DEVELOPMENT of NATURAL FIBER in NONMETALLIC BRAKE FRICTION MATERIAL

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ABSTRACT

Brakes are most important safety devices in the machines. With the rapid development of automobile industry, the brake require environmentally friendly friction materials with higher and stable friction coefficient and low wear rate, vibration, noise, and cost. Friction lining is an essential part of braking system. Different types of friction materials are used in brake lining of different machines. The brake linings generally consist of asbestos fibers embedded in polymeric matrix along with several other ingredients. The use of asbestos fiber is being avoided due to its carcinogenic nature. A new asbestos free friction materials and brake pad for heavy machine, such as palm waste has been developed. The effects of palm kernel shell fiber, palm waste carbon flake as filler, and Alumina as an abrasive on brake friction materials were evaluated. Physical properties of this new material along with wear properties have been determined and reported in this paper. The experiment results indicated that fibers and filler enhances friction coefficient and improve wear performance. The role of abrasive in nonmetallic friction materials was studied in relation to formulation, friction performance and friction.

Keywords: Asbestos, brake pad, friction materials, palm waste

1. Introduction

The brake pads (friction materials) presently used are generally made from asbestos fibre. In spite of its good properties asbestos is being withdrawn from all those applications where there is a possibility of man consuming or inhaling its dust, because of its carcinogenic brake pad [1,2]. It is necessary to use alternate material for making non-carcinogenic brake pad. Friction materials have evolved from simple formulations containing eight ingredients to complex composites with as many as 20 components. Several formulations have been developed for higher performing products.

Table 1 shows the general classification of brake pads used in the brake industry. The demands on the brake pads are such that they must [3]:

(a) Maintain a sufficiently high friction coefficient with the brake disc;
(b) not decompose or break down in such a way that the friction coefficient with the brake disc is compromised, at high temperatures;
(c) Exhibit a stable and consistent friction coefficient with the brake disc.

Brake pads typically comprise the following sub-components [3]:

(a) Frictional additives, which determine the frictional properties of the brake pads and comprise a mixture of abrasives and lubricants;
(b) fillers, which reduce the cost and improve the manufacturability of brake pads;
(c) a binder, which holds components of a brake pad together;
(d) Reinforcing fibres, which provide mechanical strength.

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Table 1. Classification of brake pads [4]

Classification	Ingredients
Metallic	Predominantly metallic, such as steel fibres, copper fibres, etc.
Semi-metallic	Mixture of metallic and organic ingredients
Non-asbestos organic	Predominantly organic, such as mineral fibres, rubber, graphite, etc.

There are several patents for asbestos free organic friction materials. Some of these materials were starting to be used in rear drum brakes in 1984, changes in brake pad formulation were also driven by the promulgation of the corporate average fuel efficiency requirements in the late 1970's and mid 1980's. These requirements led the automobile industry to switch from rear wheel drive cars to front wheel drive cars. This switch required more front braking which resulted in higher temperatures and a preference for semi-metallic brakes [2-5].

A several research has been carried out in the area of development of asbestos-free brake pads. The use of coconut shell, palm kernel shell etc. has been investigated [1, 2]. Researches all over the world are focusing on ways of utilizing either industrial or agricultural wastes as a source of raw materials in the industry. These wastes utilization will not only be economically, but may also result to foreign exchange earnings and environmental control.

Hence, the aims of this work are to develop a new asbestos free brake pad using palm waste. Palm waste is readily available and is not toxic. In this study, a new type of asbestos-free composite and its brake pad has been made and characterized for the use in motorcycle. Several samples having asbestos-free compositions were prepared and their physical and wear properties were evaluated. Apart from these properties sliding wear and abrasive wear properties were evaluated and studied.

2. Experimental

2.1 Raw materials

The content of the alumina particles, flake graphite, palm kernel shell, and phenolic resin bonding agent used as raw materials for brake friction materials are show in Table 2. Alumina as particles with the average size of 100 mesh was used as an abrasive, flake carbon (from palm waste) as a lubricant and filler, palm kernel shell as a fiber, and phenolic resin as a binder.

Table 2 Raw Materials Composition (%V)

Oxide	Carbon Flake	Fiber	Binder
50	15	5	30
45	15	10	30
40	15	15	30
35	15	20	30
30	15	25	30

(a)

(b)

Figure 1. Photo of Palm Waste (a) & (b)

2.2 Method of production

The palm waste was natural dried for about one week after extracting the oil. The dried palm waste was chopped into fiber using a cutting machine and then sieved into different sieve sizes of aperture 3-5 mm. The other of palm waste (shell) was carbonization into active carbon using a heat treatment process and then sieved into different sieve sizes of aperture 30-50 µm. A particle size of flake graphite from palm waste as filler and palm kernel shell as fiber was collected and is shown in Figure 2-3.

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Figure 2. Photo of flake active carbon (filler) from Palm Waste

Figure 3. Photo of Palm Kernel Shell Fibers

Brake friction materials measuring 30 mm diameter by 50 mm high were produced by mixing the different composition of raw materials, pressing with compression hot plate press at temperature 140^oC at 1000 kgf/cm^2 pressure at 10 minutes, and then curing for 8 hours at 120^oC [5]. The photos of the produced samples are shown in Figure 4.

Figure 4. The photo of the produced samples

2.3 Method of characterization

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The Brinell hardness values of the samples were obtained using a digital hardness tester at room temperature. The sample of diameter 30 mm was used to carry out the test as different composition. The test was conducted using steel ball indentor with a load of 3000 kg. The compressive strength test was done using the universal tensile test machine. The samples of diameter 30 mm was subjected to compressive force, loaded continuously until failure occurred. The load at which failure occurred was then recorded.

Flake carbon from palm kernel shell were analyzed by X-ray powder diffraction (XRD). The Apparent porosity of a specimens measuring diameter 30 mm by 50 mm high was estimated by the Archimedes method using kerosene. Subsequently their specific gravities were determined by dividing the unit weight of the sample by the unit volume. The wear rate for the sample was measured using pin on disc machine by sliding it over a cast iron surface at a load of 20N, sliding speed of 5.02 m/s and sliding distance of 5000 m. After running through a fixed sliding distance, the samples were removed, cleaned with acetone, dried, and weighed to determine the weight loss due to wear. The differences in weight measured before and after tests give the wear of the samples. The formula used to convert the weight loss into wear rate is [6, 7]:

Wear rate= Wear rate = $\Delta W/S$…………….(1)

Where ΔW is the weight difference of the sample before and after the test in mg, S is total sliding distance in m.

The microstructure analysis of the samples was carried out by grinding the samples using 400, 600, and 1000 grit papers respectively. Dry polishing was then carried out on these samples and the internal structures were observed under the optical microscope.

3. Results and discussion

The degree of crystallinity of the flake carbon from palm waste is determined through the characterization of X-Ray Diffractometer (XRD). X-RD spectrum of the test results shown in Fig. 4. the tendency of increasing degrees of crystallinity of the flake carbon.

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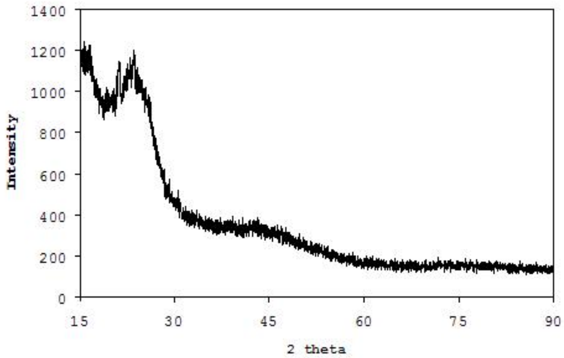

Figure 4. Result of X-RD spectrum of palm waste carbon flake.

Figures 5-8 has show the microstructure of the samples.

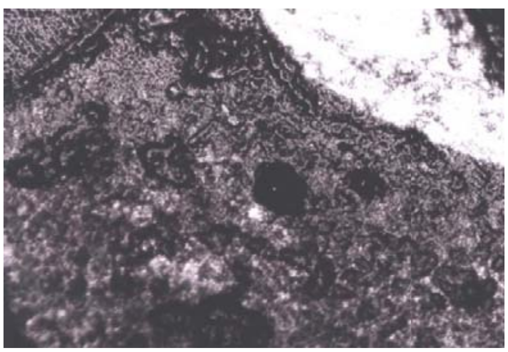

Figure 5. Microstructure of sample(X150). Showing Uniform gray region of matrix and white region of palm kernel shell fibers.

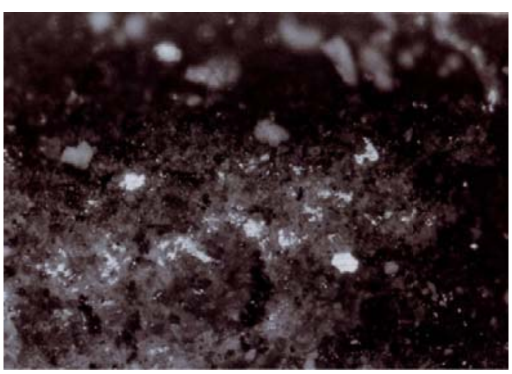

Figure 6. Microstructure of sample(X150). Showing slight uniform dark region of matrix and white spot region of alumina.

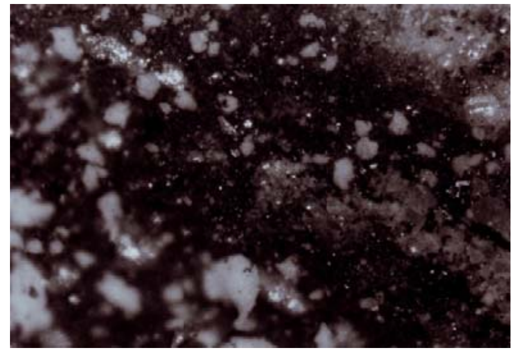

Figure 7. Microstructure of sample(X150). Showing white spot region of oxide in matrix.

Figure 8. Microstructure of sample(X150). Showing interface between matrix and fiber.

From the microstructure there is more uniform distribution of the resin with oxide, the palm kernel shell and flake carbon. This is as a result of proper bonding between the fiber and the resin and also closer inter-packing distance. This can be appreciable if one compares Figure 5 with Figure 8. The results of the hardness values are shown in Figure 9. From the figure it can be seen that as the %v fiber composition decreases and the hardness values of the samples increases.

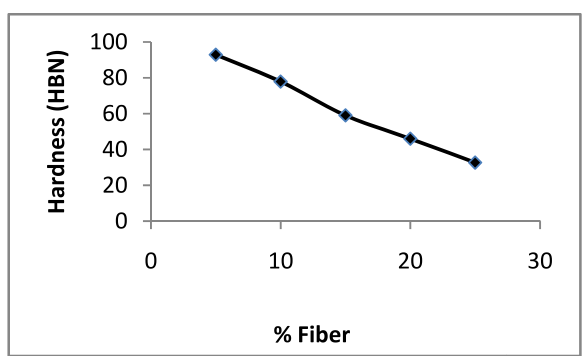

Figure 9. Variation of Hardness values with % Fiber

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The sample with 5% fiber and 50% alumina has the highest hardness value of 92.9 HBN. The high hardness for the 5% fiber and 50% alumina was as a result of reduced composition of fiber in surface area which resulted to increase bonding ability alumina with the resin. The hardness value for this material was compared with other materials from other researches as shown in the Table 2 which indicated an acceptable result with the findings of other researchers. Figure 10 shown the compressive strengths of the produced samples. From the results similar trend with that of hardness values was observed that is compressive strength increases with decreased in alumina volume fraction of the samples.

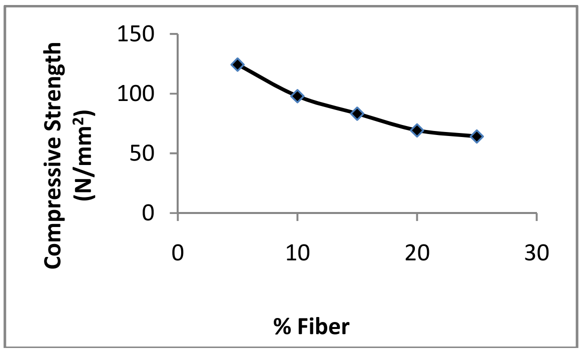

Figure 10. Variation of Compressive strength with % Fiber

The compressive strength results are shown in Fig. 10. The minimum strength in the 25% fiber and 30% alumina specimens. The 5% fiber and 50% alumina grade also has the highest compressive strength of 124.31 N/mm^2. The gradual decrease in compressive strength as the fiber volume fraction increases can be attributed to the decreasing surface area and pore packaging capability of the palm kernel shell fiber in the resin. Hence, compressive strength increases as volume fraction fiber of palm kernel shell decreases.

Results of the density measurements are shown in Fig.11. The density deceased as the %V fiber increasing in the specimens. The 5% fiber in specimens has the highest density which is as a result of closer packing of palm kernel shell particles creating more homogeneity in the entire phase of the composite body [5].

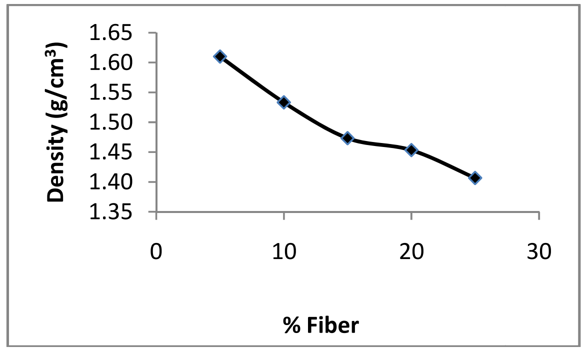

Figure 11. Variation of Density with % Fiber

Figure 12 shown the wear rate of the produced samples. The figure shows decrease in wear rate as the % palm kernel shell fiber increases. The resulted to higher/closer packing which has affected stronger binding of palm kernel shell with resin. This may also be due to high hardness values and compressive strength of the samples as %V palm kernel shell fiber is decreased.

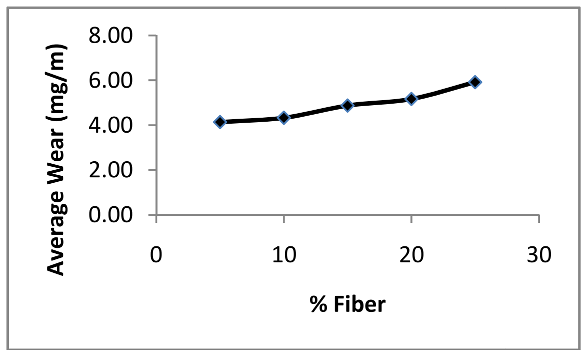

Figure 12. Variation of Wear rate with % Fiber

It can be seen from the result that sample with 50% alumina and 5% palm kernel shell fiber gave the best properties as a result of a very good dispersion of alumina, palm kernel shell and flake carbon particles as shown by the white region and dark region matrix (see Figure 7) which led to a better interfacial bonding of the binder and the palm kernel shell, flake carbon and alumina particles as seen in subsequent samples probably must have resulted to poor distribution of binder used, as denoted by the dark portions on the Figure 5-8 respectively.

Table 3. Summary of result findings compared with existing ones

Property	Asbestos [1, 2]	PKS Based* [1, 2]	New Formula
Specific Gravity	1.89	1.65	1.61
Flame resistance after 10 min.	Charred with 9% ash	Charred with 46% ash	-
Compressive strength (MPa)	110	103.50	124.31
Hardness, Brinell (at 3000 kgf)	101	92	92.9
Average wear (mg/m)	3.80	4.40	4.14

*Notes : *Optimum formulation Laboratory brake pad*
**PKS is palm kernel shell*

The result of this work indicates that sample containing (50% alumina, 5% palm kernel shell-15% palm waste flake carbon-30% binder) gave better properties than other samples tested. Hence, the lower the % palm kernel shell fiber, the better the properties. The 5% palm kernel shell fiber– 15% palm waste carbon flake results were compared with that of commercial brake pad (asbestos based) and optimum formulation laboratory brake pad (Palm Kernel Shell based without flake carbon as shown in the Table 3[1, 2]. which was tested under similar conditions.

The results are in this research. Hence asbestos free brake pad can be produced with 5% palm kernel shell fiber and 15% flake carbon from palm waste formulation. Taking into consideration, all the desired dimensions of the brake pad, a prototype of motorcycle brake pad was produced with this 5% palm kernel shell fiber and 15% flake carbon from palm waste and formulation (see Figure 15).

Figure 15. Produced palm waste brake pads

4. Conclusions

From the results and discussion in this work the following conclusions can be made:

1. The samples with 5% palm kernel shell fiber and 15% palm waste carbon flake gave the better properties in all.
2. Compressive strength, hardness and densities of the produced samples were seen to be decreasing with increase in %V palm kernel shell fiber
3. The result of this research indicates that palm kernel shell and generally palm waste can be effectively used as a replacement for asbestos in brake pad manufacture by using the 15% of flake carbon from palm waste with a composition – 5% palm kernel shell fiber and 50% of alumina.

Acknowledgements

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