water absorption and FTIR studies were carried out for polymer composites doped with Al_2O_3 and the tensile strength of a new composite material is found as 74.96 MPa.
- ❖ The resulting fiber contents exhibits a significant and direct influence on the mechanical behaviour and the ultimate strengths of samples – one observed that the higher is the fiber content the higher is the ultimate strength (and elastic stiffness).
- ❖ Failure strain was also measured for the composites.
- ❖ Water absorption of behavior is also measured at different length with different soaking time and it was found that it is less with increase in length.
- ❖ Strain rate effects in fiber-reinforced polymer composites can be divided into two categories: one is the rate-dependent deformation of composite before strain softening and the strain rate-dependent failure process inside the failure zone.
- ❖ There exists an inconsistent experimental result about the influence of the strain rate on the deformation properties and the fracture energy of composites.
- ❖ Further comparison to spectral point positions of the present study indicates that the polymer matrix is also strengthened by the bonds, like C-H, C-O and C-C stretching bonds.

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