COMPOSITE MATERIALS AND APPLICATIONS

Dr. Aravinda T
Dr. Yuvaraja Naik
Dr. Udaya Ravi M

BOOKS ARCADE

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KRISHNA NAGAR, DELHI

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BOOKS ARCADE

Regd. Office:
F-10/24, East Krishna Nagar, Near Vijay Chowk, Delhi-110051
Ph. No: +91-11-79669196, +91-9899073222
E-mail: info@booksarcade.co.in, booksarcade.pub@gmail.com
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CHAPTER 1

INTRODUCTION TO COMPOSITE MATERIALS

Dr. Aravinda T
Assistant Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India
Email Id-aravinda@presidencyuniversity.in

The aerospace, maritime, transportation, electric, chemical, building, and consumer products industries all use fiber reinforced composites more and more. In order to assemble the units and components inside the structure, pass cables and control mechanisms, and perform inspections, maintenance, and attachment to other units, the composite constructions may occasionally include various sorts of holes. The vibration analysis acquires significant relevance in practical applications[1]. For instance, it has been widely studied how several elements, such as suspension design, vehicle weight and speed, damping, matching between the inherent frequencies of the bridge and the vehicle, deck roughness, etc., affect the dynamic behavior of such structures. Future scientific study will definitely continue to focus heavily on this issue since new, higher-quality materials may be used to build lighter, more slender structures, which are more susceptible to dynamic stresses in general and moving loads in particular. Every structure with some mass and flexibility vibrates, according to this definition. The structure fails when the amplitude of these vibrations goes over the allowable limit. One must be aware of the operating frequencies of the materials under various situations, such as simply supported, fixed, or while under cantilever settings, in order to prevent such a problem[2].

Comments on the Past and Introduction: In the broadest sense, a compound is a substance made up of two or more basic materials or phases. Although traditional engineering materials like steel and aluminum contain impurities that can represent various phases of the same material and meet the broad definition of a composite, these materials are not regarded as composite materials because the elastic modulus or resilience of the secondary phases is essentially the same as that of the pure material. A composite material can be defined in a variety of ways to suit different needs. In this book, a composite material is one that has two or more separate constituents, each of which has a discrete interface and considerably different macroscopic behavior (on the microscopic level). This contains a range of composites that aren't expressly covered, as well as the continuous fiber laminated composites that are the main focus of this article[3].

Characteristics of a Composite Material: A composite material typically contains one or more discontinuity phases embedded within a single phase due to the way its component parts are organized. The continuous phase is known as the matrix, whereas the interrupted phase is called the reinforcement. Rubber-modified polymers are a family of materials made of rubber suspended particles in a stiff rubber matrix as an exception. The reinforcements are often more stiffer and stronger than the matrix. For the composite to work as intended, both components are necessary, and each must complete particular tasks.In general, a material is stronger and more rigid in its fiber form than in its bulk form. There are numerous tiny defects in bulk materials that serve as fracture starting sites[4].

Classification of Composite Materials

- **Fibrous:** Continuous (long) or chopped (whiskers) fibers are suspended in a matrix material to form a fibrous composite. From a geometric perspective, both continuous threads and whiskers may be recognized.
- **Continuous Fibers:** A continuous fiber has an extremely high length-to-diameter ratio, which is how it is geometrically defined. Compared to bulk material, they are often stiffer and stronger. Depending on the fiber, fiber diameters typically range from 0.00012 and 0.0074.
- **Whisker:** Generally speaking, a whisker is seen as a short, stubby fiber. It may be generically categorized as anything with a length-to-diameter ratio of 5 Z/d and above. The typical whisker diameter ranges from 0.787 to 3937 pin (0.02-100 pm).

It is possible to create composites with reinforcements made of discontinuous fibers or whiskers that are oriented randomly or biasedly. Single layer composites are material systems made up of discontinuous reinforcements. Although the discontinuities have the potential to result in an anisotropic material response, the random reinforcements frequently lead to composites that are almost isotropic. Composites made of continuous fibers can be single or stacked. Multilayered composites are typically referred to as laminates, while single layer continuous fiber composites might be unidirectional or woven. A continuous fiber composite often exhibits orthotropic material response. Diagrams showing the two different forms of fibrous composites[5].

Basic Terminology for Composite Materials:

The definitions provided here include some of the more popular words used with composite materials.

- **Lamina:** A flat (or occasionally curved) arrangement of woven or unidirectional fibres floating in a matrix material is known as a lamina. A lamina is often thought to be orthotropic, and the material used to create it affects how thick it is. For instance, the thickness of a graphite/epoxy lamina (graphite fibres embedded in an epoxy matrix) might be in the range of 0.005 in (0.127 mm)[6].
- **Reinforcements:** To make the composite construction or component stronger, reinforcements are applied. Although boron, glass, graphite (often referred to as just carbon), and Kevlar are the most often used reinforcements, there are other kinds as well, including alumina, aluminium, silicon carbide, silicon nitride, and titanium.
- **Fibers:** A unique type of reinforcement, fibres. They typically have continuous construction and widths between 120 and 7400 pin (3-200 pm). Unlike the same material in bulk form, which is often linear elastic or elastic-perfectly plastic, fibres are frequently stronger and stiffer. The four fibres that are most frequently utilised are Kevlar, glass, carbon, and boron. The science of fibre and whiskers is evolving constantly.

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CHAPTER 2

CLASSIFICATION OF MATRIX

Dr. Aravinda T
Assistant Professor,Department of Mechanical Engineering,
Presidency University, Bangalore, India
Email Id-aravinda@presidencyuniversity.in

Matrix

The matrix is the binder substance that holds the fibers in place while keeping them separate and safe. In the case of fiber breakage, it offers a route via which load is both supplied to the fibers and redistributed among them. Generally speaking, the matrix is less stiff, dense, and strong than the fibers. Matrices can be plastic, elastic, brittle, or ductile. Both linear and nonlinear stress-strain behavior is possible with them. Additionally, at some point during the creation of the composite, the matrix material must be able to be pushed around the reinforcement. To achieve adequate adherence to the matrix, fibers are frequently chemically treated. Carbon, glass, ceramic, metal, and polymeric matrices are the most often utilized materials. Each has unique appeal, practicality, and restrictions[1].

Carbon Matrix: The heat capacity of a carbon matrix is high per unit of weight. They have served as clutch and brake pad for aero planes as well as rocket nozzles, adjuvant shields for recovery vehicles, and rocket nozzles.

Ceramic Matrix: Ceramic matrixes are frequently fragile. In locations where harsh conditions (high temperatures, etc.) are predicted, ceramic matrices are frequently employed with carbon, ceramic, metal, and glass fibers[2].

Glass Matrix: Compared to the reinforcement, the elastic modulus of glass and composites based is often substantially lower. The most popular types of reinforcement used in glass matrix composites are carbon and metallic oxide fibers. The strength of glass or composites with ceramic matrix at high service temperature is their finest quality.

In a composite system, the idea of hybrid or mixed fiber refers to the idea of blending materials to maximize their value. As opposed to using a single fiber species, mixing two or more kinds of fiber in one matrix enables much more precise customization of composite qualities to meet particular requirements. Since traditional building materials like wood, metal, and reinforced concrete have restricted features, fiber reinforced polymer composites have attracted a lot of interest in recent years due to their distinctive and adaptable qualities. Low cost, light weight, strong mechanical capabilities, simplicity of installation, good process ability, comparatively good durability against environmental agents and fatigue, etc., are some of the diverse qualities of composite materials[3].They are widely utilized as construction materials for anything from spacecraft to homes, electric packages to medical equipment, and automotive and aviation components[4].

Composites are materials that combine several types of materials while retaining the unique characteristics of each component. Glass fibers are presently the most used synthetic fibers because of their low cost and physically and mechanically superior characteristics. When silica-based or other glass compositions are extruded into a large number of fibers with tiny diameters suitable for textile production, glass fibers are created. Because of its superior mechanical qualities, low cost, renewable nature, and significantly lower processing energy demand, jute is an appealing natural fiber for use as reinforcement in composites. It is extensively produced in tropical regions.In the manufacture of composite materials, it has already been highlighted as a prospective contender for reinforcing agent, with Bangladesh, India, and Latin America. Hessian cloth, another name for jute materials[5]. Á-cellulose, hemicelluloses, and lignin are the major components of jute. It may be feasible to develop a material that combines the benefits of the individual elements while simultaneously minimizing their less desired properties by combining two or more types of fiber in a resin to create a hybrid composite. Additionally, it should be feasible to modify these materials' qualities to meet certain needs. Both closely blending the fibers in a single matrix and laminating different layers of each kind of composite are effective approaches to create hybrid fiber reinforced materials.The last several years have seen a large amount of study into the many characteristics of jute/glass fiber hybrid composites that were made for home use, including their physical, mechanical, electrical, thermal, and structural characteristics[6].

Various places of the world have conducted considerable quantities of study. A overview of the published research on jute/glass fiber based polymer matrix hybrid composites may be found in this section. The matrix might be made of metal, ceramic, or polymer, while the reinforcement could be made of organic or inorganic materials like carbon nanotubes, glass fibers, or natural fibers. The development of composite materials has been primarily driven by the final reason. Fibers and plastics with certain great physical and mechanical qualities are mixed in fiber reinforced plastics to create a material with a novel and superior property.Plastics may be brittle or ductile, but they often exhibit high chemical resistance. A bulk material with strength and stiffness similar to fibers and the chemical resistance of plastic is created by mixing fiber and resin. Additionally, it is feasible to develop some crack-propagation resistance and the capacity to withstand energy deformation. The main wall and the secondary wall (S), which are both composed of the three layers, make up the cell wall of a fiber (S1, S2 and S3).A properly carded jute textile filament is a dead tissue made up of 20 to 80 fiber cells that range in size from 10 to 100 mm in length and 0.03 to 0.06 mm in width.

Fiber-reinforced polymers, which are widely utilized in materials for structural and nonstructural purposes, are reinforced with glass, carbon, Kevlar, and boron fibers. Plant-based natural fibers with high strength, such as jute, bamboo, coir, sisal, and pineapple, can be used for a variety of load-bearing applications. Jute fiber's primary structural component is cellulose, which is totally contained within the cell units. In contrast, lignin and hemicelluloses are dispersed throughout the whole fiber body and act as a cementing agent.

The definition of jute reinforced composite was the insemination of jute fiber with monomer, followed by polymerized. Cross-linked polymer is created using this technique. The quality of the jute, the monomer, the oligomer, and the specifics of the processing all affect the product's properties. Glass fiber's characteristics are similar to those of other fibers like carbon fiber and polymer fiber. Although not as hard or strong as carbon fiber, it is substantially less brittle and much cheaper [7]**.**

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CHAPTER 3

APPLICATION OF FABRICATION

Dr. Aravinda T
Assistant Professor,Department of Mechanical Engineering,
Presidency University, Bangalore, India
Email Id-aravinda@presidencyuniversity.in

Fabrication

Contrarily, fabrication is the process of assembling several standardized produced structural steel pieces. The components are subsequently joined by welding, assembly, or "fabrication." Therefore, the goal of the entire fabrication process is to produce steel machines, buildings, and other similar components. Therefore, in a relative sense, fabrication might be considered a step in the manufacturing process for the overall steel structure, whereas manufacturing could be thought of as the production of steel structures. The aim of manufacturing is to produce steel components that can be quickly put together and then joined. While producing strong and durable structural steel components and structures is the aim of the fabrication process[1].Depending on the material and the intended final result, several fabrication manufacturing procedures are used. The method may be applied to both mass-produced goods and unique creations. The finished products are created from a broad variety of metals and their alloys, including, but not limited to, stainless steel, carbon steel, aluminum, copper, and brass. There is a good likelihood that one or more of the following techniques will be utilized to complete or construct a part or final product in industrial fabrication operations[2].

Common Techniques or Fabrication Types

Cutting: The splitting or cutting of a metal workpiece into smaller portions is a popular manufacturing method. Cutting may be the only step required in the process, the initial stage in a much longer manufacture process. Modern cutting techniques that make use of cutting-edge equipment have replaced the traditional method of sawing. Today's techniques include laser cutting, waterjet cutting, power scissors, and plasma arc cutting, from power tools to computer numerical computer (CNC) cutters[3].

Forming: Forming is a fabrication technique used in manufacturing to bend or twist metal to create parts and components. Rolling, a compressive technique involving CNC press brakes capable of producing up to 400 tonnes of pressure, is another way to shape metal. Continuously supplied strips or sheets of metal are formed into the required shape by parallel rollers. The metal substance only loses its shape during the forming process, not its mass[4].

Punching: Metals are punched or have holes drilled into them using mechanical devices called punch presses. Punching serves two purposes in the manufacturing process. Turrets that strike metal through or into a die are housed in a punch press. The metal is "punched" or given distinctively shaped holes as a consequence. The removed irregularly shaped portions that were punched out of the metal, known as blanks, can either be used as the final product or the holes can be used for fastening. Smaller and hand-powered punch presses are often mechanical in smaller fabrication firms. Industrial CNC-programmed presses are utilized in large-scale fabrication operations to generate complicated designs at higher output to fulfil both heavy and light metalwork requirements[5].

Shearing: Shearing is a technique for trimming or removing undesired material from metal by putting two blades above and below the metal to create a single, long, straight cut. The method is mostly used to cut shorter lengths and materials with irregular shapes; the blades can be positioned at an angle to lessen the needed shearing power. Combining two tools—basically, blades—with one tool placed above the metal and the other below for providing pressure allows for straight cuts. To break the piece and finish the separation, the top blade drives the metal down onto the fixed or stationary lower blade.

Stamping: Similar to punching, stamping makes an impression during production as opposed to a hole. The die is forced to stamp forms, letters, or pictures into the metal workpiece by the pressure of the turret on the metal. Metal sheets up to 6mm (1/4 inch) thick can be shaped into precise shapes and sizes using mechanical or hydraulic methods. Metal sheets can be cast, punched, cut, and shaped by stamping machines to make a variety of goods. Stamping machines are used for tasks including metal coining, blanking, and four slide shaping.

Welding: Welding is the practise of putting two or more pieces of metal together using a combination of heat and pressure. It is one of the more popular production procedures. Metals can have different sizes or shapes. Stick or arc welding, MIG welding, and TIG welding are the three primary types of welding techniques. Two further adaptable welding techniques employed in industrial metal fabrication workplaces are spot welding and stud welding[6].

It is a very well-known technique, mostly due to its adaptability—it may join almost any metal elements. The four most common forms of welding are FCAW, MIG/GMAW, SMAW, and TIG. Flux Cored Arc Welding, or FCAW, eliminates the requirement for a secondary gas source by using a wire electrode with a core that produces shielding gas. In general, this kind of welding is identical to MIG welding, also known as metal inert gas welding. It prevents the metal piece from interacting with numerous ambient elements by using an external gas supply together with a solid wire electrode, which speeds up and improves the consistency of the process.The most basic type of welding instrument is called SMAW, or shielded metal arc welding; it consists of an electrode stick that creates an electric arc when it comes into contact with metal. The high temperature of the arc's impact is what joins the metal pieces together.

TIG, or tungsten inert gas welding, is the final type of welding that is more suited to heavy metals. It makes use of a tungsten electrode rod to produce brief arcs, which are more suited for heavy construction. Even though it is one of the trickier types of welding and needs a highly experienced expert to use it effectively, it is effective for the majority of metal-based items and is useful for even the most challenging jobs.

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CHAPTER 4

INTRODUCTION TO CFRP AND GFRP

Dr. Yuvaraja Naik
Assistant Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India
Email Id-yuvarajanaik@presidencyuniversity.in

CFRP and GFRP

CFRP: Epoxy, polyester, nylon, and vinyl are examples of carbon fiber-reinforced polymers (CFRPs). However, in addition to carbon, the fibers frequently contain glass or aluminum. Strength and stiffness are provided by this material variety in CFRP. The ratio of fiber to polymer, the kinds of additives, and the matrix structure all affect the characteristics of CFRP. Carbon Fiber Reinforced Polymer Composites (CFRP) are strong, lightweight materials utilized in the production of many items we use every day. It is a name for a fiber-reinforced composite material whose main structural component is carbon fiber. The "P" in CFRP can be either "plastic" or "polymer," it should be emphasized [1].

Typically, thermosetting resins like epoxy, polyester, or vinyl ester are used in CFRP composites. Even though "Carbon Fiber Reinforced Thermoplastic Composites" (CFRP Composites) employ thermoplastic resins, they are frequently referred to as CFRTP composites. It's crucial to comprehend the jargon and acronyms used while dealing with composites or in the composites sector. Understanding the characteristics of FRP composites and the capabilities of the various reinforcements, such as carbon fiber, is more significant [2].

Properties of CFRP: When other materials can no longer support the load, CFRP is typically employed. The value of CFRP's low weight and resistance cannot be overstated: it is up to five times lighter than steel and weighs only approximately 60% as much as aluminum. High fatigue strength, X-ray transparency, and minimal thermal expansion are other characteristics. An individual component's precise qualities may be targeted altered, regulated, and maximized.

Lightweight: A standard fiber glass reinforced composite with continuous glass fiber has a density of.065 pounds per cubic inch and typically has a fiber content of 70% glass (weight of glass / total weight). A CFRP composite, on the other hand, may generally have a density of.055 pounds per cubic inch with the same 70% fiber weight.

Increased Stiffness: CFRP composites are substantially stronger and stiffer per unit of weight than carbon fiber composites, in addition to being lighter overall. Comparing carbon fiber composites to glass fiber and metals demonstrates how accurate this is.

Drawback of CFRP:

Cost: There is a reason why carbon fiber is not utilized in every application, despite being a fantastic material. CFRP composites are now prohibitively expensive in many situations. The cost of carbon fiber can vary significantly depending on the supply and demand dynamics of the market, the kind of carbon fiber (commercial vs. aerospace grade), and the size of the fiber tow. On a price-per-pound basis, raw carbon fiber can cost five to twenty times as much as fiber glass. When contrasting steel and CFRP composites, this difference is much more pronounced [3].

Conductivity: Depending on the application, conductivity can either be a benefit or a drawback for carbon fiber composites. Glass fiber is insulative but carbon fiber has a high conductivity. Glass fiber is used in many applications since carbon fiber or metal cannot be used due to conductivity [4]

GFRP: Glass fiber reinforced plastic, commonly referred to as glass fiber reinforced polymer, and is a composite material made by fusing polyester and E-glass fibers together. While only weighing 25% as much as steel, it may have tensile strengths of 44–2358 MPa and compressive strengths of 140–350 MPa. A thermosetting polymer, such as epoxy, resin, or thermoplastic, can be used to harden woven materials.

In the 1960s, the composite material was first manufactured. When fiberglass reinforced polymer (FRP) was employed in a Japanese high-speed rail project in the 1980s, it gained commercial recognition. The question is why standard reinforcing materials are weak and why engineers require composite material to produce robust and long-lasting structures. The service life of a concrete building is shortened as a result of corrosion, which is the answer. Engineers and construction workers must thus choose materials that can withstand extreme weather conditions to strengthen concrete buildings.

Due to its resistance to corrosive substances and ability to prevent rusting or weakening of concrete, FRP rebar is increasing in commercial value. A kind of FRP is GFRP, or glass fiber reinforced polymer rebar. In the late 1990s, the US and Canada embraced advanced composite materials like FRP for structural purposes. Corrosion-resistant rebar must be used to strengthen sensitive concrete structures including seawalls, dams, and power plants. Thus, it is thought that fiberglass reinforcing material is the best material for delicate concrete constructions [5].

- **Advantages of GFRP:**

Rebar made of glass fiber reinforced polymer has a number of benefits. It is a high-value building material. Governments and other large-scale infrastructure providers increasingly recognize that GFRP is an affordable building material with the ability to increase the lifespan of public facilities where corrosion can have a significant negative impact on the economy and the environment. The use of fiberglass reinforcing material has grown significantly as a result of the growth in corrosion caused by climate change. Future versions of these sophisticated composite materials would be able to more clearly exhibit their strengths and characteristics. The following are some benefits of GFRP rebar in various applications:

- High-quality vinyl ester resin that is resistant to corrosion and extends the life of a concrete structure is one of the components of GFRP.
- GFRP rebar is twice as strong in terms of tensile strength and weighs 14 as much as typical steel rebar.
- Since GFRP rebar doesn't carry heat or electricity, it's a great material for buildings like power plants and scientific institutions.
- In comparison to epoxy-coated or stainless steel, GFRP rebar is a more affordable product when considering the long-term advantages.
- Chloride ions and other chemical elements have no effect on it.
- It may be produced in lengths, bends, and forms that are customized.
- With its ability to be easily cut and machined, GFRP rebar has a highly straightforward installation method.
- Radio waves and the electrical field may both pass through it.
- Because GFRP rebar requires no maintenance, construction companies may avoid paying for rehabilitation [6].

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CHAPTER 5

CHARACTERIZATION OF HYBRID COMPOSITES

Dr. Satish Babu
Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India
Email Id-satishbabu@presidencyuniversity.in

Multiple types of fiber are combined in a single matrix material to create hybrid composites .Although a hybrid may theoretically contain several types of fiber, it is more likely that a mix of just two types of fiber would be advantageous. They were created as a natural progression from one fiber, traditional composites. In comparison to traditional composites, hybrid composites offer special properties that may be employed to suit a variety of design needs more cheaply. This is so that less expensive fibers like glass and Kevlar may partially replace more expensive fibers like graphite and boron. The balanced strength and stiffness, balanced bending and membrane mechanical properties, balanced thermal distortion stability, reduced weight and/or cost, continued to improve fatigue resistance, reduced notch sensitivity, improved fracture toughness and/or crack arresting properties, and improved impact resistance are just a few of the specific benefits of hybrid composites over conventional composites[1].

To comprehend the impacts of different fibers, their volume fractions, and matrix characteristics in hybrid composites, experimental methodologies can be used. These tests call for the creation of several composites with the aforementioned characteristics, which is time- and money-consuming. As a result, a computational model is developed, which will be covered in more detail later. This model can be readily modified to simulate hybrid composites with various volume percentages of constituents, which will save the designer a lot of time and money. The rule of hybrid mixtures (RoHM) equation, which is frequently used to estimate the strength and modulus of hybrid composites, may be utilized to assess the mechanical characteristics of hybrid short fiber composites. However, it is demonstrated that RoHM performs best for the hybrid composites' longitudinal modulus and longitudinal tensile strength. The overall modulus of the composite has no relationship with the randomness of the fiber position since the modulus values in a composite are volume averaged over the constituent micro stresses. On the other hand, strength values depend on the interaction between the fiber and matrix and the quality of the interface, not solely on the strength of the elements[2].

Any slight (microscopic) flaw in the specimen during tensile testing may cause stress to build up, therefore failure cannot be precisely anticipated using RoHM calculations. For any volume fraction ratio of fibers, in this example, carbon and glass, the computational model given in this research accounts for random fiber position inside a sample volume element. On the transverse strength of the hybrid composites, the influence of randomization appears to have a significant impact. A semi-empirical relationship that resembles Halpin-Tsai equations has been found for the transverse modulus, with the Halpin-Tsai parameter calculated for hexagonal packing of circular fibers. The results, which demonstrate a good agreement with actual results for effective modulus for hybrid composites containing ternary systems, were obtained using finite element-based micromechanics (two fibers and a matrix). Although conservative, the Direct Micromechanics Approach (DMM), which is based on the first element failure method, is used to forecast strength and gives a good estimate for failure start.

By mixing two or more reinforcing fibers, hybrid composites go one step farther. Although fiberglass and carbon fiber are frequently utilized, a hybrid may also be created using a number of different fibers, such as natural fibers. By utilizing a hybrid construction, the ideal mechanical property ratio of both materials may be achieved to meet the requirements of a certain application [4].

Bringing about advantages:

The benefits of hybrid composites are numerous. It is feasible to combine the advantages of several fiber types while also lessening their drawbacks by using a hybrid of fibers. These advantages allow hybrids to be utilized in a wide range of sectors and for a wide range of goods. The economic benefits of utilizing a hybrid may be the most evident benefit. Composite materials aren't especially recognized for their affordability, and because carbon fiber is so expensive, it's unusual to see a car composed primarily of it. Hybrid composites can help consumer's lower costs since they minimize the amount of pricey product while still preserving its benefits by fusing carbon fiber with a less expensive material. The toughness and durability of the material would unquestionably be improved by combining those fibers into a composite solution. Combining carbon fiber with fiberglass would provide clients an excellent choice for applications where low density is a crucial design factor, such as aerospace, where it is also preferred for its light weight[5].

However, carbon fiber has certain disadvantages, such being brittle and breaking more quickly under impact. Manufacturers can boost the stiffness and impact resistance of the product by mixing carbon fiber with a more flexible fiber, like fiberglass. Additionally, carbon fiber conducts electricity, which, depending on the situation, can be both a benefit and a drawback. Conversely, fiberglass composites are insulators and can thwart the passage of electricity. It's a case of opposites attracting: more fiberglass can help insulate it for applications like electrical enclosures, where conducting currents could harm equipment, but more carbon fiber can enhance the completed product's electrical conductivity.

Better mechanical qualities are a result of the link between the fiber and matrix. The composite should have good mechanical characteristics if the bond is strong. One technique for strengthening the connection between fiber and matrix is surface treatment. The contaminants on the surface should be eliminated by this treatment, which will also improve the qualities of the fibers and composites. Multiple fibers are employed in some composites. Hybrid composites are what these materials are known as. The stacking order affects the composites' mechanical qualities as well. Superior fiber and matrix stacking results in better mechanical characteristics. Mechanical qualities should be improved with fiber content increases up to a particular point below the weight % of the matrix. Increased fiber content in the composite enhances the mechanical characteristics. The mechanical characteristics of composites are also influenced by the fiber's shape. Because natural fibers naturally absorb moisture, composites reinforced with them cannot be utilised in outdoor applications. The mechanical qualities of natural fibers are inferior to those of synthetic fibres. One method for improving the mechanical characteristics of composites reinforced with natural fibers is hybridization. Moisture absorption is one of natural fibres' biggest drawbacks. As the percentage of natural fibers rises, so does their potential to absorb moisture. Chemical therapy can diminish it using substances like silane, NaOH, and occasionally even water. The weight and diameter of the fibers are determined by the surface treatment. Natural fibers can be employed in industries due to their mechanical characteristics and ease of usage available. One of the significant disadvantages of natural fibers is their hydrophilic character, which weakens the interaction between the fiber and the matrix. Fibers' hydrophilic nature can be changed via surface treatment. The two basic types of fibers are natural and synthetic fibers. Natural fibers are fibers that are produced naturally. Synthetic fibers are those created by artificial means. Primary fibers and secondary fibers are once more used to categories plant fibers Jute, sisal, hemp, and other plants that are farmed primarily for their fibers are classified as primary [6], [7].

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CHAPTER 6

HAND LAY-UP PROCESS

Dr. Yuvaraja Naik
Assistant Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India
Email Id-yuvarajanaik@presidencyuniversity.in

The open moulding technique of hand lay-up may be used to create a wide range of composite goods, from very small to extremely big. Despite the modest manufacturing volume per mould, several moulds can be used to create significant production numbers. The simplest composites moulding technique is hand lay-up, which offers inexpensive equipment, straightforward processing, and a variety of part sizes. Modifications to the design are simple. Equipment requires a minimum investment. Good production rates and consistent quality are achievable with trained personnel.One of the oldest and most used techniques for producing composite components is the hand (wet) lay-up[1]. Continuous fibre reinforced composites include hand lay-up composites. A material with desirable qualities in one or more directions is produced by layering unidirectional or weaving composites. Each layer is positioned to make the most use of its own qualities. The performance of the laminated composite material can be improved overall by combining layers of various materials. Hand-impregnated resins are added to fibres to create woven, knitted, sewn, or bonded textiles. In addition to the increasingly popular nip-roller type impregnators, which employ revolving rollers and a resin bath to force resin into the textiles, this is often done with brushes or rollers. Laminates are allowed to cure in typical atmospheric circumstances[2].

Hand lay-up process:

- Hand the lay-up approach is the most basic way to manufacture composites. This strategy requires little in the way of infrastructure. The procedures in the processing are really basic.
- To prevent polymer from adhering to the surface of the mould, a release gel is first sprayed on it.
- Cut to fit the size of the mould, reinforcement is then positioned on top of the mould in the form of woven mats or chopped strand mats.
- The liquid thermosetting polymer is then completely combined with the recommended hardner (curing agent) in the proper proportion and poured onto the surface of the mat that has previously been put in the mould.
- A brush is used to distribute the polymer evenly. After that, a second layer of mat is applied to the polymer surface, and the mat-polymer layer is gently rolled by a roller to release any trapped air and extra polymer.
- Up until the necessary number of layers are stacked, the procedure is repeated for each layer of polymer and mat[3].

- The created composite item is removed from the mould after curing, either at ambient temperature or at a particular temperature, and is then treated further.

Below is a diagram of a Hand lay-up:

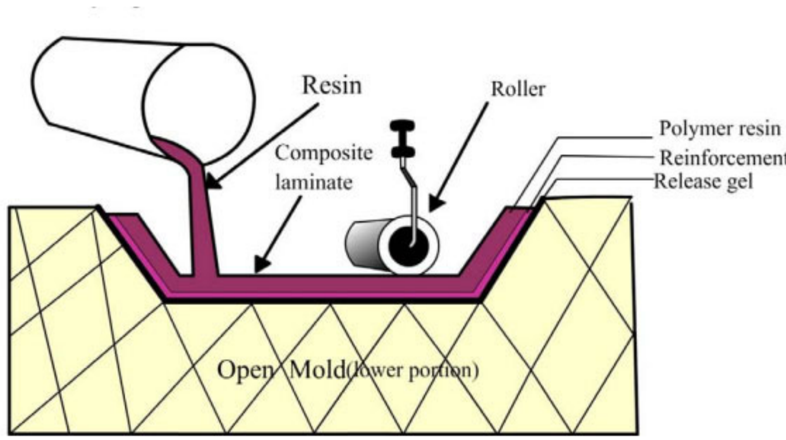

Figure 1: Represented the Hand Layup Process [4]**.**

Less capital and infrastructure are needed than with previous approaches. In processed composites, a large volume proportion of reinforcement is challenging to accomplish because production rates are low (Figure 1) [5].

Hand layup method for FRP has certain benefits.

- Simple moulds and tools are all that are needed; this requires less investment, produces results quickly, and is appropriate for the growth of township firms in China;
- Although production technology is simple to learn and can be mastered with little training, producing very high-quality products requires extensive experience and study.
- Large cruise ships, circular roofs, sinks, etc. are examples of things whose manufacturing is not constrained by size and shape;
- It may be joined simultaneously with other materials (such as metal, wood, foam, etc.);
- Some enormous items, like giant cans and large roofs, can be created right away[6].

Drawbacks of the hand layup method:

- It is not appropriate for the mass production of the product due to its poorer production efficiency, slower speed, and longer production cycle when compared to the FRP pultrusion, pulwinding, and filament winding processes;
- Machine quality is not as consistent. The stability of product quality is not very excellent due to the difference in operational staff level and manufacturing environment circumstances;
- The industrial atmosphere is filled with powder and aromas. Since other methods cannot completely replace the benefits of the hand layup moulding process, it is important to address any operational weaknesses.

- There are many applications for fiberglass hand lay-up items, including sports, building construction, corrosion-resistant goods, etc [7].

Layers of matched fibers are layered on top of a matrix material to create high-performance composites. These fibers give composites their remarkable structural qualities, but they also make them difficult to produce since they need to be constructed layer by layer. Prepreg, a type of reinforcement, is manually laid down in individual layers or plies during the production process known as "hand layup." This is made up of many fibres that have been pre-impregnated with resin, bundled into tows, and either woven together or organized in a single unidirectional ply. Each ply must be manually formed into the desired shape before being securely adhered to the surface of the preceding layer or mould, leaving no space between the plies. This can manufacture intricate features of high quality, has affordable startup costs, and is very flexible to new components and design modifications. It is far from ideal, though, as there can be poor production rates and occasionally high labor and material expenses. Human variation might lead to differences between pieces, much like with other manual operations. Despite these drawbacks, hand layup is still a vital component of the composites industry, serving as the primary manufacturing process for many manufacturing facilities thanks to its versatility and quality. The lack of written information on the manual phase of the hand layup process is somewhat unexpected in light of this [8].

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CHAPTER 7

COMPOSITE MATERIAL

Dr. Udaya Ravi M
Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India
Email Id-udayaravim@presidencyuniversity.in

When two or more distinct substances, each with its qualities, are mixed to produce a new substance with attributes that are superior to those of the original components in a solid, the result is a composite material, also known as composite particular application.Individual materials are combined to form composite materials. There are two basic groups of these discrete materials, which are referred to as component materials. The matrix binder is one, while the reinforcement is the other. At least some of each sort is required. The matrix surrounds the reinforcing and preserves its relative locations, reinforcing with support. As the reinforcements transmit their extraordinary physical and mechanical qualities, the matrix's characteristics get better. Synergism causes the mechanical characteristics to disappear from the separate constituent materials. The designer of the item or structure is given alternatives to select the best combination from the range of matrix and strengthening materials at the same time. The designed composites must be produced to be shaped[1].

The designed composites must be produced to be shaped. The reinforcement is inserted into the casting process or onto the mold surface. The reinforcement can be exposed to the matrix either before or after this. The matrix goes through a merging process, which mandates the portion form. Depending on the kind of matrix, this melding process may take place in a variety of methods, such as chemical polymerization for a thermoset polymer matrix or solidification from a molten state for a thermoplastic polymer matrix composite. Various shaping techniques might be employed depending on the demands of the end-item design. The primary variables affecting the process are the characteristics of the selected matrix and reinforcement. Another important issue is the total amount of material to be produced[2].

Large volumes can be utilized to support substantial capital investments in quick and automated production technologies. Small production numbers are aided by cheaper capital expenditures but higher personnel and tooling costs that increase more slowly. A polymer matrix substance commonly referred to as a resin solution is used in many commercially made composites. Depending on the initial basic materials, there are a wide variety of polymers available. There are several main categories, and within each, there are many subcategories. The most often used ones are PEEK, polyester, vinyl ester, epoxy, phenolic, polyimide, polyamide, and polypropylene. In addition to routinely powdered minerals, textiles are frequently used as reinforcing materials. The numerous techniques listed below have been developed to either enhance the insoluble fiber or decrease the resin content of the finished product.The polymer is ductile, whereas the glass fiber is quite robust, and rigid, but also fragile[3]. As a result, the resultant polyester is ductile, robust, flexible, and moderately rigid.

Co-curing or comment preparation with several other media, such as foam or honeycomb, is also a part of many composite layup designs. This is typically referred to as a sandwich construction. For the creation of cowlings, windows, endplates, or other non-structural elements, this is a more generic layup. The most often used core materials are foams with open or closed cell structures, such as polycarbonate, polyurethane, polyethylene or styrene foams, balsa, syntactic foams, and honeycombs. As core materials, open- and closed-cell metallic foam can also be used. Recently, core structures made of 3D graphene (also known as graphene froth) have also been used[4].

Semi-crystalline polymers can be characterized as composite materials both statistically and qualitatively, even though the two phases are chemically similar. The more rigid, amorphous phase is reinforced by the crystalline part, which has a larger elastic modulus. The crystallinity, or volume percentage, of polymeric materials, can range from 0% to 100% depending on the molecular structure and thermal history. Different processing methods may be used to alter the percentage of crystallinity in these materials, changing their mechanical characteristics, which are covered in the section on physical properties. This phenomenon may be observed in a wide range of materials, including commercial plastics like polyethylene bags for groceries and spiders that can create silk with various mechanical characteristics[5].

These materials frequently behave like spherules, which are particle composites made up of randomly distributed crystals. To behave more like fiber-reinforced composites, they can also be made to be anisotropic. In the case of spider silk, the material's qualities may even be influenced by the crystals' sizes rather than their volume portion. Ironically, some of the most easily tunable composite materials in existence are single-component polymeric materials.

Within a mold, the reinforcing and matrix elements are combined, compressed, and treated to undergo a fusing event. Following the melding action, the component form is substantially established. It may, however, distort certain processing circumstances. The merging occasion of a curing reaction for a thermoset polymer matrix material is brought on by the potential for additional heat or chemical reactivity such as an organic peroxide. For a thermoplastic polymeric matrix material, the melding event is the solidification from the molten state. For a metal matrix like titanium foil, the melding event is a fusing at pressure and a temperature close to the melting point. One element of a mold can be referred to as a "lower" mold for a variety of shaping techniques[6].

It is appropriate to refer to one mold component as a "lower" mold and another mold piece as an "upper" mold for various process parameters. Lower and higher relate to the various faces of the molded panel, not to how the mold is arranged in space. In this tradition, there is almost usually a bottom mold and occasionally an upper mold. The bottom molds are then covered with materials to start part construction. In comparison to more frequent and precise terminology like male side, female side, a-side, and, tool side, bowl, hat, mandrel, etc., lower mold and upper mold are more broad descriptors. Distinct terminology is used in continuous production. The manufactured item is typically referred to as a panel.

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CHAPTER 8

BASICS OF FIBERS

Dr. Udaya Ravi M
Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India
Email Id-udayaravim@presidencyuniversity.in

We all like wearing and consuming various sorts of clothing. There are specific clothing items that are worn for particular events and others that are specific to the season. For instance, we wear cotton clothing in the summer to stay cool, wool clothing in the winter to be warm, and raincoats in the rainy season to stay dry. These various clothing items are made from fibers[1].Generally speaking, fibers are long, thin, flexible structures that resemble threads. Animals and plants are the two primary suppliers of fiber. The finest textiles are then woven using the acquired yarns and spun fiber. A single long strand may be spun into yarn for a variety of fabric kinds.

"Fibers" are long molecular strands that are braided together to produce a straight, string-like structure. Natural or synthetic fibers like cotton, silk, and jute are examples. When early humans understood they needed to cover and shield their skin and hair from the elements, fibers were found. Early ancestors hunted animals whose skins provided them with food and warmth since they would live in frigid climates. The early men found that using this skin consistently made it tougher to hunt, so they eventually began to treat it to keep it supple. Much later, they began sewing with animal bones as the thread and their bones as the needles[2].

A natural or manmade material that is substantially longer than it is wide is known as fiber. Fibers are frequently used to create other materials. Fibers are frequently used in the strongest engineering materials, such as composite materials and ultra-high-molecular-weight polyethylene. Fibers can sometimes be manufactured more cheaply and in greater quantities than synthetic materials, but for clothing, natural fibers have several advantages over synthetic ones, such as comfort[3].

The natural fiber is any raw material that resembles hair and can be obtained directly from an animal, vegetable, or mineral source. It can be spun into threads to create woven textiles or nonwoven materials like felt or paper. Natural fiber can also be described as an accumulation of cells having a small diameter relative to their length. Although there are many fibrous materials in nature, particularly cellulosic ones like cotton, wood, grains, and straw, very few of them can be exploited to make textiles or for other industrial uses. A fiber's suitability for commercial usage is influenced by a variety of factors, including its length, strength, pliability, elasticity, resistance to abrasion, absorbency, and other surface characteristics. The majority of textile fires are thin, flexible, and rather robust[4].

Fiber, also spelled fiber, refers to a type of carbohydrate that is found in plant foods and cannot be digested by the human body. It is found in a wide variety of plant-based foods, including fruits, vegetables, beans, nuts, and grains. It is an important component of a healthy diet, as it helps to keep the digestive system regular and promotes the feeling of fullness after a meal. There are two types of fiber: soluble and insoluble. Soluble fiber dissolves in water and forms a gel-like substance, while insoluble fiber does not dissolve in water and helps to add bulk to the stool. It is recommended that adults consume at least 25 grams of fiber per day[5].

Fiber is a type of carbohydrate found in plant-based foods that the human body cannot digest. It is an important part of a healthy diet because it helps to keep the digestive system regular and promotes the feeling of fullness after a meal. In addition to its digestive benefits, fiber has been linked to several other health benefits, including:

1. Lowering cholesterol levels
2. Regulating blood sugar levels
3. Reducing the risk of heart disease
4. Reducing the risk of certain types of cancer, such as colon cancer
5. Aiding in weight management

There are two main types of fiber: soluble and insoluble. Soluble fiber dissolves in water and forms a gel-like substance, while insoluble fiber does not dissolve in water and helps to add bulk to the stool. It is recommended that adults consume at least 25 grams of fiber per day.Good sources of fiber include fruits, vegetables, beans, nuts, and whole grains. It is important to consume a variety of fiber-rich foods to get a balance of both soluble and insoluble fiber.

Here are a few more things you might find interesting about fiber:

1. Many people do not get enough fiber in their diet. The recommended daily intake of fiber for adults is 25 grams for women and 38 grams for men. However, the average intake for adults in the United States is only about 15 grams per day.
2. There are many ways to increase your fiber intake. Some easy ways to add more fiber to your diet include adding fruit or vegetables to your meals and snacks, choosing whole grain slices of bread and cereals, and snacking on nuts and seeds.
3. It is important to drink plenty of water when increasing your fiber intake. Fiber absorbs water in the digestive tract and can help to prevent constipation. However, if you do not drink enough water, fiber can have the opposite effect and cause constipation.
4. It is generally recommended to increase fiber intake gradually. This can help to prevent digestive discomforts such as bloating, gas, and diarrhea.
5. Some high-fiber foods, such as beans and certain types of vegetables, can cause gas and bloat. This is because they contain a type of soluble fiber called Raffi nose that is not

easily digested by the body. However, these symptoms usually go away as the body becomes used to the increased fiber intake.

There are two main types of fiber: soluble and insoluble.

Soluble fiber dissolves in water and forms a gel-like substance. It is found in foods such as oats, beans, apples, and pears. Soluble fiber can help to lower cholesterol levels and regulate blood sugar levels.

Insoluble fiber does not dissolve in water and helps to add bulk to the stool. It is found in foods such as wheat bran, nuts, and vegetables. Insoluble fiber helps to promote regular bowel movements and prevent constipation. Both types of fiber are important for a healthy diet. It is recommended to consume a variety of fiber-rich foods to get a balance of both soluble and insoluble fiber[6].

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CHAPTER 9

BANANA FIBER

Dr. Udaya Ravi M
Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India
Email Id-udayaravim@presidencyuniversity.in

Banana fiber is a natural fiber that is obtained from the stem and the pseudo stem (part of the plant that supports the leaves) of the banana plant. It is a strong and durable fiber that is resistant to water, insects, and rot. Banana fiber is used to make a variety of products, including textiles, paper, and other products. It is considered to be an environmentally friendly and sustainable material, as it is a waste product that is generated when bananas are harvested and can be processed without the use of chemicals. Banana fiber is also biodegradable, which means that it can be broken down by natural processes into its constituent parts[1].

Few things in knowing about banana fiber:

1. Banana fiber is extracted by first removing the outer layers of the stem and the pseudo stem. The inner part of the stem is then peeled to reveal the fibers, which are then separated and cleaned.
2. Banana fiber can be spun into yarn and used to weave fabric or make other textiles. It is soft and silky to the touch and has a natural sheen.
3. Banana fiber is often mixed with other natural fibers, such as wool or cotton, to create a stronger and more durable fabric.
4. Banana fiber is a popular choice for eco-friendly and sustainable products, as it is a natural and biodegradable material that is produced without the use of chemicals.
5. In addition to being used in textiles, banana fiber can also be used to make paper, baskets, and other products.

Banana plants are grown in tropical and subtropical regions around the world and are a major source of food and income for millions of people. Banana plants are fast-growing and can produce a new stem and a new crop of bananas every year. This means that banana fiber is a renewable resource that can be harvested repeatedly without damaging the plant. The process of extracting banana fiber is labor-intensive, as it requires removing the outer layers of the stem and the pseudo stem by hand. However, the use of machines to extract fiber is being developed in some countries. Banana fiber has several properties that make it a good choice for certain applications. It is strong and durable, resistant to water and insects, and has a natural sheen. It is also biodegradable, which makes it an environmentally friendly material. In addition to being used in textiles and paper, banana fiber has also been used to make bags, hats, and other products. It has the potential to be used in a wide range of applications, including in the automotive and construction industries[2].

Banana fiber is a natural fiber extracted from the stem and outer skin, or pseudo stem, of the banana plant. It is similar to other plant fibers such as hemp, flax, and bamboo, and can be used in a variety of applications, including textiles, paper, and building materials. Banana fiber is known for its strength, durability, and resistance to water, making it a suitable alternative to synthetic fibers in certain products (Figure 1). It is also biodegradable and renewable, making it an eco-friendly choice. Banana fiber is typically produced in tropical countries where bananas are grown, and it is often a byproduct of the banana cultivation process[3].

Figure 1: Illustrate the Banana Fiber.

More details about banana Fiber:

- The process of extracting banana fiber involves separating the fiber strands from the stem and outer skin of the banana plant. This is typically done by hand, using a process called retting, which involves soaking the stem and outer skin in water to soften and decompose the non-fiber components. The fibers are then cleaned, combed, and spun into yarn[4].
- Banana fiber is a versatile material that can be used in a variety of applications. It is often used to make textiles such as fabrics, clothing, and home furnishings, as well as paper and other paper products. It can also be used to make ropes, mats, and other products that require strong, durable fibers[3].
- Banana fiber is known for its strength and durability. It is also resistant to water and UV radiation, making it a suitable choice for outdoor products. In addition, it is biodegradable and renewable, making it an eco-friendly alternative to synthetic fibers.
- Banana fiber is typically produced in tropical countries where bananas are grown, such as India, Thailand, and the Philippines. It is often a byproduct of the banana cultivation process, and its production can provide an additional source of income for farmers.
- Banana fiber has several potential benefits over synthetic fibers. It is more breathable and moisture-absorbent than synthetic fibers, which makes it more comfortable to wear. It is

also more durable and less prone to pilling, which is the formation of small balls of fiber on the surface of a fabric. In addition, banana fiber is biodegradable and renewable, which makes it a more sustainable choice than synthetic fibers, which are derived from non-renewable fossil fuels and take hundreds of years to break down in the environment[5].

- Banana fiber has several potential applications in the fashion industry. It can be used to make clothing, such as tops, dresses, and pants, as well as accessories such as bags and scarves. It can also be used to make home furnishings such as towels, bed linens, and curtains. Banana fiber is known for its soft, silky feel, which makes it comfortable to wear and touch.
- There are several companies that are working to promote the use of banana fiber in the fashion industry. These companies are working to develop new products made from banana fiber and to educate consumers about the benefits of using natural, sustainable fibers. In addition, organizations such as the Banana Fiber Development Association are working to support small-scale producers of banana fiber and to promote its use in a variety of applications[6].

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CHAPTER 10

GLASS FIBER

Dr. Udaya Ravi M
Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India
Email Id-udayaravim@presidencyuniversity.in

Glass fiber is a material made from extremely fine fibers of glass. It is used as a reinforcement material in a variety of products, including composites, insulation, and textiles. Glass fiber is made by melting silica (silicon dioxide) sand at high temperatures to create a liquid that is then extruded through tiny nozzles to form fibers. These fibers are then collected and formed into a mat or woven into a fabric. The properties of glass fiber, such as its high strength and low weight, make it an attractive material for use in a wide range of applications[1].Glass fibers are very strong for their size and have a high tensile strength, which means they can withstand a lot of strain before breaking. They are also very lightweight and have a high melting point, making them resistant to heat and fire. In addition, glass fibers are non-conductive and have a low coefficient of thermal expansion, which means they do not expand or contract much with temperature changes.

One of the main advantages of glass fiber is its ability to be used in composite materials, which are materials made by combining two or more different materials to create a new material with improved properties. Glass fiber-reinforced plastics (GFRP) are commonly used in the aerospace, automotive, and construction industries due to their high strength-to-weight ratio and corrosion resistance. Glass fiber is also used in insulation materials, such as fiberglass insulation, which is used to insulate buildings to help keep them warm in the winter and cool in the summer. Glass fiber is also used in textiles, such as fiberglass-reinforced fabrics, which are used in a variety of applications, including boat hulls, protective clothing, and sporting goods[2].

There are a few different types of glass fibers, including E-glass, S-glass, and C-glass. E-glass, which stands for electrical glass, is the most common type of glass fiber and is used in a wide range of applications due to its good electrical insulation properties and low cost. S-glass, which stands for strength glass, is a higher-strength glass fiber that is used in applications where strength is more important than electrical insulation, such as in the aerospace industry. C-glass, which stands for chemical glass, is a type of glass fiber that is resistant to chemical corrosion and is used in applications where the material will be exposed to chemicals.Glass fibers can be made in a variety of diameters and lengths, and the properties of the finished product can be customized by adjusting the composition of the glass and the manufacturing process. Glass fibers are generally more expensive to produce than other types of fibers, such as carbon fibers, but they have the advantage of being more readily available and easier to process[3].

In addition to their use in composite materials, insulation, and textiles, glass fibers have several other applications. They are used as reinforcing material in a variety of products, including boat hulls, car bodies, and sporting goods, and they are also used to make fire blankets and other fire-resistant materials. Glass fibers are also used in filters and as an abrasive in products such as scouring pads.

Glass fibers can be made into a variety of different forms, including strands, yarns, fabrics, and mats. They can be woven into fabrics or formed into mats or other shapes through processes such as needling or spraying. Glass fibers can be combined with other materials, such as resin or plastic, to create composite materials with improved properties.Figure 1 Shows the E-glass Fiber. One potential disadvantage of glass fibers is that they can be brittle and may break or shatter when subjected to high impacts. They also tend to be more brittle at lower temperatures and may become more flexible when heated. Glass fibers can also cause irritation to the skin and eyes and should be handled with caution[4].

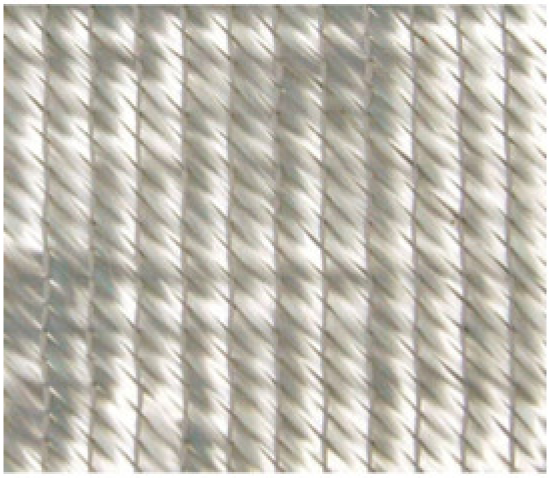

Figure 1: Illustrate the E-glass Fiber.

There are a few different methods that can be used to manufacture glass fibers. The most common method is called the "melt spinning" process, in which the glass is melted and then extruded through small holes, or "nozzles," to form fibers. The fibers are then collected on a moving belt or drum and cooled to solidify them. The fibers can then be collected and formed into a mat or woven into a fabric[5].

Another method for producing glass fibers is called the "sol-gel" process, in which a solution of silica is formed and then dried to create a glassy material that can be ground into a fine powder. The powder can then be mixed with a binder and formed into fibers using a process similar to melt spinning.There are also several variations on these basic methods, such as the "dry spinning" process, in which the glass is heated until it becomes a viscous liquid and is then extruded through a spinneret to form fibers[4].

The fibers are then collected and cooled to solidify them.There are a few factors that can affect the properties of glass fibers, including the type of glass used, the diameter of the fibers, and the manufacturing process.The type of glass used to make the fibers can affect the strength, stiffness, and other properties of the fibers. Different types of glass, such as E-glass, S-glass, and C-glass, have different properties and are used in different applications[2].The diameter of the fibers can also affect their properties. In general, smaller-diameter fibers are weaker and more flexible, while larger-diameter fibers are stronger and more rigid.

The manufacturing process can also affect the properties of the fibers. For example, the temperature at which the glass is melted and the rate at which it is cooled can affect the strength and other properties of the fibers. The way in which the fibers are collected and formed into a mat or woven into a fabric can also affect their properties[6].

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CHAPTER 11

EPOXY RESIN

Dr. Udaya Ravi M
Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India
Email Id-udayaravim@presidencyuniversity.in

Epoxy resin is a type of synthetic polymer that is made up of a combination of epoxide groups and other molecules. It is a strong and durable material that is resistant to heat and chemicals, and it is widely used in a variety of applications, including adhesives, coatings, and composite materials.Epoxy resin is known for its excellent adhesion properties, which means it can bond strongly to a wide range of materials, including metals, plastics, and wood. It is also resistant to moisture and can be used to seal and protect surfaces from water damage. Epoxy resin is often used as an adhesive for bonding materials together, and it is also used as a coating to provide a protective layer on surfaces[1].

In addition to its use as an adhesive and coating, epoxy resin is also used in the production of composite materials. When combined with fibers, such as glass fibers or carbon fibers, epoxy resin can be used to create strong and lightweight materials that are used in a variety of applications, including the aerospace, automotive, and construction industries.

There are a few different types of epoxy resin, including standard epoxy resin, modified epoxy resin, and reactive diluents. Standard epoxy resin is the most common type and is made up of a combination of epoxide groups and other molecules. It is known for its excellent adhesion and chemical resistance and is used in a variety of applications.Modified epoxy resin is a type of epoxy resin that has been modified with other chemicals to improve its properties. For example, adding a plasticizer to epoxy resin can make it more flexible, while adding a fire retardant can make it more resistant to fire.

Reactive diluents are chemicals that are added to epoxy resin to adjust its viscosity or thickness. By adding a reactive diluent to epoxy resin, it is possible to make the resin thinner or thicker, depending on the specific needs of the application.Epoxy resin can be cured, or hardened, through a chemical reaction called polymerization. This reaction occurs when the epoxy resin is mixed with a hardener, which triggers the cross-linking of the polymer chains. The curing process can be accelerated by applying heat or by using a faster-reacting hardener[2].

There are a few factors that can affect the properties of epoxy resin, including the type of resin, the hardener used, the ratio of resin to hardener, and the curing conditions.The type of epoxy resin can affect the properties of the finished material. For example, standard epoxy resin is known for its excellent adhesion and chemical resistance, while modified epoxy resin may have additional properties, such as increased flexibility or fire resistance.

The hardener used in the curing process can also affect the properties of the finished material. Different hardeners can cure at different speeds and can result in different properties, such as strength, flexibility, and chemical resistance.The ratio of resin to hardener is important in achieving the desired properties of the finished material. If too much hardener is used, the material may become too brittle, while too little hardener may result in a material that is too soft[3].

The curing conditions, such as temperature and humidity, can also affect the properties of the finished material[4]. In general, higher temperatures and higher humidity levels can accelerate the curing process, while lower temperatures and lower humidity levels can slow it down (Figure 1).

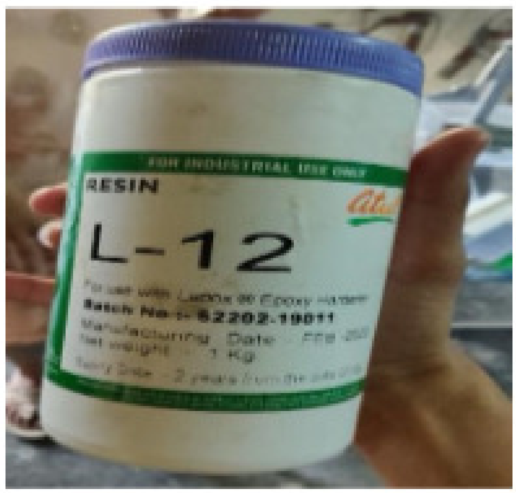

Figure 1: It Shows the Epoxy Resign.

Epoxy resin is a versatile material that has a wide range of applications, including adhesives, coatings, and composite materials. Some common uses for epoxy resin include:

Adhesives: Epoxy resin is used as an adhesive for bonding a variety of materials, including metals, plastics, and wood. It is known for its excellent adhesion properties and is used in a variety of applications, including the automotive and construction industries[5].

Coatings: Epoxy resin is used as a coating to provide a protective layer on surfaces. It is resistant to moisture and is often used to seal and protect surfaces from water damage.

Composite materials: When combined with fibers, such as glass fibers or carbon fibers, epoxy resin can be used to create strong and lightweight composite materials. These materials are used in a variety of industries, including the aerospace, automotive, and construction industries.

Electrical insulation: Epoxy resin is an excellent insulator and is often used in the electrical industry to coat electrical components and insulate wiring.

Castings: Epoxy resin can be poured into a mold to create a custom shape or component. It is often used to create custom parts for a variety of applications[6].

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CHAPTER 12

CONCEPT OF CHARCOAL

Dr. Ashish Srivastava
Assistant Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India
Email Id-ashishsrivastava@presidencyuniversity.in

Charcoal is a porous, black solid that is made by heating wood or other organic materials in the absence of oxygen. The process of making charcoal is called "charring," and it removes water, gases, and other volatile compounds from the organic material, leaving behind a carbon structure that is rich in carbon and has a high surface area[1].Charcoal has several properties that make it useful in a variety of applications. It is highly porous and has a high surface area, which makes it an effective adsorbent material. It is also an excellent conductor of heat and electricity, and it has a high melting point.

Charcoal is often used as a fuel, and it is a common ingredient in barbecue grills. It is also used in the production of metallurgical coke, which is used as a fuel in the iron and steel industry. Charcoal is also used as a filter in gas masks and other respirators to remove impurities from the air.In addition to its use as a fuel and adsorbent, charcoal is also used in several other applications, including in the production of water purification tablets, as an ingredient in animal feed, and as a dietary supplement.There are a few different methods for making charcoal, including the "retort" method and the "pit" method[2].

The retort method involves heating the organic material in a sealed container, or retort, in the absence of oxygen. This process removes the water, gases, and other volatile compounds from the organic material, leaving behind a carbon structure. The retort method is a more efficient way of making charcoal, as it produces a higher yield of charcoal and generates less pollution than the pit method[2].The pit method involves heating the organic material in a pit in the ground, with a fire built on top of the material. The pit is covered with dirt or sand to exclude oxygen and allow the organic material to char. The pit method is a slower process than the retort method, and it produces a lower yield of charcoal.

There are also a few different types of charcoal, including wood charcoal, coconut shell charcoal, and bamboo charcoal. Wood charcoal is made from wood, and it is the most common type of charcoal. Coconut shell charcoal is made from the shells of coconuts, and it is used as a fuel and in the production of activated carbon. Bamboo charcoal is made from bamboo, and it is used as a fuel and in the production of activated carbon. Figure 1 shows the charcoal.

Figure 1: Shows the Charcoal.

Activated carbon, also known as activated charcoal, is a form of carbon that has been treated with oxygen to make it extremely porous and highly adsorbent. Activated carbon has a large surface area and a large number of tiny pores, which makes it an effective adsorbent material. It is used to remove impurities from a wide range of liquids and gases, including water, air, and food[3].Activated carbon is made from a variety of materials, including wood, coconut shells, and bamboo. The raw material is heated to a high temperature in the absence of oxygen, which removes the water, gases, and other volatile compounds from the material and leaves behind a carbon structure with a high surface area. The carbon is then treated with oxygen to create a porous, highly adsorbent material[4].

Activated carbon is used in several different applications, including water purification, air purification, and the removal of contaminants from food and beverages. It is also used to remove odors and volatile organic compounds (VOCs) from the air, and it is used in gas masks and other respirators to filter out impurities.There are a few different factors that can affect the effectiveness of activated carbon as an adsorbent material. These include the surface area of the carbon, the pore size of the carbon, and the nature of the impurities being removed[5].

The surface area of the carbon refers to the total surface area of the carbon particles. Activated carbon with a high surface area has more pores and a larger number of active sites, which makes it more effective at removing impurities.The pore size of the carbon refers to the size of the pores on the surface of the carbon particles. Activated carbon with small pores is more effective at removing small impurities, while activated carbon with larger pores is better at removing larger impurities.The nature of the impurities being removed can also affect the effectiveness of activated carbon. Some impurities are more difficult to remove than others, and certain types of activated carbon may be more effective at removing certain impurities[6].

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CHAPTER 13

FABRICATION PROCESS

Sandeep G M
Assistant Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India
Email Id- sandeepgm@presidencyuniversity.in

Fabrication is the process of creating a product or structure by assembling, shaping, and joining materials. There are many different methods of fabrication, including welding, cutting, and machining, and the specific method used will depend on the materials being used and the product or structure being created[1].Welding is a fabrication method that involves joining materials together by melting and fusing them. There are many different types of welding, including MIG welding, TIG welding, and stick welding, and each type is suitable for different materials and applications[2].

Cutting is a fabrication method that involves using a tool, such as a saw or a laser, to remove material from a workpiece. There are many different types of cutting, including sawing, laser cutting, and water jet cutting, and each type is suitable for different materials and applications.Machining is a fabrication method that involves shaping materials by removing material using a cutting tool[3]. There are many different types of machining, including turning, milling, and drilling, and each type is suitable for different materials and applications.

In general, fabrication refers to the process of creating or constructing something, often using raw materials or components. Fabrication can refer to the creation of physical objects, such as building a piece of furniture or assembling a machine. It can also refer to the creation of abstract or intangible things, such as fabricating a story or lie[4]. Fabrication is often used in the manufacturing industry, where raw materials are transformed into finished products through various processes such as cutting, shaping, and assembly. Fabrication can also refer to the practice of making something appear to be true or real, even if it is not.

Composites are materials made up of two or more distinct components that, when combined, create a material with improved characteristics compared to the individual components. There are many different methods for fabricating composites, including:

1. **Hand lay-up:** This is a simple method in which sheets or plies of reinforcement material, such as fiberglass or carbon fiber, are placed by hand on a mold and then soaked with a polymer resin. The resin is then allowed to cure, forming the composite material[5].
2. **Compression Molding:** This method involves placing the reinforcement material and resin into a heated mold and applying pressure to consolidate the material. This process is often used for large, complex shapes.

3. **Injection Molding:** In this method, the reinforcement material and resin are combined and injected into a cooled mold under pressure. This process is often used for the high-volume production of small, simple shapes[6].

4. **Pultrusion:** This method involves pulling continuous strands or tows of reinforcement material through a bath of resin and then through a heated die, which shapes the composite material into a desired shape.

5. **Filament Winding:** This method involves winding continuous strands or tows of reinforcement material onto a mandrel or form in a predetermined pattern, and then soaking the reinforcement with resin. The resin is then allowed to cure, forming the composite material.

6. **Resin Transfer Molding (RTM):** This method involves injecting resin into a closed mold that contains the reinforcement material. The resin is then allowed to cure, forming the composite material.

7. **Vacuum Bagging:** This method involves placing the reinforcement material and resin on a mold and then sealing the material inside a vacuum bag. A vacuum is applied to the bag to remove excess air and help consolidate the material.

8. **Autoclave Processing:** This method involves placing the reinforcement material and resin into a mold and then curing the material under heat and pressure in an autoclave, which is a sealed chamber that can control temperature and pressure.

9. **Hot Pressing:** This method involves placing the reinforcement material and resin into a heated press, which applies pressure to consolidate the material.

10. **Three-Dimensional Printing:** Also known as additive manufacturing, this method involves building up layers of reinforcement material and resin to create a three-dimensional object. This process can be used to create complex shapes that would be difficult to fabricate using other methods (Figure 1).

Figure 1: Shows the Fabrication.

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