Chapter 1

Introduction
# Chapter 1

## Chapter 1- Introduction

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1. INTRODUCTION

1.1 INTRODUCTION

The need of development of new materials to meet the challenges for innovative applications in the scientific and technological fields has become a very much essential in the recent days. The present conventional materials are unable to fulfill all the conditions and the requirements such as higher strength, heat distortion temperature, and light weight with low cost. In order to achieve the above requirements an attempt has been made in the technology to find a novel material called ‘composite’ whose constituents will act synergistically to solve the need of the applications. As we cross the threshold into the ‘composite material age’, it becomes increasingly important to understand the properties, performance, cost and potential of the composites. Composite is one such material, which has revolutionized the concept of high strength.

The composites are well known to mankind since pre-historical period and were practiced as well. Polymer composites due to their light weight, chemical and corrosion resistance as well as heterogeneous composition provide unlimited possible of deriving any characteristics, such as ease of manufacturing, high specific strength, stiffness, shape molding, corrosion resistance, durability, adaptability and cost effectiveness, have attracted the attention of engineers and material scientist and technologists. They have become materials of
21st century to meet the requirement of space, missile, and marine and medical aid technologies.

Over the past 50 years there has a lot of interest develops to manufacturing materials with durable, light weight, and stiff. Composite materials are engineered materials made from two or more constituent materials with significantly different physical or chemical properties and which remain separate and distinct on a macroscopic level within the finished structure. The resultant product is endowed with the properties superior to any of it parental components. The components of a composite neither takes part in a chemical reaction nor does they dissolve completely or merge with one another. They remain strongly bonded together while maintaining an interface between each other and act in concept to give a much-improved performance.

Composites are not new to mankind; probably the first composite was made in biblical times when man added chopped straw to clay to make stronger bricks. The steel rod reinforced concrete widely used in modern buildings is also an example of composite.

In recent years it was identified due lightweight, high tensile strength composites gained good popularity which are need to withstand to applying at very high loads, such as aerospace components, boat and scull hulls, bicycle frames and racing car bodies. Each year, composites find in many applications in wide areas
like space craft marine, sports, missile etc. There are some other like chemical storage tanks and machinery construction.

In the last few years there has been rapid development in the usage of these composite materials in engineering applications and there is every indication that this will continue. Some idea of the range of applications for composite material is given in Table 1.1. The rapid growth has been attained mainly by the placing of traditional materials, instead of primarily metals. This reveals that, in composite materials have rich properties over compare with conventional materials.

<table>
<thead>
<tr>
<th>Industry</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft</td>
<td>Wings, fuselages, Landing gear, helicopter blades</td>
</tr>
<tr>
<td>Automobiles</td>
<td>Body parts, lamp-hosing, front –end panels, bumpers, leaf springs, seat housing, drive shafts,</td>
</tr>
<tr>
<td>Boat</td>
<td>Hulls, decks, masts</td>
</tr>
<tr>
<td>Chemicals</td>
<td>Pipes, tanks, pressure vessels</td>
</tr>
<tr>
<td>Furniture and Equipment</td>
<td>Panels, housing, Chairs, tables, ladders</td>
</tr>
<tr>
<td>Electrical</td>
<td>Panels, switchgear, insulators</td>
</tr>
<tr>
<td>Sport</td>
<td>Fishing rods, golf clubs, swimming pools, skies canoes</td>
</tr>
</tbody>
</table>
There is big problem for civil engineers in constructing houses because they were use steel and alloys etc., this may give high cost and effective. They were looking alternative materials for these materials for reducing their cost and maintenance of structure from corrosion. For example, the maintenance cost is bridges at highways composed with steel reinforced with concrete are up to $80 billion/year. For this they found the fiber reinforced polymer is new class of composite materials which are high dense, less weight, high efficient and economical. These are use for replacement of steel in civil engineering.

Fiber reinforced composite materials can be classified into two categories 1.short fiber reinforced materials and 2.continuous fiber reinforced materials.

The following can be considered as the ‘standard’ properties typically exhibited by an FRP composites component.

- Light weight at high strength
- Ability to tailor properties to meet wide-ranging performance specifications
- Molding to close dimensional tolerances, with their retention under in-service Conditions
- Best electrical, compression, and impact properties
- Capability to noticeably decrease part assembly
- Outstanding resistance in environment
 Capability to manufacture one piece molding

 Shown operating track record

 Tooling cost reduced

 Fabrication cost is less

 Capable to Build both color and texture

 Outstanding Chemical resistance and Corrosion resistance

 Good stability for high UV radiation

 Outstanding fire resistance

 Excellent structural reliability

 Capable to sound attenuate

 Good abrasion resistance

 prepared bonding to dissimilar materials

 Medium-to-high productivity rates

 1.2 CONSTITUENTS OF COMPOSITES

 When the composite material is designed properly it would be good strength over compare with conventional materials because the composite materials were composed with reinforcement like particles, fibers, fillers etc., embedded in a matrix. This holds the matrix and also improved the mechanical properties of matrix.

 The composite materials have two phases, continuous phase and discontinuous phase. The continuous phase is called the matrix,
which enhances chemical and hygroscopic resistance and process ability of the material. The discontinuous phase is called reinforcement or reinforcing material, which is generally fiber, which is added to provide strength and stiffness to a composite.

1.3 MATRIX

There is a continuous character at primary phase, and the matrix is usually more ductile and less hard phase. It holds the dispersed (i.e. reinforcement) and shares a load with it. The matrix binds the fibers together holding them aligned in the important stress direction. Loads are applied to the composite, and then transferred into the fibers. Matrix provides a uniform distribution of the structural and environmental load to the reinforcing fiber through a good adhesion to and a strong interface with the reinforcing fiber through a good adhesion to and a strong interface with the reinforcement. The matrix must isolate the fibers, so that they can act as separate entities. The matrix protects the surface of the composite against abrasion, wear and tear, and corrosion, all of which can initiate fracture. Matrixes absorb the impact of loads and minimize stress concentration by enhancing the fracture toughness. The matrixes resist high temperature and withstand repeated cycling of operations, especially under hygroscopic conditions and thus prevent or delay the onset of micro cracking in the composite. The composite matrix can be classified as a polymer matrix, metal matrix, ceramic matrix and
carbon matrix. It is responsible for the integrity of the composite compound.

1.3.1 Polymer Matrix Materials

Polymers make ideal matrix material as they can be easily processed having light weight, and offer desirable mechanical properties. Plastic (resin) matrix basis composites constitutes more than 95% of composite materials in use today. Two types of polymers are used as matrix materials; they are 1. Thermosets and 2. Thermoplastics.

1.3.1.1 Thermosets

Thermo sets have qualities such as a well-bonded three dimensional molecular structure after curing. They can be retained in partly cured condition over a prolonged period of time. Thus their use is very flexible. During curing polymer molecules takes place crosslink when thermosetting polymers undergo chemical reactions. Once cross linked, thermo sets become permanently hard and simply undergo chemical decomposition under the application of excessive heat. Due to good impact and flexural properties, it was found chopped fiber composites form particularly as a premixed or molding compound. They are most suited for fiber composites and in structural engineering applications. Some of the thermosetting polymers used are epoxy, polyester, phenolics, poly imides and cyanate esters.
1.3.1.2 Thermo Plastics

One or two-dimensional molecular structure have thermoplastics and soften at an elevated temperature and melt. The process of softening or melt can be reserved to regain its properties during cooling which facilitate the compression molding technique to mould the compound. They find greater use and have become emerging group of composites. They have a greater fictional advantage for new avenues including replacement of metals in die casting process.

The benefits of thermoplastics over thermosets are that, there is no chemical reactions takes place in it. This cause in release of gas or heat. Manufacturing is limited by the time required for heating, shaping and cooling the structure. Thermoplastic resins are sold molding compounds. Thermoplastic heat resistance rises by adding reinforcement. But all thermoplastic composites tend to lose their strength at elevated temperature.

1.3.2. Metal Matrix Materials

Metal matrix composites are, at present, not as widely used as their polymer counter parts. In metal matrix composite, the choice of the metal is governed by the factors such as light weight and high temperature resistance. The aerospace industry has always stressed its need for light weight materials, metal alloys or substitute that could be used to make aircraft parts. These increase the fuel efficiency
and maneuverability of an aircraft without jeopardizing safety. Boron reinforce aluminum is very popular for aircraft application. Titanium, aluminium and magnesium are popular metal matrix materials.

1.3.3. Ceramic Matrix

Normally, composites are made up of two dissimilar materials. But in certain cases there are exceptions. Ceramic-ceramic composite is one of them. In these composites, the ceramic matrix is reinforced with ceramic fibers. These are considered as composites, even though both the matrix and reinforcement are ceramic, because the two are in different forms. Ceramic matrices are chosen for their toughness. High compressive strength, corrosion resistance, melting point, advantages of the ceramic matrix materials. Therefore, ceramic matrices are chosen for high temperature applications especially of the order of 1500 °C

1.4. REINFORCEMENTS

Reinforcement is another constituent of composites that has high and more rigidity. It can be fiber, fabric particulates or whiskers. Fibers are the most important class of reinforcement, because it gives good mechanical strength of matrix and its properties. The reinforcement is added to provide strength and stiffness to a composite. A wide variety of fibers are available for use in composites. Fibers can be used in many forms, which can differ in amount of fiber – fiber type, fiber length, orientation and fiber hybridization [2].
The fibers may be continuous or discontinuous. When the fibers are short in nature, the composites are known as short fiber composite. In the case of composite materials, the most spectacular reinforcement may be achieved when the fibers are continuous, aligned the comprise more than 50% of the volume of the composite. Generally the fibers are classified into two categories: natural and synthetic.

1.4.1 Natural Fibers

The Natural fibers derived from annually renewable resources, as reinforcing fibers in polymer matrix composites provide positive environmental benefits with respect to ultimate disposability and raw material utilization [4]. Advantages of natural fiber over traditional reinforcing materials are [3] low cost, low density, high toughness, acceptable specific strength properties, reduced tool wear, reduced dermal and respiratory irritation, good thermal properties, ease of separation, enhanced energy recovery and biodegradability. The main drawback of natural fiber is their hydrophilic nature, which lowers the compatibility with hydrophobic polymeric matrix during composite fabrications. The other disadvantage is the relatively low processing temperature required due to the possibility of fiber degradation and/or the possibility of volatile emissions that could affect composite properties. The processing temperatures for most of the natural fiber are thus limited to about 200 °C, although it is possible to use higher temperatures
for short periods [4-6]. Other reasons for their increased use may be seen in Table 1.2. Depending on their origin, the natural fibers may be grouped into: leaf, bast, seeds and fruit origin. The classification of natural fibers presented in Fig 1.1.

The major constituents of natural fiber (lignocelluloses) are cellulose, hemi cellulose and lignin. The amount of cellulose, in lignocellulosic systems, can vary depending on the species and age of the plant. Cellulose is a hydrophilic glucan polymer consisting of a linear chain of 1, 4-β-bonded anhydroglucose units, which contain alcoholic hydroxyl groups. These hydroxyl groups form hydrogen bonds inside the macromolecule itself and among other cellulose macromolecules as well as with hydroxyl groups from the atmosphere. Therefore, all of the natural fibers are hydrophilic in nature; their moisture content reaches 8–12.6% [7].

![Diagram of natural fibers classifications](image)

**Fig: 1.1 classifications of natural fibers**
There is a lot of interest developed in making composites with reinforced natural fiber because it shows remarkable features in environmental and biodegradable. Many of the tropical regions had great interest in development of these composites with natural fibers due to flexible availability [8-22].

**1.4.2 Synthetic Fibers**

Synthetic fibers have good mechanical properties than natural fiber composites. Another advantage of synthetic fiber is their moisture repellency, whereas poor resistance to moisture absorption in natural fiber reinforced composites. The widely used synthetic polymer fibers glass, carbon, Kevlar, polyesters, nylon etc.

The other optional constituents in composites include fillers, additives, and auxiliary chemicals. Fillers are added to the resin matrix for controlling material cost and improving mechanical and
chemical properties. Calcium carbonate, alumina trihydrate, mica, silica, talc, synthetic fibers, cellulose products and glasses are some of the fillers used in composite industry. Additives are used in composites especially chosen and added to materials for improve characteristics.

1.5 FIBER MATRIX ADHESION

Once the fabrication process has productively met a uniform dispersion of matrix material around the reinforcing filaments, the Matrix and fiber surface interaction must be considered. To ensure good mechanical properties of composite it was important to take matrix and fiber adhesion. If there is no adhesion between two, the composite will respond as if it were the bulk matrix material with voids retaining the shape of the included fibers (at low strains). The interface is the area of contact between the reinforcement and the matrix material.

The performance of a composite material not only depends on the selection of the matrix, reinforcing and auxiliary materials, but also on the fiber-matrix interface. The interface must be as narrow as possible. Sometimes the bonding between the matrix and the reinforcement may be poor. In such cases the performance of the composite can be improved either by the modification of the reinforcement or the matrix. The fibers can be modified by graft co-polymerization with another polymer or by using a coupling agent.
The matrix may be modified by toughening with it thermoplastics, or elastomers.

The fiber matrix adhesion play important role in physical and mechanical properties of composite materials. At the aqueous and corrosive environments adhesion was the good factor for existing fracture, toughness properties of composite materials. Due to weak interface fiber with matrix it gets affect on strength and stiffness of composite material but not fracture.

1.5.1 Classification of Polymer Composites

Polymers composites have been classified in many ways depending on the ideas and concepts that need to be identified. A useful and all-embracing classification is set out in table 1.3 with some examples.

Table 1.3 Broad classifications of composite materials

<table>
<thead>
<tr>
<th>Examples</th>
<th>Wood, Bone, Bamboo, Muscle and other Tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural composite materials</td>
<td></td>
</tr>
<tr>
<td>Micro composite materials</td>
<td>Metallic alloys: e.g. steels</td>
</tr>
<tr>
<td></td>
<td>Toughened thermoplastic:</td>
</tr>
<tr>
<td></td>
<td>e.g. impact polystyrene, ABS</td>
</tr>
<tr>
<td></td>
<td>Sheet moulding composites</td>
</tr>
<tr>
<td></td>
<td>Reinforced thermoplastic</td>
</tr>
<tr>
<td>Macro composites</td>
<td>Galvanizedsteel</td>
</tr>
<tr>
<td>(Engineering Products)</td>
<td>Reinforced concrete beams</td>
</tr>
</tbody>
</table>
More relevant classification for the purpose of this thesis is given in Table [1.4]. This is concerned with micro composite material and is based on the size, shape and distribution of the two or more phases in the composite. The composite materials described in this thesis are in this second category and fall into the second and seventh Groups in Table [1.4].

Table 1.4 Classification of micro composite materials

| 1. Continuous fibers in matrix: aligned, random |
| 2. Short fibers in matrix: aligned, random     |
| 3. Particulates (spheres, plates, ellipsoids, irregular, hollow or solid) in matrix |
| 4. Dispersion strengthened, as for 3 above, with particle size <10^-8 m |
| 5. Lamellar structures                        |
| 6. Skeletal or interpenetrating networks      |
| 7. Multicomponent, fibers, particles, etc     |

1.6 HYBRID COMPOSITES

Hybrid composites are material made by combining two or more different types of fibers in a common matrix. This reinforcement of fibers gives wide range properties by selecting the suitable fibers. This cause reduces the cost, weight and increasing the strength of material. This process proven it is very useful for making the materials for different purpose.
There is a large diversity takes place in composite materials due to this reinforcement of fibers in matrix. Cow dung/glass fiber is a good example of hybrid composite possessing very good combined properties.

To take advantage of both natural and synthetic fibers, the author proposes to combine them in cow dung/glass fiber in the same matrix to develop hybrid composites. For this, the unsaturated polyester is used as a matrix to produce this composite with low cost and light weight.

### 1.6.1 Classification of Hybrid Composites

There are several types of hybrid composites and categorized as:

1. Interplay or tow-by-tow,

2. Sandwich hybrids, also known as core–shell,

3. Interplay or laminated

4. Intimately mixed hybrids

5. Other kinds, such as those reinforced with ribs, pultruded wires, and thin veils of fiber or combinations of the above.

### 1.6.2 Advantages of Hybrid Composites

The importance of hybrid composite materials is related to:

i. With the replacement of less expensive fibers instead of expensive fibers, the fabrication cost can be minimized.
ii. With the change in volume fraction of reinforcement it gives outstanding properties in mechanical and physical properties.

iii. The possibility of obtaining unique properties, singly or in combination which are not readily obtained when using one type of fiber alone

1.7 AIM AND SCOPE OF THE PRESENT WORK

With the advancement of civilization, man felt the need for more advanced material for his livelihood. So, to meet his ever-growing and diversifying needs, he started fabricating new materials from a judicious combination or manipulation of the existing old materials. Composite is one such material, which has revolutionized the concept of high strength. They have numerous applications in our daily life because of their superior properties. Composites are currently being used in several fields like aerospace, defense, transportation, marine engineering, electrical, construction, space technology, sports goods, automobiles and many engineering applications. The growth has been attained by the replacement of traditional materials, primarily metals.

The performance of composites depends on the selection of the constituent materials also on the bonding between them. Reinforcing material or the fiber is one of them. Natural and synthetic fibers are the two types of fibers and the large quantity of work has been done in composites reinforced with fibers. But both these fibers have added advantages very well. Recent years natural fibers have rich importance
as reinforcing materials. Natural fibers are renewable, eco friendly, and biodegradable. Natural fibers are cheaper than synthetic fibers. Synthetic fibers have advantage over compare with natural fiber because the moisture repellence and where natural fibers are poor in repellence of moisture there by the composites reinforcement with natural fiber is less attractive. But the mechanical properties of natural fiber composites are much lower than the synthetic fiber composites because the inherent hydrophilicity of plant fibers usually leads to poor interfacial adhesion with hydrophobic polymer matrices. With this view, the author studied the relationship of surface modification and mechanical properties such as tensile, flexural, and compressive, impact and dielectric properties of cow dung/glass fiber composites. The chemical resistance test for this composite was also studied for this ASTM method has been employed.

The author used unsaturated polyester resin as a matrix, due high strength and low manufacturing costs. This has been widely used in industry. In the present work the author used the hand lay-up method for preparing the composite. The test specimens are prepared and the tests are carried out as per the ASTM standards. The first part related to how to improve the conditions of intake between the fiber and the matrix. This part deals with the improvement of conditions when the fiber is treated with different chemicals especially with NaOH.
To take advantages of both natural and synthetic fibers, they can be combined in the same matrix to produce hybrid composites that take full advantage of the best properties of the constituents, and thereby an optimal, superior but economical composite can be obtained. With this view, the author has developed hybrid composites of cow dung/glass fiber with random orientation. The mechanical properties such as compressive, tensile, flexural, and impact properties have been studied for these hybrid composites. The test specimens are prepared and the tests are carried out as per the ASTM standards. The variation of mechanical properties with different weight ratios of fibers and chemical treatment was also studied for these hybrid composites. Unsaturated polyester resin was used as the matrix for these hybrid composites. As the composites find applications as chemical storage tanks, the author also proposed to study their chemical resistance behavior. For this the author used the ASTM method.

There is a lot of scope for further work on these hybrid composites. More investigation is needed to improve the properties of materials with using different fibers. For example the effect of mechanical, thermal properties can be studied for Cow dung/glass fiber hybrid composites. It was found the thermal conductivity of the materials has to be reduced by adding cow dung this is the best result forever decreasing the emission of heat from the material. These hybrid composites can be prepared using other thermoset matrices.
like phenol formaldehyde, epoxy etc., The Cow dung fiber with adding other fillers reinforced composites and hybrid composites can also be subjected to other tests such as aging, flame test, inter laminar shear strength, void content test and thermal analysis. The author wants to continue this future also part of the further research work. The author also asks the researchers to search some hidden natural fibers around the world and built a material possible to usage by replacing the metals.