



Investigation of Flexural behavior of hybrid natural fiber composite with recycled polymer matrix

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Abstract: Natural fiber reinforced composites (NFRC) is an emerging area in polymer science. Environmental awareness of the general public resulted in an increasing use of natural materials, recycled polymers & their composites. The present experimental study aims at learning the flexural behavior of hybrid natural fiber reinforced composite. In this work Composites based on recycled high density polyethylene (RHDPE) and natural fibers were made. Samples are prepared with HDPE (50% virgin & 50% post consumer) as polymer matrix. Sisal and hemp are used as reinforcing fibers. The weight fraction of fiber and matrix is kept up to 30%. Specimens are manufactured by using injection molding according to ASTM standards. The results showed that the maximum Flexural Strength and maximum Specific Flexural strength is obtained from the sample having 20% Sisal fiber + 5% hemp fiber as reinforcement with HDPE as a matrix. It is also evident that by the addition of fiber and using recycled HDPE the flexural strength of material increases in the range of 15.5% to 25.5% using different fiber ratio.

Keywords: NFRC, Recycled, Hybrid composite, RHDPE, Flexural strength.

I. Introduction

Nowadays, ecological concern has resulted in a renewed interest in natural materials and issues such as recyclability and environmental safety are becoming increasingly important for the introduction of new materials and products. Lignocellulosic fibers have many advantages as they are biodegradable, renewable and environmentally friendly. (Arbelaiz et al [1])

Although natural fibers have many advantages which offer greater opportunities to develop a new class of environmental friendly structural composites – the drawbacks for the application of cellulosic fibers are the strong hydrophilic nature of their surface, which causes poor adhesion and non-homogeneous dispersion in most non-polar matrices, as well as water absorbance, causing a decrease of the mechanical performances. Indeed, good dispersion of fibers in the polymer matrix and good adhesion is an important prerequisite for obtaining good mechanical properties of the resulting composites. To improve the filler-matrix interactions and thus the composite properties, either surface modification of fiber and/or matrix are necessary. (haque et al. [2])

Lignocellulosic materials are lighter, much less abrasive, and renewable compared to other inorganic fillers (glass, clays, minerals, etc.), and have improved thermal stability over products made with unfilled material. Thermoplastics used with lingo cellulotics, including polypropylene, polystyrene, polyvinylchloride (PVC), and low- and high-density Polyethylene, must melt or soften at or below the degradation point of the lignocellulosic component, normally 200–220 °C (yemele et al. [3]).

During the last decade many works have been carried out on natural fiber based polymer composites with polyolefin matrices (PP, PE, PS, etc.) and it have been reported that composites with modified fiber and/or modified matrix showed improved properties as compared to composites containing non-modified fibers and matrix. ([4], [5], [6])

Several of the major areas of interest behind the development of natural composites are the environmental impacts, potential economic impacts and the ability of natural composite to meet economic, social and material needs worldwide. The aim of our study is to determine the Flexural strength and Specific flexural strength of Recycled natural fiber reinforced Hybrid composite (RNFRHC).

II. Experimental procedure

Material

The matrix (HDPE & RHDPE) was purchased from Goyal Polymer, Industrial Area Phase-2, Chandigarh. The fibers were provided by Chandra Prakash & co from Jaipur (Rajasthan).

Preparation of fiber

The length of fibers available is usually long so before treatment it is necessary to cut them into desired length. I took fiber of 4 to 5 mm (approx) length. The fibers obtained were then soaked in distill water for 1 hour at

80°C. The water was then drained off and fibers were placed on filter paper to soak the extra amount of water present in the fibers. The fibers so obtained were oven dried for 5 hours at 100°C in universal hot air oven.

Chemical treatment.

Sisal mercerization was conducted by keeping it in 10 wt% NaOH solution at room temperature for 3 h. After mercerization, the sisal was rinsed with water to remove the soda excess until pH ~7 was reached and dried in oven at 100°C for 3 hour.(favarro *et al*;2010)

For alkali treatment, the pre-dried hemp fibers were soaked in an aqueous solution of sodium hydroxide (10wt. % solution of NaOH) for two hours at room temperature (20 °C). Afterwards, the fibers were rinsed with distilled water until the filtrate reached pH = 7. Next, the fibers were dried again at 105 °C, until a constant mass was reached.

Maleic anhydride modification was carried out *via* soaking the fibers in a solution of Maleic anhydride (10 wt. %) in acetone for two hours at elevated temperatures (55 °C). Afterwards, the fibers were rinsed to obtain pH = 7 and dried at 105 °C until constant mass was observed. (kaczmar *et al*;2011)

At last, fibers were placed in air tight container with silica gel so as to prevent the absorption of moisture from the atmosphere by the fibers.

III. Manufacturing of composite.

Table-1 presents the detail of composite prepared. The table was constructed on the basis of sisal fiber density =1.45g/cc, hemp fiber density = 1.45 g/cc and the density of HDPE matrix =0.94 g/cc. of flexural specimen. The volume of flexural specimen from the drawing came was 5.16cm³.

Table1- Weight of different constituents used to make composite

SAMPLE	HDPE%	SISAL%	HEMP%	DENSITY OF COMPOSITE (g/cc)	FLEXURAL WEIGHT OF COMPOSITE (gram)	WEIGHT OF HDPE (PER SAMPLE)	WEIGHT OF SISAL (PER SAMPLE)	WEIGHT OF HEMP (PER SAMPLE)
1	75	20	5	1.068	5.508	4.131	1.102	0.275
2	75	5	20	1.068	5.508	4.131	0.275	1.102
3	70	30	0	1.093	5.64	3.948	1.692	0
4	70	0	30	1.093	5.64	3.948	0	1.692

Injection molding machine (model no BH 100) was used to manufacture the composites in J. B. Industries Pvt. Ltd., Ambala.

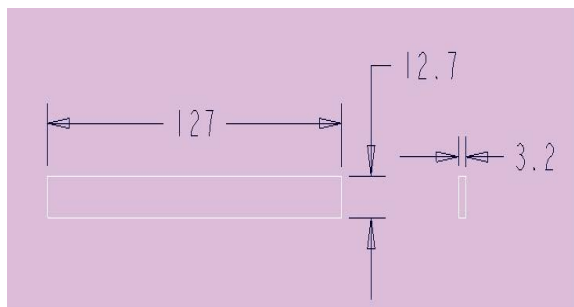
The Flexural strength of prepared composites is compared with the virgin HDPE. The value of flexural strength of virgin HDPE is referred from book, “Mechanical behavior of sisal fiber reinforced HDPE composite” by Harsimrandeep Salaria, Dharmpal Deepak & Vinay Gupta; LAP LAMBERT Academic Publishing; ISBN-13: 978-3-659-50695-6



a) Chemical treatment of fiber



b) PH checking



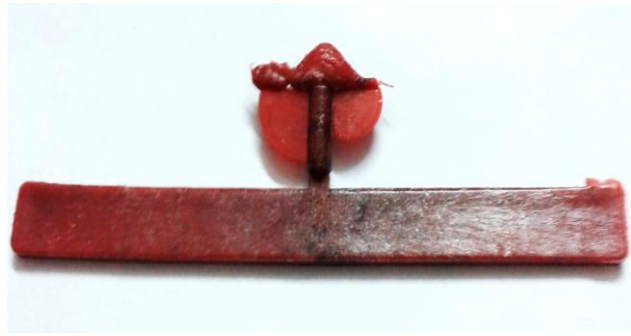
c) Drawing of flexural specimen



d) Die to prepare flexural specimen



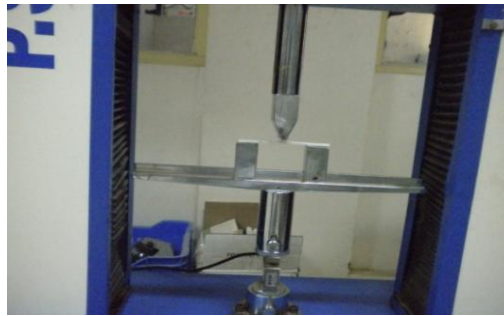
e) Injection molding machine (BH100)



f) Manufactured specimen

IV. Flexural Testing

This was performed according to ASTM D 790 test method. The slot used for testing consisted of five samples for different constitutions. The specimens were kept according to **ASTM** standard at 23°C for 40 hours in Environmental Test Chamber at Central Institute of Plastics Engineering Technology, Amritsar (CIPET). The samples were then examined using the three-point bending test. The whole procedure was carried out using UTM with cross head speed 2mm/min and load used for test was 10KN at Central Institute of Plastics Engineering Technology, Amritsar (CIPET).



g) UTM machine for flexural testing

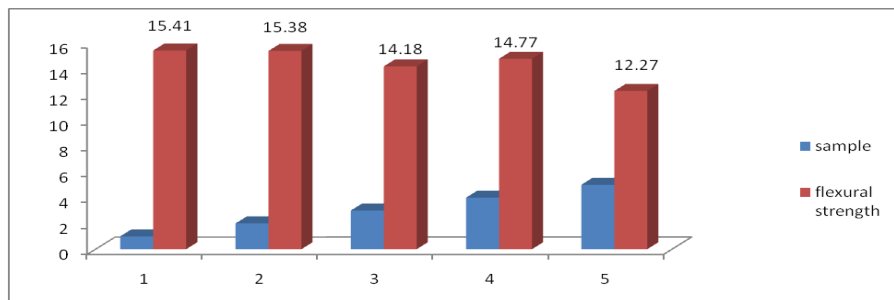
V. Observation Table:

I have taken the five readings as an average value from samples belonging to different percentage of fiber i.e. 20% sisal+5% hemp, 20% hemp +5% sisal, 30% hemp and 30% sisal in HDPE matrix for flexural strength test.

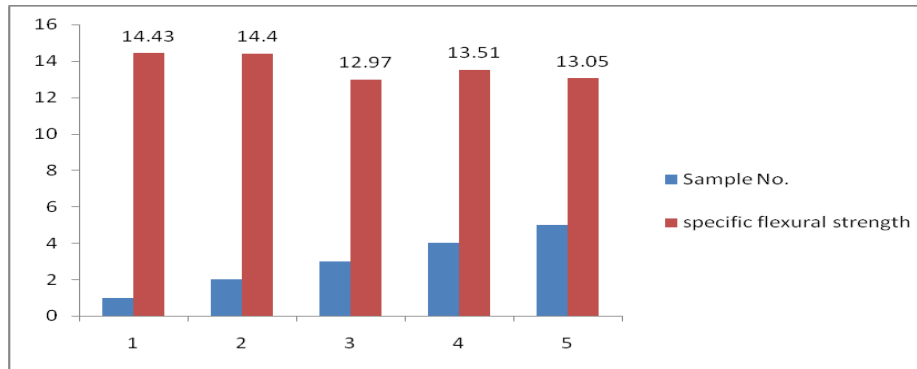
Table- 2, Flexural and Specific Flexural strength of different composites prepared

Sample no.	1	2	3	4	5
Constituent	HDPE 75%, SISAL 20%, HEMP 5%	HDPE 75%, SISAL 5%, HEMP 20%	HDPE 70%, SISAL 30%, HEMP 0%	HDPE 70%, SISAL 0%, HEMP 30%	HDPE 100%, SISAL 0%, HEMP 0%
Density	1.068	1.068	1.093	1.093	0.94
Flexural Strength(Mpa)	15.41	15.38	14.18	14.77	12.27
Specific Flexural Strength (Nm/kg)	14.43	14.40	12.97	13.51	13.05

Graphs:



Graph 1: Showing Flexural strength of different samples



Graph 2: showing specific flexural strength of different samples

VI. Results and Discussions

Graph1 that has been drawn was constructed from the observations obtained after performing testing on composites. In graph abscissa represents the samples having different fiber percentage in HDPE (recycled + fresh) while the ordinate depicts Flexural Strength (MPa). After careful analysis of the graph it is clear that by the addition of fiber and using recycled HDPE the flexural strength increases (15.5% to 25.5%). The maximum flexural strength is 15.41 MPa which is obtained from sample containing 25% fiber (20% sisal+ 5% hemp) in 75% HDPE (fresh + recycled), which is more than sample containing 30% of single fiber (i.e. sisal or hemp separately). So it is evident that the Flexural strength of hybrid composite is more than that of composite having single fiber as reinforcement.

Graph2 gives the Specific Flexural strength of different materials. Specific flexural strength is the ratio of flexural strength and material density. From the graph it is evident that maximum Specific Flexural strength obtained is 14.43Nm/kg for sample (which contains 20% sisal, 5% hemp and 75% HDPE), having density 1.068g/cc. While pure HDPE having density 0.94g/cc gives specific flexural strength of 13.05Nm/kg. The minimum Specific Flexural strength obtained is 12.97Nm/kg from sample having density 1.093g/cc (which contains sisal 30% and HDPE 70%). So reinforcement with hybrid fibers also gives maximum specific flexural strength.

VII. Acknowledgments

Authors thankfully acknowledge Head of the Department of Mechanical Engineering and Applied sciences, MMU, for their encouragement and support in carrying out this work. Special thanks to Itender Singh of J. B. Industries Pvt. Ltd., Ambala to provide machinery in the manufacturing of composite.

VIII. References

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