Studies on Mechanical Behavior of Sisal Fiber and Human Hair Hybrid Sandwich Composites

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Abstract - - Recently, due to growing environmental impact that are associated with production, disposal and recycling of synthetic fiber based polymer composites that are triggered the development if eco-friendly composite for various applications mainly in automotive ,marine, chemical ,infrastructure, sporting goods etc. Almost there are various types of fibers kenaf, jute,oil palm, cotton, banana, hemp and sisal. Sisal will play a key role to fabricated a varied range of structural and non –structural industrial products with different polymer matrix.

Also, Hairs is discarded material for our society and easily available in municipal waste, homes etc and available in bulk amount of volume is found in dump/waste streams due to slow degradation. So it is better to develop the approach for utilizations this waste as resources or raw material. Composites are very common and light weighted materials and so its application could be found almost everywhere with different reinforced materials. Hence, this paper presents a review on mechanical properties of sisal-human hairs fiber reinforced polymer composites.

Key Words: sisal fiber, human hair, epoxy resin, polyester resin, composite.

1. INTRODUCTION

There is a growing importance for the green products that are biodegradable in the field of composites that has narrowed the use of synthetic materials in various engineering applications. Demand of polymer based natural fiber reinforced composites has increased dramatically in recent years. For now various types of natural fibers like (wood, cotton, sisal, flex, leaf fibers ,bamboo and hairs etc) are used in development of reinforced composites. Synthetic fiber reinforced composites (SFC) have outstanding mechanical properties in comparison with the Natural fiber reinforced composites (NFC). However, limitations of synthetic fibers due to their non –degradability involves disposal, recycling and environmental impact leads immense pollution to the surrounding environment which are the matter of concern for the government and researchers. In addition to the ecological perspective , the suitability of biodegradable polymers and natural fibers for many applications has increased their demand .Hence, various industrial sectors are focusing on employment of environmentally friendly products .In order to obtain low cost, easily disposable, Research and engineering interest has been shifting form huge materials to Natural Fiber reinforced polymeric materials .In all many authors have reported the mechanical properties of natural fiber reinforced composites .But less efforts have been focused on Natural hybrid fiber reinforced polymers. So this paper provides overview of natural sisal -Human Hair fiber reinforced polymers.

1.1 SISAL FIBER

Sisal fiber is extracted from the leaves of sisal plant (Agave Sisalana),which is currently found in Orissa ,Bihar, Maharashtra, West Bengal.About 275 species are distributed in tropical region of India .Sisal can be easily cultivated in short plantation time. These plant grows naturally in the hedges of field and railway tracks .A study illustrated that around 4.5million tons per year sisal fiber are extracted throughout the world. Sisal fiber extracted from leaves is classified into three types: Mechanical, Ribbon and Xylem. Leaves are crushed and beaten by rotating wheel set with blunt knives, so that only fibers remain .The other parts of leaf are washed away by water and dried under the Sun naturally so that the moisture content in it is removed as the fiber quality depends upon moisture content, so proper drying is important. And to get good quality artificially drying is done and the optimum moisture content for best quality is 13.5%. After that fibers are combined and machined on basis of sizes and groups.

Fig-1: Raw Sisal fiber

TABLE.1

Chemical Composition of moisture content of sisal fiber.

Cellulose (%)	Hemicellulose s(%)	Lignin (%)	Moisture content (%)
65-68	10-22	9.9-14	10-22

TABLE.2

Comparative Mechanical properties of sisal with other natural fibers.

FIBERS	DENSITY (g/cm^3)	ELONGATIO N(%)	TENSILE STRENGTH (MPa)
Sisal	1.33-1.5	2.0-14	400-700
Bamboo	0.6-1.1	-	140-800
Oil Palm	0.7-1.55	25	248
Coir	1.2	15-30.0	175-220
Jute	1.3-1.46	1.5-1.8	393-800
Harake ke	1.3	4.2-5.8	440-990
Vakka	0.00081	3.46	549

TABLE.3

Comparative Mechanical properties of pure thermoset composites and respective sisal reinforced composites.

Properties	Epoxy	Sisal/Epoxy	PE	Sisal/PE
TS (MPa)	33.86	83.96	31.5	65.5
TM (GPa)	0.712	1.5	0.63	1.90
FS (MPa)	118.75	252.39	55.08	99.5
FM (GPa)	5.781	11	1.535	2.49
IS	5.67 (KJ/m^2)	2 (Kj/m^2)	-	-

Abbreviations:
TS- Tensile Strength
TM- Tensile Modulus
FS- Flexural Strength
FM- Flexural Modulus
IS- Impact Strength

1.2 HUMAN HAIR

Hair is a protein filament that grows from follicles found in the dermis or skin. It is one of the defining characteristics of mammals. The human hair keratins have 65-95% proteins depending on the humidity and up to 32% of water. It has long chains (polymers) of amino acids. In terms of raw elements, on an average hair is composed of 50.65% carbon, 20.85% oxygen, 17.14% nitrogen, 6.36% hydrogen, and 5.0% sulphur. Amino acid present in hair contain cytosine, serine, glutamine, threonine, glycine, leucine, valine and arginine.

The Hair shaft is essentially composed of Keratin. Hair keratin is hard, compact and strong. This fibrous protein is gradually formed inside cells from presence of amorphous keratin while the cortical cells have a structure of filaments surrounded by a keratin substances that is richer in sulphur and contains amino acids. The keratin of these filaments forms a helix ,with a distance between the turns of 0.51 nanometers and a structure maintain by hydrogen bonds. This protein plays a key role in the cohesion and physical properties of hairs.

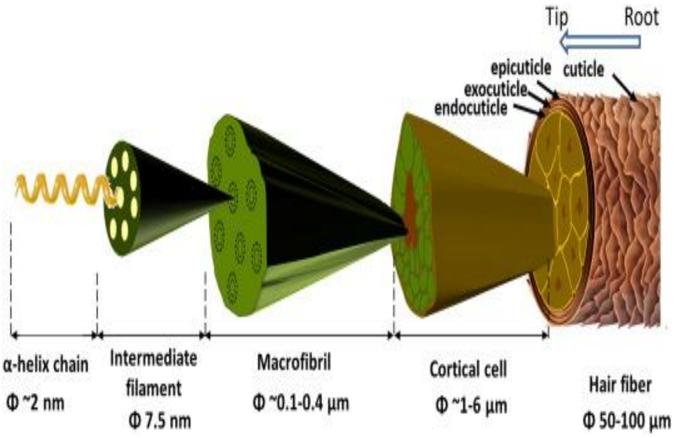

Fig-2: Schematic representation of hierarchical structure in human hair starting α-helix chains and progressing to the entire section.

1.3 Epoxy and polyester resin

The epoxy resin (LY556) and hardener (HY951) was taken in the ratio of 10:1 (i.e.100ml for 1 lit. of resin) for the reinforcing the composite material.

And polyester resin and hardener was taken in the ratio of 100:3 (i.e. 30ml for 1 lit. of resin).

2. .METHODOLOGY

2.1 FOR WATER TREATMENT:

We took both the natural fibers approximately 250gm of Hair and Sisal immersed into the distilled water for 24 hours in about 5 liters of tub in measured quantity. After 24hours taking both the fibers out and then putting for drying naturally in the Sun so that all the moisture content present in it should be completely removed or evaporated.

Fig-3: Hair with water

Fig-4: Sisal fiber with water

2.2 FOR NaOH TREATMENT :

Same for NaOH treatment, taking 5 liters of water and adding 50gm of NaOH in it in measured quantity. Then dipping both fibers in different tubs and keeping for 24 hours. After 24hrs taking both fibers outside of tub and for washing these fibers with distilled water 3-5 times with the Acetic Acid (CH_3COOH) to neutralize the NaOH content present in sisal fiber and human hair. For this to check we used phenolphthalein indicator so that we get NaOH content free fibers. Finally again washing it with fresh water and putting it again for drying naturally till its moisture gets eradicated.

Fig-5: Hair with NaOH

Fig-6: Sisal fiber with NaOH

3. PROCEDURE

After human hair and sisal fiber get treated with water and NaOH sisal fiber are cut in 175mm and human hair are cut randomly in very fine length about 10mm. then sisal fiber and human hair are arranged in 180mm×180mm cavity alternately. Firstly we arranged sisal fiber and after that human hair layer. We arranged alternate 5 layers (I.e. 2 layers of human hair and 3 layers of sisal fiber) of it and after every layer we use resin as a binder. After layers are arranged in cavity we apply pressure on it by using C-clamp and after 24hrs we remove the pressure from the cavity and we get the 50mm thick layer of composite material. finally we cut it into strips by using grinding machine.

Fig 7: Final products cutted into strips

We have created 3 different patterns parallel, perpendicular and inclined.

4. Result and discussion

3.1 Tensile Test

The tensile strength of the composite material were measured by using universal testing machine. The strip of material are of dimension of 170mm×25mm×5mm. After testing the material average value is reported.

3.2 Flexural Test

The flexural strength of the composite material were measured by using universal testing machine.

Table 4: With Epoxy resin

Sr. No.	Sample Identification	Ultimate Tensile strength (N/mm^2)	Flexural load (Kg)
1.	A1	19.44	48.1
2.	B1	16.69	38.5
3.	C1	20.79	33.2
4.	D1	33.99	61.3
5.	E1	25.00	16.9
6.	F1	24.84	39.8

Where, A1 - Parallel matrix with NaOH
B1 - Perpendicular matrix with NaOH
C1 - Inclined matrix with NaOH
D1 - Parallel matrix with water
E1 - Perpendicular matrix with water
F1 - Inclined matrix with water

Table 5: With Polyester resin

Sr. No.	Sample Identification	Ultimate Tensile strength (N/mm^2)	Flexural load (Kg)
1.	A2	17.57	72.6
2.	B2	13.22	44.9
3.	C2	26.95	33.2
4.	D2	26.77	64.7
5.	E2	23.29	41.5
6.	F2	16.69	36.5

Where, A2 - Parallel matrix with NaOH
B2 - Perpendicular matrix with NaOH
C2 - Inclined matrix with NaOH
D2 - Parallel matrix with water
E2- Perpendicular matrix with water
F2 - Inclined matrix with water

3.3 Water Absorption Test

In this test the strips of products are dipped in distilled water for 24 hrs. and water absorption capacity calculated.

% of water absorption= $[(W2-W1/W1)]\times100$

Table 6: With Epoxy resin

Sr. No.	Sample Identification	Weight before dipped into water (W1 in gm)	Weight after 24 hrs (W2 in gm)	Water absorption capacity (%)
1.	A1	44	45	2.272
2.	B1	38	39	2.631
3.	C1	32	33	3.125
4.	D1	33	34	3.030
5.	E1	31	32	3.225
6.	F1	34	35	2.941

Where, A1 - Parallel matrix with NaOH
B1 - Perpendicular matrix with NaOH
C1 - Inclined matrix with NaOH
D1 - Parallel matrix with water
E1 - Perpendicular matrix with water
F1 - Inclined matrix with water

Table 7: with polyester resin

Sr. No.	Sample Identification	Weight before dipped into water (W1 in gm)	Weight after 24 hrs (W2 in gm)	Water absorption capacity (%)
1.	A2	33	33	0
2.	B2	35	35	0
3.	C2	33	34	3.030
4.	D2	32	32	0

5.	E2	34	34	0
6.	F2	34	34	0

Where, A2 - Parallel matrix with NaOH
B2 - Perpendicular matrix with NaOH
C2 - Inclined matrix with NaOH
D2 - Parallel matrix with water
E2- Perpendicular matrix with water
F2 - Inclined matrix with water

5. Conclusions

- Mechanical properties such as tensile and flexural are found to be increasing with different patterns of sandwich structure pattern.
- The average values of Polyester resin (NaOH) for tensile and flexural test is 19.24 N/mm^2 and 50.23Kg which is comparatively more than Epoxy resin (NaOH) samples i.e. 18.97 N/mm^2 and 39.93 Kg.
- Water absorption capacity is greater in epoxy resin as compare to polyester resin.
- Natural fiber composites have good mechanical properties and are slowly replacing synthetic fibers and are helping to reduce environmental impact caused by synthetic fibers.
- Mechanical properties can be attained by using treated fibers and correct method of fabrication.

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