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COMPRESSIVE, WEAR AND WATER ABSORPTION BEHAVIOURS OF SUNNHEMP-POLYESTER COMPOSITES

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ABSTRACT

During the course of evolution, the traditional knowledge and practices developed by our ancestors on various uses of plants have been transmitted to future generations. Among the commonly used plant species by man, the fiber yielding plants hold the second position after the food plants with respect to their economic potential. Disposal problems, as well as strong regulations and criteria for cleaner and safer environment, have directed a great part of the scientific research toward eco composite materials. In the last few years, the components obtained from bio fiber reinforced composite material are mostly used to produce the non-structural parts.

Keywords: *Sunnhemp, Retting, Compression molding, Specific wear rate and Water absorption.*

1. Introduction

Natural fiber reinforced composites are used now a days for most of the engineering applications due to their better strength and stiffness to weight ratio. The synthetic fiber reinforced composites are replaced by natural fiber reinforced composites. The natural fiber is obtained from various parts of the plant can be used to reinforce the composites. The main problem of using natural fiber is specific wear and water absorption phenomena. The present investigation is focused to find out the compressive strength, specific wear rate and water absorption behavior of sunnhemp fiber reinforced polyester composites, by varying parameters like fiber length, diameter and orientation angle. The Growth period is favoured by the atmospheric temperature of 23-30oC and rainfall of 400mm. The Sunnhemp is often referred to as Madras hemp. The Photographic image of Sunnhemp Seed and plant is shown in Figure 1.

Among the natural fiber reinforced composites, the sunnhemp fibers are having high specific strength and low density and hence it can be used for the reinforcement of composites made by using polypropylene and polyester as matrix material to get better results [1]. Some of the researchers worked on the bio-composites made by banana, sisal, coir and jute as the reinforcing material and evaluated the various mechanical properties for the purpose of using these composites for the engineering applications such as fall ceilings, automotive interiors [2]. Polymer-based composite materials possess superior properties such as good corrosive resistance, high strength and hence they are preferred for aerospace, automotive and sports equipments which require high strength to weight ratio [3].

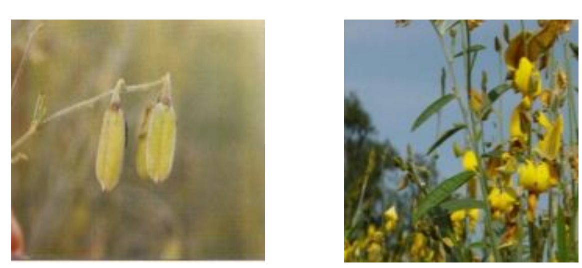

Figure 1. Photographic image of Sunnhemp seed and plant

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At present, in the automotive industry glass fiber reinforced composites are replaced by natural fiber reinforced polymer systems. It was observed that the mechanical properties of the fibers can be increased by using appropriate mercerization Parameters. The effects of different mercerization parameters such as concentration of alkali (NaOH), temperature, and duration time modifies the tensile stress applied to the fibers on the structure and properties of hemp fibers. By using the technique of mercerization, the fiber properties can be homogenized and controlled [4-5]. Current investigation is focused on the improvement of the compressive strength, specific wear rate and water absorption behavior of sunnhemp fiber reinforced polyester composites.

2. Materials and Manufacturing

2.1 Materials

Reinforcement: Sunnhemp fiber
Resin : Polyester
Accelerator : Cobalt Octoate
Catalyst : Methyl Ethyl Ketone Peroxide

2.2 Extraction of fibers

The water retting process was followed for the extraction of Sunnhemp fibers. Retting is a process to separate fibers in the bark obtained from the woody portion by the action of micro organisms present in the water.

Figure 2. Photographic image of various stages of Sunnhemp fiber extraction by retting process.

The number of days required for retting depends on water temperature, locality, weather conditions, depth and source of water, thickness of stalks and quantity of straw in relation to volume of water. The retting period is usually 3 to 5 days. If on testing of the retted stalks fiber is found loosening, it is considered ready for extraction. The softening of fiber takes place due to action of the enzyme released by the bacteria acting on the stem. The photographic image of various stages of Sunnhemp fiber extraction by retting process is shown in Figure.2.

2.3 Composite fabrication

Sunnhemp fiber laminates are fabricated by using compression molding technique for both untreated and alkaline treated fiber. Untreated and alkaline treated Sunnhemp fibers are prepared to the desire length by using scissors for various different fiber Orientation angles (Chopped, Random, 00, 300, 450, 600,900,Bi-axial and Triaxial). In all the fabricated plates, the sunnhemp fiber content is about 20% of weight and 80% of resin (Polyester) is used. For each type of composite plates, the fibers are kept in between the matrix material. The wax is coated on both the mould plate (Upper and Lower part of the compression Molding Machine) and OHP sheets are affixed over the coated wax to avoid sticking of laminates with the mold plate. In compression molding, the resin mixture was poured in to the fiber mat until it is completely soaked. The whole assembly was pressed at a temperature of 75°C at pressure of 2.6 MPa for 15 minutes. Then composite laminates were removed from compression molding machine. The laminate specimens are prepared to required ASTM standard sizes by cutting for different investigations. The photographic images of processing in compression molding machine and the fiber mat are shown in Figure.3.

Figure 3. Processing in Compression Molding Machine

2.4 Compressive test

The untreated and alkaline treated Sunnhemp fiber reinforced laminates are tested for compressive strength as per ASTM D 3410 standards with sizes of 25 × 25 × 3 mm. The test is carried out using a Universal Testing Machine at a compression rate of 5 mm/min.

2.5 Specific wear rate

The untreated and alkaline treated Sunnhemp fiber reinforced laminates are tested for Dry sliding wear test as per ASTM G-99 standards with sizes of 30 ×4 × 4 mm^3 using the Pin on disc set up (model: TR-20-M26) as shown in Figure 4.

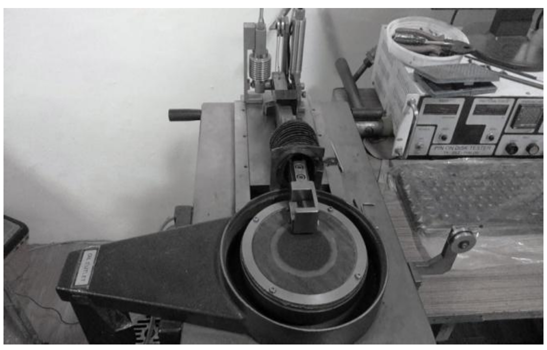

Figure 4. Photographic image of pin on disc set up.

The wear testing machine is having a hardened alloy steel disc with a surface roughness of 0.25–0.30 μm and the experiment is conducted at room temperature. The accurate sizes of the samples are obtained using emery sheet to ensure proper contact between pin and disc with the counter surface. The pin is initially weighed using electronic balance meter at an accuracy of 0.0001g. Sliding wear is measured using weight loss method, in which the difference between the initial and final weights of the specimen is calculated (Xing et al. 2004).

Five specimens are tested in each laminates and the average value was taken. The specific wear is measured by loss in weight which is converted into wear volume and then calculated the specific wear rate using the following equation (1)

$$\text{Specific wear rate } k_s = \frac{V}{L \times D} \quad (mm^3/Nm) \text{----------} \quad (1)$$

where, V is the volume loss (mm^3)
L is the applied load (N)
D is the sliding distance (m)

2.6 Water absorption

A study of water absorption shows that absorption can disrupt hydrogen bonds among segments of the polymers and cause swelling of polymer. The water absorption phenomena increase the diffusion coefficient of water within the polymer composites. The water absorption behavior of Sunnhemp polyester composite samples are performed in accordance with the ASTM D570 standard with the specimen of 76.2 x 25.4 x 3 mm and dried in an oven for 24 hours at a temperature of 60^oC and are submerged in distilled water at room temperature for about 1-10 days. Weight differences between dried and submerged samples are measured at regular time intervals using high precision weight balance. Water absorption of NaOH and Untreated composites is to be computed by the equation (2) shown below:

$$WA(t)= \frac{W_t - W_0}{W_0} \text{ X } 100 \text{--------------------} (2)$$

Where WA (t) is the water absorption (%) at time t, W_0 is the weight measured after oven dried and W (t) is the weight of specimen at a given immersion time t. Specimens immersed in water (1^{st} day) at room temperature are shown in Figure 5.

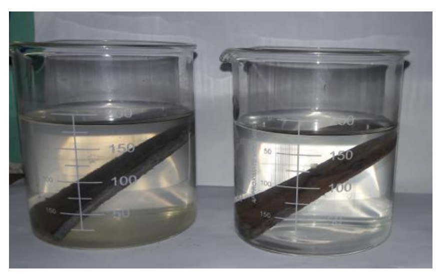

Figure 5. Photographic image of water absorption specimen.

3. Results and Discussion

3.1 Compressive strength of untreated and alkaline treated Sunnhemp- polyester composites :

The compressive strength of NaOH treated and untreated Sunnhemp-polyester composite is minimum when the fiber is chopped (71.2 MPa and 67.6 MPa respectively) and the compressive strength is maximum (92.3 Mpa and 80.7 Mpa respectively) when the fiber orientation angle in tri-axial. It was observed that the Compressive strength is increased when the fiber orientation angle is varies from 00 to tri-axial orientation. The Compressive strength takes any value in between the minimum and maximum values when the fiber orientation angle is in between 0^0 to tri-axial. The comparison of compressive srength, specific wear and water absorption properties of NaOH treated and untreated Sunnhemp-polyester composite is shown in Table 1. It was observed that the compressive strengths of alkaline treated sunnhemp polyester composite specimens are more than the untreated sunnhemp polyester composite specimens. The graph for Compressive strengths for NaOH treated and untreated sunnhemp-polyester composites are shown in Figure 6.

Figure 6. Graph for compressive strength for NaOH treated and untreated fibers.

3.2 Specific wear rate of untreated and alkaline treated sunnhemp-polyester composites:

The specific wear rate of NaOH treated and untreated Sunnhemp-polyester composite is minimum when the fiber is chopped (0.011 mm^3/Nm and 0.009 mm^3/Nm respectively). The specific wear rate is maximum (0.033 mm^3/Nm and 0.030 mm^3/Nm) when the fiber orientation angle in tri-axial. It was observed that the specific wear rate is increased when the fiber orientation angle is varies from 0^0 to tri-axial orientation.

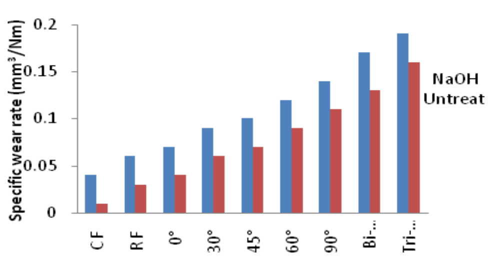

Figure 7. Graph for specific wear rate for NaOH treated and untreated fibers.

The specific wear rate takes any value in between the minimum and maximum values when the fiber orientation angle is in between 0^0 to tri-axial. It was observed that the specific wear rates of alkaline treated sunnhemp polyester composite specimens are more than the untreated sunnhemp polyester composite specimens. The graph for specific wear rate for untreated and NaOH treated Sunnhemp-polyester composite is shown in Figure 7.

3.3 Water absorption on sunnhemp-polyester composites

The NaOH treated plates absorbs less water when compared with untreated sunnhemp-polyester plates. The Figure 8 shows the weight of water intake for the sunnhemp-polyester composites with different period of immersion time ranging from 1-10 days. The composite sample of sunnhemp-polyester composites plates with NaOH treated absorbs less water. It shows high intake of water because of its hydroscopic nature. It was observed that the water absorption rates of alkaline treated sunnhemp polyester composite specimens are more than the untreated sunnhemp polyester composite specimens. The graph of water absorption % for NaOH treated fibers and untreated is shown in the Figure 8.

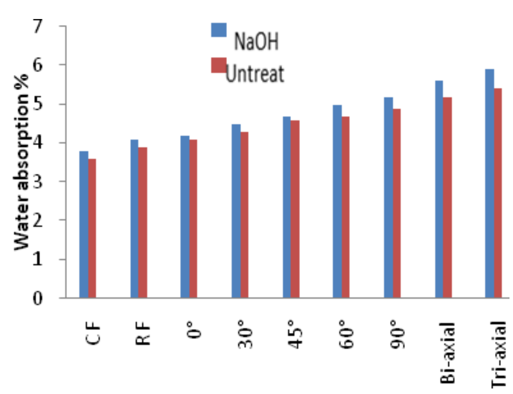

Figure 8. Graph for water absorption% for NaOH treated and untreated fibers.

4. Conclusions

The Sunnhemp fiber is being one of the new fibers introduced in the field of composite materials. So far this fiber is used only in the field of agriculture to increase the fertility of soils. Our research indicates that there is a vast scope to this fiber in the field of engineering to manufacture an eco friendly composite materials and it may replace the existing plastic and metal parts. The evaluation of the mechanical behaviours of untreated and NaOH treated sunnhemp fiber reinforced with polyester resin laminates was studied in this investigation. From the evaluated properties of compressive strength, specific wear and water absorption in sunnhemp-polyester composites, the fiber orientation angle of tri-axial shows the best results when compared with other orientation angles. The NaOH treated sunnhemp polyester laminates show better results than the un-treated sunnhemp polyester laminates in all fiber orientation angles. Water absorption result shows NaOH treated fibers absorb more water weight gain percentage than untreated laminates. It is concluded that the Sunnhemp fiber reinforced composite plates can be used for manufacturing engineering components like Panelled Doors, Table Tops, Partition Walls, Cup Boards, Racks, Switch Board cover plate, Auotomobile Side Doors and similar components where the applied load is within the capacity of this composite material. The comparison of compressive strength, specific wear and water absorption properties of NaOH treated and untreated Sunnhemp-polyester composites is given in table 1.

Table 1. Comparison of compressive strength, specific wear and water absorption properties of NaOH treated and untreated Sunnhemp-polyester composites.

Fiber Orientation Angle	Compressive Strength (MPa)		Specific Wear Rate (mm^3/Nm)		Water Absorption (%)	
	NaOH	Un-treated	NaOH	Un-treated	NaOH	Un-treated
Chopped fiber	71.2	67.6	0.04	0.01	3.8	3.6
Random fiber	72.5	68.8	0.06	0.03	4.1	3.9
0^0	74.1	71.4	0.07	0.04	4.2	4.1
30^0	75.8	73.1	0.09	0.06	4.5	4.3
45^0	76.2	75.2	0.10	0.07	4.7	4.6
60^0	78.5	77.6	0.12	0.09	5	4.7
90^0	83.4	78.5	0.14	0.11	5.2	4.9
Bi-axial	87.5	79.6	0.17	0.13	5.6	5.2
Tri-axial	92.3	80.7	0.19	0.16	5.9	5.4

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