Research Work On Composite Epoxy Matrix & Ep Polyester Reinforced Material

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ABSTRACT

Composite material has been used in India for last three years. Indigenous production of unsaturated polyester resin has started in 1962 and of ep polyester fibers in 1965, preparing the foundation for growth of composites in India. Polymer composites are gaining popularity in many industrial applications due to their higher specific strength and module .Now days, the fiber reinforced composites have dramatically come into use. These composites have gained so much recognition because of their processing advantages and good technical properties like strength, density, impact, stiffness, elastic modulus, creep rate, damping. Furthermore, these properties showed considerable improvement with increasing silk fabric content. The waste silk collected from the factory outlets were used to fabricate silk reinforced epoxy composites and various samples were developed with varying silk content. In recent years the natural fiber composites have attracted substantial importance as a potential structural material. The attractive features of ep polyester fiber have been their low cost, light weight, high specific modulus, renewability and biodegradability. Natural composites reinforced with such natural fibers have thus been a subject of intense study for high strength, low cost application in contrast to the synthetic fiber reinforced composite.

In the present work "**COMPOSITE RESEARCH WORK ON EPOXY MATRIX AND EP POLYESTER REINFORCED MATERIAL**" tests were performed to find tensile strength, density, impact,damping. of the composites for the different variables. The composites were fabricated using Epoxy resin as polymer, Araldite as hardener, ep polyester as reinforcement. Single, double and four layer composites were made. They were then experimented in the universal testing machine and more test.

Introduction

A composite is a material made from two or more different constituent materials having different physical or chemical properties which do not merge in the finishing structure i.e. the individual constituents retain their   properties. Nowadays, natural fiber composites have gained increasing interest due to their eco-friendly properties. A lot of research work has been done by the researchers in this field. Natural fibers are potential alternatives for artificial fibers. The composite materials exist long before we came to know about its whereabouts and most importantly its significance. Wood is a composite of cellulose fibers in a matrix of lignin. The most primitive man-made composite materials

were straw and mud combined to form bricks used for structural purposes. Silk has been an important fabric in the textiles industry due to its luster and superb mechanical properties.. Light, strong and corrosion-resistant, composite materials are being used in an increasing number of products as more manufactures discover the benefits of these versatile materials. In an advanced society like ours we all depend on composite materials in some aspect of our lives. Fiberglass, developed in the late 1940s, was the first modern composite and is still the most common. It makes up about 65 per cent of all the composites produced today and is used for boat hulls, surfboards, sporting goods, swimming pool linings, building panels and car bodies. We may well be using something made of fiberglass without knowing it. The strength and lightness of composites has made them particularly attractive for transportation. Composites have made airplanes lighter, more economical, and more affordable and solved problems such as cracking and metal fatigue.

Fig-1.1 Airplane Composite Wings

Composites are not just useful in making things fly. Cars of the future must be safer, more economical, and more environmentally friendly, and composites could help achieve all three. Although composites such as GRP have been used in the manufacture of automobile parts since the 1950s, most cars are still made from steel. High-temperature ceramic-matrix composites are also making possible cleaner-burning, more fuel-efficient engines for both cars and trucks. Composites are increasingly used in place of metals in machine tools. being lighter and stronger, they can offer better performance than metals at high temperatures and do not develop potentially dangerous weaknesses such as fractures and fatigue. Further, the need of composite for lighter construction materials and more seismic resistant structures has placed high emphasis on the use of new and advanced materials that not only decreases dead weight but also absorbs the shock & vibration through tailored microstructures. Composites are now extensively being used for rehabilitation/ strengthening of pre-existing structures that have to be retrofitted to make them seismic resistant, or to repair damage caused by seismic activity. Unlike conventional materials (e.g., steel), the properties of the composite material can be designed considering the structural aspects. The design of a structural component using composites involves both material and structural design.

be tailored to almost any specific engineering requirement. Whilst the use of composites will be a clear choice in many instances, material selection in others will depend on factors such as working lifetime requirements, number of items to be produced (run length), complexity of product shape, possible savings in assembly costs and on the experience & skills the designer in tapping the optimum potential of composites.
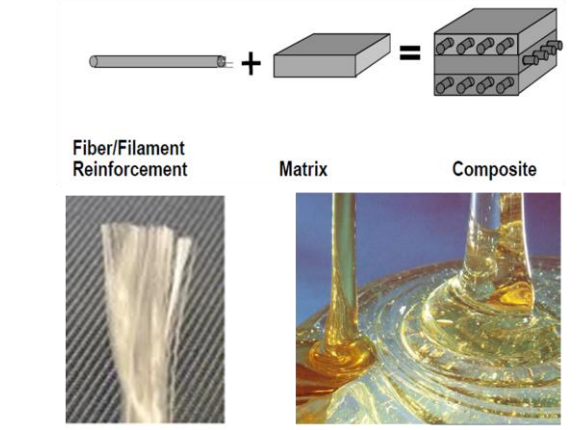
CONSTITUENTS OF PMCS

Fig-1.3 Constituents of PMCS

CHARACTERISTICS OF THE COMPOSITES

Composites consist of one or more discontinuous phases embedded in a continuous phase. The discontinuous phase is usually harder and stronger than the continuous phase and is called the 'reinforcement' or 'reinforcing material', whereas the continuous phase is termed as the 'matrix'.

Properties of composites are strongly dependent on the properties of their constituent materials, their distribution and the interaction among them. The composite properties may be the volume fraction sum of the properties of the constituents or the constituents may interact in a synergistic way resulting in improved or better properties. Apart from the nature of the constituent materials, the geometry of the reinforcement (shape, size and size distribution) influences the properties of the composite to a great extent. The concentration distribution and orientation of the reinforce- ment also affect the properties. The shape of the discontinuous phase (which may by spherical, cylindrical, and rectangular cross-sanctioned prisms or platelets), the total size and size distribution (which controls the texture of the material) and

volume fraction determine the interfacial area, which plays an important role in determining the extent of the interaction between the reinforce- ment and the matrix. Concentration, usually measured as volume or weight fraction, determines the contribution of a single constituent to the overall properties of the composites. It is not only the single most important parameter influencing the properties of the composites, but also an easily controllable manufacturing variable used to alter its properties.

PROPERTIES OF COMPOSITE

The following are some of the properties of composite materials for which they are widely used:

• The strength of the fibers and matrix interface significant in determining the properties of the composites.

• The interfacial bond strength must be sufficient enough for the load to be transferred from the matrix to the fibers
.
• The interface must not be so strong that it does not fail for improved toughness of the com- posites.

• Volume fractions of the composites play a significant role in determining properties. It is regarded as the most important parameter for determining the properties of the composites.

• Homogeneity is also an important characteristic that determines the extent to which a material may differ in physical and mechanical properties from the average properties of the material.

• The isotropy of the system is affected by the orientation of the reinforcement of the matrix in the composites.

TYPES OF COMPOSITES

Broadly, composite materials can be classified into three groups on the basis of matrix material.

They are:

(a) Metal Matrix Composites (MMCs)

(b) Ceramic Matrix Composites (CMCs)

(c) Polymer Matrix Composites (PMCs)

(a) METAL MATRIX COMPOSITES (MMCs)

Metal matrix composites, as the name implies, have a metal matrix. Examples of matrices in such composites include aluminum, magnesium and titanium. The typical fiber includes carbon and silicon carbide. Metals are mainly reinforced to suit the needs of design. For example, the elastic stiffness and strength of metals can be increased, while large co-efficient of thermal expansion, and thermal and electrical conductivities of metals can be reduced by the addition of fibers such as silicon carbide.

(b) CERAMIC MATRIX COMPOSITES (CMCs)

Ceramic matrix composites have ceramic matrix such as alumina, calcium, alumino silicate reinforced by silicon carbide. The advantages of CMC include high strength, hardness, high service temperature limits for ceramics, chemical inertness and low density. Naturally resistant to high temperature, ceramic materials have a tendency to become brittle and to fracture.

(c) POLYMER MATRIX COMPOSITES (PMCs)

The most common advanced composites are polymer matrix composites. These composites consist of a polymer thermoplastic or thermosetting reinforced by fiber (natural carbon or boron). These materials can be fashioned into a variety of shapes and sizes. They provide great strength and stiffness along with resistance to corrosion. The reason for these being most common is their low cost, high strength and simple manufacturing principles. Due to the low density of the constituents the polymer composites often show excellent specific properties.

CLASSIFICATION OF COMPOSITES

Composite materials can be classified on the basis of different attributes in various ways. In general there are two phases in a composite material. One is the primary phase called matrix this keeps the secondary phase, the reinforcement undamaged from the external forces. Based on the type of secondary phase the composites are broadly classified into three categories.

They are as follows:

• Fiber reinforced composite material

• Flake reinforced composite material

• Particle reinforced composite material

Based on the matrix material, the composites can be broadly classified into three categories.
They are as follows:

• Metal Matrix Composites

• Polymer Matrix Composites

• Ceramic Matrix Composites

PARTICLE REINFORCED COMPOSITES

Particle reinforced composites consist of particles of one material dispersed in the matrix of second material. The particles may be of any shape and size. Generally the particles are spherical polyhedral, ellipsoidal, or irregular in shape. The particles which are incorporated into the matrix may be treated with chemicals or can be applied untreated. The particles are often used to improve the strength of the materials, modify the electrical and thermal

conductivity, reduce friction, increase wear and abrasion resistance, improve machinability and reduce shrinkage.

Particle composites are of two types. They are:

• Composites with random orientation of fibers

• Composites with preferred orientation of fibers

FIBER- REINFORCED COMPOSITE

A fiber is defined by its length which is much larger as compared to its cross-section. Fibers improve the fracture resistance of the matrix as a reinforcement having a long dimension inhibits the growth of incipient cracks normal to the reinforcement which might otherwise lead to failure of the composites.

These are high performance fiber composites made by cross linking of cellulosic fiber molecules with resins in the material matrix. Fiber reinforcement enhances the strength and modulus of elasticity of the composites. Hence it is necessary for the fibers to posses' higher modulus than the matrix material, so that the load is transferred to the fiber from the matrix more effectively. It is widely used in outdoor deck floors, railings, fences, landscaping timbers, cladding and siding, park benches, molding and trim, window and door frames, and indoor furniture.

These are composites are again classified into two groups based on the length of fibers used.

They are as follows:

• Continuous Fiber reinforced composites

• Discontinuous Fiber reinforced composites

Continuous fiber reinforced composites have continuous fibers and they do not have discontinuity which is different from the discontinuous fiber reinforced composites. The discontinuous fiber reinforced composites are again of two types namely aligned FRCs and random FRCs (based on orientation of fibers).

NATURAL FIBER COMPOSITES

Natural fiber has attracted the attention of researchers worldwide as a potential reinforcement for composites because of their easy availability, easy process ability, low density, light weight, non abrasivity and lower cost and eco-friendly characteristics like sequestration of carbon dioxide (reduction of greenhouse effect). The silk fiber produced by spiders, silkworms, scorpions, mites and flies may have different composition, structure and material properties depending upon the specific source. These flaws can be avoided by spinning under controlled conditions to produce uniform cross-sectional area of silk fiber. Replacement of fiberglass with natural fibers removes worries about the lung disease caused by the former which is a great step towards sustainable development.

These fibers are animal or plant products; the latter are essentially micro composites consisting of cellulose fibers in an amorphous matrix of lignin and hemi cellulose. Cotton, jute, silk, wool, hemp and sisal are some of the natural fiber composites.

Fig - 1.4 NATURAL FIBER COMPOSITES

FIBER REINFORCED POLYMER COMPOSITES

These consist of polymer matrix embedded with high strength fibers. These are the most advanced composites that are used.

Some of the features of FRPCs are as follows:

• Low cost

• Simple Fabrication methods

• High tensile strength

• High stiffness

• Good abrasion, puncture and corrosion resistance

• Good fatigue strength

Limitations of FRPCs are as follows:

• Low operating temperature

• Low thermal and moisture resistance

• High coefficient of thermal expansion

• Low elastic properties in transverse direction

COMPONENTS OF COMPOSITE MATERIAL

Matrix Materials

The primary phase having a continuous character is called matrix. Matrix is usually more ductile and less hard phase. It holds the dispersed phase and shares a load with it. Matrix is composed of any of the three material types- polymers, metals or ceramics. The matrix forms the bulk form of the part or the product.Most of the materials when they are in a fibrous from show very good strength properties. In order to achieve these properties the fibers must be bonded by suitable matrix. The matrix separates one fiber from the other in order to prevent wear and abrasion. It also prevents the formation of new surface flaws and holds the fibers in place. A good matrix is one which possesses the ability to deform easily under applied load, transfer the load into the fibers and distribute the stress concentrations evenly. The natural fibers are embedded in a biopolymer matrix system which serves the purpose of holding the fibers together thereby stabilizing the shape of the composite structure. This helps to transmit the shear forces between the mechanically high quality fibers, and to protect them against radiation and external forces. Polymers are classified into two categories namely thermo sets and thermoplastics. Both these varieties are suitable for use as matrix in the bio composites. There are large numbers of ways of modifying the matrices. So it is essential that the materials for matrix are chosen according to the requirements. The criteria for choosing a suitable matrix system for high performance construction materials are the temperature in which it is to be used, amount of mechanical loading under consideration, manufacturing technology followed, etc. An important criterion for the selection of matrix is its adequately low viscosity for a good impregnation of the reinforcing fibers.

FUNCTIONALLY GRADED COMPOSITES

Functionally graded material (FGMs) is a kind of multiphase material, the material parameters change continuously along the thickness to meet the different requirements of the components' different parts, and achieve the purpose of optimizing the structure (Gupta *et al*, 2005). FGM is widely used in aerospace, nuclear reactors, internal combustion engines and other fields (Noda *et al*, 1998).In the technical world the concept of FGM was first proposed around 1984-85 when Japanese researchers studied advanced materials for aerospace applications working on a space plane project. The body of the space plane will be exposed to a very high temperature environment of about 1700°C with a temperature gradient of approximately 1000°C between inside and outside of the space plane. There was no uniform material able to endure such conditions. It requires a high wear resistance outside (enamel) and a ductile inner structure for reasons of fatigue and brittleness. Further it requires a translucent outer area and a specific set of colour nuances for reason of aesthetics.

REINFORCEMENT

The secondary phase is embedded in the matrix in a discontinuous form. The dispersed phase is usually harder and stronger than the continuous phase and is

called reinforcement. It serves to Strengthen the composites and improves the overall mechanical properties of the matrix.

The main purpose of the reinforcement in composites is primarily improving the mechanical properties of the neat resin system. The varieties of fibers used in composites have different properties and therefore impart different properties to the composites.

NEED OF FUNCTIONALLY GRADED MATERIALS

The most light weight composites materials which have high ratios of strength to weight and stiffness to weight have been used successfully used in aircraft industry and other engineering applications. But inspite of their good properties sometimes these composite materials are incapable to use under high temperature conditions. If we talk about metals, they are used in engineering field for many years on account of their excellent strength and toughness but in high temperature conditions the strength of the metals get reduced as was in the case of composite materials. Ceramic materials would be an option as they have excellent characteristics of heat resistance but are limited in use due to their low toughness.

That is why keeping in view all those points a new class of composite materials has been formed known as Functionally Graded Materials. Basically FGM is an inhomogeneous component made from different phases of material constituents generally ceramics and metals. The ceramic part gives good thermal resistance characteristics and the metal constituents provide stronger mechanical performance while reducing the possibilities of catastrophic fracture. Within the FGM different micro structural phases have different functions and the overall FGM attains the multi structure status from their property gradation.

Applications of Functionally Graded Materials

The overview of important applications of FGM is shown in Fig. and also given as under,

*Rocket engine components, Space plane body

*Cutting tools, shafts, rollers, turbine blades, engine components

*Nuclear reactor components, first wall of fusion reactor, fuel pellet

*Optical fibres, lens

*Artificial skin implant, drug delivery system

*Heat exchanger, heat pipe, slurry pump, reaction vessel

*Thermoelectric generators, thermionic convertor, solar cell

*Building material, sports goods

*Car body, window glass

Fig 1.5 Applications of Functionally Graded Materials

CREEP AND ITS MECHANISMS

Creep is the tendency of a solid material to slowly move or deform permanently under the influence of stresses (Kraus, 1980). It occurs as a result of long term exposure to high levels of stress that are below the yield point strength of the material. Creep is more severe in materials that are subjected to high temperature for long periods, and near melting point. Creep always increases with increase in temperature.

Creep is defined as time-dependent permanent deformation of material under constant load. Large plastic strains and finally rupture can result from creep. For some materials however such as polymer and composite including wood and concrete, temperature is not an important factor and creep can occur strictly from long term application. For practical purposes, when creep becomes important, a material should be designed to resist a specified creep strain for a given period of time. In this case an important mechanical property that is used for the design of members subjected to creep is creep strength of the material. This parameters represents the highest initial stress the material can withstand during a specified time without causing a given amount of creep strain.To determine the engineering creep curve of a metal, a constant load is applied to a tensile specimen maintained at constant temperature and the strain (extension) of the specimen is determined as the function of time. An initial rapid elongation of the specimen, the creep rate decreases with time, then reaches essentially a steady state in which creep rate changes little with time and finally the creep rate increases rapidly with time until fracture occurs. Creep mainly has three stages as shown in Fig. The first stage of the creep I known as primary creep represents a region of decreasing creep rate. In this stage the creep resistance of the material increases by virtue of its own deformation. The second stage of the creep is known as secondary creep is a period of nearly constant creep rate which results from a balance between the competing processes of strain hardening and recovery. For this reason creep is usually referred to as steady state creep. The average value of the creep rate during secondary creep is called the minimum creep rate. Third stage or Tertiary creep mainly occurs in constant load creep tests at high stresses at high temperatures. Tertiary creep occurs when there is an effective reduction in cross-sectional area either because of necking or internal void formation. The creep rate of hot pressure-loaded components in a nuclear reactor at power can be a significant design-constraint, since the creep rate is enhanced by the flux of energetic particles. In steam turbine power plants, pipes carry steam at high temperatures (566 $°C$) and pressures (3500 psi). In jet engines, temperatures can reach up to 1400 $°C$ and initiate creep deformation in even advanced-coated turbine blades (Dieter, 1988). Hence, it is crucial for correct functionality to understand the creep deformation behavior of materials.

CREEP UNDER VARIABLE STRESS

In the previous section, creep has been described under constant uniaxial state of stress. However, in most of the engineering components subjected to creep, the stress is variable due to two reasons. Firstly, the load applied on the structure may vary and secondly, the stress distribution may continuously vary with time under constant load. Therefore, the creep laws derived for constant one dimensional stress condition cannot be applied to variable stress conditions and hence must be modified. Time hardening and strain hardening are two popular theories,Which take into account the variable stress and variable time (Boresi and Schmidt, 2003). The

time hardening theory states that for a constant temperature and variable stress condition, creep rate ($\dot{\varepsilon}_c$) is a function of stress and time.

$$\dot{\varepsilon}_c = f(\sigma, t) \qquad (2.1)$$

However, in case of strain hardening theory it is assumed that the creep rate is a function of stress and accumulated strain.

$$\dot{\varepsilon}_c = f(\sigma, \varepsilon) \qquad (2.2)$$

The particular forms of these laws can be obtained by assuming that the creep curve can be represented by Bailey-Norton law, which is a common representation of creep in the primary and secondary creep ranges under isothermal conditions and is given below,

$$\varepsilon_c = A\sigma^n t^m \qquad (2.3)$$

where *A*, *m* and *n* are constants whose values depend upon the material type.

Pickel *et al* (1971) also noticed that the strain hardening model is unable to accurately predict the creep behaviour resulting from structural instabilities. But for structurally stable materials, the predictions by strain hardening model are fairly reliable. However, in the case of gradually varying stress, both the laws give approximately similar predictions.
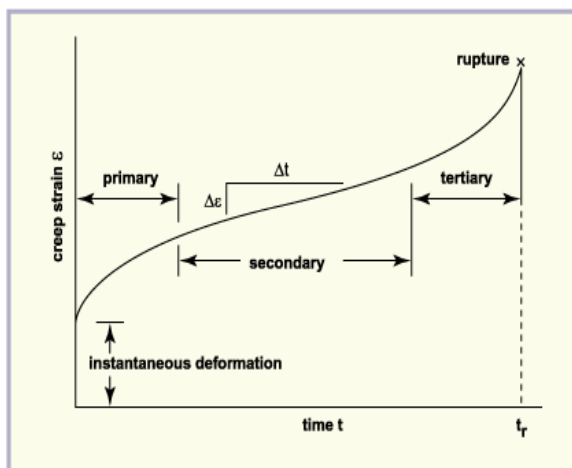
WHY USE COMPOSITES

The greatest advantage of composite materials is strength and stiffness combined with lightness. By choosing an appropriate combination of reinforcement and matrix material, manufacturers can produce properties that exactly fit the requirements for a particular structure for a particular purpose.

Modern aviation, both military and civil, is a prime example. It would be much less efficient without composites. In fact, the demands made by that industry for materials that are both light and strong has been the main force driving the development of composites. It is common now to find wing and tail sections, propellers and rotor blades made from advanced composites, along with much of the internal structure and fittings. The airframes of some smaller aircraft are made entirely from composites, as are the wing, tail and body panels of large commercial aircraft.

In thinking about planes, it is worth remembering that composites are less likely than metals (such as aluminum) to break up completely under stress. A small crack in a piece of metal can spread very rapidly with very serious consequences (especially in the case of aircraft). The fibers in a composites act to block the widening of any small crack and to share the stress around. The right composites also stand up well to heat and corrosion. This makes them ideal for use in products that are exposed to extreme environments such as boats, chemical-handling equipment and spacecraft. In general, composite materials are very durable.

Another advantage of composite materials is that they provide design flexibility. Composites can be moulded into complex shapes – a great asset when producing something like a surfboard or a boat hull.

The downside of composites is usually the cost. Although manufacturing processes are often more efficient when composites are used, the raw materials are expensive. Composites will never totally replace

traditional materials like steel, but in many cases they are just what we need. And no doubt new uses will be found as the technology evolves. We haven't yet seen all that composites can do.

EPOXY RESINS

Epoxy is a copolymer; that is, it is formed from two different chemicals. These are referred to as the "resin" and the "hardener". The resin consists of monomers or short chain polymers with an epoxide group at either end. Most common epoxy resins are produced from a reaction between -epichlorohydrin and bisphenol-A, though the latter may be replaced by similar 45 chemicals. The hardener consists of polyamine monomers, for example triethylenetetramine (TETA). When these compounds are mixed together, the amine groups react with the epoxide groups to form a covalent bond. Each NH group can react with an epoxide group, so that the resulting polymer is heavily cross linked, and is thus rigid and strong.

a. Excellent adhesion to different materials.

b. High resistance to chemical and atmospheric attack.

c. High dimensional stability.

d. Free from internal stresses.

e. Excellent mechanical and electrical properties.

f. Odorless, tasteless and completely nontoxic.

g. Negligible shrinkage.

LITERATURE REVIEW

Natural fiber composites combine good mechanical properties with a low specific mass (approximately 1.2+ 1.5 g/cm3). But their high level of moisture absorption, poor wetability and an inadequate level of adhesion between untreated fibers and a non-polar polymer matrix lead to debonding with age. On the other hand, the tensile strength of natural fibers is only 20+50% of that of E-glass fibers. The Young's modulus, for flax for instance, at approximately 28GPa is much closer to the characteristic values of E-glass fibers. Unfortunately, all mechanical and other physical properties of natural fibers are influenced by their growing conditions, fiber-processing technique and, as for other fiber types, by the conditions, fiber-processing technique and, as for other fiber types, by the fineness of the fiber and sample test-length. Although, as with most of the other plant-based natural fibers, also plays an important part in determining the characteristic properties of the fibers.

Polyester is a very versatile fiber. Fabrics composed of polyester fiber offer the following characteristics: Generally low priced compared to those made from high temperature resistance or high modulus fibers. A wide range of fiber sizes available for fabric development. Can be heated and chemically treated to accommodate tight specification applications. Melting point approximately 482°F (295°C). Tenacity up to 8.5 grams per denier. Quick-drying and mildew resistant. Good abrasion resistance. Polyester is more resistant to stretching and shrinking than nylon. Relatively hydrophobic, more so than nylon fabrics. Excellent retention of properties under very low temperature conditions. Resistant to degradation in acidic environments (pH<7.0). Significant strength degradation over time with extended UV exposure.

Wacker G.et [5].al studied the influence of fiber content on the dynamic modulus of ep polyester/epoxy composites with untreated and alkali treated ep polyester fibers. Their results showed slower damage growth in the composite with NaOH treated fibers. Dipa ray K Sarkar, s das, ak rana [6] studied Vinyl –resin –matrix reinforced with untreated and 5% NaOH treated jute fibers for 4 and 8 hrs with different fiber loading subjected to dynamic mechanical and thermal analysis to determine their dynamic properties as a function of temperature. Their results shows that for all the composites the storage modulus decreases with increase in temperature with a significant fall in the

temperature range 110-170. Mohanty [7] examined the potential of jute fiber as an alternative to traditional manmade fibers in fiber reinforced plastics.
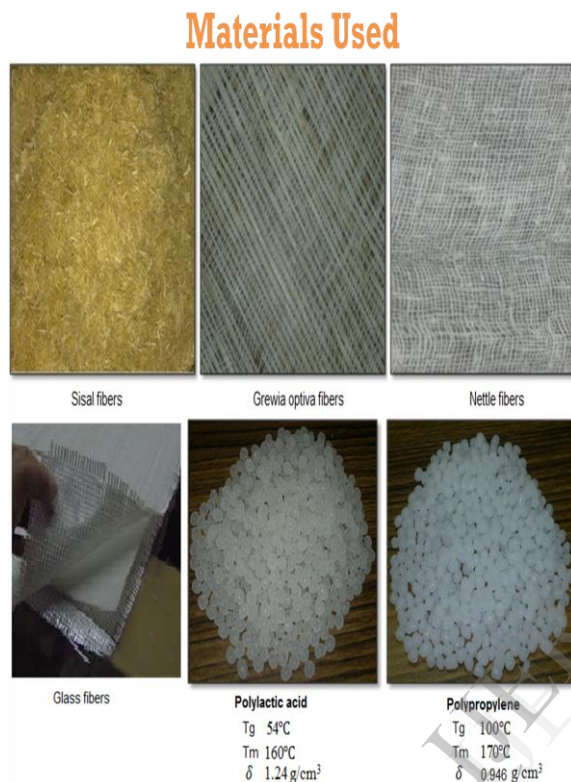
Materials Used

Fig -2.1 Different Types of Fiber Polyester

Gassan, Jochen, Bledzki [8] tried to improve the mechanical properties of natural fiber by the use of a NaOH treatment processes. they found the improvement in the dynamic modulus of the composite as a result of the use of treated fibers.

Several authors for composite application having good bonding between fiber and the resin matrix treated ep polyester with alkali a processes known as mercerization properties. Rana [9] gave a comparison of the ep polyester as a reinforced material compared to glass fiber and conclude that this natural fiber possesses some draw backs and needs chemical modification for

improvement in properties Natural fiber composites have been a subject of interest for last few decades, for their attractive features. Several authors for

composite applications having good bonding between fiber and the resin matrix treated jute with alkali a processes known as mercerization properties.

Ep polyester is one of the common fiber which obtain high tensile modulus and low elongation at break. If the low density (1.4 g/cm3) of this fiber is taken into consideration, then its specific stiffness and strength are comparable to those of glass fiber There are many reports about the use of jute as reinforcing fibers for thermosets. Previous works suggest that jute can also be used as reinforcing fiber for polypropylene (PP) and polyethylene.

- ▸ Results for tests carried out on commercially available polyester, vinyl ester and epoxy resin systems cured at 20°C and 80°C
- ▸ After a cure period of seven days at room temperature it can be seen that a typical epoxy will have higher properties than a typical polyester and vinyl ester for both strength and stiffness.
- ▸ Polyester and vinyl esters require considerable molecular rearrangement to reach their cured state and can show shrinkage of up to 8%.

Polyester is a synthetic fiber derived from coal, air, water, and petroleum. Developed in a 20th-century laboratory, polyester fibers are formed from a chemical reaction between an acid and alcohol. In this reaction, two or more molecules combine to make a large molecule whose structure repeats throughout its length. Polyester fibers can form very long molecules that are very stable and strong.

Rana et al. [9] studied the DTM behavior of short jute-fiber-reinforced polypropylene composites and observed the effect of compatibilised on the dynamic properties of the composites. They observed that the loss modules increased and higher temperatures with the increase of the fiber loading I the composites. The

Efficiency of the compatibilised system was more prominent at higher temperature and at higher fiber loading. They reported a tiny hump at a temperature higher than the glass transition temperature (Tg) and explained it as movement towards the Tg of the dry cellulose (2000 C) gassan, Jochen, Bledzki, Andrzej K [8] tried to improve the mechanical properties of natural fiber ep polyester by the use of and Na OH treatment processes. They found the improvement in the dynamic modulus of the composite as a result of the use of treated fibers. Mohanty et al examined the potential of jute fiber as an alternative reinforcement to traditional man-made fibers in fiber reinforced plastics. Mwaikambo, Leonard Y.[10] tried to use the plant fibers as potential for polymer reinforcement as they are rich in cellulose and they are cheap, easily renewable source of fibers. Hemp, sisal, ep polyester and kapok fibers were subjected to alkalization by using sodium hydroxide. The thermal characteristics, crystalinity index, reactivity, and surface morphology of untreated and chemically modified fibers have been studied on EP polyester and Compared to glass fiber and conclude that this natural fiber possesses some draw back and needs Chemical modification for improvement in properties.Polyester is used in the manufacturing of many products, including clothing, home furnishings, industrial fabrics, computer and recording tapes, and electrical insulation. Polyester has several advantages over traditional fabrics such as cotton. It does not absorb moisture, but does absorb oil; this quality makes polyester the perfect fabric for the application of water-, soil-, and fire-resistant finishes. Its low absorbency also makes it naturally resistant to stains. Polyester fabric resists shrinking and will not stretch out of shape. The fabric is easily dyeable, and not damaged by mildew. Textured polyester fibres are an effective, nonallergenic insulator, so the material is used for filling pillows, quilting, outerwear, and sleeping bags.

EXPERIMENTATION

The methodology for performing the experiments towards determining the validity of the thesis consists of several phases, namely, the processing of the ep polyester, density measurement, particle size analysis, XRD analysis, specimen preparation, mechanical testing, micro-hardness,
tensile strength and flexural strength.

Methods Used

Fig-2.2 Hand lay-up process

PREPARATION OF COMPOSITE
Raw Materials Used
POLYMER

The polymer used in the preparation of composite is EPOXY. It is a thermosetting polymer. Because of its high strength, low viscosity and low flow rates, it allows good wetting of fibers and prevents misalignment of fibers during processing. Following are the most outstanding characteristics of epoxy for which it is used.

• Low volatility during cure.

• Available in more than 20 grades to meet specific property and processing requirements.

• Excellent adhesion to different materials

• Great strength and toughness resistance

• Chemical and moisture resistant.

• Excellent electrical insulating properties.

• Low shrink rates.

EP POLYESTER FIBER

Both plant based fibers and nylon polyester based fibers have become potential alternatives for producing biodegradable, biomedical and bio-restorable composite materials. This protein layer called sericin resists has a lot of excellent qualities like resistance to oxidation, antibacterial nature, UV ray resistant, and releases moisture easily. This protein layer can be cross linked co polymerized and blended with other artificial polymers to produce composites with improved properties

HARDENER

In the present work Hardener (araldite) HY 951 is used.

CALCULATION

For the preparation of composites with different compositions of ep polyester fibers and polymer, a rough estimate of volume of silk fiber and polymer was made. The following calculations show the different compositions of ep polyester fiber composites.Total Volume of the Sample = 15*20*0.4 = 120 cm3.Total Mass of the Sample = Volume * Density = 120*1.4 = 168 g

SAMPLE PREPARATION

Mould Preparation

For the sample preparation the first and foremost step is the preparation of the mould which ensures the exact dimension of the composite to be prepared. We have to prepare moulds for the preparation of 2%, 4%, 6%, 8% fiber of the composite. A clean smooth surfaced wooden board is taken and washed thoroughly. The wooden board was covered with a mould release sheet.

Silk Yarn Preparation

The raw waste silk yarns collected from the factory outlets are filled with dirt, dust and are aggregated. The silk yarns collected were cleaned thoroughly with water and dried. Then the aggregations are gently dispersed with hand sitting patiently. After that the silk yarns were measured accurately for the preparation of different samples.

Polymer-Hardener Mixture Preparation

A measured amount of polymer was taken for different volume fraction of fiber composite (i.e. 2, 4, 6 & 8%) and mixed with the hardener in the ratio 10:1. The mixture was stirred properly for uniform mixing. Care was taken to avoid formation of bubbles.

CASTING

The silk fibers prepared in the above steps were put on the already designed mould. After putting the silk fibers in the mould, the polymer-hardener mixture was slowly poured over it. The silk fiber due to its light weight and high volume gets swelled up. For that reason only we roll a roller

gently till the sample fits in the mould. Then we cover the sample with a non-reacting plastic cover and place the glass on it such that no voids or air gaps leave behind. These voids weaken the composite and makes testing difficult. For the composite of perfect dimension weight should be carefully put above it. Weight should be put in such a way that no polymer hardener mixture seeps out of the glass. The composite sheet takes 72 hrs for curing in room temperature. Then the samples were cut into desired dimensions for experimental purposes depending on the standards.

EROSION WEAR

The progressive loss of material from its surface is called wear. It is the response of the material to the external stimulus and can be mechanical and chemical in nature. Wear is an unwanted

phenomenon that takes place on the surface of the material and its effects on the reliability of industrial components is recognized widely; also, the cost of wear has also been recognized to be high. The efforts in wear research were started around in 1960s in industries. The direct costs of wear failures, such as replacements of wear parts, increased work and time due to wear, reduction in productivity, as well as indirect losses of energy and the increased environmental burden, are the major problems in everyday work and business. In catastrophic failures, there is potential threat to human lives. Although wear has been extensively studied scientifically, numerous wear problems exist in the industrial applications in the 21st century. This actually reveals the complexity of the wear phenomenon A typical wear mode named as solid particle erosion wear is defined as the loss of materials from the surface by the repeated impingement of small solid particles. Solid particle erosion is an useful phenomenon in sand blasting and high speed abrasive water jet cutting but in engineering systems like steam jets and turbines, pipelines and valves these cause serious problems. Solid particle erosion is expected to take place when hard particles entrained in gas or liquid medium impinge on the solid surface at a significant velocity. Composites are often used as engineering and structural components where erosive wear takes place. The study of erosion wear characteristics of silk fiber composites is highly essential due to their operational requirements.

EROSION WEAR TEST APPARATUS

Description of equipments

Major parts of air-jet erosion test rig are:

• Sand hopper. • Sand flow control knob.

• Sand nozzle height adjustment

• Vibrator pad, pneumatic type

• Conveyor belt system

• Mixing chamber funnel

• Specimen holding heater blocks, specimen shape and indexing unit

• Double disc assembly motor, upper disc units slit, lower disc without slit.

• Dust collecting unit

• Display panel

DENSITY MEASUREMENT

Density determination by pycnometer is a very precise method. The theoretical density of coconut shell ash using pycnometer can be obtained by the following equation:

$\rho = [(W2-W1) / \{(W4-W1) - (W3-W2)\}] \times$ Density of kerosene (0.816 g/cc)

Where W1 is the weight of the empty clean and dry pycnometer, W2 is the weight of the pycnometer containing the sample, W4 is the weight of the pycnometer containing the kerosene, W3 is the weight of the pycnometer containing the sample and kerosene. Using the formula, the value of density was measured.

MECHANICAL TESTING The characterization of the composites reveals that the volume % of fibers having significant effect on the mechanical properties of composites. Mechanical testing includes testing of micro-hardness, tensile strength and flexural strength respectively.

MICRO-HARDNESS

Hardness is a mechanical property which represents the resistance of the material to penetration and scratching, it is measured by the distance of indentation and recovery that occurs when the ndenter is pressed into the surface under constant load. Leitz micro-hardness tester was used for ardness measurement. This tester had a diamo in the form a right pyramid with a square base and an angle 136°

between opposite faces, is forced in to the material under a load ranging from 0.3 to 3N.

TENSILE STRENGTH

Tensile strength indicates the ability of a composite material to withstand forces that pull it apart as well as the capability of the material to stretch prior to failure. The commonly used specimens for tensile test are the dog-bone type and the straight side type with24end tabs. During the test a uni-axial load is applied through both the ends of the specimen.

Figure -3.4 Tensile strength testing machine

The tensile strength were conducted according to the ASTM 790 standard on computerized universal testing machine INSTRON H10KS. The value of gauge length (L), width (d) and thickness (t)of the test specimen used in the experimentation as 100 mm, 12 mm and 6 mm. The tests were performed with a constant strain rate of 0.5 mm/min.

Tensile strength was calculated by the formula: S= F/A where F is the maximum load (in Newton's); A is the area of the specimen.

Tensile modulus and modulus of elasticity was determined as: E = FL/AΔL where F is the maximum load; L is the distance between the supports; A is the area of the specimen, and ΔL is the deflection (in millimeters) corresponding to the load F.

IMPACT STRENGTH

The impact strength of the composites was done by using a charpy impact testing machine. The specimens were of rectangular shape having dimensions 50X50X5 mm. The test has been done at a impact speed of 4m/s and an incident energy of 15J. A span of 20 mm was employed maintaining a hammer weight of 0.6kg.
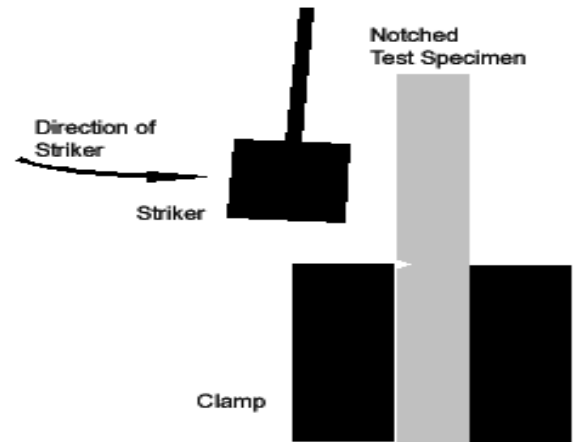

Fig-3.5 IMPACT STRENGTH

MICRO-HARDNESS

Micro-hardness measurement is done using a Lecco Vickers Hardness (LV 700) tester .A diamond indenter, in the form of a right pyramid with a square base and an angle 1360 between opposite faces, is forced into the material under a load F. The two diagonals *D1* and *D2* of the indentation left on the surface of the material after removal of the load are measured and their arithmetic mean *L* is calculated. In the present study, the load considered $F = 0.3$KgF and Vickers hardness number is calculated using the following equation:

Hv = 0.1889F / D2 **and** *L = (D1+D2) / 2* (3.2)

Where *F* is the applied load (KgF), *L* is the diagonal of square impression (mm), *D1* is the horizontal length (mm) and *D2* is the vertical length (mm).

LEXURAL STRENGTH

Flexural strength is the ability of the composite material to withstand bending forces applied perpendicular to its longitudinal axis. The inter-laminar shear strength (IILS) is the maximum shear stress existing between layers of laminated material. Flexural test were performed using 3-point bending method according to ASTM D790-03 standard procedure. The specimens were tested at a crosshead speed of 0.5 mm/min. The loading arrangement in the specimen was shown in figure. The value of gauge length (L), width (d) and thickness (t)of the test specimen used in the experimentation as 100 mm, 20 mm and 6 mm.
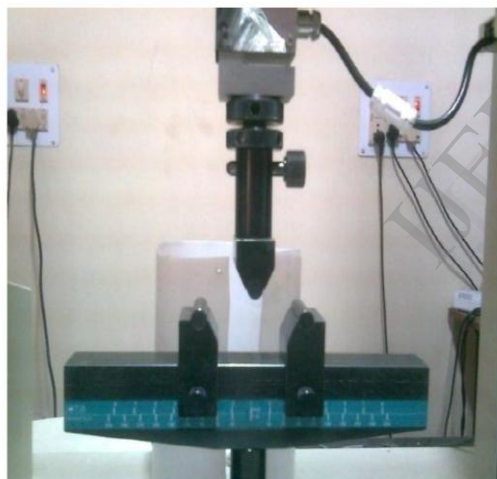

Figure -3.6 Flexural strength testing machine

The flexural strength was calculated by the formula: $= 3FL / 2bt2$where F is the maximum load (in Newton's); L is the distance between the supports (in millimeters); b is the width of the specimen (in millimeters) and t, the thickness (in millimeters). The flexural modulus was determined as: $E = FL3/4bt3d$where F is the maximum load; L is the distance between the supports; b is the width of the specimen, t is the thickness of the specimen, and d is the deflection (millimeters) corresponding to load F.

The inter-laminar shear strength was calculated by the formula: $IILS = 3FL / 4bt$where F is the maximum load (in Newton's); L is the distance between the supports (in millimeters); b is the width of the specimen (in millimeters) and t, the thickness (millimeters).

EPOXY RESIN AND HARDENER

Epoxy resins are relatively low molecular weight pre-polymers capable of being

processed under a variety of conditions. Two important advantages of these over

unsaturated polyester resins are: first, they can be partially cured and stored in that state, and second they exhibit low shrinkage during cure. However, the viscosity of conventional an epoxy resin is higher and they are more expensive compared to polyester resins. The cured resins have high chemical, corrosion resistance, good mechanical and thermal properties, outstanding adhesion to a variety of substrates, and good and electrical properties. Approximately 45% of the total amount of epoxy resins produced is used in protective coatings while the remaining is used in structural applications such as laminates and composites, tooling, moulding, casting, construction, adhesives, etc.

The type of epoxy resin used in the present investigation is Araldite LY-556 which

chemically belongs to epoxide family. Epoxy resins are characterized by the presence of a three-membered ring containing two carbons and an oxygen (epoxy group or epoxide or oxirane ring). Epoxy is the first liquid reaction product of bisphenol-A with excess of epichlorohydrin and this resin is known as Diglycidyl-Ether of Bisphenol-A DGEBA is used extensively in industry due to its high fluidity, processing ease, and good physical properties of the cured of resin. The hardener with IUPAC name NNO-bis (2amino ethyl ethane-1,2diamin) has been used with the epoxy designated

as HY 951. Both the epoxy and hardener were supplied by Ciba-Geigy of India Ltd.

PREPARATION OF COMPOSITE LAMINATES

A wooden mold of dimension (120x100x6) mm was used for casting the composite sheet. The first group of samples was manufactured with 10, 15, 20 and 30 % volume fraction of fibers. Usual hand lay-up technique was used for preparation of the samples. For different volume fraction of fibers, a calculated amount of epoxy resin and hardener (ratio of 10:1 by weight) was thoroughly mixed in a glass jar and placed in a vacuum chamber to remove air bubbles that got introduced. This procedure was performed for 10 minutes 39 initially. The mixture was re-stirred and the vacuum procedure was performed again for 10 minutes for further removal of bubbles. Figure 3.8 illustrates the mold used to construct the composite. For quick and easy removal of composite sheets, mold release sheet was put over the glass plate and a mold release spray was applied at the inner surface of the mold. After keeping the mold on a glass sheet a thin layer ($\Box$ 2 mm thickness) of the mixture was poured. Then the required amount of fibers was distributed on the mixture. The remainder of the mixture was then poured into the mold. Care was taken to avoid formation of air bubbles. Pressure was then applied from the top and the mold was allowed to cure at room temperature for 72 hrs. During application of pressure some amount of mixture of epoxy and hardener squeezes out. Care has been taken to consider this loss during manufacturing of composite sheets. After 72 hrs the samples were taken out of the mold. Figure 3.9 shows the photograph of the composite and some of the specimen cut for further experimentation.After cutting they were kept in airtight container.

Table- 4.1 MECHANICAL PROPERTIES OF THE HYBRID EP POLYESTER FIBER WITH EPOXY COMPOSITE

Sample Details	Name of the Test	Test Method/Standard	Unit	Average Value
One Sample of Plastic Sheet	Density	ASTM D 792	Gm/cc	1.13
	Tensile strength	ASTM D 638	Mpa	25.29
	Izod Impact (Notched)	ASTMD-256(A)	j/m	290.8
	Fiber Content	CIPET Method	% age	0.13

TESTING OF MECHANICAL PROPERTIES OF COMPOSITE

The study of mechanical properties such as tensile strength, flexural strength, impact strength and hardness of untreated bagasse fiber reinforced (randomly distributed in the epoxy matrix) composite have been conducted as per ASTM standard.

DENSITY MEASUREMENT

Density determination by pycnometer is a very precise method. The theoretical density of coconut shell ash using pycnometer can be obtained by the following equation:

$\rho = [(W2-W1) / \{(W4-W1) - (W3-W2)\}] \times$ Density of kerosene (0.816 g/cc)

Where W1 is the weight of the empty clean and dry pycnometer,W2 is the weight of the pycnometer containing the sample, W4 is the weight of the pycnometer containing the kerosene, W3 is the weight of the pycnometer containing the sample and kerosene. Using the formula, the value of density was measured

DENSITY

Density is 'the degree of compactness of a substance.' $\rho = m/v$. The reciprocal of density of a substance is called its specific volume. Density of a material varies with temperature and pressure. Tricky thing about density in you can't add densities.

Eg: if I have a rock that is mode up of two minerals, one with density 2.8 g/cm^3 and one with density 3.5 g/cm^3, the rock will have a density between 3.5 and 2.8, not a total of both. Density of a substance will determine if it will float on another.

ASTM D-792 is **1.13 Gm/cc** , A test method used to describe the determination of specific gravity and density of solid plastic like sheet, rods, tubes etc.

IZOD IMPACT STRENGTH

The impact strength of the composites was done by using a charpy impact testing machine. The specimens were of rectangular shape having dimensions 50X50X5 mm. The test has been done at a impact speed of 4m/s and an incident energy of 15J. A span of 20 mm was employed maintaining a hammer weight of 0.6kg. ASTM D-256(A) is **290.8 j/m**, A standard method of determining impact strength. Dimension of a standard specimen for ASTM D-256 are 63.5*12.7*3.2 mm. Impact test determine the toughen of a material. A material's toughness' is a factor of its ability to absorb energy during plastic deformation. Generally, at low temperature, Impact strength of a material is decreased. The size of a specimen also affects the Izod test. It may allow a different no. of imperfection in the material.

TENSILE STRENGTH

The most commonly used specimen geometries such as the dog-bone specimen and straight-sided specimen with end tabs was prepared from the flat samples. A uni-axial load is applied through the ends.

The standard test method as per ASTM D 3039-76 has been used; length of the test specimen used is 154 mm. The tensile test is performed in universal testing machine INSTRON H10KS. A cross head speed of 10 mm/min has been used for the test. Each composite of five samples were tested and average value was taken for analysis.

TENSILE STRENGTH

Tensile strength is **25.29 Mpa** an intensive property. Its value does not depend on the size of the specimen. However it is dependent on preparation of specimen, presence of surface defect and temperature

Of test environment and material. Its unit is Mega-Pascal. Tensile strength formula is F/A (N/mm^2). Tensile strength of a material is measured when it is pulled apart and plotted against its deformation. The deformation that is measure is the elongation.

RESULT AND DISCUSSION

At the pace of result where I get all the value of our developed new composite material having matrix epoxy resign and reinforcement EP polyester fiber to replace the expensive and costly material and make them less expensive and having high strength. And also compare it with the properties of fiber wool. The density of polyester is less as compare to glass so it can float in water and air. The Izod impact of polyester is three times more than the glass. The shrinkage of glass is more as compare to polyester.

TABLE - 4.2 COMPARISON MECHANICAL PROPERTIES O F THE EP POLYESTER FIBER COMPOSITE WITH GLASS WOOL FIBER COMPOSITE

Average Value

Sample Details	Name of the test	Test Method Standard	EP Polyester fiber epoxy composite	Glass Wool fiber epoxy composite
One Sample of Plastic Sheet	.Density	ASTM D 792	1.13 Gm/cc	1.55 Gm/cc
	Tensile strength	ASTM D 638	25.29 Mpa	109.6 Mpa
	.Izod Impact Notched	ASTM D256(A)	290.8 j/m	102.4 j/m
	Fiber Content	CIPET Method	0.13 %	.32 %

CONCLUSION :

From the analysis of the results and discussion given above, the following conclusions can be made as eollows :

1) In density test, it is observed that the density of EP Polyester fiber with epoxy composite is less as compare to wool glass fiber so it can float in water as well as air. the density of EP Polyester fiber with epoxy composites **1.3 Gm/cc** where as the density of glass wool fiber is more.

2) In tensile test, we found that the tensile strength of the EP polyester is not good .

3) In Izod test we found that the impact load of EP Polyester fiber with epoxy composite is approximately three times more than the Glass Wool fiber with epoxy composite and the impact load which is bearded by a double layer EP Polyester fiber with epoxy resin is **290.8 j/m** ,which is best to bear the impact load of any material.

4) In the overall process we see that the Density of this material is low and the impact load of this composites material is very high.

5) We can use EP Polyester fiber with epoxy resin at many places to reduce the weight and cost of the product and increase the Impact strength and make them more suitable for uses. We can use it in bullet proof Jackets, Helicopter Wings, Helmets, Ships, furniture and buckets etc.

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