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EXPERIMENTAL ANALYSIS ON THE WEAR BEHAVIOR OF NATURAL FIBER REINFORCED POLYMER COMPOSITES

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ABSTRACT

Natural fiber reinforced composites are widely used in many applications such as automobile, construction because they are recyclable, renewable, cost effective and it offers high strength and weight ratio compared to a composite made by synthetic fibre reinforced composites. Also the availability of natural fiber is enormous compared to synthetic fiber. The latest thermo plastic developments have resulted in higher material properties. In this experimental work experiment was conducted using a polymer composite reinforced with kenaf fiber with different process parameters. The specimen was prepared separately using a thermoplastic polymer and suitable hardener, accelerator and catalyst for the improvement of the process. The equipment used for the experimental work is pin on disc. Further the specimen was subjected to experiments on a pin on disc equipment to study the loss of weight with respect to the different parameters. the parameters varied here are load, time and the distance. The weight was measured before and after the experiment is conducted. The effects of the tribological operating parameters applied load, sliding velocity and sliding distance on the frictional and wear performance of natural fibre polymer composites are demonstrated.

Keywords: *Kenaf fiber, Natural fiber, Adhesive, Friction and Wear.*

1. Introduction

Natural fiber-reinforced composites is growing rapidly due to their mechanical properties, low cost, processing advantages and low density. The availability of natural fibers such as Kenaf in Asia is more and also has some advantages over traditional reinforcement materials in terms of cost, density, renewability, recyclability, abrasiveness and biodegradability. The performance of the fiber reinforced composites mainly depends on the fiber matrix and the ability to transfer the load from the matrix to the fiber [1- 3].

Natural fibre usage in industry promotes a sustainable material development through utilization of renewable resources. Composite reinforcement with natural fibres becomes an interest to many researchers and designers because of the positive aspects of the product. Nowadays, all of these natural fibres are beginning to find their way into commercial applications such as in automotive industries, marine hardware and household applications. From the tribological point of view, few works have been pursued on kenaf , betel nut , carbon and E-glass fibres and promising results were reported on the use of kenaf as alternative. For instance, the presence of kenaf fibres has enhanced the wear performance of composites [4]. In addition, natural reinforcement composites have economical and environmental advantages [5].

Kenaf plant is a renewable plant that can reach 3-4 meters height within 4-5 months. It can be harvested 2-3 times per year. Kenaf plant has three layers; bast, core, and pith. Kenaf bast represents one third of the plant. Core and pith represent the rest. Kenaf bast fiber has better mechanical properties than the other parts of the plant. Natural fiber reinforced composite is an emerging area in polymer science. At present, natural fibers are used in combination with plastics. The purpose of reinforcement is to provide strength and rigidity, helping to sustain structural load. Position and orientation of the reinforcement is maintained by the matrix or binder (organic or inorganic). Using natural fibers with polymer based on renewable resources will allow many environmental issues to be solved [6-8].

Sisal fibre is a kind of plant fibre with cellulose structure. A piece of sisal fiber is not a single filament like carbon or glass fiber but a bundle of cellular aggregate consisting of more than 100 irregular hexagonal hollow ultimate cells. Aramid fibers are highly crystalline aromatic polyamide fibers. These are synthetic fiber that is man-made. They have one of the lowest density and the highest strength to weight ratio among the reinforcing fibers [9].

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The most famous trade name for aramid fiber is Kevlar. They have a high degree of toughness and damage tolerance which leads to impact/ballistic performance. Aramid fibers do not fail by brittle cracking like glass or carbon fibres, they fail by a series of small fiber failures. These many small failures absorb much energy and, therefore, result in very high toughness [10]. Aramid fiber have a great load carrying capacity. Delamination in aramid fiber is not very obvious i.e., visible [11]. Aramid fiber has the tendency to absorb water which leads to the decrease in it compressive strength [12]. Drying of fibre leads to its elongation and to some increase in the Young's modulus. The same is true for the effect of fibre irreversible strain. Creep leads to an increase of Young's modulus of aramid fiber [13].

They also have a negative coefficient of thermal expansion in the longitudinal direction. The main disadvantages of reinforced composites with aramid are their low compressive strengths and difficulty in cutting or machining. Aramid fibers reinforced composites are used in many marine and aerospace applications where lightweight, high tensile strength, and resistance to impact damage are important. Aramid fiber in the form of cloth is used in making bullet proof gear and other army equipment. Aramid fibers provide superior wear and lower friction coefficients. Aramid fiber have a great load carrying capacity. Delimitation is aramid fiber is not very obvious i.e., visible [14, 15]. The same author also have attempted to conduct experiment on carbon fibre reinforced polymer composites using various machining conditions with the help of different cutting tool materials [16, 17]

2. Experimental Procedure

The mechanical properties of natural fibres mainly depend on its cellulose contents. Hence, it can be said that natural fibres with higher cellulose content have higher values in tensile strength and Young's modulus. Table 1.illustrates some of the mechanical properties of natural fibres as compared to glass fibres. From the table, it Is noticed that the tensile strength of glass fibres is relatively higher than that of natural fibres. However, considering the specific modulus of natural fibres, it can be seen that natural fibres show values that are comparable to or better than those of glass fibres. These high specific properties are among the major advantages of using natural fibres as reinforcement in polymeric composites where in their desired properties in weight reduction is of particular interest.

Table 1. Properties of Fibre [18]

Type of fibre	Density (g/cm^3)	Elongation (%)	Tensile strength (MPa)	Young's modulus (GPa)	Specific gravity	Specific Modulus (GPa)
Sisal	1.3-1.6	1.9-15	400-700	8.5-40	1.3	6.5-30.8
Kenaf	0.6-1.5	1.6-4.3	223-1191	11-60	1.1-1.4	10-42.9
Banana	0.5-1.5	2.4-3.5	711-789	4.0-32.7	1.1-1.2	3.6-27.3
Jute	1.3-1.5	1.4-2.1	385-850	9-31	1.3-1.5	6.9-20.7

Fiber is dipped in distilled water for 24 hrs and then dried in direct sun light Fig. 1. In this work we have used natural fiber reinforced composites. The kenaf fibre reinforced polyester is thus used as composites. To fabricate the specimens to the ASTM standards using hand layup process for Kenaf Fibre reinforced Polymer, which is shown in Fig. 2

Fig. 1 Kenaf fibre

Fig. 2 Size of the different specimen used for experiment

The experimental evaluation of friction coefficient and wear rate using pin-on-disc is a common laboratory procedure. When considering materials for use in a sliding component, it is often desirable to subject them to tribo tests to determine their wear behavior under conditions similar to those they will encounter in service. The schematic diagram of the pin on disc apparatus is shown in Fig. 3. [19].

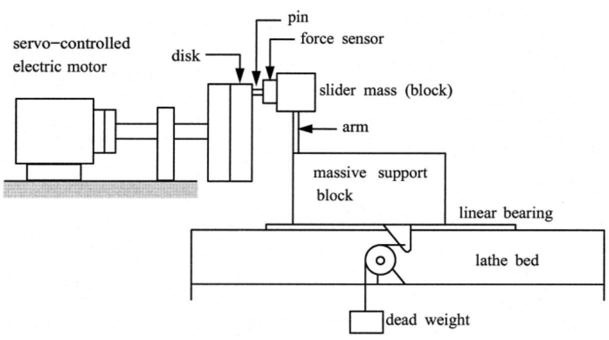

Fig. 3 Schematic representation of the Pin on Disc apparatus

3. Results and Discussion

To perform the pin-on disc experiment, samples had to be made in the form of a rod. The rod was fabricated to have a diameter of 0.8mm and length of 55mm. The fibers used were kenaf fibers. The polymer matrix used was general purpose polyester. The material was fabricated with the aid of a tube of the required diameter. First the polyester was mixed with 2% catalyst and 1.8% accelerator. Then the fiber was wet with the mixture of polymer. It was done in a ratio of 50% fiber and 50% polymer mixture. The fiber wet with the polymer mixture was then pulled into the tube. The composite then was allowed to set inside the tube for 4-5 hours. Once the composite has set, the tube was cut open and the piece was removed. Finally the composite piece was cut to the size required and the edges were flattened using a file.

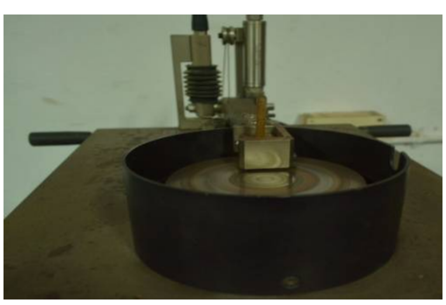

Fig.4. Wear and Friction test experimental set up with specimen

Abrasion Resistance Tester (TR 600) as shown in Fig.4 was used in this sliding wear test. Sample of fibre composite material was attached to rotational disc and in contact with rotating abrasive wheels made of vitrified bonded silicon carbide. Before each test, abrasive wheels were cleaned using a dry brush from any dust. Summary of the operational conditions was tabulated in Table 2. For each applied load, a new disc specimen was used. The amount of weight loss for each specimen was measured before and after a test at suitable intervals by weighing the disc specimen to an accuracy of +0.0001g using a precision balance.

Table.2 Experimental Condition

Specimen	Load (N)	Speed (rpm)	Time (min)	Weight (before experiment) (gm)	Weight (after experiment) (gm)	Weight loss (gm)
Kenaf	20	300	30	1.7421	1.7394	0.0027
	40	300	30	1.7456	1.7421	0.0035

Experimental results were plotted in figures Fig. 5 increasing the sliding velocity increases the frictional force. Increasing the sliding velocity increases the weight loss. In Fig. 6 Weight loss and specific wear rate (Ws) of the kenaf fibre reinforced composite against different sliding velocities. The difference in the weight loss is because of different rate of material removal process due to the difference in the size of the abrasive wear particles. In other words, the weight lose is influenced by the abrasive grade sizes which agrees with the results

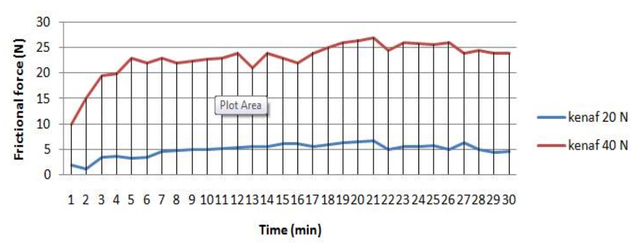

Fig. 5 Frictional Force vs Time for kenaf fibre

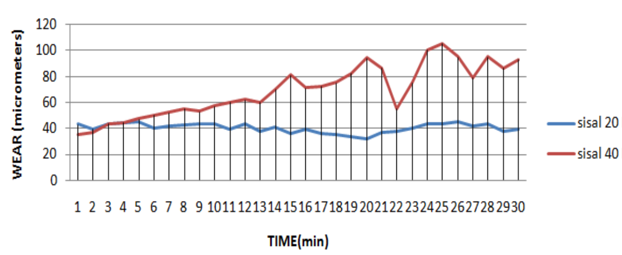

Fig.6 Wear vs Time for kenaf fibre

Fig.7 indicates that there is an improvement in friction and coefficient for the two orientations of Kenaf fibre polymer composite applied load of 20N subjected to different sliding velocities as compared to Kenaf fibre polymer composite applied load of 40N. The following wear resistance increasing the load and frictional force of the KPEC (40N) shown in Fig.8.

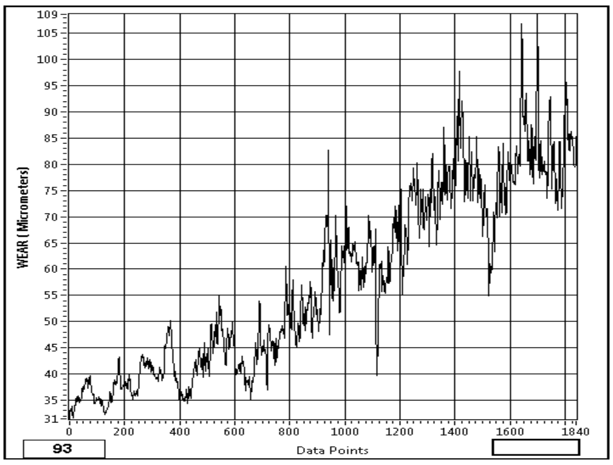

Fig.7 Wear vs Time of pin on disc for the load of 40N

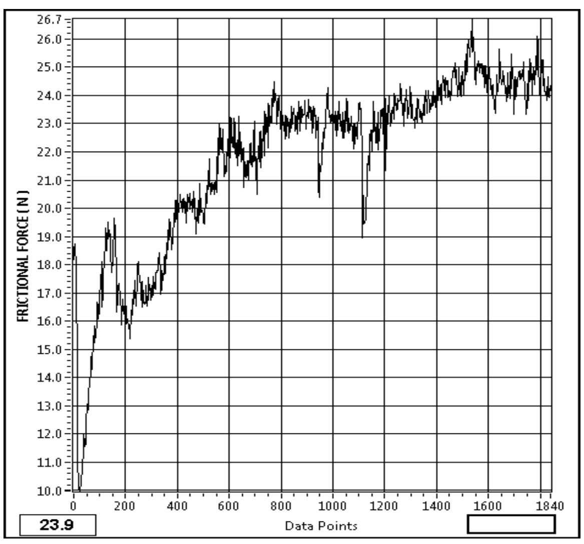

Fig. 8 Frictional Force Vs Time of pin on disc for the load of 40N

4. Conclusions

Experiment was carried out with Kenaf fiber reinforced polymer composite on Pin on disc equipment. The results obtained were analyzed leading to the following concluding remarks. The wear performance of kenaf fibre composite was found improved with the increase of load. The friction performance of kenaf composite was also found to be improved at the higher sliding velocity. Weight loss was more with the increase in the load and the sliding velocity.

References

1. *Jeyanthi S Janci Rani J (2012), "Improving Mechanical Properties by Kenaf Natural Long Fiber Reinforced Composite for Automotive Structures", Journal of Applied Science and Engineering, Vol.15, 275-280.*

2. *Yihui Pan Zheng Zhong (2014), "A non linear constitutive model of unidirectional natural fiber Reinforced composites considering moisture absorption", Journal of the Mechanics and Physics of Solids, Vol. 69, 132–142.*

3. *Alkbir M F M Sapuan S M Nuraini A A Ishak M R (2014), "Effect of geometry on crashworthiness parameters of natural kenaf fibre reinforced composite hexagonal tubes", Materials and Design, Vol. 60, 85-93.*

4. *Azwa Z Yousif N B F (2013), "Characteristics of kenaf fibre/epoxy composites subjected to thermal degradation", Polymer Degradation and Stability, Vol.98, 2752-2759.*

5. *Faseha Shukor Azman Hassan M D Saiful Islam Munirah Mokhtar Mahbub Hasan (2013), Materials and Design, S0 261-3069,00723-1.*

6. *El-Shekeil Y A Sapuan S M Jawaid M Al-Shuja O M (2014), "Influence of Fiber Content on Mechanical, Morphological and Thermal Properties of Kenaf Fibers Reinforced Poly(vinyl chloride)/Thermoplastic Polyurethane Poly-blend Composites", Materials and Design, S0 261-3069.*

7. *Nor Amalina Nordin Fauziah Md Yussof Salmiah Kasolang Zuraidah Salleh Mohamad Ali Ahmad (2013), "Wear Rate of Natural Fibre: Long Kenaf Composite", Procedia Engineering, Vol. 68 , 145 -151.*

8. *El-Tayeb N S M (2008), "A study on the potential of sugarcane fibers/polyester composite for tribological applications", wears, Vol. 265, 223-235.*

9. *Yousif B F Umar Nirmal K J Wong (2010), "Three-body abrasion on wear and frictional performance of treated betelnut fibre reinforced epoxy (T-BFRE) composite", Materials and Design, Vol. 31, 4514-4521.*

10. *Xu Xin Cheng Guang Xu Liu Fei Qing (2007), "Friction properties of sisal fibre reinforced resin brake composites", Wear, Vol. 262, 736-741.*

11. *Mallick P K (2008), "Fiber Reinforced composites", Third Edition.*

12. *Reis P N B Ferreira J A M Santos P Richardson M O W Santos J B (2012), "Impact response of Kevlar composites with filled epoxy matrix", Vol. 9, 3520-3528.*

13. *Sinan Fidan Tamer Sınmazcelik Egemen Avcu (2012), "Internal damage investigation of the impacted glass/glass+aramid fiber reinforced composites by micro-computerized tomography", NDT & E international, Vol. 51, 1-7.*

14. *Krystyna Imielinska Laurent Guillaumat (2004), "The effect of water immersion ageing on low-velocity impact behaviour of woven aramid–glass fibre/epoxy composites", Composites Science and Technology, Vol. 64, 2271-2278.*

15. *Rogozinsky A K and Bazhenov S L (1991), "Effect of creep on the Young's modulus of aramid fibres", Polymer, Vol. 33, 1391-1398.*

16. *Rajasekaran T Palanikumar K Vinayagam B K (2011), "Application of fuzzy logic for modeling surface roughness in turning CFRP composites using CBN tool", Prod. Eng. Des. Devel, Vol. 5, 91-199.*

17. *Rajasekaran T Palanikumar K Vinayagam B K (2011), "Experimental investication and analysis in turning of CFRP composites", Journal of Composite Materials, Vol. 46(7), 809-821.*

18. *UmarNirmal Jamil Hashim MegatAhmad M M H(2015), "A review on tribological performance of natural fibre Polymeric composites", Tribology International, Vol. 83, 77-104.*

19. *Woytek Tworzydlo W Osama N Hamzeh Wieslaw Zaton Tom J Judek (1999), "Friction-induced oscillations of a pin-on-disk slider analytical and experimental study", wears, Vol. 236, 9–23.*

