

**FABRICATION OF DECORATIVE FLUORESCENT
COMPOSITE MATERIAL**

A dissertation submission in the partial fulfillment

For the degree of Master of Science in Physics

Under academy autonomy

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By

**LATA DEEP
(409PH2090)**

**DEPARTMENT OF PHYSICS
NATIONAL INSTITUTE OF TECHNOLOGY
ROURKELA**



Under the Guidance of

**Dr. DILLIP KUMAR BISOYI
&
Dr. SIDDHARTHA JENA**

**DEPARTMENT OF PHYSICS
NATIONAL INSTITUTE OF TECHNOLOGY
ROURKELA-769008**



Department of Physics
National Institute of Technology
Rourkela - 769008
Odisha, India

CERTIFICATE

This is to certify that the thesis entitled “**Fabrication of Decorative Fluorescent Composite Material**” being submitted by **Lata Deep** in partial fulfillment of the requirements for the award of the degree of Master of Science in Physics at National Institute of Technology, Rourkela is an authentic experimental work carried out by her under our supervision. To the best of our knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any degree or diploma.

Date:

(Dr. Dilip Kumar Bisoyi)

(Dr. Sidhartha Jena)

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ABSTRACT

Decorative Composites are the composite materials having artistic characteristics in addition to functional characteristics. It is high possible that the decorative composites produce a new field on the fibrous composite industry. Natural fiber reinforced composite is attracting attention and considered as an environmentally friendly material. Usually cellulosic fibers are used to reinforce the composites, In this paper, we proposed a method of producing artistic composite from artistic fabric by using sisal fiber reinforced composite, In order to expand applications of the fiber reinforced composite, we performed the hand lay up method for the preparation of mold with the help of themocoul. Then using epoxy resin as matrix we prepared a decorative composite with sisal fiber as reinforced material.

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CHAPTER-1

1.1 INTRODUCTION

Man's evolution has been tied to his progress in materials. Yesterday it was the Stone, Bronze and Iron Ages. Today it is the Age of Composites. However, even in these earlier ages man experimented with and learned to use composite materials. This is evidenced by the Israelites' use of chopped straw in their brick; the Egyptian sarcophagi fashioned from glued and laminated wood veneer and also their use of cloth tape soaked in resin for mummy embalming; the Mongol warriors' high-performance, recurved archery bows of bullock tendon, horn, bamboo strips, silk and pine resin, which are 80% as strong as our modern fiberglass bows; Chinese bamboo rockets reinforced with rope wrappings; Japanese Samurai swords formed by the repeated folding of a steel bar back on itself; the early fabrication of steel and of iron gun barrels in Damascus; and the Roman artisans' use of ground marble in their lime plaster, frescoes and pozzolanic mortar. The ancients also used goat hair in their clay for the fabrication of pottery which, after firing, was converted to a form of carbon, the forerunner of modern carbon fiber reinforced ceramics.

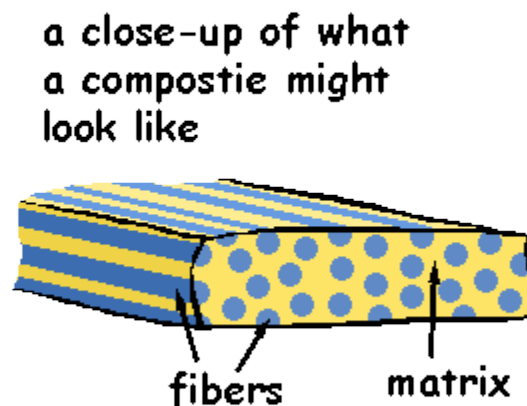
Composites are becoming the essential part of today's materials because they offer advantages such as low weight, corrosion resistance, high fatigue [2] strength, faster assembly etc. Composites are used as material ranging from making aircraft structure to golf club, electronic packaging to medical equipment and space vehicles to home buildings. Composites are generating curiosity and interest in student all over the world. They are seeing everyday application of composite material in commercial market and job opportunities are also increasing in this field.

The purist considers a composite to consist of two or more identifiable constituents which just about includes everything except homogeneous or single phase materials. The other extreme is the group that believes composite materials do not include sandwiches, laminates, felts, etc., but consist only of a continuous matrix phase that surrounds the reinforcing phase structure.

There also are those who differentiate between a composite material and a composite structure such as safety glass or other laminates. Others classify composites into microcomposites, which include reinforced and toughened thermoplastics, sheet molding compounds and metallic alloys; and macrocomposites, which include reinforced concrete, galvanized steel and helicopter blades. Still another author does not accept natural composites such as wood or bone because they do “not have a structure of arbitrary variation.” Any definition of a composite material is also at best a compromise. Too narrow and rigid definition of a composite will restrict the type and number of entries. The following is the one chosen after deliberation:

1.2 COMPOSITES

A composite is when two or more different materials are combined together to create a superior and unique material. The first uses of composites date back to the 1500s B.C. when early Egyptians and Mesopotamian settlers used a mixture of mud and straw to create strong and durable buildings. Straw continued to provide reinforcement to ancient composite products including pottery and boats. A composite is when [3] two or more different materials are combined together to create a superior and unique material. The first uses of composites date back to the 1500s B.C. when early Egyptians and Mesopotamian settlers used a mixture of mud and straw to create strong and durable buildings. Straw continued to provide reinforcement to ancient composite products including pottery and boats. Fig 1.1 shows structure of a composite.



(fig 1.1)

composite material is basically a combination of two or more materials, each of which retains its own distinctive properties. Multiphase metals are composite materials on a micro scale, but generally the term composite is applied to materials that are created by mechanically bonding two or more different materials together. The resulting material has characteristics that are not characteristic of the components in isolation. The concept of composite materials is ancient. An example is adding straw to mud for building stronger mud walls. Most commonly, composite materials have a bulk phase, which is continuous, called the matrix; and a dispersed, non-continuous, phase called the reinforcement. Some other examples of basic composites include concrete (cement mixed with sand and aggregate), reinforced concrete (steel rebar in concrete), and fiberglass (glass strands in a resin matrix).

1.1.1 DEFINITION

A heterogeneous solid consists of two or more materials (matrix and dispersed) that are mechanically or metallurgically bonded together. The materials are of different physical and chemical properties which remain separate and distinct at the microscope or microscale within the finished structure.

1.1.2 CONSTITUENTS OF COMPOSITE MATERIALS

The individual materials that make up composites are called *constituents*. Most composites have two constituent materials

1. Matrix materials
2. Reinforcement materials
3. Interface between interface and matrix

Matrix: - The matrix holds the reinforcements in an orderly pattern. Because the reinforcements are usually discontinuous, the matrix also helps to transfer load among the reinforcements. Matrix prevents propagation of cracks from fiber to fiber. Matrix should be ductile, prevents fiber from surface damage, adhere well to minimize pull out. Matrix materials are usually some type of plastic, and these composites are often called *reinforced plastics*. There are other types of matrices, such as metal or ceramic, but plastics are by far the most common. [2,3]

Functions of a Matrix

In a composite material, the matrix material serves the following functions:

- Holds the fibres together.
- Protects the fibres from environment.
- Distributes the loads evenly between fibres so that all fibres are subjected to the same amount of strain.
- Enhances transverse properties of a laminate.
- Improves impact and fracture resistance of a component.
- Helps to avoid propagation of crack growth through the fibres by providing alternate failure path along the interface between the fibres and the matrix.
- Carry interlaminar shear.

Properties of a Matrix

The needs or desired properties of the matrix which are important for a composite structure are as follows:

- Reduced moisture absorption.
- Low shrinkage.
- Low coefficient of thermal expansion.
- Good flow characteristics so that it penetrates the fibre bundles completely and eliminates voids during the compacting/curing process.
- Reasonable strength, modulus and elongation (elongation should be greater than fibre).
- Must be elastic to transfer load to fibres.
- Strength at elevated temperature (depending on application).
- Low temperature capability (depending on application).
- Excellent chemical resistance (depending on application).
- Should be easily processable into the final composite shape.
- Dimensional stability (maintains its shape).

Reinforced materials: - The reinforcement is usually much stronger and stiffer than the matrix, and gives the composite its good properties. Reinforcements basically come in three forms: *particulate*, *discontinuous fiber*, and *continuous fiber*. A particle has roughly equal dimensions in all directions, though it doesn't have to be spherical. Gravel, micro balloons, and resin powder are examples of particulate reinforcements. Reinforcements become fibers when one dimension becomes long

compared to others. Discontinuous reinforcements (chopped fibers, milled fibers, or whiskers) vary in length from a few millimeters to a few centimeters. Most fibers are only a few microns in diameter, so it doesn't take much length to make the transition from particle to fiber.[5]

Types of Fibers

i. Glass fibers

A huge percentage (more than 95%) of the fibers used in reinforced plastics are glass fibers, as they are inexpensive, easy to manufacture and possess high strength and stiffness with respect to the plastics with which they are reinforced. Their low density, resistance to chemicals, insulation capacity are other bonus characteristics, although the one major disadvantage in glass is that it is prone to break when subjected to high tensile stress for a long time. However, it remains break-resistant at higher stress-levels in shorter time frames. This property mitigates the effective strength of glass especially when glass is expected to sustain loads for many months or years continuously.

ii. Metals fibers

As reinforcement, metal fibers have many advantages. They are easily produced using several fabrication processes and are more ductile, apart from being not too sensitive to surface damage and possess high strengths and temperature resistance. However, their weight and the tendency to react each other through alloying mechanisms are major disadvantages. Metal wires, of the continuous version, also reinforce plastics like polyethylene and epoxy. Such combinations ensure high strength, light weight and good fatigue resistance. Besides, continuous metal fibers are easily handled, unlike glass fibers. Better flexural properties are observed in some metal fibers reinforced plastic composites which also offer improved strength and weight, than glass fibers. However, their poor tolerance of high temperature and the resultant steep variations of thermal expansion coefficient with the resins are a discouragement that limits their their application.

iii. Alumina Fibers

Alumina aluminum oxide fibers, basically developed for use in metal matrices are considered a potential resin-matrix composite reinforcement. It offers good compressive strength rather than tensile strength. It's important property is it's high melting point of about 2000°C and the composite can be

successfully used at temperature up to about 1000°C. Magnesium and aluminum matrices frequently use alumina fiber reinforced composites as they do not damage the fiber even in the liquid state.

iv. Boron Fibers

They are basically composites, in which boron is coated on a substance which forms the substrate, usually made of tungsten. Boron-tungsten fibers are obtained by allowing hot tungsten filament through a mixture of gases. Boron is deposited on tungsten and the process continued until the thickness is achieved. The tungsten however remains constant in its thickness. Properties of boron fibers generally change with the diameter, because of the changing ratio of boron to tungsten and the surface defects that change according to size. However, they are known for their remarkable stiffness and strength. Their strengths often compare with those of glass fibers, but their tensile modulus is high, almost four to five that of glass. Boron coated carbons are much cheaper to make than boron tungsten fiber. But its low modulus of elasticity often works against it.

v. Silicon Carbide fibers

Silicon carbide can be coated over a few metals and their room temperature tensile strengths and tensile moduli are like those boron-tungsten. The advantages of silicon carbide-tungsten are several and are more desirable than uncoated boron tungsten fibers. However, Silicon carbide-tungsten fibers are dense compared to boron-tungsten fibers of the same diameters. They are prone to surface damage and need careful, delicate handling, especially during fabrication of the composite. Silicon carbide on carbon substrates have several advantages, viz. no reaction at high temperature, being lighter than silicon carbide tungsten and possessing tensile strengths and modulus that is are often better than those of silicon carbide-tungsten and boron fibers.

vi. Aramid Fibers

Aramid fibers are made aromatic polyamides which are long polymeric chains and aromatic rings. They are structures in which six carbon atoms are bonded to each other and to combinations of hydrogen atoms. In aramid fibers, these rings occur and reoccur to form the fibers. They were initially used to reinforce automobile tires. Since then, they have also found other uses like bullet proof vests. As high strength applications, their use in power boats is not uncommon.

Aramids have high tensile strength, high modulus and low weight. Impact-resistant structures can be produced from aramids. The density of aramid fibers is less than that of glass and graphite fibers. They are fire resistant apart from being high-temperature resistant and unaffected by organic solvents fuels. But their resistance in acid and alkaline media is poor. They are supple and allow themselves to be woven into matrices by simple processes. Aramid fibers have a negative coefficient of thermal expansion in the fiber direction and failure of aramid fibers is unique. When they fail, the fibers break into small fibers, which are like fibers within the fibers. This unique failure mechanism is responsible for high strength.

vii. Quartz and Silica Fibers

The glass-types typically contain about 50 to 70% silica. Silica glass is a purer glass fiber that can be made by treating fiberglass in an acid bath, which removes all impurities without affecting the silica. The final product contains 93 to 99% silica. Quartz is even more pure, and quartz fibers are made from natural quartz crystals that contain 99.9% silica, possessing nearly all the properties of pure solid quartz. Ordinary fiberglass, high silica and quartz fibers share several characteristics and can be produced in a range of fiber diameter. Roving or yarns and other forms of fibers can be made from high silica as well as quartz too. They differ from glass in many factors, however, especially in heat-related properties. Although quartz crystals are commonly available, pure crystals are hard to come by. On the other hand, high silica comes from the same material as glass fibers and is easily accessible. However, quartz makes up for its rarity with its capacity to withstand high temperatures, which silica is incapable of. Barring this difference, silica and quartz are similar in other respects. They are highly elastic and can be stretched to 1% of their length before break point. Both silica and quartz are not affected by acid attacks and are resistant to moisture. A Owing to their thermal properties, silica and quartz are the natural choice as fibers in several applications. They have good insulating properties and do not melt at temperature up to 1600°C. In addition, they have a low thermal expansion coefficient which makes them withstand high temperatures.

viii. Graphite Fibers

While use of the term carbon for graphite is permissible, there is one basic difference between the two. Element analysis of poly-acrylo-nitrile (PAN) base carbon fibers show that they consist of 91 to 94% carbon. But graphite fibers are over 99% carbon. The difference arises from the fact that the fibers are made at different temperatures. The properties of graphite remain unchanged even at high

temperatures, but its willingness to react readily with most metals at the fabrication stage or during use at very high temperatures is often a stumbling block. Graphite fibers are some of the stiffer fibers known. The stiffness of the fiber is as high as the graphite content. But a major drawback is that stiffness and strength are inversely proportional to each other. Forbidding costs make the use of graphite fibers prohibitive.

ix. Multiphase Fibers

Spoolable filaments made by chemical vapour deposition processes are usually the multiphase variety and they usually comprise materials like boron, silicon and their carbides formed on surface of a very fine filament substrate like carbon or tungsten. They are usually good for high temperature applications, due to their reduced reaction with higher melting temperature of metals than graphite and other metallic fibers. Boron filaments are sought after for structural and intermediate-temperature composites. A poly-phase fiber is a core-sheath fiber consisting of a poly-crystalline core.

x. Whiskers

Single crystals grown with nearly zero defects are termed whiskers. They are usually discontinuous and short fibers of different cross sections made from several materials like graphite, silicon carbide, copper, iron etc. Typical lengths are in 3 to 55 N.M. ranges. Whiskers differ from particles in that, whiskers have a definite length to width ratio greater than one. Whiskers can have extraordinary strengths upto 7000 MPa. Metal-whisker combination, strengthening the system at high temperatures, has been demonstrated at the laboratory level. But whiskers are fine, small sized materials not easy to handle and this comes in the way of incorporating them into engineering materials to come out with a superior quality composite system.. Ceramic material's whiskers have high moduli, useful strengths and low densities. Specific strength and specific modulus are very high and this makes ceramic whiskers suitable for low weight structure composites. They also resist temperature, mechanical damage and oxidation more responsively than metallic whiskers, which are denser than ceramic whiskers. However, they are not commercially viable because they are damaged while handling.

Interface:- A surface, forming a common boundary between two objects (matrix and reinforcement

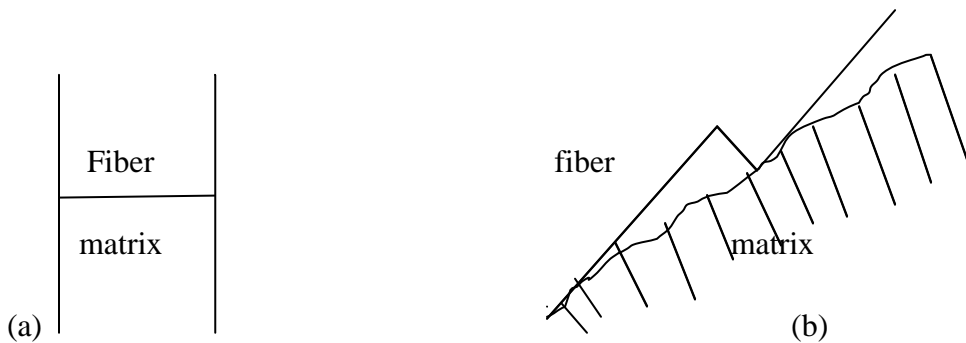


Fig.: (a) An ideal planar interface between fiber and matrix (b) A more likely real, jagged interface between fiber and matrix

The interface between reinforcement and matrices are rough

- The interface is a bounding surface or zone where a discontinuity occurs, whether physical, mechanical, chemical etc.
- The matrix material must "wet" the fiber. Coupling agents are frequently used to improve wettability. Well "wetted" fibers increase the interface surface area.
- To obtain desirable properties in a composite, the applied load should be effectively transferred from the matrix to the fibers via the interface. This means that the interface must be large and exhibit strong adhesion between fibers and matrix. Failure at the interface (called debonding) may or may not be desirable. This will be explained later in fracture propagation modes.
- Bonding with the matrix can be either weak vander Waals forces or strong covalent bonds.
- The internal surface area of the interface can go as high as $3000 \text{ cm}^2/\text{cm}^3$.
- Interfacial strength is measured by simple tests that induce adhesive failure between the fibers and the matrix. The most common is the Three-point bend test or ILSS (interlaminar shear stress test)

1.3 CHARACTERISTICS OF COMPOSITES

- Light weight
- High specific strength and modulus, as well as high fatigue strength and fatigue damage tolerance
- Isotropic nature

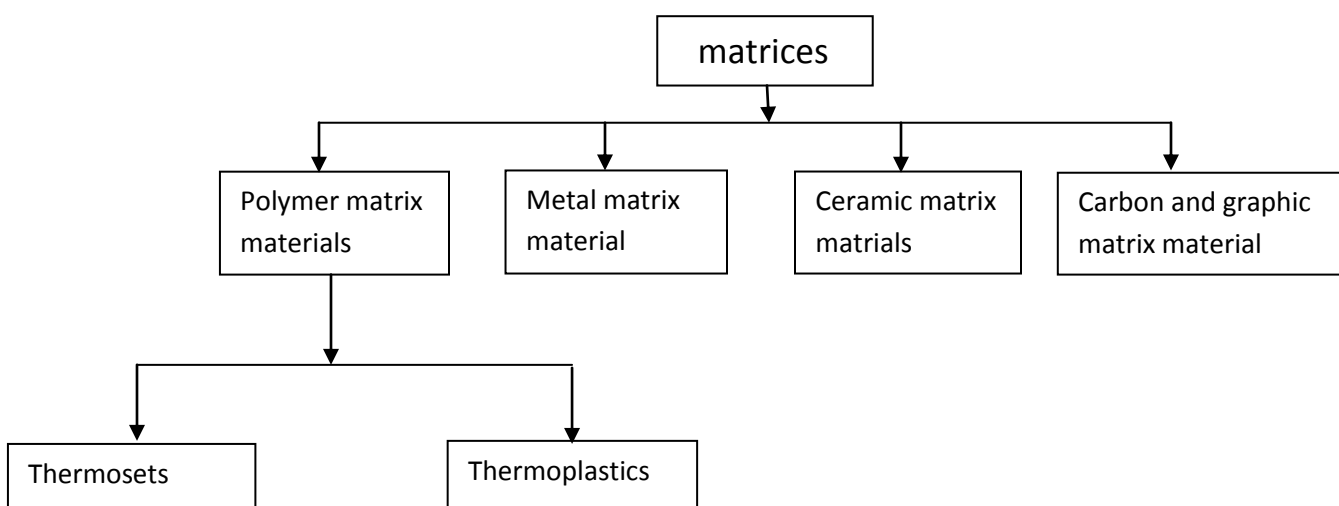
- Designable or tailorable materials for both microstructure and properties
- Production of both material and structure or component in a single operation- *manufacturing flexible, net-shape, complex geometry*
- Corrosion resistance and durable
- Easy moldable to complex forms
- Easy bondable
- Good dumping
- Low electrical conductivity and thermal expansion
- Good fatigue resistance
- Part consolidation due to lower overall system costs
- Low radar visibility
- Internal energy storage and release
- Other unique functional properties-*damping, low CTE (coefficient of thermal expansion)*

1.4 CLASSIFICATION OF COMPOSITE

Composite materials are commonly classified at following two distinct levels:

The **first level** of classification is usually made with respect to the matrix constituent. The major composite classes include Organic Matrix Composites (OMCs), Metal Matrix Composites generally assumed to include two classes of composites, namely Polymer Matrix Composites (PMCs) and carbon matrix composites commonly referred to as carbon-carbon composites. Figure 1.2 helps to classify matrices.

Fig-1.2



1.4.1 Polymer Matrix Materials

Polymers make ideal materials as they can be processed easily, possess lightweight, and desirable mechanical properties. It follows, therefore, that high temperature **resins** are extensively used in aeronautical applications. Two main kinds of polymers are thermosets and thermoplastics.

Thermosets have qualities such as a well-bonded three-dimensional molecular structure after curing. They decompose instead of melting on hardening. Merely changing the basic composition of the resin is enough to alter the conditions suitably for curing and determine its other characteristics. They can be retained in a partially cured condition too over prolonged periods of time, rendering Thermosets very flexible. Thus, they are most suited as matrix bases for advanced conditions fiber reinforced composites. Thermosets find wide ranging applications in the chopped fiber composites form particularly when a premixed or moulding compound with fibers of specific quality and aspect ratio happens to be starting material as in epoxy, polymer and phenolic polyamide resins.[4,5,6]

Thermoplastics have one- or two-dimensional molecular structure and they tend to at an elevated temperature and show exaggerated melting point. Another advantage is that the process of softening at elevated temperatures can reversed to regain its properties during cooling. Resins reinforced with thermoplastics now comprised an emerging group of composites. The theme of most experiments in this area to improve the base properties of the resins and extract the greatest functional advantages from them in new avenues, including attempts to replace metals in die-casting processes.

1.4.2 Metal Matrix Materials

Metal matrix composites, at present though generating a wide interest in research fraternity, are not as widely in use as their plastic counterparts. High strength, fracture toughness and stiffness are offered by metal matrices than those offered by their polymer counterparts. They can withstand elevated temperature in corrosive environment than polymer composites. Most metals and alloys could be used as matrices and they require reinforcement materials which need to be stable over a range of temperature and non-reactive too. The melting point, physical and mechanical properties of the composite at various temperatures determine the service temperature of composites. Most metals, ceramics and compounds can be used with matrices of low melting point alloys. The choice of reinforcements becomes more stunted with increase in the melting temperature of matrix materials.

1.4.3 Ceramic Matrix Materials

Ceramics can be described as solid materials which exhibit very strong ionic bonding in general and in few cases covalent bonding. High melting points, good corrosion resistance, stability at elevated temperatures and high compressive strength, render ceramic-based matrix materials a favourite for applications requiring a structural material that doesn't give way at temperatures above 1500°C. Naturally, ceramic matrices are the obvious choice for high temperature applications.

1.1.4 Carbon Matrices

Carbon and graphite have a special place in composite materials options, both being highly superior, high temperature materials with strengths and rigidity that are not affected by temperature up to 2300°C.

This carbon-carbon composite is fabricated through compaction of carbon or multiple impregnations of porous frames with liquid carboniser precursors and subsequent pyrolyzation. They can also be manufactured through chemical vapour deposition of pyrolytic carbon. Carbon-carbon composites are not be applied in elevated temperatures, as many composites have proved to be far superior at these temperatures. However, their capacity to retain their properties at room temperature as well as at temperature in the range of 2400°C and their dimensional stability make them the obvious choice in a garnut of applications related to aeronautics, military, industry and space.

Components, that are exposed to higher temperature and on which the demands for high standard performance are many, are most likely to have carbon-carbon composites used in them.

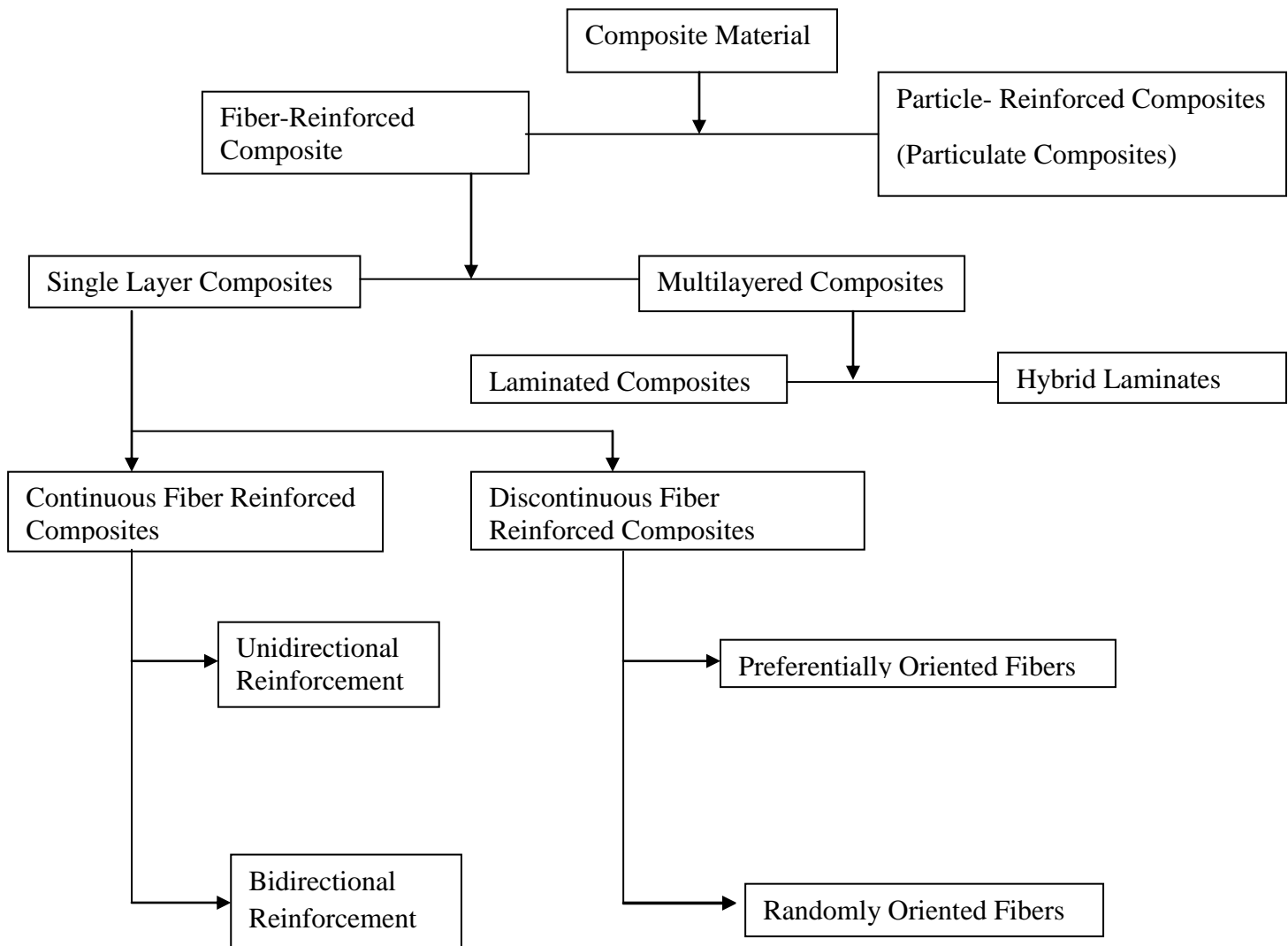
The **second level** of classification (fig-1.3) refers to the reinforcement form - fibre reinforced composites, laminar composites and particulate composites. Fibre reinforced composites can be further divided into those containing discontinuous or continuous fibres. Fibre Reinforced Composites are composed of fibres embedded in matrix material. Such a composite is considered to be a discontinuous fibre or short fibre composite if its properties vary with fiber length. On the other hand, when the length of the fiber is such that any further increase in length does not further increase, the elastic modulus of the composite, the composite is considered to be continuous fiber reinforced. Fibers are small in diameter and when pushed axially, they bend easily although they have very good tensile properties. These fibers' must be supported to keep individual fibers' from bending and buckling. Laminar Composites are composed of layers of materials held together

by matrix. Sandwich structures fall under this category. Particulate Composites are composed of particles distributed or embedded in a matrix body. The particles may be flakes or in powder form. Concrete and wood particle boards are examples of this category. [6]

1.1.5 Fiber Reinforced Composites

Fiberglass is likely the best know fiber reinforced composite but carbon-epoxy and other advanced composites all fall into this category. The fibers can be in the form of long continuous fibers, or they can be discontinuous fibers, particles, whiskers and even weaved sheets. Fibers are usually combined with ductile matrix materials, such as metals and polymers, to make them stiffer, while fibers are added to brittle matrix materials like ceramics to increase toughness. The length-to diameter ratio of the fiber, the strength of the bond between the fiber and the matrix, and the amount of fiber are variables that affect the mechanical properties. It is important to have a high length-to-diameter aspect ratio so that the applied load is effectively transferred from the matrix to the fiber

(Fig 1.3)



1.1.6 Particle Reinforced Composites

The particles in these composite are larger than in dispersion strengthened composites. The particle diameter is typically on the order of a few microns. In this case, the particles carry a major portion of the load. The particles are used to increase the modulus and decrease the ductility of the matrix. An example of particle reinforced composites is an automobile tire which has carbon black particles in a matrix of polyisobutylene elastomeric polymer. Particle reinforced composites are much easier and less costly than making fiber reinforced composites. With polymeric matrices, the particles are simply added to the polymer melt in an extruder or injection molder during polymer processing. Similarly, reinforcing particles are added to a molten metal before it is cast.

1.5: ADVANTAGES AND DISADVANTAGE OF COMPOSITES

1.5.1 Advantages

Summary of the advantages exhibited by composite materials, which are of significant use in aerospace industry are as follows:

- High resistance to fatigue and corrosion degradation.
- High 'strength or stiffness to weight' ratio.
 - Due to greater reliability, there are fewer inspections and structural repairs.
- Directional tailoring capabilities to meet the design requirements. The fibre pattern can be laid in a manner that will tailor the structure to efficiently sustain the applied loads.
- Fabre to fiber redundant load path.
- Improved dent resistance is normally achieved. Composite panels do not sustain damage as easily as thin gage sheet metals.
- It is easier to achieve smooth aerodynamic profiles for drag reduction. Complex double-curvature parts with a smooth surface finish can be made in one manufacturing operation.
- Composites offer improved torsional stiffness. This implies high whirling speeds, reduced number of intermediate bearings and supporting structural elements. The overall part count and manufacturing & assembly costs are thus reduced.
- High resistance to impact damage.

- Thermoplastics have rapid process cycles, making them attractive for high volume commercial applications that traditionally have been the domain of sheet metals. Moreover, thermoplastics can also be reformed. Like metals, thermoplastics have indefinite shelf life. [8]
- Composites are dimensionally stable i.e. they have low thermal conductivity and low coefficient of thermal expansion. Composite materials can be tailored to comply with a broad range of thermal expansion design requirements and to minimise thermal stresses.
- Manufacture and assembly are simplified because of part integration (joint/fastener reduction) thereby reducing cost.
- The improved weatherability of composites in a marine environment as well as their corrosion resistance and durability reduce the down time for maintenance.
- Close tolerances can be achieved without machining.
 - Material is reduced because composite parts and structures are frequently built to shape rather than machined to the required configuration, as is common with metals.
- Excellent heat sink properties of composites, especially Carbon-Carbon, combined with their lightweight have extended their use for aircraft brakes.
- Improved friction and wear properties.
 - The ability to tailor the basic material properties of a Laminate has allowed new approaches to the design of aeroelastic flight structures. The above advantages translate not only into airplane, but also into common implements and equipment such as a graphite racquet that has inherent damping, and causes less fatigue and pain to the user.

1.5.2 Disadvantages of Composites

Some of the associated disadvantages of advanced composites are as follows:

- High cost of raw materials and fabrication.
- Composites are more brittle than wrought metals and thus are more easily damaged.
- Transverse properties may be weak.
- Matrix is weak, therefore, low toughness.
- Reuse and disposal may be difficult.
- Difficult to attach.

- Repair introduces new problems, for the following reasons:
 - a. Materials require refrigerated transport and storage and have limited shelf life.
 - b. Hot curing is necessary in many cases requiring special tooling.
 - c. Hot or cold curing takes time.
- Analysis is difficult.
- Matrix is subject to environmental degradation.

1.6 APPLICATIONS OF COMPOSITES

- Composites have high stiffness, strength, and toughness, often comparable with structural metal alloys. Further, they usually provide these properties at substantially less weight than metals: their “specific” strength and modulus per unit weight is near five times that of steel or aluminum. This means the overall structure may be lighter, and in weight-critical devices such as airplanes or spacecraft this weight savings might be a compelling advantage. [13,14,15]
- Composites can be made anisotropic, i.e. have different properties in different directions, and this can be used to design a more efficient structure. In many structures the stresses are also different in different directions; for instance in closed-end pressure vessels – such as a rocket motor case – the circumferential stresses are twice the axial stresses. Using composites, such a vessel can be made twice as strong in the circumferential direction as in the axial.
- Many structures experience fatigue loading, in which [7] the internal stresses vary with time. Axles on rolling stock are examples; here the stresses vary sinusoidally from tension to compression as the axle turns. These fatigue stresses can eventually lead to failure, even when the maximum stress is much less than the failure strength of the material as measured in a static tension test. Composites of then have excellent fatigue resistance in comparison with metal alloys, and often show evidence of accumulating fatigue damage, so that the damage can be detected and the part replaced before a catastrophic failure occurs.
- Materials can exhibit damping, in which a certain fraction of the mechanical strain energy deposited in the material by a loading cycle is dissipated as heat. This can be advantageous, for instance in controlling mechanically-induced vibrations. Composites generally offer relatively high levels of damping, and furthermore the damping can often be tailored to desired levels by suitable formulation and processing.

- Composites can be excellent in applications involving sliding friction, with tribological (“wear”) properties approaching those of lubricated steel.
- Composites do not rust as do many ferrous alloys, and resistance to this common form of environmental degradation may offer better life-cycle cost even if the original structure is initially more costly.
- Many structural parts are assembled from a number of subassemblies, and the assembly process adds cost and complexity to the design. Composites offer a lot of flexibility in processing and property control, and this often leads to possibilities for part reduction and simpler manufacture. Of course, composites are not perfect for all applications, and the designer needs to be aware of their drawbacks as well as their advantages. Among these cautionary notes we can list:
 - Not all applications are weight-critical. If weight-adjusted properties not relevant, steel and other traditional materials may work fine at lower cost.
 - Anisotropy and other “special” features are advantageous in that they provide a great deal of design flexibility, but the flip side of this coin is that they also complicate the design. The well-known tools of stress analysis used in isotropic linear elastic design must be extended to include anisotropy, for instance, and not all designers are comfortable with these more advanced tools.
 - Although composites have been used extensively in demanding structural applications for a half-century, the long-term durability of these materials is much less certain than that of steel or other traditional structural materials.

1.7 FLOUROSCENCE

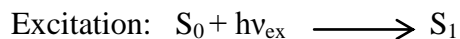
Luminescence is a is a general term that describe any process in that describe any process in which energy is emitted from a substance at a different wave length from that at which it is observed. It covers fluorescent, phosphorescence and triboluminescence. Fluorescence by definition is the absorption of light by a substance and the spontaneous emission of light in a longer wave length within 10^{-8} sec of activation. In dentistry it has been traditionally assume that fluorescence is the absorption

by a substance of ultra violet (UV) light (black light) and the emission of visible light in the bluish spectrum.

The molecule is in a high vibration state after electronic excitation, then excess vibrational energy may be lost by intermolecular collision. The vibrational energy is converted to kinetic energy and appears as heat in the sample, such transfer between energy level is referred to as 'radiationless'. When the excited molecule has reached a lower vibrational state (for example $v'=0$), it may then emit radiation and revert to the ground state, the radiation emitted, called the fluorescence spectrum, is normally of lower frequency than that of the initial absorption, but under certain condition it may be of higher frequency. The time between initial absorption and return to the ground state is 10^{-8} sec.

Photo chemistry:-

Fluorescence occurs when an orbital electron of a molecule or atom is excited to a higher quantum state by some type of energy and then it relaxes to its ground state by emitting a photon of light.



(Here, h = Planck's constant, ν = frequency of light, S_0 = ground state

& S_1 = first excited state)

A molecule in excited states can relax in several ways. The most common way is that in which the excitation energy is dissipated as heat. Excited molecules can also be relaxed via conversion to a triplet state which may subsequently relax via phosphorescence or by a secondary non-radiative relaxation.

CHAPTER-2

2.1 LITERATURE SURVEY

A composite is when two or more different materials are combined together to create a superior and unique material. The first uses of composites date back to the 1500s B.C. when early Egyptians and Mesopotamian settlers used a mixture of mud and straw to create strong and durable buildings. Straw continued to provide reinforcement to ancient composite products including pottery and boats.

Later, in 1200 AD, the Mongols invented the first composite bow. Using a combination of wood, bone, and “animal glue,” bows were pressed and wrapped with birch bark. These bows were extremely powerful and extremely accurate. Composite Mongolian bows provided Genghis Khan with military dominance, and because of the composite technology, this weapon was the most powerful weapon on earth until the invention of gunpowder. The modern era of composites did not begin until scientists developed plastics. Until then, natural resins derived from plants and animals were the only source of glues and binders. In the early 1900s, plastics such as vinyl, polystyrene, phenolic and polyester were developed. These new synthetic materials outperformed resins that were derived from nature. However, plastics alone could not provide enough strength for structural applications. Reinforcement was needed to provide the strength, and rigidity. In 1935, Owens Corning introduced the first glass fiber, fiberglass. Fiberglass, when combined with a plastic polymer creates an incredibly strong structure that is also lightweight. This is the beginning of the Fiber Reinforced Polymers (FRP) industry as we know it today. Many of the greatest advancements in composites were incubated by war. Just as the Mongols developed the composite bow, World War II brought the FRP industry from the laboratory into actual production. Alternative materials were needed for lightweight applications in military aircraft. Engineers soon realized other benefits of composites beyond being lightweight and strong. It was discovered that fiberglass composites were transparent to radio frequencies, and the material was soon adapted for use in sheltering electronic radar equipment (Radomes). By the end of the WWII, a small niche composites industry was in full swing. With lower demand for military products, the few composites innovators were now ambitiously trying to introduce composites into other markets. Boats were an obvious fit for composites, and the first commercial boat hull was introduced in 1946.

At this time Brandt Goldsworthy, often referred to as the “grandfather of composites,” developed new manufacturing processes and products. He is credited with numerous advancements including being the first to fiberglass a surfboard, which revolutionized the sport. Goldsworthy also invented a manufacturing process known as pultrusion. Today, products manufactured from this process include ladder rails, tool handles, pipes, arrow shafts, armor, train floors, medical devices, and more. In the 1970s the composites industry began to mature. Better plastic resins and improved reinforcing fibers were developed. DuPont developed an aramid fiber known as Kevlar, this fiber has become the standard in armor due to its high tenacity. Carbon fiber was also developed around this time; it has since been replacing metal as the new material of choice. The composites industry is still evolving, with much of the growth is now focused around renewable energy. Wind turbine blades are constantly pushing the limits on size and are requiring advanced materials, designs, and manufacturing. In the future, composites will utilize even better fibers and resins, many of which will incorporate nano-materials. Dedicated university programs and research institutions will continue to develop improved materials and ways to manufacture them into products. Additionally, composites are on the path towards being more environmentally friendly. Resins will incorporate recycled plastics and bio-based polymers. Composites will continue to make the world lighter, stronger, more durable, and a better place to live. [9, 10, 11]

2.2 OBJECTIVES

The objectives of the project are outlined below.

- Fabrication of sisal fibre reinforced epoxy based composite.
- Form a decorative composite.
- In order to expand applications of the fiber reinforced composite, we performed the hand lay up method for the preparation of mold with the help of themocoul.

2.3 THESIS ORGANIZATION

The thesis consists of four chapters.

Chapter-1:- This chapter gives an idea about composites, characteristic of composites, classification of composites and its advantages and disadvantages.

Chapter-2:- This chapter also summarized an overview of the past work done on composite. Main objective of the work has been discussed in this chapter.

Chapter-3:- The different methods fabrication has been discussed here.

Chapter-4:- This chapter deals with the different materials and methods used in this research work

Chapter-5:- Summary and conclusion drew from the present work.

CHAPTER-3

3.1 FABRICATION

Manufacturing process, in which an item is made (fabricated) from raw or semi-finished materials instead of being assembled from ready-made components or parts. There are numerous methods for fabricating composite components. Some methods have been borrowed (injection molding, for example), but many were developed to meet specific design or manufacturing challenges. Selection of a method for a particular part, therefore, will depend on the materials, the part design and end-use or application.[1]Composite fabrications processes involve some form of molding; a mold tool is required to give the unformed resin and its fiber reinforcements their shape prior to cure.

3.2 TYPES OF FABRICATION

3.2.1 Hand layup molding

Hand lay-up is a simple method for composite production. A mold must be used for hand lay-up parts unless the composite is to be joined directly to another structure. The mold can be as simple as a flat sheet or have infinite curves and edges. For some shapes, molds must be joined in sections so they can be taken apart for part removal after curing. Before lay-up, the mold is prepared with a release agent to insure that the part will not adhere to the mold. Reinforcement fibers can be cut and laid in the mold. It is up to the designer to organize the type, amount and direction of the fibers being used. Resin must then be catalyzed and added to the fibers. A brush, roller or squeegee can be used to impregnate the fibers with the resin. The lay-up technician is responsible for controlling the amount of resin and the quality of saturation. Other fabrication processes such as vacuum bagging, vacuum resin transfer molding and compression molding can be used with hand lay-up to improve the quality of the finished part or save time.

3.2.2 Vacuum bagging

Follows similar steps to the hand lay-up process. When the resin is adequately impregnated into the fibers with excess, the part is sealed with vacuum bagging materials. A layer of peel ply is laid down on the part because the resin will not stick to peel ply. Then a layer of breather cloth is laid down to soak up excess resin and insure an adequate path for the vacuum pressure. Then a layer of plastic sheeting is laid down and sealed around the part to isolate the part from the atmosphere. A hose

connected to a vacuum is attached to the sealed part. A vacuum is then applied to the enclosed part. The part will be compacted by the vacuum and the breather cloth will collect the excess resin

3.2.3 Vacuum resin transfer molding

The first steps of hand lay-up. The mold is prepared with a release agent, the fibers are cut and placed into the mold, and then new steps are taken. The next steps are as follows: a layer of peel ply is laid down on the fibers, a layer of mesh netting is laid on the part, special air tubes are fixed at desired entrance and exit points, vacuum tubes are connected to the air tubes, the part is sealed with plastic sheeting and a vacuum is applied. The part and mold are then heated with vacuum still applied to allow resin transfer into the part occur properly. Catalyzed resin is then degassed to remove volatiles. When the part and mold have reached the desired temperature, one vacuum tube will remain connected to the vacuum and the other will be used to draw the degassed resin. The part will be left under vacuum and cured under additional heat for a predetermined amount of time. Compression molding is similar in theory but opposite in application to vacuum techniques.

3.2.4 Compression molding

May follow the first steps of hand lay-up, but normally the process will be much more complicated. The mold for a compression-molded part must be designed for proper routing of excess resin. A male and female mold will be necessary. They can both be solid molds or a bladder mold can be used to compress into the other mold. Once fabrication techniques have been organized, the production process can begin. First the molds must be prepared with a release agent. Then fibers must be cut and placed on the surface of one or both of the molds. Catalyzed resin must be impregnated into the fibers with excess. The two molds are then joined and adequate pressure can be applied by air or mechanical force. If the mold is set up properly, the desired amount of resin will disperse throughout the fibers and out through the proper exit channels

3.2.5 Filament winding:

Filament winding is a process for composite production that usually involves a high initial investment. A machine must be purchased or created to wind filaments in exact locations on a mandrel. Control necessities to complete these tasks are proper filament tow, longitudinal placement and mandrel winding speed. Some advantages of filament winding are low material and labor costs and accuracy

of product dimensions. Some disadvantages of filament winding are cost and design constraints of removable mandrels and the inability of winding on concave surfaces. Part production by filament winding keeps increasing and only seems limited by imagination.

3.2.5 Pultrusion

Pultrusion is a composite fabrication process designed for structural shapes. The investment cost is very high and therefore only feasible for mass production parts. Fibers are drawn through a resin bath and then through a forming block. Heaters are used to insure fast curing through steel dies and then the part is cut to proper length. Pultruded parts are strongest in the longitudinal direction because of their fiber orientation. Fiber orientation can be changed to increase strength in other directions. Solid, open sided and hollow shapes can be produced at almost any length. Cores such as foam and wood can be built inside of the pultruded shapes. Due to the pressure and designs of production, protruded production can be up to 95% effective in material utilization. Figure 8 shows the basic pultrusion process.

CHAPTER-4

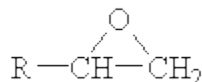
4. MATERIALS AND METHODS

4.1 MATERIALS: - The raw materials used in this work are

1. Sisal fiber
2. Epoxy resin

Sisal fibers:- Sisal Fibre is exceptionally durable with a low maintenance with minimal wear and tear and it is Recyclable. Sisal fibres are obtained from the outer leaf skin, removing the inner pulp. Fine fiber available as plaid, herring bone and twill. Sisal fibers are anti static, do not attract or trap dust particles and does not absorb moisture or water easily. The fine texture takes dyes easily and offers the largest range of dyed colours of all natural fibres. It exhibits good sound and impact absorbing properties. Its leaves can be treated with natural borax for fire resistance properties.

Epoxy resin: - Epoxy resin is defined as a molecule containing more than one epoxide groups. The epoxide group also termed as, oxirane or ethoxyline group, is shown below,



These resins are thermosetting polymers and are used as adhesives, high performance coatings and potting and encapsulating materials. These resins have excellent electrical properties, low shrinkage, good adhesion to many metals and resistance to moisture, thermal and mechanical shock. Viscosity, epoxide equivalent weight and molecular weight are the important properties of epoxy resins.

Curing of Epoxy Resins

The curing process is a chemical reaction in which the epoxide groups in epoxy resin reacts with a curing agent (hardener) to form a highly crosslinked, three-dimensional network. In order to convert epoxy resins into a hard, infusible, and rigid material, it is necessary to cure the resin with hardener. Epoxy resins cure quickly and easily at practically any temperature from 5-150°C depending on the choice of curing agent.

Curing Agents (Hardeners)

A wide variety of curing agent for epoxy resins is available depending on the process and properties required. The commonly used curing agents for epoxies include amines, polyamides, phenolic resins, anhydrides, isocyanates and polymercaptans. The cure kinetics and the T_g of cured system are dependent on the molecular structure of the hardener. The choice of resin and hardeners depends on the application, the process selected, and the properties desired. The stoichiometry of the epoxy-hardener system also affects the properties of the cured material. Employing different types and amounts of hardener which, tend to control cross-link density vary the structure. The amine and phenolic resin based curing agents, described below, are widely used for curing of epoxy resins.

Amine based curing agents:

Amines are the most commonly used curing agents for epoxy cure. Primary and secondary amines are highly reactive with epoxy. Tertiary amines are generally used as catalysts, commonly known as accelerators for cure reactions. Use of excessive amount of catalyst achieves faster curing, but usually at the expense of working life, and thermal stability. The catalytic activity of the catalysts affects the physical properties of the final cured polymer.

Phenolic novolac resins:

Epoxy resins when cured with phenolic hardener, gives excellent adhesion, strength, chemical and flame resistance. Phenolic novolac-cured epoxy systems are mainly used for encapsulation because of their low water absorption, excellent heat and electrical resistance. An accelerator is necessary for the complete cure to occur.

4.2 METHODS: - Required shape of thermo coul mould has been prepared for the fabrication of composite (fig-1). Sisal fibers are chopped with a pair of scissiors. On the bottom of the mould a releasing sheet is kept and heavy duty silicon spray is applied on the realising sheet for the easy removal of the composite. Then chopped fibers are distributed uniformly on the bottom of the mould. A mixture of epoxy resin (LY556, thermosetting, easy to processing and easily available) and hardner (HY951) in the ratio 10:1 is mixed to form a matrix. The fiber and matrix are taken in the weight percentage ratio of 15:85. The matrix is poured over the chopped fibers in the mould. Then it is

covered with a releasing sheet spread with silicon spray and it pressed down with an iron roller to release the entrap air. After 12 hours curing we get the required shape decorative composite (fig-2) has been extracted out of the mould.



Fig-1



fig-2

In order to fabricate a fluorescent decorative fluorescent material (i.e.-glitter pen ink) is added in the mixture of epoxy resin and hardener. The curing property of the epoxy resin got disturb when it was added due to the presence of some amount of water content in it. When it is taken to the heat treatment the water got evaporated and a required fluorescent decorative composite is formed.

CHAPTER-5

5.1 CONCLUSION

In this project work the properties of composite materials, their classification, advantages and disadvantages and also their application has been studied. It came to know that decorative composite materials having artistic characteristic in addition to functional characteristic. In order to expand applications of the fiber reinforced composite, the hand layup method has been done for the preparation of mould with the help of themocoul. An artistic composite from artistic fabric has been prepared by using sisal fiber reinforced composite. To make it more attractive fluorescent materials has been added which disturbed the curing property of epoxy resin but after a heat treatment we finally got decorative fluorescent composite materials with desired shape.

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