PROJECT ON WASTE SILK YARN REINFORCED EPOXY LAMINATE

A THESIS SUBMITTED IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology
in
Mechanical Engineering

By

CHANDRA BHANU DAS

Department of Mechanical Engineering
National Institute of Technology
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CHANDRA BHANU DAS
Under the Guidance of
Prof. S. K. ACHARYA

Department of Mechanical Engineering
National Institute of Technology
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Rourkela

CERTIFICATE

This is to certify that thesis entitled, "PROJECT ON WASTE SILK YARN REINFORCED EPOXY LAMINATE" submitted by Sri. CHANDRA BHANU DAS in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in Mechanical Engineering at National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in this thesis has not been submitted to any other university/ institute for award of any Degree or Diploma.

Date:

Prof. S.K.Acharya
Dept. of Mechanical Engineering
National Institute of Technology
Rourkela-769008

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Date: **Chandra Bhanu Das**
Roll No.:-10503028

ABSTRACT

Fibre reinforced composites have gained popularity nowadays because of their processing advantages and good technical properties like strength, stiffness, elastic modulus ,creep rate, damping. These properties were found to increase with silk fabric content. Waste silk fabric reinforced epoxy laminates were developed with varying content of silk. silk fibre because of the presence of many functional groups like –NH2-,COOH,NHCO,CH2OH on its surface is polar in nature .This fibre has got a non-cellular structure in contrast to other natural fibre like jute and cotton.The above characteristic of fibre and polymer are expected to produce excellent adhesion between silk fibre and polymer in their composite.The importance of fibre reinforcement in production of hoses ,v-belts and the manufacture of complex shaped mechanical goods. Apart from that specially tailored lightweight structural parts with continuous fibre reinforcements, biocomposites are very well suited for panelling elements in cars, railways and aeroplanes, etc. using different kinds of nonwovens from single fibres (needlefelt nonwovens, fleeces etc.) to be easily adapted to the usually curved shapes of panellings, fairings etc.

CONTENTS

CHAPTER 1

INTRODUCTION

1.1BACKGROUND

A composite is a material made by combining two or more dissimilar materials in such a way that the resultant material is endowed with properties superior to any of its parental ones. Fiber-reinforced composites, owing to their superior properties, are usually applied in different fields like defense, aerospace, engineering applications, sports goods, etc. Nowadays, natural fiber composites have gained increasing interest due to their eco-friendly properties. A lot of work has been done by researchers based on these natural fibers . Natural fibers such as jute, sisal ,silk and coir are inexpensive, abundant and renewable, lightweight, with low density, high toughness, and biodegradable.

Natural fibres such as silk have the potential to be used as a replacement for traditional reinforcement materials in composites for applications which requires high strength to weight ratio and further weight reduction . Silk has been an important fabric in the textiles industry due to its luster and superb mechanical properties.Silk yarn are easily available as the waste product of textile industry,so the composite is cost effective and perfect utilization of waste product.

1.2DEFINITIONS OF COMPOSITES

A typical composite material is a system of materials composing of two or more materials (mixed and bonded) on a macroscopic scale.

Generally, a composite material is composed of reinforcement (fibers, particles, flakes, and / or fillers) embedded in a matrix (polymers, metals, or ceramics). The matrix holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix. When designed properly, the new combined material exhibits better strength than would each individual material.

As define by Javitz[1] , “ Composites are multifunctional material systems that provide characteristic not obtainable from any discrete material. They are cohesive structures made by physically combining two or more compatible materials, different in composition and characteristics and sometimes in form.

Kelly[2] very clearly stresses that the composition should not be regarded simple as a combination of two materials. In the broader significance; the combination has own distinctive properties. In terms of strength or resistance to heat or some other desirable quality, it is better than either of the components alone or radically different from either of them.

Berghezan [3]defines as “ the composites are compound materials which different from alloys by the fact that the individual components retain their characteristics but are so incorporated into the composite as to take advantage only of their attributes and not of their shortcomings’, in order to obtain an improved material.

Van suchetclan [4]explains composite materials as heterogeneous materials consisting of two or more solid phases which are in intimate contact with each other on a microscopic scale. They can be also considered as homogeneous materials on a microscopic scale in the sense that any portion of it will have the same physical property composite.

1.3CHARACTERISTICS OF THE COMPOSITES :

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

1.3.1 Density & dimension :

Density of the composite depends on the type and amount of reinforcement. Again, when the composites are treated at the various environmental conditions, there will be a change in volume due to absorption of moisture etc. Hence the measurement of density and the dimensional changes from time to time is to be monitored.

(b) Flexural strength :

Flexural strength is not recommended for generating design data, but it does provide a simple test for quality control.

(c) Measurement of Volume Fraction of the reinforcement :

The dimensional changes were monitored time to time from which the change in volume fraction can be calculated.

(d) Study of fracture surface :

The composites were studied under SEM so that the mode of fracture and the propagation of fracture can be determined.

1.3.2 Properties of composite:

Some of the important properties of a composite are:

i. The chemical and strength characteristics of the interface between the fibers and the matrix are particularly important in determining the properties of the composites.
ii. The interfacial bond strength has to be sufficient for load to be transferred form the matrix to the fibers if the composite is to stronger than the unreinforced matrix.
iii. If we are concerned with the toughness of the composites, the interface must not be so strong that it does not fail, and allow toughening mechanisms such as debonding the fiber pull-out to take place.
iv. Volume fraction plays a major role in determining properties. The volume fraction is generally regarded as the single most important parameter influencing the composite properties.
v. Homogeneity is also an important characteristic that determines the extent to which a representative volume of the material may differ in physical and mechanical properties from the average properties of the material.
vi. Non informative of the system should be avoided as much as possible because it is reduces those properties that will cover by the weaker part of the composite.
vii. The orientation of the reinforcement wit in the matrix affects the isotropy of the system.

1.4 CLASSIFICATION OF COMPOSITES:

Composite materials can be classified in different ways. Classification based on the geometry of a representative unit of reinforcement is convenient since it is the geometry of the reinforcement which is responsible for the mechanical properties and high temperature performance of the composite. A typical classification is given in

As per the classifications the composites are basically divided in to two broad classes.

They are:

i. Particle-reinforced Composites
ii. Fiber- reinforced Composites

i. Particle-reinforced Composites:

a) These materials utilize larger particles than in dispersion-strengthened composites, and in
b) greater concentrations. The particles strengthen the composite by bearing a significant portion of
c) the load and by restricting the flow of the softer matrix material. Particle fillers are widely used
d) to improve the properties of matrix materials such as to modify the thermal and electrical
e) conductivity's, improve performance at elevated temperature, reduce friction, Increase wear and
f) abrasion resistance, improve machinability, increase surface hardness and reduce shrinkage.

ii. Fiber- reinforced Composites:

A fiber is characterized by its length being much greater compared to its cross-sectional dimensions. The dimensions of the reinforcement determine its capability of contributing of thief properties to the composites. Fibers are very effective in improving the fracture resistance of the matrix since a reinforcement having a long dimension discourages the growth of incipient cracks normal to the reinforcement that might otherwise lead to failure, particularly with brittle matrices. Volume fraction (Vf) varies from a few percentage to as high as 70%. Usually the fiber reinforcement is done to obtain high strength and high modulus. 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.

1.5 NATURAL FIBER COMPOSITES

Natural fiber has attracted worldwide attention as potential reinforcement for composites because of their easy availability, easy processability, Low density, Light weight, non abrasivity, and Lower cost and above all eco-friendly characteristics

Silk Fiber Composite

Composition, structure and material properties of silk fibre produced by spiders, silkworms, scorpions, mites and flies may differ widely depending on the specific source and the uncontrollable reeling conditions of those insects. Spinning under controlled conditions will have more uniform cross-sectional area of silk fibre, reproducible molecular alignment and fewer micro-structural flaws. The size and weight of cocoons decrease with an increase in temperature and cocoons can bear efficiently both external static forces and dynamic impact loadings . Normal compact cocoon exhibits a high ability of elastic deformation with an elastic strain limit higher than 20 % in both longitudinal and transverse directions. Anisotropic properties mainly due to the non-uniform distribution and orientations of silk segments and the inner layer of cocoon has low porosity (higher silk density) and smaller average diameter of silk, therefore, there is an increase in elastic modulus and strength from outside to inside layers. That is, the thinner the silk, the higher the elastic modulus and tensile strength and the maximum values at the innermost layer. On the other hand, temperature above the glass transition temperature, the cocoon and its layers become softer and softer and behave similar to a rubber-like material. Silk fibre have higher tensile strength than glass fibre or synthetic organic fibre, good elasticity, and excellent resilience . They resist failure in compression, stable at physiological temperatures and sericin coating is water-soluble proteinaceous glue.

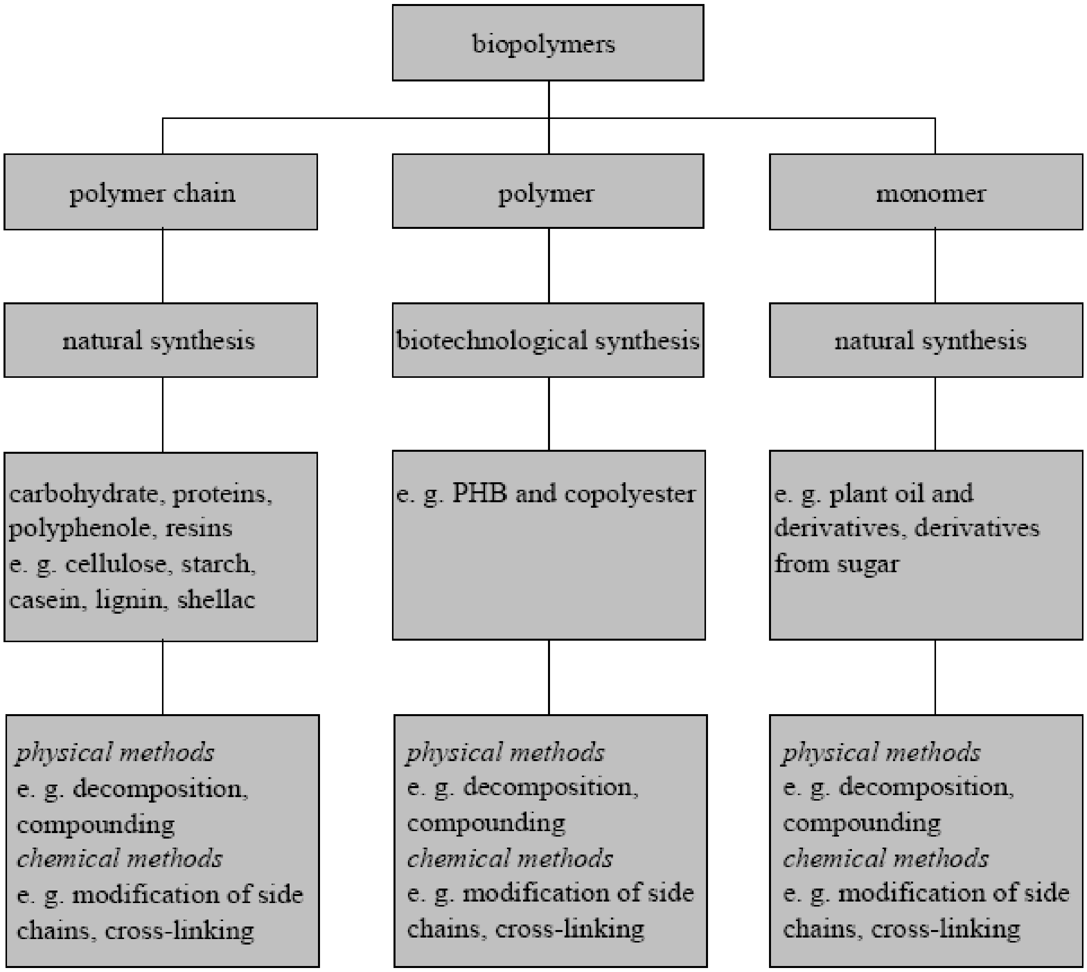
silks are insoluble in most solvents, including water, dilute acid and alkali. Reactivity of silk fibre with chemical agents is positively correlated to the largeness of internal and external surface areas . When fabricating silk-based composites, the amount of resin gained by fibre is strongly related to the degree of swelling of the non-crystalline regions, that is, the amorphous regions and the micro-voids inside the fibre. So the composite made from silk fibres are have high elastic modulus ,tensile strength and furthermore it is cost effective as it’s a waste material of silk industry.

1.6 COMPONENTS OF A COMPOSITE MATERIAL

1.6.1 Matrix Materials:

Role of Matrix in a composite

Many materials when they are in a fibrous from exhibit very good strength properties but to achieve these properties the fibers should be bonded by a suitable matrix. The matrix isolates the fibers from one another in order to prevent abrasion and formation of new surface flaws and acts as a bridge to hold the fibers in place. A good matrix should possess ability to deform easily under applied load, transfer the load into the fibers and evenly distribute stress concentrations. The natural fibres are embedded in a biopolymeric matrix system, the task of which is to hold the fibres together, thus giving and stabilising the shape of the composite structure, to transmit the shear forces between the mechanically high quality fibres, and to protect them against radiation and aggressive media. Usually, polymers are subdivided into thermosets and thermoplastics, both of them suitable as matrix systems for construction materials from bio-composites. In the following, polymers with the basic parts predominantly consisting of renewable resources are termed biopolymers. In addition, the basic parts can be formed either by the main chain, or by the side chain(s) or even by monomers as basic elements of a polymer. Numerous variations for optional structures of biopolymers result from this fact. There are various options to modify the available matrices (Klein et al., 1997; Herrmann, Nickel and Riedel, 1998), thus, the material selection has to be adapted to the given requirements. Criteria forselecting a suitable matrix system for high performance construction materials are the temperature in use, mechanical loading, manufacturing technology, etc. An important demand for the matrix is also an adequately low viscosity for a good impregnation of the reinforcing fibres. Additional basic qualities, e.g. the elongation at failure, which should match the corresponding values of natural fibres, and a good adhesion to the natural fibres must be given, too.



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1.6.2 Reinforcement

The role of the reinforcement in a composite material is fundamentally one of increasing the mechanical properties of the neat resin system. All of the different fibres used in composites have different properties and so affect the properties of the composite in different ways. For most of the applications, the fibres need to be arranged into some form of sheet, known as a fabric, to make handling possible. Different ways for assembling fibres into sheets and the variety of fibre orientations possible to achieve different characteristics.

1.6.3 Interface

It has characteristics that are not depicted by any of the component in isolation. 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 wetability . 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.

In the course of the experiment we have fabricated different layers of composites (single, double, four) using raw materials like Epoxy resin, Jute fiber, Red mud and Araldite. The Jute fiber was first alkali treated for 4 Hours. The composite was then fabricated The composites were then experimented in the erosion testing machine to find out the mass loss for different variables (pressure, temperature, stand off distances and sand particle size.

CHAPTER 2

LITERATURE SURVEY

LITERATURE SURVEY

The use of natural fibre as a reinforcement in fibre reinforced composite to replace synthetic fibre such as glass is receiving attention because of advantages such as renewability ,low density and high specific strength. Recent studies have investigated the development of biodegradable composite material using natural fibre such as flax ,bamboo, pineapple, silk, sisal, jute,kenaf and ramie as a reinforcement .These studies have examined molding condition, mechanical properties and interfacial bonding. Plant-based natural fibres like flax, jute, sisal and kenaf have been more frequently utilized and studied so far, due to their natural abundance, cost effectiveness, world annual production and a wide range of properties depending on the plant source. A large number of literatures have been reported on composites based upon these plant-based natural fibres earlier . However, use of animal-based natural fibres like silk and wool in a composite material has been rarely reported.

Silk fibres (Bombyx mori) spun out from silkworm cocoons are consisted of fibroin in the inner layer and sericin in the outer layer, all protein-based. Each raw silk thread has a lengthwise striation, consisting of two fibroin filaments of 10–14 lm each embedded in sericin. The chemical compositions are, in general, silk fibroin of 75–83%, sericin of 17–25%, waxes of about 1.5%, and others of about 1.0% by weight . Silk fibres are biodegradableand highly crystalline with well-aligned structure. It has been known that they also have higher tensile strength than glass fibre or synthetic organic fibres, good elasticity, and excellent resilience . Silk fibre is normally stable up to 140 _C and the thermal decomposition temperature is greater than 150 C. It is known that the densities are in the range of 1320–1400 kg/m3 with sericin and 1300–1380 kg/m3 without sericin, respectively. Silk fibres are also commercially available in a continuous fibre type.

Study by Sang Muk Lee , Donghwan Cho , Won Ho Park , Seung Goo Lee , Seong Ok Han , Lawrence T. Drzal[5] shows that, novel short silk fibre (Bombix mori) reinforced poly(butylenes succinate) bio-composites have been fabricated with varying fibre contents by a compression molding method and their mechanical and thermal properties have been studied in terms of tensile and flexural properties, thermal stability, thermal expansion, dynamic mechanical properties, and microscopic observations. The results demonstrate that chopped silk fibres play an important role as reinforcement for improving the mechanical properties of PBS in the present system although raw silk fibres are used without any surface modification normally done to enhance the interfacial adhesion between the natural fibre and the matrix. The tensile and flexural properties of PBS matrix resin are markedly improved with increasing the short fibre content in the composites, showing a maximum value at a fibre loading of 50 wt%.

Maryam, Che, Ahmad, Abu Bakar[6] studied The effect of surface treatment on the inter-laminar fracture toughness of silk/epoxy composite has been studied. The multi-layer woven silk/epoxy composites were produced by a vacuum bagging process in an autoclave with increasing layers of silk fibre of between 8 and 14 layers. Two sets of sample were prepared, in the first sets silk were treated with a surface treatment using a silane-based coupling agent and in the second sets, silk fibre were not treated at all. All the samples have been tested for mode I inter-laminar fracture using double cantilever beam specimens (DCB) testing method. It was found that the inter-laminar fracture toughness, GIC of the composite in set 1 are higher than set 2 and GIC increases as the number of silk layers increases for both sets.

Chemical resistant composite was prepared by Raghu, Noorunnisa Khanam and S.Venkaita naidu[7] shown abrupt improvement in the silk fibre epoxy laminate. composites of untreated and alkali treated silk-sisal unsaturated polyester-based hybrid composites were prepared by using hand lay-up technique. The fiber length was taken as 2 cm and the sisal fibers were treated with 2% NaOH. The chemical resistance of the treated and untreated silk/sisal hybrid composites to various acids, alkalis, and solvents was studied.

Since the past few decades, research and engineering interest has been shifting from traditional monolithic materials to fibre reinforced polymer-based materials due to their unique advantages of high strength to weight ratio, non-corrosive property and high fracture toughness. The composite materials consisted of high strength fibres such as carbon, glass and aramid, and low strength polymeric matrix, now have dominated the aerospace, leisure, automotive, construction and sporting industries. Unfortunately, these fibres have serious drawbacks such as (i) non-renewable, (ii) non-recyclable, (iii) high energy consumption in the manufacturing process, (iv) health risk when inhaled and (v) non-biodegradable. Biodegradation is the chemical breakdown of materials by the action of living organisms which leads to changes in physical properties. It is a concept of vast scope, ringing form decomposition of environmental wastes involving micro-organisms to host-induced of biomaterials. Although glass fibre reinforced composites have been widely used due to its advantages of low cost and moderate strength, for many years to provide solutions to many structural problems, the use of these materials, in turn would induce a serious environmental problem that most Western countries are now concerning. Recently, due to a strong emphasis on environmental awareness worldwide, it has brought much attention in the development of recyclable and environmentally sustainable composite materials. Environmental legislation as well as consumer demand in many countries is increasing the pressure on manufacturers of materials and end-products to consider the environmental impact of their products at all stages of their life cycle, including recycling and ultimate disposal. In the United State, it encourages manufacturers to produce materials and products by practicing the 4Rs, which are (i) Reduce the amount and toxicity of trash to be discard (sourced reduction); (ii) Reuse containers and products; (iii) Repair what is broken (iv) Recycle as much as possible, which includes buying products with recycled content. After these processes are gone, the materials finally are entitled to be disposed to the landfill.

Annamaria et al. [8] discovered in the studies that environmentally-friendly biodegradable polymers can be produced by blending silk sericin with other resins. Nomura et al. [9] identified that polyurethane foams incorporating sericin are said to have excellent moisture-absorbing and –desorbing properties. Hatakeyama [10] also reported for producing sericin-containing polyurethane with excellent mechanical and thermal properties. Sericin blends well with water-soluble polymers, especially with polyvinyl alcohol (PVA). Ishikawa et al. [11] investigated the fine structure and the physical properties of blended films made of sericin and PVA. Moreover, a recent patent reported on a PVA/sericin cross-linked hydrogel membrane produced by using dimethyl urea as the cross-linking agent had a high strength, high moisture content and durability for usage as a functional film [12].

Silk fibroin film has good dissolved oxygen permeability in wet state but it is too brittle to be used on its own when in dry state; whereas for chitosan, it is a biocompatible and biodegradable material which can be easily shaped into films and fibres. Park et al. and Kweon et al. [13-14] introduced an idea of silk fibroin/chitosan blends as potential biomedical composites as the crystallinity and mechanical properties of silk fibroin are greatly enhanced with increasing chitosan content.

Furthermore, Katori and Kimura [15] and Lee et al. [16] examined the effect of silk/poly(butylenes succinate) (PBS) bio-composites. They found that the mechanical properties including tensile strength, fracture toughness and impact resistance, and thermal stability of biocomposites would be greatly affected by their manufacturing processes. Moreover, a good adhesion between the silk fibre and PBS matrix was found through the observation and analysis by Scanning Electron Microscope (SEM) imaging

The mechanical properties of Bombyx mori, twisted Bombyx mori and Tussah silk fibres were also investigated through tensile property tests. It was found that Tussah silk fibre exhibited better tensile strength and extensibility as compared with others, and the stiffness of all samples was almost the same. This may be due to the distinction of silkworm raising process, cocoon producing and spinning conditions. Based on the Weibull analysis, it was shown that the Bombyx mori silk fibre has a better reproducibility in terms of experimental measurement, than that of the Tussah silk fibre. By using silk fibre as reinforcement for biodegradable polymer, the mechanical properties do have a substantial change. Cheung et al. [17] have demonstrated that the use of silk fibre to reinforce PLA can significantly increase its elastic modulus and ductility to 40 % and 53 %, respectively as compared with a pristine sample

CHAPTER 3

MATERIALS AND METHODS

3.1PREPARATION OF COMPOSITE

3.1.1 Raw Materials Used

POLYMER:

Epoxy resin (Araldite LY 556) made by CIBA GUGYE Limited, having the following outstanding properties has been used.

1. Excellent adhesion to different materials
2. Great strength, toughness resistance
3. Excellent resistance to chemical attack and to moisture
4. Outstanding electrical insulating properties
5. Absence of volatile on curing
6. Negligible shrinkage

SILK FIBRE:

Apart from the plant-based fibres, animal-based fibres become other alternatives for producing biodegradable, biomedical and bio-resorbable composite materials for bioengineering and orthopaedic applications. Cocoons are natural polymeric composite shells made of a single continuous silk strand with length in the range of 1000 – 1500 m and conglutinated by sericin. This protein layer resists oxidation, is antibacterial, ultra-violet (UV) resistant, and absorbs and releases moisture easily. Since this protein layer can be cross-linked, copolymerized, and blended with other macromolecular materials, especially artificial polymers, to produce materials with improved properties. In average, the cocoon production is about 1 million tonnes worldwide, and this is equivalent to 400,000 tonnes of dry cocoon.

(a) (b)

Fig 3.1 Raw Cocoon silks (a) and side view of the silk fibre (b)

HARDENER

In the present work Hardener (araldite) HY 951 is used. This has a viscosity of 10-20 poise at 25^{o}C.

3.2 CALCULATION

For the preparation of the composite we calculate the amount of silk yarn, polymer and hardener required from the table we come to know about the amounts accurately.

S.No.	Volume of composite (V_c)	% of fiber	Volume of fiber (V_f)	Wt. of fiber $W_f=V_f*\rho_f$ $\rho_f=1.33$ g/cc	Volume of polymer (V_p) cc	Wt. of polymer $Wf=V_p*\rho p$ $P_p=1.0974$	Wt. of hardener(W_H) =10% of W_p
1	70.125 cc	2%	1.4 cc	1.86 gm	68.725	75.416 gm	7.54 gm
2	70.125 cc	5%	3.5 cc	4.66 gm	66.625	73.112 gm	7.31 gm
3	70.125 cc	8%	5.61 cc	7.46 gm	64.515	70.79 gm	7.07 gm

3.3 PREPARATION OF SAMPLE

3.3.1Mould Preparation

First of all the mould for the composite is prepared. We have to prepare three moulds of size 8.5`` by 3.5 `` for the preparation of 2%, 5%, 8% of fiber of the composite. A clean smoothed surfaced wooden board is taken and washed thoroughly. We give a cover to the wooden board with a non-reactive thin plastic sheet. Then the glass of equal size that of the mould is taken. We place the glass on the wooden board. Square bits of 8mm are cut in desired dimension and are nailed surrounding the glass. These bits should be nailed in such a way that no polymer leaks out while casting. The bits are carefully nailed so that the glass does not move aside, so that the dimension of the mould is not distorted. After nailing the bits, the glass is smoothly taken out leaving behind the mould.

3.3.2 Silk Yarn Preparation

Raw waste silk yarns which are brought from the factories are filled with dirt, dust and are aggregated. First of all the silk yarn is cleaned with water and dried. Then the aggregations are gently dispersed with hand sitting patiently. Then this silk yarns are measured accurately with a measuring instrument for the three moulds.

3.3.3 Polymer-Hardener Mixture Preparation

For the making of good composite the measurement of the samples should be accurate and the mixture should be very uniform. We take accurate amount of polymer which we have calculated earlier and 10% of its hardener. Then this mixture is stirred thoroughly till it becomes a bit warm. Bit extra amount of hardener is taken for the wastage in the process. Hardener should taken very minutely because little extra amount of hardener can spoil the composite.

3.4 CASTING

The prepared silk fibers are put on the pre designed mould layer wise. Then slowly we pour the polymer hardener mixture. The silk fiber due to its light weight and high volume than polymer gets swelled up. For the reason 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 can make real hindrance in future. 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. This sample is then left for 24 hours. The composite gets dried up in 24 hours in which the silk fiber and the polymers adheres itself tightly in the presence of hardener.
After a day we put out the weights. Then carefully the nailed bits are removed from the wooden board. Now we have the composite attached with the glass. The hardener has so strong effect that it attachés the glass with the composite. This attachment is slowly and gently hammered on the boundary of its attachment when the glass and the composite separate out. Then we see whether any undesired voids are left behind. We fill the voids with polymer and the sample is prepared.

3.5 PROBLEMS FACED DURING SAMPLE PREPARATION

The silk fibers are aggregated very tightly. The separation of these aggregations is very difficult. As these are waste silk yarns it is mixed with dust and dirt. So it is very difficult to clean it up. The polymers are very adhesive in nature. So it sticks to the container in which it is taken, so a little extra amount of it is taken very precisely. Whereas the hardener is a very active item and it should be handled very carefully. A little more amount of hardener can totally spoil the casting. In the process we experienced that two extra drops of hardener made the reaction so exothermic than the produced heat burnt the silk fibers completely. Another problem that we faced during the process of casting is the high volume of silk fiber. In the preparations of the composite, 2% of the fiber is not that difficult but with 5% and 8% it becomes very difficult as the silk fiber get swelled up after pitting in the polymer. It is very difficult to fit inside the mould. It has to be rolled several times and in the process many polymer hardener mixture gets stick together. The weights has to be put very accurately because if we put a little extra weight the polymer gets leaked out through the side of the glass.

3.6 EROSION WEAR TEST

Solid particle is a form of materials degradation caused by impact of hard materials against a target material at reasonably high speed (greater than 10m/s). Mechanically solid particle erosion is quite different from other form of erosion .solid particle erosion importance as illustrated in the examples like performance of aircrafts and helicopters, industrial gas turbines etc.

Description of equipments

Major parts of air-jet erosion test rig are:

i. Sand hopper.
ii. Sand flow control knob.
iii. Sand nozzle height adjustment
iv. Vibrator pad, pneumatic type
v. Conveyor belt system
vi. Mixing chamber funnel
vii. Specimen holding heater blocks, specimen shape and indexing unit

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

ix. Dust collecting unit

x. Display panel

Air jet erosion test rig

Procedure

i. Double disc arrangement unit is placed in its position and clamped firmly

ii. Upper disc is removed

iii. Lower disc is set to a speed of 2000 rpm

iv. Lapping test is applied to lower disc

v. Sand impression are removed

vi. Disc are cleared with tissue paper
vii. Upper disc is then placed on lower disc
viii. Reference line of lower disc is material with respect to upper disc slot
ix. Double disc is switched on and rpm is set
x. Sand flow control knob is opened and all doors are closed
xi. Cycle star button is pressed
xii. When test duration is completed, all regulators are set to zero
xiii. Upper disc is removed and impression on lower disc are seen
xiv. Particle velocity in meter per second is calculated

CHAPTER 4

CONCLUSION

The following conclusions are drawn from the above studies.

- As silk fiber used in our project is a waste material of textile industy so it is cheaply available and it shows the perfect utilization of waste product
- Silk fibers bio-degaradable and highly crystalline with well aligned structure. So it has been known that they also have higher tensile strength than glass fibre or synthetic organic fibers ,good elasticity, excellent resilience and in turn it would not induce a serious environmental problem like in glass fibres.
- As in glass fibres have serious drawbacks like non-renewable, non-recyclable, non-biodegradable and high energy consumption in manufacturing process therefore it’s a perfect replacement for glass fibres composites.

RECOMMENDATION FOR FURTHER RESEARCH

- A large number of literatures have been reported on bio-composites based upon these plant-based natural fibers earlier. However, use of animal-based natural fibers like silk and wool in a bio-composite material has been rarely reported, so its latest and interesting work to carry out.

CHAPTER 5

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