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EFFECT OF ANGLE PLY ORIENTATION ON WEAR PROPERTIES OF RAMIE FIBRE REINFORCED POLYMER COMPOSITE

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Abstract:
The influence of angle orientation on the wear factors of materials reinforced with ramie fibers is studied in the present work. In this study, ramie fiber-reinforced composites were fabricated by a hand-layup process using a thermoset matrix. The composite specimens were produced by developing a variety of fiber orientations, including [0°/0°/0º/0º], [0°/90°/0º/90º], [45°/-45°/45°/-45º], and [0°/45°/-45°/90°] in four layers. Using a pin-on-disc tribometer, the wear characteristics of the composites were evaluated during dry sliding conditions. Different weight types were used in the trials, as were sliding speeds and sliding distances, to completely capture the wear behavior. Additionally, wear increased as sliding speed and weight increased, regardless of fiber orientation.
Keywords: fiber orientation, wear characteristics, sliding speed, load-bearing.

Introduction I

Natural fibers are becoming increasingly frequently chosen as reinforcement for composite materials as a result of growing environmental concerns, including the demand for sustainable resources. A natural bast fiber called ramie, which comes from the Boehmeria nivea plant, possesses special mechanical qualities, such as excellent tensile strength, stiffness, and low density, which make it a suitable choice for composite applications. Ramie fiber-reinforced composites have received a lot of attention recently due to their biodegradability and potential to be less hazardous for the environment than conventional composite materials [1].

The orientation of the fibers has a big impact on their physical, mechanical, and composite properties [2]. The alignment of the fibers inside a matrix affects how loads and stresses are distributed during loading, which affects how well the composite performs overall. Many studies [3] have looked into how the orientation of the fibers impacts the tensile and flexural strengths of various natural fiber-reinforced composites. A clear information gap exists about how fiber orientation impacts wear characteristics, particularly with regard to ramie composites.

A crucial component of material performance is wear resistance, especially in applications where surfaces are in sliding proximity to abrasive forces [4]. To enhance the performance of the composite in wear-prone applications, it is essential to understand whether the angle orientation of the ramie fibers affects the wear parameters of the composite. It might be able to improve wear resistance and encourage the use of ramie composites in several engineering sectors by altering the fiber orientation.

This study aims to determine what effect angle orientation has on the wear properties of composites reinforced using ramie fibers. By gradually switching the orientation of the fiber from longitudinal to transverse with respect to the sliding direction, we hope to understand how the various configurations affect wear resistance. The wear behavior will be evaluated under several types of operating conditions, such as variable sliding speeds and weights, in order to thoroughly comprehend the wear resistance of these composites [5].

The conclusions of this research can further our fundamental appreciation of ramie composite wear and deliver beneficial advice for developing ramie-based materials for certain wear-related applications. Additionally, by emphasizing sustainable and green materials, this research may help achieve the larger objective of creating green composites with increased wear resistance and little environmental effect [6–8].

Materials and Methods II

Materials:

Ramie Fibers:

The composite's reinforcing was made with excellent ramie fibers. The fibers were produced as continuous yarn or fabric with a particular area weight or linear density.

Matrix Material: The matrix was made of a thermoset resin, such as epoxy. The resin was chosen because it could successfully connect with the ramie fibers and give the composite mechanical stability.

Composite Fabrication III

Hand Lay-up Method:

Hand lay-up remained used for manufacturing the composite specimens. Layers of ramie fibers were manually positioned in four layers in this process in the desired orientation, such as [0°/0°/0º/0º], [0°/90°/0º/90º],[45°/-45°/45º/-45º], and [0°/45°/-45°/90°] inside a mold, as shown in figure 3.1-3.4.

Resin Infusion: Once the fiber stack was complete, the matrix resin was introduced into the fiber layers using a roller or brush to ensure proper drying and impregnation of the fibers.

Curing: In order to help the resin polymerize and solidify the composite structure, the composite lay-up was then cured at a specified temperature and pressure.

Figure 3.1 fibre orientation

Figure 3.2 Fabrication process

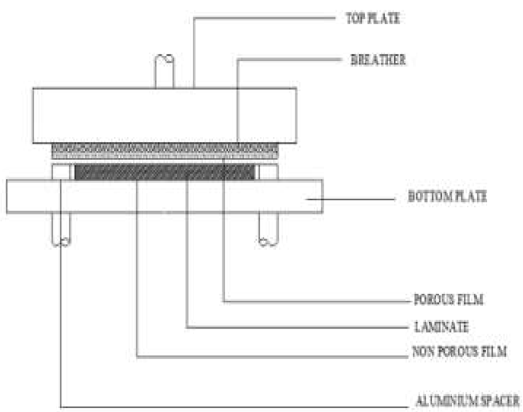


Figure.3.3hand lay-up process

Figure.3.4 Composite material

Specimen Preparation:

Standard Dimensions: The rectangular specimens with the required dimensions for wear testing were cut from the cured composite panels, as illustrated in figure 3.5.

Figure 3.5 wear test specimen

Surface Finishing: To create a clean and flat finish on the specimen surfaces, this would remove surface flaws during wear testing.

Mechanical characterization IV

Wear Testing:

Wear testing remained done with a pin-on-disc tribometer, a common technique for analyzing the sliding wear behaviors of materials. In most test arrangements, the counter-surface is a rotating disc, and the composite specimen is loaded against the disc at a predefined normal stress.

Sliding Parameters: To estimate the impact of these factors on wear qualities, a variety of sliding parameters, including sliding speed, normal load, and sliding distance, have been altered through wear testing.

Dry Sliding: The wear tests remained achieved under dry sliding conditions, simulating real-world applications where lubrication might be limited or absent.

Figure 4.1 Pin –disc wear test machine

Wear Rate Calculation: In accordance with the wear volume data gathered during the studies, wear rate was determined as the amount of volume loss per unit of sliding distance or time.

Calculation for Wear

The wear rate was determined by subtracting the specimen's weight before and after each test. By comparing the weight of the specimen before and after each test, the amount of weight loss was determined. The lost weight is listed below.

$$(\mathbf{w}) = (w_a - w_b)\ \text{gm} \quad \text{--(1)}$$

While W denotes the weight loss in grams, W_a and w_b stand for the final weights before and after an abrasion test, respectively. The formula below can be used to plan the use of the abrasive wear rate (W).

$$W = \frac{\Delta w}{(\rho \times S_d)} \quad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (2)}$$

Where "w" denotes wear rate (in cm3/m), "Sd" denotes sliding distance (in meters), "Δw" denotes weight loss (in grams), and "ρ" denotes composite density. Table 5.1 displays the mean weight loss and wear rate for each batch. The particular wear rate describes the impact of abrasive wear on composite materials. This shows the volume loss of the composite for each sliding distance and force unit. The inverse of the particular rate of wear is often used to indicate the volumetric wear rate. Another formula for determining an object's wear rate (k0) is Equation.

$$k_0 = \frac{\Delta w}{(\rho \times S_d \times L)} \quad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_(3)}$$

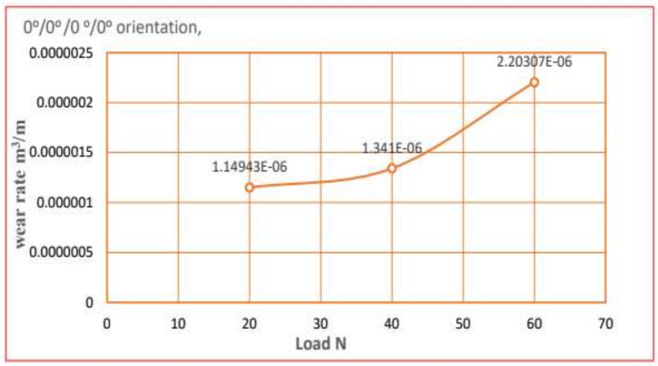
Where 'w' indicates weight loss per grams, 'S_d' as sliding distance in meters, with 'L' as applied load in N, 'k0' stands to indicate the specific wear rate as m3 /Nm.

RESULT AND DISCUSSION V

Table5.1 wears characteristics of ramie composites of different orientations

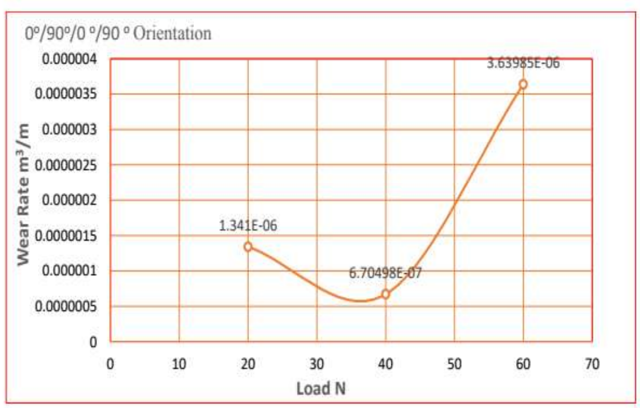
Orientation	**Sample ID**	**Load N**	**Weight loss (W)**	**Wear rate m^3/m**	**Specific wear rate (K0) m^3/mN**
	A-1	20	0.0012	1.14943E-06	6.66667E-08
[0º/0º/0º/0º]	A-2	40	0.0014	1.341E-06	3.88889E-08
	A-3	60	0.0023	2.20307E-06	4.25926E-08

[0°/90°/0°/90°]	B-1	20	0.0014	1.341E-06	7.77778E-08
	B-2	40	0.0007	6.70498E-07	1.94444E-08
	B-3	60	0.0038	3.63985E-06	7.03704E-08
[45°/-45°/45°/-45°]	C-1	20	0.0002	1.91571E-07	1.11111E-08
	C-2	40	0.0023	2.20307E-06	6.38889E-08
	C-3	60	0.0031	2.96935E-06	5.74074E-08
[0°/45°/-45°/90°]	D-1	20	0.0004	3.83142E-07	2.22222E-08
	D-2	40	0.002	1.91571E-06	5.55556E-08
	D-3	60	0.0024	2.29885E-06	4.44444E-08



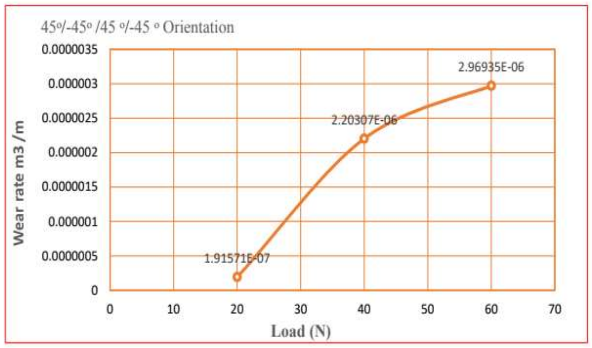
Graph 5.1 Ramie composite's wear rate for [0°/0°/0°/0°] orientation

The orientation of the [0°/0°/0°/0°] ramie composite wear rate properties shown in graph 5.1 comprises 20N, 40N, and 60N. 20 N, 40 N, and 60 N had wear rates of 1.14943E-06, 1.341E-06, and 2.20307E-06, respectively. The wear rate increases with load, reaching its maximum at 60 N and its lowest at 20 N.



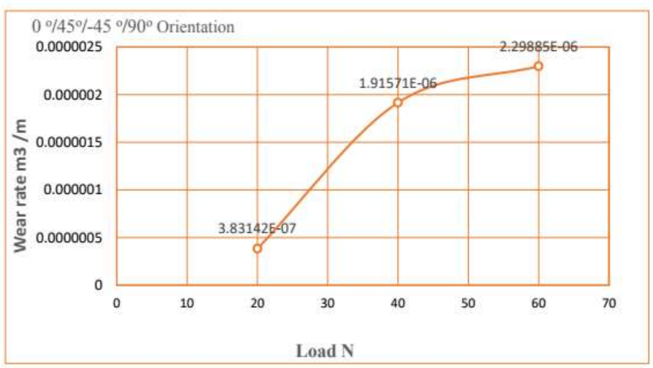
Graph 5.2 the Ramie composite's wear rate for [0°/90°/0/90^0] orientation

For different loads, such as 20 N, 40 N, and 60 N, the rate of wear properties of ramie composites at [0º/90º/0º/90º] orientation is shown in graph 5.2. The wear rates were 1.341E-06 with 20 N, 6.70498E-07 with 40 N, and 3.63985E-06 at 60 N. When the wear rate grows in load, 60 N is the largest wear rate, and 40 N is the lowest.



Graph 5.3 the Ramie composite's wear rate for [45º/-45º/45º/45º] orientation

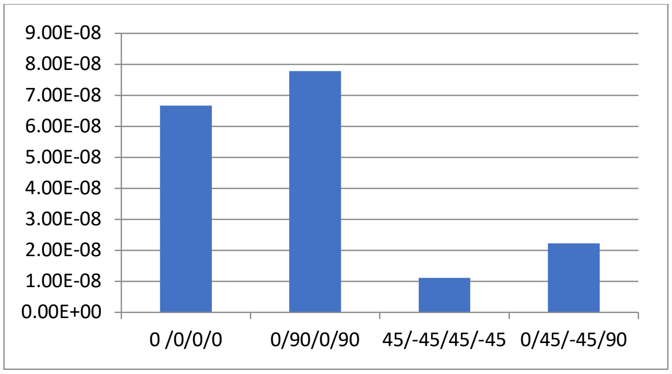
The wear rate characteristics for a ramie composite having [45º/-45º/45º/45º] orientation at various load conditions, such as 20 N, 40 N, and 60 N, are shown in Figure 5.3. It demonstrates how the wear rate fluctuates between 20 N and 60 N, with 60 N having the highest wear rate and 20 N having the lowest. Wear rates increase as weight increases.



Graph 5.4 the Ramie composite's wear rate for orientations [0º/45º/-45º/90^0]

The wear rate properties of a ramie composite having [0º/45º/45º/90º] orientation are shown in Graph 5.4 for a range of loads, including 20 N, 40 N, and 60 N. As the load increases, the rate of wear is shown to increase from 3.83142E-07 at 20 N to 1.91571E-06 at 40 N and 2.29885E-06 at 60 N. 20 N represents the least wear rate, and 60 N is the highest wear rate.

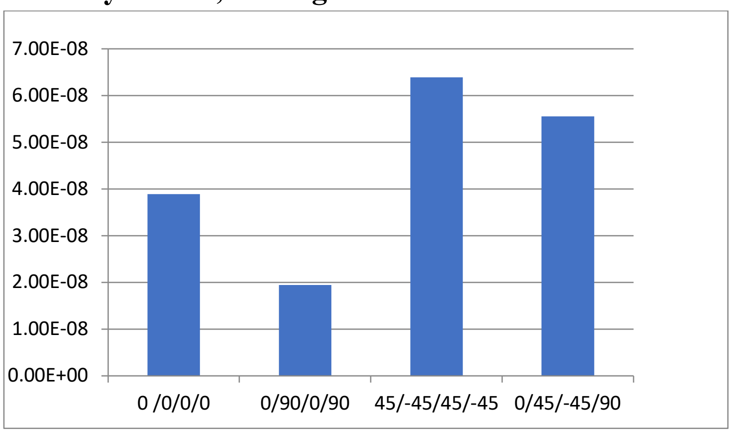
Specific wear rate;
Load 20 N, Sliding Velocity1.5 m/s, Sliding Distance 900m



Graph 5.5 the Ramie Composite's specific wear rate for various orientations under 20 N loads

Graph 5.5 displays the specific wear rate for ramie composites with different orientations at 20 N, 1.5 m/s, and 900 mm at sliding distance. For orientations [0º/90º/0º/90º], the greater specific wear rate was 7.77778E-08m3/m N, and for orientations [45º/-45º/45º/-45º], the smaller specific wear rate was 1.11111E-08m3/m N.

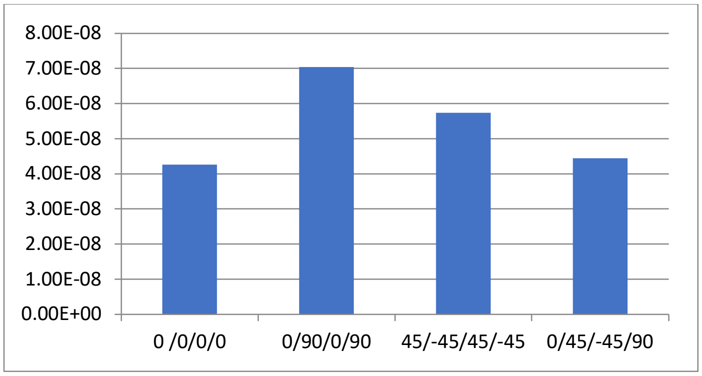
Load 40 N, Sliding Velocity1.5 m/s, Sliding Distance 900m



Graph 5.6 the specific wear rate of the Ramie Composite in different orientations at a 40 N load

The specific wear rate for ramie composites with various orientations at 40 N, 1.5 m/s, as well as 900 mm for sliding distance is shown in Graph 5.6, with the orientation [45º/-45º/45º/-45º] having the higher specific wear rate and the orientation [0º/90º/0º/90º] having the lower specific wear rate.

Load 60 N, Sliding Velocity1.5 m/s, Sliding Distance 900m



Graph 5.7 the specific wear rate of a Ramie composite for various orientations under 60 N of load

Graph 5.7 displays a specific wear rate for ramie composites in different orientations. The figure shows that for [0º/90º/0º/90º] orientation, the greater specific rate of wear is 7.03704E-08 m3/m N, while the lesser specific wear rate is 4.25926E-08 m3/m N.

CONCLUSION VI

The current work achieved four distinct orientations in accordance with ASTM testing criteria. The preliminary investigation's findings about the direction of fibers in the ramie fiber reinforcement epoxy composites fact to the following conclusion: it has been absorbed that the wear rate is less 0.000000191571m3/m in case of [45º/-45º/45º/-45º] at 20N load and specific wear is less 0.0000000111111m3/mN in the case of [45º/- 45º/45º/-45º] at 20N load.

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