Investigation of Mechanical Properties in Epoxy Fiber Based Composite Material

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Abstract- **Epoxy is a thermosetting resin used to produce composite materials. Epoxy resins are widely used in composites parts, structures and concrete repairs. Major benefits of using epoxy based materials have the ability to suit to prepare different products, their low shrinkage, strong mechanical properties, resistance to corrosive liquids and environments, superior electrical properties, good performance at elevated temperatures, and good adhesion to substrates. In this paper, epoxy fiber based composite material is prepared and study their mechanical properties such as hardness, toughness, corrosion resistance, strength on this composite material with an addition of bio waste able material such as egg shell and wood apple shell in semi-solid form by pultrusion process. Adding biodegradable shell particulates to an epoxy resin matrix yields superior thermal stability and mechanical properties while lowering fabrication cost and results are discussed**

Index Terms- **Bio waste material, Composite materials, Epoxy, Pultrusion.**

1. INTRODUCTION

A composite material consists of two or more physically and/or chemically distinct, suitably arranged or distributed phases, with an interface separating them. It has characteristics that are not depicted by any of the components in isolation. Most commonly, composite materials have a bulk phase, which is continuous, called the matrix, and one dispersed, non-continuous, phase called the reinforcement, which is usually harder and stronger. Matrix phase is 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. Dispersed (reinforcing) phase, is the second phase (or phases) is embedded in the matrix in a discontinuous form. This secondary phase is called dispersed phase. Dispersed phase is usually stronger than the matrix, therefore it is sometimes called reinforcing phase. There are two classification systems of composite materials. One of them is based on the matrix material (metal, ceramic, polymer) and the second is based on the material structure. Types of Composites materials are Metal matrix composites, Ceramic matrix composites, polymer matrix composites. Polymeric matrix composites are composed of a matrix from thermosetting (unsaturated polyester, epoxy or thermoplastic polycarbonate, polyvinylchloride, nylon, polystyrene and embedded glass, carbon, steel or Kevlar fibers (dispersed phase). The applications of polymer composites include consumer goods, sporting goods industry, aerospace industry, marine applications, automotive industry, construction and civil structures, industrial applications.

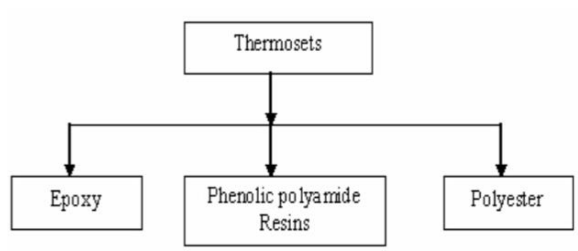

Fig 1. Thermosetting resin

Fiber-reinforced polymer composites have played a dominant role for a long time in a variety of applications for their high specific strength and modulus. By natural fiber composites, a composite material that is reinforced with fibers, particles or platelets from natural or renewable resources. Natural fibers include those made from plant, animal and mineral sources. we are investigating the *Aegle marmelos*(Wood apple) fruit shell as a new reinforcement medium for composites

Manufacturing of a composite material is to combine the polymeric resin system with the fiber reinforcement. Since the orientation of the fibers is critical to the end properties of the composite.

Manufacturing process is utmost important to align the fibers in desired direction. A good manufacturing process will produce a higher, uniform fiber volume fraction along with a higher production of a large volume of parts economically and have repeatable dimensional tolerances.

2. LITERATURE SURVEY

Persistence of plastics in the environment, the shortage of landfill space, the depletion of petroleum resources, concerns over emissions during incineration, and entrapment by and ingestion of pack-aging plastics by fish, fowl and animals have spurred efforts to develop biodegradable/bio based plastics. This new generation of bio based polymeric products is based on renewable bio based plant and agricultural stock and form the basis for a portfolio of sustainable, eco-efficient products that can compete in markets currently dominated by products based on petroleum feedstock in applications such as packaging, automotive, building products, furniture and consumer goods. Biopolymers or synthetic polymers reinforced with natural/bio fiber frequently termed 'bio composites' can be viable alternatives to glass fiber reinforced composites.

The use of natural fibers for the reinforcement of the composites has received increasing attention both by the academic sector and the industries. Natural fibers have many significant advantages over synthetic fibers currently, many types of natural fibers have been investigated for use in plastics including flax, hemp, jute straw, wood, rice husk, wheat, barley, sisal, coir, bamboo etc. The fibers are basically a rigid, crystalline cellulose micro fibril-reinforced amorphous lignin and/or with hemicellulose matrix. Hemicellulose is responsible for the biodegradation, micro absorption and thermal degradation of the fiber as it shows least resistance, whereas lignin is thermally stable but prone to UV degradation.

Yan Le at all presents a summary of recent developments of sisal fiber and its composites. The properties of sisal fiber itself interface between sisal fiber and matrix, properties of sisal fiber-reinforced composites and their hybrid composites have been reviewed. The mechanical and physical properties of sisal-fiber-reinforced composites are very sensitive to processing methods, fiber length, fiber orientation and fiber-volume fraction. Sisal and glass fiber can be combined to produce hybrid composites which take full advantage of the best properties of the constituents; almost all the mechanical properties have show positive hybrid effects.

3. MATERIALS AND METHODS

The raw materials used in this work are

- Epoxy resin
- Hardener
- Natural fibers (Wood apple shell powder, Egg shell powder)

Epoxy resin

Features of Epoxy resin is Light weight, Resists most alkalis and acids, Resists stress cracking, Retains stiffness and flexibility, Low moisture absorption, Non-staining, Easily fabricated

Applications of Epoxy resin in Structural, Industrial tooling and composites, Electrical system and electronics

Hardener

Hardener is a curing agent for epoxy or fiberglass. Epoxy resin requires a hardener to initiate curing; it is also called as catalyst, the substance that hardens the adhesive when mixed with resin. It is the specific selection and combination of the epoxy and hardener components that determines the final characteristics and suitability of the epoxy coating for given environment.

Wood apple shell

Limonia acidissima is a large tree growing to 9 metres (30ft) tall, with rough, spiny bark. The leaves are pinnate, with 5-7 leaflets, each leaflet 25–35 mm long and 10–20mm broad, with a citrus-scent when crushed. The fruit is a berry 5–9cm diameter, and may be sweet or sour. It has a very hard rind which can be difficult to crack open, it appears greenish-brown in colour from outside and contains sticky brown pulp and small white seeds. The fruit looks similar in appearance to the Bael fruit (Aegle marmelos).

Egg shell

lnsects and other arthropods lays a variety of styles and shapes of eggs. Some have gelatinous or skinlike coverings, others have hard eggshells. Softer shells are mostly protein. It may be fibrous or quite liquid. Some arthropod eggs do not actually have shells, rather, their outer covering is actually the outermost embryonic membrane, the choroid, which serves to protect inner layers. The choroid itself can be a complex structure, and it may have different layers within it. It may have an outermost layer called an exochorion. Eggs which must survive in dry conditions usually have hard eggshells, made mostly of dehydrated or mineralized proteins with pore systems to allow respiration. While the bulk of eggshell is made of calcium carbonate, it is now thought that the protein matrix has an important role to play in eggshell strength. These proteins affect crystallization, which in turn affects the eggshell structure.

METHODOLOGY

Step 1 : selection of material

Epoxy resin belonging to the epoxide family was taken as the matrix was used the hardener.

step 2 : selection of reinforcement and natural fibers

Natural fiber such as wood apple shell, egg shell were taken to fill as reinforcements in the polymer composite.

step 3 : pulverizing fibers

Wood apple shell powder

Wood apple (Aegle marmelos) the fruit is spherical. The shell starts with gray-green colour, then turns into pale yellow. The shell is very hard and needs to be cracked with a machete or hammer. The pulp is yellow, fibrous and very aromatic. The fruit may contain resinous hairy seeds, covered with mucilage. The taste of the pulp is like a marmalade, but tangy and slightly astringent with aroma of a rose. The fruit can be used when it is unripe and ripe.

Egg shell powder

The eggshell are quite coarse and is made into a fine powder with a small mortar and pestle. Then put these crushed shells in blender.

Step 4 : Pultrusion process for sample preparation

In the standard pultrusion process the reinforcement materials like fibers or woven or braided strands are impregnated with resin, possibly followed by a separate preforming system, and pulled through a heated stationary die where the resin undergoes polymerization. The impregnation is either done by pulling the reinforcement through a bath or by injecting the resin into an injection chamber which typically is connected to the die. Many resin types may be used in pultrusion including polyester, polyurethane, vinylester and epoxy. Resin provides the resistance to the environment, (i.e., the corrosion resistance, the UV resistance, the impact resistance, etc.) and the glass provides strength, in addition to safety from fire.

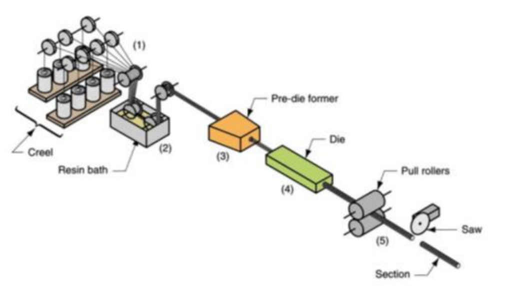

Fig. 2 pultrusion process

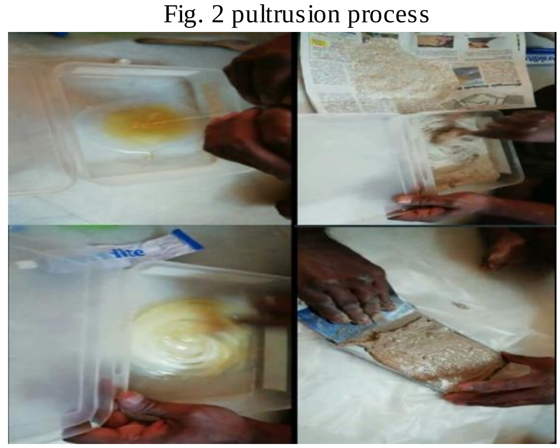

Fig 3. Sample preparation by pultrusion process

As the materials are pulled through a die in the standard pultrusion process the process is only suited to manufacture straight profiles.

4.TEST AND RESULTS

Sample composition

sample 1 :

L*B*H=(200*100*10) mm (RECTANGULAR PLATE)

SAMPLE	MATRIX MATERIAL (EPOXY RESIN)	REINFORCEMENT MATERIAL (EGGSHELL POWDER)	REINFORCEMENT MATERIAL (WOOD APPLE SHELL POWDER)
1	150 G	150G	100G

TESTING AND RESULT

Fig. 4 Sample

The epoxy fibre based composite with subjected to following measurements and evaluate its mechanical properties.

- Hardness test (brinell's & rockwell)
- Impact test
- Tensile test

HARDNESS TEST

HARDNESS TEST ON THE METALS – BRINELL HARDNESS NUMBER

DIAMETER OF THE INDENTOR (D): 10mm (diamond)

LOAD (P) : 3000 kg

S NO	MATERIAL	DIAMETER OF THE INDENTOR (D) mm	SCALE READING	AVERAGE SCALE READING	BRINELL HARDNESS NUMBER (BHN)
1	COMPOSITE MATERIAL	10	6.2	6.2	88.67

BHN = LOAD IN Kg / SPHERICAL AREA OF INDENTATION IN mm^2

$= 2P/ D\pi (D - \sqrt{D^2 - d^2})$

$= 6000 / 67.635$

BHN $= 88.67$ Kg/mm^2.

Fig. 5 Brinell hardness Test – Sample

HARDNESS TEST ON THE METALS – ROCKWELL HARDNESS NUMBER

MAJOR LOAD = 250 KG

S NO	MATERIAL	DIAMETER OF THE INDENTOR (D) mm	SCALE READING	AVERAGE SCALE READING	ROCKWELL HARDNESS NUMBER (RHC OR RHN)
1	COMPOSITE MATERIAL	DIAMOND (250) BLACK	93 92 94	93	93 HRC

THE ROCKWELL HARDNESS NUMBER = 93 HRC .

Fig. 6 Rockwell Hardness Test - Sample

IMPACT TEST

MATERIAL OF THE SPECIMEN: COMPOSITE MATERIAL

TRIAL NO	INITIAL SCALE READING IN JOULES	INITIAL ENERGY STORED IN HAMMER IN JOULES	FINAL SCALE READING IN JOULES	ENERGY ABSORBED BY THE SPECIMEN (FINAL-INITIAL) IN JOULES
1	0	0	48	(48-0) = 48
2	0	0	42	(42-0) = 42

1. IMPACT STRENGH (OR) ENERGY ABSORBED BY THE SPECIMEN = FINAL IZOD SCALE READING- INITIAL SCALE READING

= 48 – 0 = 48 JOULES.

2. TOUGHNESS OF THE SPECIMEN = ENERGY ABSORBED BY THE SPECIMEN / VOULME OF THE SPECIMEN

$= 48/ (72X10) = 0.066$ J/mm^3

VOLUME OF THE SPECIMEN = LXBX D (mm^3)

IZOD TEST

THE IMPACT STRENGTH OF THE GIVEN SPECIMEN = 48 JOULES

THE TOUGHNESS OF THE GIVEN SPECIMEN = 0.066 JOULES/mm^3

Fig.7 Impact Test - Sample

TENSILE TEST

The following table provides the details of the impact test results obtained for the epoxy fiber based composite

Test Name	TENSILE TEST		Test Type	Normal	Test Mode	Tensile
Elongation Device	Cross Head		Test Parameter	Peak Load	Test Speed[mm/min]	0.50
Sample No	CS/Area [mm^2]	Peak Load [N]	% Elongation	Break Load [N]	UTS [N/mm^2]	
001	130.000	454.370	1.040	7.671	3.492	
002	130.000	391.301	0.880	7.858	3.012	
Summary Report						
	CS/Area [mm^2]	Peak Load [N]	% Elongation	Break Load [N]	UTS [N/mm^2]	
Min	130.000	391.301	0.880	7.858	3.012	
Max	130.000	454.370	1.040	7.671	3.492	
Avg.	130.000	422.836	0.960	7.765	3.252	
Std Dev.	0.000	44.596	0.113	0.132	0.340	
Variance	0.000	1988.817	0.013	0.017	0.116	
Median	130.000	422.836	0.960	7.765	3.252	

Table 1. Tensile test result.

Fig. 8. Tensile Test - Sample

5. CONCLUSION

1. The result confirmed that epoxy fiber composite is clearly superior to base plastic in comparison of tensile strength, impact strength as well as hardness.
2. It appears form this study that UTS start increase with increase the percentage of elongation.
3. Dispersal mixing of epoxy fiber composite is investigated and estimated the mechanical properties using the SOM.
4. The hardness increases after addition of epoxy resin matrix.

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