Characterization of Palf Reinforced Composites

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***Abstract*: Pineapple leaf fibre (PALF) which is rich in cellulose, relatively inexpensive, and abundantly available has the potential for polymer reinforcement. The present study investigated the tensile, flexural, impact and water absorption behaviour of PALF-reinforced polyester composites as a function of fibre loading, fibre length, and fibre surface modification. The tensile strength and Young's modulus of the composites were found to increase with fiber content in accordance with the rule of mixtures. The PALF polyester composites possess superior mechanical properties compared to other cellulose-based natural fibre composites. Mechanical properties of pineapple leaf fibre reinforced low density polyethylene composites have been studied with special reference to the effects of interface modifications. Various chemical treatments using reagents such as NaOH carried out to improve the interfacial bonding. It has been found that the treatments improved the mechanical properties significantly. However, the effect varied according to the nature of the treatments.The addition of a small quantity of NaOH increased the mechanical properties considerably. For the testing and analysis we are using four laminates which consist of 20%, 25%, 30% and 35% fibre respectively.**

Keywords-Pineapple leaf fibre, epoxy resin.

I.INTRODUCTION

The development of composite materials and related design and manufacturing technologies is one of the most important advances in the history of materials. Composites are multifunctional materials having unprecedented mechanical and physical properties that can be tailored to meet the requirements of a particular application. Many composites also exhibit great resistance to high-temperature corrosion and oxidation and wear. These unique characteristics provide the mechanical engineer with design opportunities not possible with conventional monolithic (unreinforced) materials.

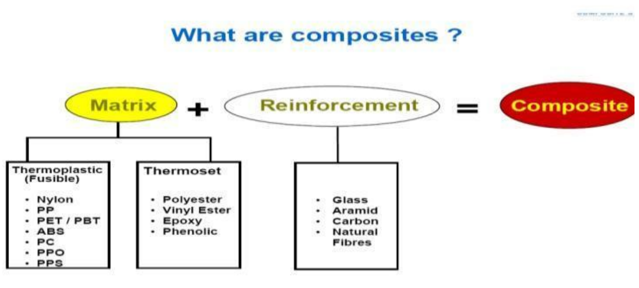

Fig 1.1 Composites

Many types of reinforcements also often have good thermal and electrical conductivity, a coefficient of thermal expansion (CTE) that is less than the matrix, and/ or good wear resistance. There are, however, exceptions that may still be considered composites, such as rubber-modified polymers, where the discontinuous phase is more compliant and more ductile than the polymer, resulting in improved toughness.

Common examples include materials which are stronger, lighter or less expensive when compared to traditional materials. Typical engineered composite materials include:The most advanced examples perform routinely on spacecraft and aircraft in demanding environments. Popular fibres available as continuous filaments for use in high performance composites are glass, carbon and aramid fibres.

Significance of Composites:

Composite materials are generally costlier as compared to conventional materials but still their use is becoming increasingly popular because of their under mentioned properties.

- Lightness: The strength-to-weight ratio is high in composite materials as compared to conventional materials and therefore, they require less energy for moving them around. As a result, weight reduction contributes to fuel economy in transportation by road, rail, sea or air. This property is regarded as a boon in the age of shortage of energy.

ISSN: 2278-0181
NCRAIME-2015 Conference Proceedings

- High specific properties: Composite materials possess better strength, stiffness and less weight and thus, their use for fabrication of structural parts of an aircraft or automobile provides an additional advantage. Specific strength and modulus of composite materials are superior to meta1s and therefore, they are preferred to conventional metals.
- Design and processing flexibility: Composite materials offer a wide design flexibility and products may be fabricated by adopting simple hand lay-up or by using very sophisticated numerically controlled machines.
- Cost effectiveness: Products from. Composite materials can be easily moulded into any complex shape, and steps like machining, drilling, cutting, etc. are altogether eliminated; thus making production cost-effective and efficient.
- Functional superiority: Composite materials possess better properties and functional advantages. Thus their products are corrosi6n resistant, good electrical insulators, anti-magnetic and therefore, are suitable for chemical equipment, transformer tubes and mine sweepers respectively.
- Durability: Composite materials are more durable. Under adverse environmental conditions and at the same time, require less maintenance. As a result, they work out to be cheaper over a longer life-span in spite of their highest initial costs.

***MATRIX*:**

Matrix is also known as binder material. It (i) provides shape to the composite material, (ii) makes the composite material generally resistant to adverse environments and (iii) protects reinforcement material from adverse environments. The materials which constitute matrix of composite materials are plastics, metals, ceramics and rubber.

a) Plastics matrix: Plastics matrix based composite materials constitute more than 95 per cent of composite materials in use today. Both thermosets as well as thermoplastics are used as matrix materials. As thermosets mostly exist in liquid state before cross-linking, it is very convenient to combine reinforcements in the required proportion, shape the product and cure it into solid. Thermoplastics, on the other hand, have to be heated and liquefied for adding inserts.

b) Metal matrix: Metals can also be reinforced with high strength fibres in order to improve the strength and stiffness (Young's modulus). However, it reduces elongation and toughness. Boron reinforced aluminium is very popular for aircraft applications.

c) Ceramic and other brittle matrix: Ceramic, carbon and glass are widely used for this purpose. The introduction of fibres into ceramics improves tensile strength and toughness. Similarly, carbon glasses reinforced with carbon fibres have better toughness.

d) Rubber matrix: Rubber is highly elastic and incorporation of fibre or particulate filler enhances rigidity of rubbers. Carbon black, cotton, nylon and steel fibres are widely used for this purpose.

1.3 FIBRES

Organic and inorganic fibres are used to reinforce composite materials. Almost all organic fibres have low density, flexibility, and elasticity. Inorganic fibres are of high modulus, high thermal stability and possess greater rigidity than organic fibres and no withstanding the diverse advantages of organic fibres which render the composites in which they are used.

Primary Function:

- “Carry load along the length of the fibre, provides strength and or stiffness in one direction”.
- Can be oriented to provide properties in directions of primary loads.

Types of Fibres

I. Natural Fibre

Fibres are a class of hair-like material that are continuous filaments or are in discrete elongated pieces, similar to pieces of thread. They can be spun into filaments, thread, or rope Natural fibres have recently attracted the attention of scientists and technologists because of the advantages that these fibres provide over conventional reinforcement materials, and the development of natural fibre composites has been a subject of interest for the past few years.1–4 these natural fibres are low-cost fibres with low density and high specific properties. These are biodegradable and nonabrasive, unlike other reinforcing fibers. E.g. coir, pineapple, sisal, hemp, etc

II. Man-Made Fibres

Man-made fibre, whose chemical composition, structure, and properties are significantly modified during the manufacturing process. The chemical compounds from which man-made fibres are produced are known as polymer, a class of compounds characterized by long, chainlike molecules of great size and molecular weight. Man-made fibres are Aramid, Boron, Carbon/Graphite, Glass, Nylon

RESINS

Resin is a generic term used to designate the polymer, polymer precursor material, and/or mixture or formulation thereof with various additives or chemically reactive components. The resin, its chemical composition and physical properties, fundamentally affect the processing, fabrication and ultimate properties of composite materials. Variations in the composition, physical state, or morphology of a resin and the presence of impurities or contaminants in a resin may affect handleability and processability, lamina/ laminate properties, and composite material performance and long-term durability. This section describes resin materials used in polymer matrix composites and adhesives, and considers possible sources and consequences of variations in resin chemistry and composition, as well as the effects of impurities and contaminants, on resin processing characteristics and on resin and composite properties.

2.MATERIAL DETAILS

The composite material used in this research was manufactured pineapple leaf fibre of 0.3 mm thickness as synthetic reinforcement. Pineapple leaf fibres were used as natural reinforcement. We are including pineapple leaf fibre and epoxy resin for making the laminate.

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2.1 Pineapple leaf Fibre

Pineapple Leaf Fibre (PALF) serving as reinforcement fibre in most of the plastic matrix has shown its significant role as it is cheap, exhibiting superior properties when compared to other natural fibre as well as encouraging agriculture based economy. PALF is multi-cellular and lignocelluloses materials extracted from the leave of plant Ananas cosomus belonging to the Bromeliaceae family by retting (separation of fabric bundles from the cortex). PALF has a ribbon-like structure and is cemented together by lignin, pentosan-like materials, which contribute to the strength of the fibre. PALF is a multicellular fibre like other vegetable fibres. PALF has a good potential as reinforcement in thermoplastic composite.

Among natural fibers, pineapple-leaf fiber (PALF) is one of the most important plant based fibers for composite materials due to its moderate specific strength and stiffness. Both the thermosets and thermoplastic resins have been used as matrices for this natural fibre

It stressed on mechanical properties of composite prepared by two methods, namely the melt mixing and solution mixing. The influences of fibre length, fibre loading and fibre orientation have also been evaluated. Besides, the fibre breakage and damage during processing were analyzed from fibre distribution curve and optical and scanning electron micrographs. Recyclability of the composites was found to be very good; its properties remain constant up to third extrusion. This is beyond the marginally decrease of property due to thermal effect and degradation of the fibre. The mechanical behavior of PALF reinforced polyester composites as a function of fiber loading, fiber length, and fiber surface modification. Tensile strength and modulus of this thermoset composite were found to increase linearly with fiber content. The impact strength was also found to follow the same trend. However in the case of flexural strength, there was a leveling off beyond 30 wt % fiber content. A significant improvement in the mechanical properties was observed when treated fibers were used to reinforce the composite.

However the storage modulus E' increased with increase of fibre loading in dynamic mechanical thermal analysis. It was also found that improved interaction exerted by the chemical treatments makes the composition more mechanically and thermally stable than the untreated fibre composite.

PROPERTIES	VALUE	UNIT
Density	1.526	g/cm^3
Softening point	104	^{0}C
Tensile strength	170	MPa
Young's modulus	6260	MPa
Specific modulus	4070	MPa
Elongation of break	3	%
Moisture regain	12	%

Table 2.1: properties of PALF

Epoxy Resin:

Epoxy is a general description of a family of polymers which are based on molecules that contain epoxide groups. An epoxide group is an oxidant structure, a three-member ring with one oxygen and two carbon atoms.

Fig 2.1 Epoxy resin

Epoxies are used widely in resins for prepares and structural adhesives. The advantages of epoxies are high strength and modulus, low levels of volatiles, excellent adhesion, low shrinkage, good chemical resistance, and ease of processing. Their major disadvantages are brittleness and the reduction of properties in the presence of moisture.

3. FABRICATION DETAILS

3.1 PREPARING THE MOLD:

Remove any dust and dirt from mold. The mold is of new fibreglass was applied with soft wax and buff with soft towel. Spray or brush with PVA, parting compound and allow it to dry. The mold material is well-cured fibreglass, so apply three coats of hard wax, carnauba type, buffing between each coat.

3.2 HAND LAY-UP PROCESS:

Hand lay-up technique is the simplest method of composite processing. The infrastructural requirement for this method is also minimal. The processing steps are quite simple. First of all, a release gel is sprayed on the mold surface to avoid the sticking of polymer to the surface. Thin plastic sheets are used at the top and bottom of the mold plate to get good surface finish of the product. Reinforcement in the form of woven mats or chopped strand mats is cut as per the mold size and placed at the surface of mold after Perspex sheet. Then thermosetting polymer in liquid form is mixed thoroughly in suitable proportion with a prescribed hardener (curing agent) and poured onto the surface of mat already placed in the mold. The polymer is uniformly spread with the help of brush. Second layer of mat is then placed on the polymer surface and a roller is moved with a mild pressure on the mat-polymer layer to remove any air trapped as well as the excess polymer present.After placing the plastic sheet, release gel is sprayed on the inner surface of the top mold plate which is then kept on the stacked layers and the pressure is applied.

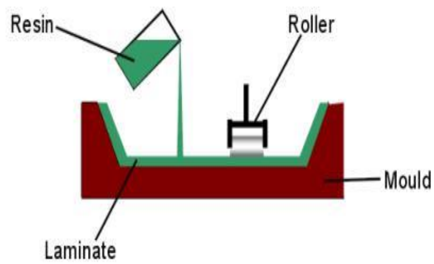

Figure 3.1 Hand lay-up process

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3.3 APPLYING THE GEL-COAT:

The gel-coat is to be brushed on the layers from 1 to 10 layers, allow first coat to cure and then apply the second coat to make sure there are no light spots. When gel-coat has cured long enough that your fingernail cannot easily scrape it free (test at edge of mold where damage will not show on part) then proceed with next step.

3.4 LAY-UP SKIN COAT:

Natural pineapple leaf fibre of dimension 270×210 mm are cut from the big roll. Brushes catalyzed resin over gel-coat, and then apply the mat. Work with roller adding more resin where necessary until all white areas in mat fibers have disappeared and all air bubbles have escaped. Resin-rich areas weaken the part. Where rollers will not reach, brushes must be used. When this step is complete clean all tools in acetone. Allow skin coat to cure before next step.

3.5 REINFORCEMENT OF PINEAPPLE LEAF FIBERS:

Apply each layer as in step 3, but it will not be necessary to wait for curing between these layers. Be sure to shake all acetone out of brushes and rollers before applying resin. Acetone drips can result in uncured spots in the lay-up.

3.6 TRIM**:**

The natural pineapple fibre laminate which hangs over the edge of the mold can be trimmed off easily with razor knife on the trim stage, of the period after the lay-up has gelled but before it has hardened.

3.7 CURE**:**

It take time for curing from 24 hours to 48 hours, depending upon turnover desired, temperature, canalization, and nature of the part. In a female mold, longer cure will affect shrinkage and easier parting. In the case of the male mold, the part comes off more easily before it shrinks appreciably.

4.TESTING METHODS

The main objective is to determine the material properties (Tensile Strength, Flexural Strength, and Impact Strength) of natural fibre reinforced composite material by conducting the following respective tests.

- Tensile Test
- Flexural Test
- Impact Test
- Water Absorption Test

4.1 TENSILE TEST:

As per ASTM D3039 standard the dimensions of the tensile test specimen should be 250×25×3 mm for Tensile Test.Specimen were placed in the grips and were pulled at a speed of 2mm/min until failure occurred.

Fig 4.1 Tensile test specimens

The tensile characterization was conducted according to ASTM D3039 testing standard using a 125 KN machine in displacement control test mode.Data for load, displacement strain were obtained from the test procedure.

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4.2 FLEXURAL TEST:

This flexural test method covers the determination of the comparative properties of pineapple leaf fiber composite, when subjected to flexural stress with standard shape specimens and under defined conditions of pretreatment, temperature, relative humidity and testing technique

fig 4.2 Flexural test specimen of pineapple leaf fibre

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4.3 IMPACT TEST:

The work of fracture and impact strength of pineapple leaf fibre composites as a function of fibre loading. The impact strength increased almost linearly with the weight fraction of the fibre

Figure 4.3 Impact test specimen of pineapple leaf fibre

4.4 WATER ABSORPTION TEST

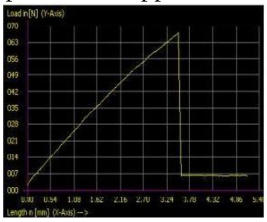
Water absorption in a composite is the amount of water absorbed by the composites as a function of time. When an organic matrix composite is exposed to a humid environment or liquid, both the moisture content and material temperature may change with time

Fig 4.4 Water absorption test specimen of pineapple fibre

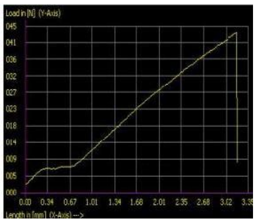
5. RESULT AND DISCUSSION

5.1 FLEXURAL TEST:

Flexural strength is the ability of the material to withstand bending forces applied perpendicular to its longitudinal axis. Sometime it is referred as crossbreaking strength where maximum stress developed when a bar-shaped test piece, acting as a simple beam, is subjected to a bending force perpendicular to the bar. This stress decreased due to the flexural load is a combination of compressive and tensile stresses. There are two methods that cover the determination of flexural properties of material: three-point loading system and four point loading system. As described in ASTM D790, three-point loading system applied on a supported beam was utilized.

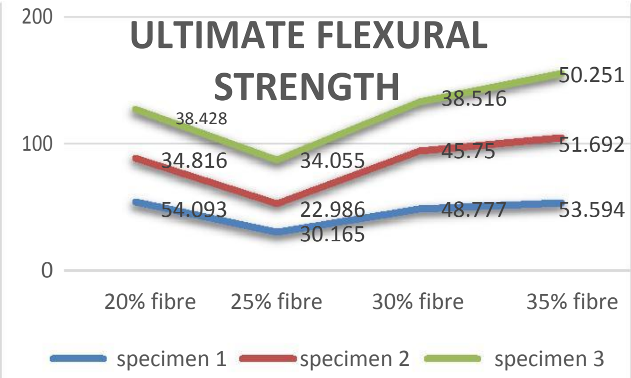


Graph 5.1 flexural test on sample 1 Specimen



Graph 5.2 Flexural test on sample 2 Specimen

In this way it is having 3 specimen in each 20%,25%,30%, and 35%. The comparative result as follows in graph 6.3



Graph 5.3: Flexural load comparison of different composite Specimens

The composite sample specimen testing and flexural load reading given in table 5.1

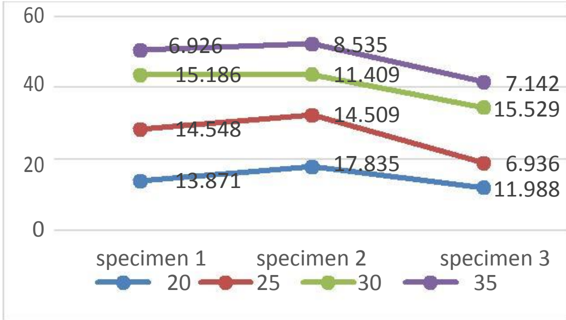
	CS AREA (mm^2)	Peak load (N)	Flexural Strength (Mpa)	Flexural Modulus (Gpa)
Min	39.00	28.459	22.986	396.264
Max	39.00	66.973	54.093	4745.906
Avg	39.00	51.910	41.927	2618.815
Std. Dev.	0.00	12.625	10.197	1370.692
Variance	0.00	159.400	103.985	1878795.810
Median	39.00	52.165	42.133	2778.924

Table 5.1 Flexural test values on UTM machine

5.2 TENSILE TEST:

Tensile test is a measurement of the ability of a material to withstand forces that tend to pull it apart and to what extent the material stretches before breaking. The stiffness of a material which represented by tensile modulus can be determined from stress-strain diagram.

Fig 5.2: specimen after tensile test



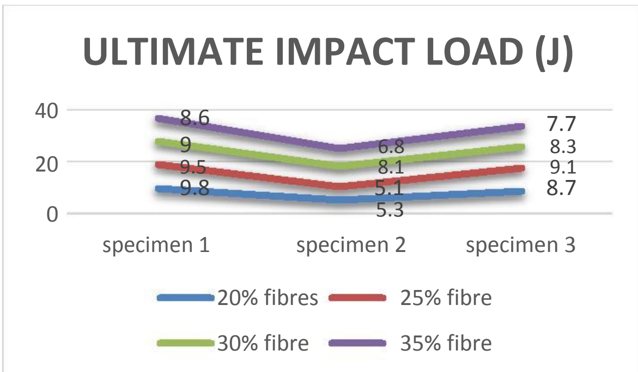
Graph 5.4 Tensile test of different composite samples

As the tensile test starts, the specimen elongates; the resistance of the specimen increases and is detected by a load cell.

5.3 IMPACT TEST:

The impact properties of the material are directly related to the overall toughness which is defined as the ability to absorb applied energy. Area under the stress-strain curve is proportional to the toughness of a material. Nevertheless, impact strength is a measure of toughness.

Fig.5.3 Specimens after impact testing



Graph 5.5 Comparative result of impact load

ISSN: 2278-0181

The minimum value is obtained from the lamina made up of 20% fibre.

5.4 Water Absorption Test

Water absorption is used to determine the amount of water absorbed under specified conditions, factors affecting water absorption include: type of material, additives used, temperature and length of exposure. The data sheds light on the performance of the materials in water or humid environments.

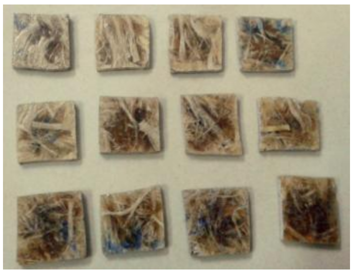
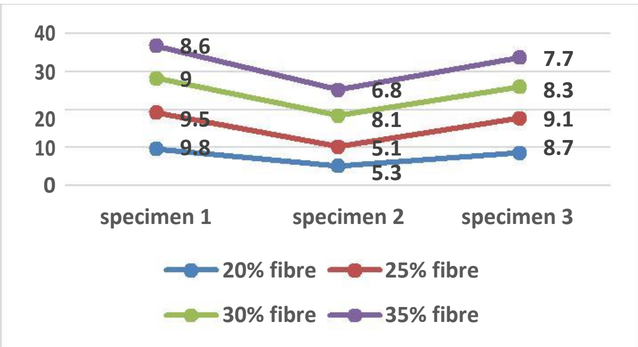


Fig 5.4 specimen after water absorption test

Water absorption test is carried out to understand the ability of the specimen at what rate the material absorb water. The specimen is dipped in the water for 48 hrs.



Graph 5.7Comparative result of water absorption

6.CONCLUSION

The pineapple fibre with epoxy resin is tested under tensile, impact, flexural and water absorption test. When the specimen undergoes tensile test, it can withstand with the maximum tensile load. Among the three specimen, the maximum value of tensile load (1337.45N) is obtained from the specimen II, which contain 20% fibre. For the flexural test the maximum ultimate flexural modulus (4745.91gpa) is obtained from the specimen II, which contain 35% fibre. The maximum impact load (2.15) is for the specimen consist of 25% fibre. From this test we can understand the material specification quality and structural design.This test method is designed for compression strength test. From this we can understand the modulus of elasticity in bending flexural stress flexural strain, flexural stress strain response. While doing the impact test we can understand that the impact strength increased linearly with the weight fraction of fibre. From the water absorption test the absorption capacity of material under the certain condition like time temperature and quantity of fibre.

7.FUTURE WORK

The different percentage of fibre makes change in the strength of the laminate. Here we are using 20%, 25%, 30%, 35% fibre. While using the increasing amount of fibre will gradually increases the strength of the laminate. Apart from this we can increase the percentage of fibre. When we increase the percentage, we can get a wide range of properties in the laminate. The natural fibre composite have variety of properties like light weight, easily availability, cheap cost and ecofriendly. Due to their extensive features, natural fibers are widely used in many areas. Now a days researches are going on the area of natural fibre composites, because of the availability and withstanding properties at extreme conditions.

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