

Development of Asbestos Free-Brake Pad Using Solid Waste

By

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ABSTRACT

The Development of asbestos free break-pad using solid waste is to replace asbestos due to its carcinogenic nature. Watermelon peels was used in this work together with pure water sachet which serves as the binder. The brake pad formulation was produced by varying the resin from 5-30wt%. The properties tested were; wear, thickness swelling in water and SEA oil, flame resistance, specific gravity, compressive strength, and hardness values. The results showed that proper bonding was achieved with the formulations using watermelon peels at 25wt% resin. The result obtained shows that 25wt% resin formulation compared favourably with the commercial brake pad. Hence, this grade can be used in production of asbestos free brake pad.

Key words: watermelon peels; brake pad; specific gravity; compressive strength; wear properties.

INTRODUCTION

Brake pads are important parts of braking system for all types of vehicle that are equipped with disc brake. Brake pads are steel backing plates with friction material bound to the surface facing the brake disc. Different types of brake materials are used in different machines.

The brake pads generally consist of asbestos fibres embedded in polymeric matrix along with several other ingredients. The use of asbestos fibre has faced criticism because of its carcinogenic nature. Hence the need to develop asbestos free friction material and brake pads. It is envisaged that future development in the trend of brake friction material will closely mimic the current trends in the automotive industry, where a shift towards environmentally friendly cars has already seen the release of hybrid cars such as

Toyota prius, Honda Insight and Ford Escaped SUV (Dagwa and Ibadole, 2006).

A lot of research has been carried out in the areas of developing asbestos free brake pads. The use of coconut shell and palm kernel shell (Dagwa and Ibadole, 2006), has been researched on. Researches all over the world today 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 economical but may also provide foreign exchange earnings and above all reduce environmental pollution. It is in view of this that the idea of using water melon peels was conceived.

In this project, a review of the materials and constituents currently used in automotive brake friction material after the phasing-out of asbestos is presented as asbestos has faced widespread criticism as being carcinogenic.

Although the introduction of the asbestos ban in some countries only came about in 1989. All forms of asbestos are carcinogenic. This ban was overruled in 1991 due to widespread complaints of the difficulty of finding replacement for the asbestos. However, existing use of asbestos is still permitted but new applications and uses have been banned (Blau, 2001). Therefore, this research is aimed at producing an asbestos free brake-pad composites using characterized water melon peels and used water sachet as the resin.

MATERIALS AND METHODS

Materials

The following materials were used for the study used package water sachet, water melon peels, Engine oil (SEA 20/50), Hydraulic press, Brake pad mould, Heater, Cups, Vernier caliper, Grinder, Digital weighing balance, Sieve, Honsfield Tensometer, Hardness tester.



Plate 1.0 photograph of water melon peels



Plate 1.1 photograph of used package water sachet

METHODS

Characterisation of water melon peels.

The water melon peels were collected, dried and grinded to powder. The sieve analysis of the water melon peels particles was carried out in accordance with BSI377:1990. About 100g mass of the particles was place unto a set of sieves arranged in descending order of fineness and shaken for 15minute which is the recommended time to achieve complete classification, the particles that was retained in the BS. 100µm was used.



Plate 1.2 photograph of water melon peel powder

SAMPLE PREPARATION

Metal Moulds were used in the production of the composites samples. Each mould had a cavity to accommodate the pad composites samples. The dimensions of cavities were made according to the size and shape of the samples. Agro-waste particles and the waste pure water sachet (binder) were mixed by compounding it into a homogenous mixture. It formed non-uniform plates which were cut into bits then compacted using metal moulds at a temperature of about 150°C and a pressure of about 10mpa to form the plates which was cut into different sizes for the various tests to be carried out. The resin (binder) was varied from 20 to 30wt% with 5wt% interval.

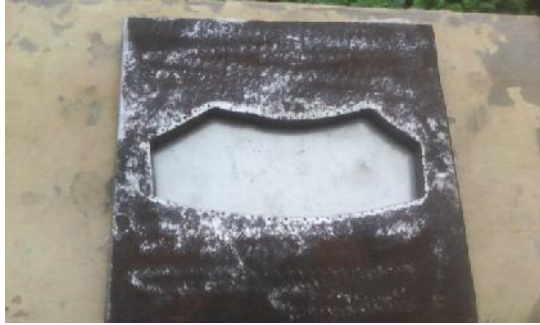


Plate 1.3 photograph of mould for the production

After the sample was prepared some mechanical and physical properties were carried out on the sample to ascertain its reliability.

Mechanical Properties

The mechanical properties carried out on the sample were the hardness and the compressive strength tests.

HARDNESS TEST

The Brinell hardness values were obtained using a digital hardness tester. The material diameter 22.7mm was used to carry out the test. The hardness values were determined according to the provisions in American Society of testing and materials (ASTM E18-79) using the Brinell hardness tester on "B" scale (Frank Welltest Brinell Hardness Tester, model 38506) with 1.56mm steel ball indenter, minor load of 10kg, major load of 100kg and hardness value of 101.2HRB as the standard block. The samples were placed on the anvil which acted as a support for the test samples. A minor load of 10kg was applied to the sample in a controlled manner without inducing the impact or vibration until zero datum position was established. A major load of 100kg was then applied; the reading was taken when the large pointer came to rest or had slowed appreciably and dwelled for up to 2 seconds. The load was then removed by returning the crank handle

to the latched position and the hardness value read directly from the semi-automatic digital scale.

COMPREHENSIVE STRENGTH TEST

The comprehensive strength was done using the Honsfield Tensometer. The material of diameter 22.7mm was subjected to compressive force loaded continuously until failure occurred. The load at which failure occurred was then recorded.

PHYSICAL PROPERTIES

The following tests were carried out on the sample to determine the physical properties of the sample.

FLAME RESISTANCE TEST

To test for the flame resistance of the brake pad material, the specimens was placed on wire gauze positioned directly on the blue flame of a Bunsen burner. The specimens weight before and after burning was taken after 10 minutes on the flame.

WATER AND OIL SOAK TEST

The 24-hour water and oil test determine the water and oil absorption behavior of the asbestos-free experimental brake pad and the effect of the absorbed water and oil on its dimensions. After oven drying of the specimens ($0 - 250^{\circ}\text{C}$), its weight was measured. Subsequently, the thickness of the specimens was measured using a Vernier caliper. After twenty-four hours of submersion in water and engine oil, SEA 20/50 at 26°C to 30°C , the specimens were weighed after the excess water and oil had drained off. The following formula was used:
 Water absorption (%) = $(W_w - W_i) * 100 / W_i$
 Where W_w = Wet Weight

W_i = Initial Weight of oven dry specimen

SPECIFIC GRAVITY

The true density of the brake pad materials was determined by weighing the samples on a digital weighing machine and measured their volume by liquid displacement method. Subsequently, their specific gravities were determined by dividing the unit weight of brake pad material by the unit weight of water.

WEAR TEST

The wear rate for the sample was measured using pin on disc machine by sliding it over cast iron surface at a load of 20N, sliding speed of 5.02m/s and sliding distance of 500m. All tests were conducted at room temperature. The initial weight of the samples was measured using a single pan electronic weighing machine with an accuracy of 0.01g. A friction detecting arm connected to a strain gauge held and loaded the pin samples vertically into the rotating hardened cast iron disc. 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 sample.

The formula used to convert the weight loss into wear rate is:

$$\text{Wear rate} = \frac{\Delta W}{S} \dots\dots\dots 1$$

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

RESULTS

The results obtained from the various tests carried out on the samples are presented in the tables 1 and 2

Table 1: The results of Specific gravity, Wear, Thickness swelling in water and oil

Sample Wt%	Specific gravity(g/c m ³)	Average Wear(mg/m)	Swelling in Water (%)	Thickness Swelling in SEA oil (%)
5	1.0	6.20	5.67	2.15
10	1.12	5.80	5.50	2.00
15	1.22	5.53	4.78	1.89
20	1.25	4.85	4.05	1.41
25	1.28	4.20	3.25	1.18
30	1.28	4.15	3.20	1.14

Table 2: The results of Hardness, compressive strength and flame resistance tests

Sample wt%	Hardness Values	Compressive strength (N/mm ²)	Flame Resistance e (%)
5	78.9	87.9	40.23
10	85.0	89.0	40.12
15	98.5	90.7	35.21
20	98.5	90.7	30.56
25	99.8	95.6	29.80
30	98.9	98.5	26.67



Plate 3.5: 25 wt% Resin Water Melon Peels Brake Pad produced

DISCUSSION

Specific Gravity

As shown in table 1 the specific gravity increases as the wt% resin of the watermelon

peels particles. The increased in specific gravity can be attributed to the increase achieved in bonding that is, increased packing of watermelon peels. The levels of specific gravity obtained are within the recommended values for brake pad application (Yesnik, 1996) and (Kim et al, 2003)

Thickness Swelling in Water and SEA Oil

These properties decrease as the wt% resin increases as shown in table 1, this can be attributed to decreases pores because of the close interface packing achieved. More so, increased in the interfacial bonding between the resin and the watermelon peels could lead to decreased in the two properties, hence the solubility values of the brake pad composites. The results obtained for the formulation brake pad composites are within the recommended standard. These results are in agreement with the observations made by (Yesnik, 1996) and (Mathur et al, 2004).

Flame Resistance

From the results it was observed that the flame resistance decreases as the weight percentage of the resin increases as shown in table 2 above. This may be attributed to the proper bonding of the brake pad formulation which makes it difficult to burn-off easily.

Hardness values and Compressive strength

From the result obtained it can be seen that as the weight percentage of resin increases the hardness values of the samples increases as shown in table 2, this is in line with the work of (Dagwa and Ibadode, 2006).

Similarly, the compressive strengths of the samples show similar trend with the result of the hardness that is compressive

strength increases with increased in the wt% of resin. This can be attributed to good distribution and dispersion of the watermelon peels particles and resin resulting in strong-particles-resin interaction. This good particle dispersion will improve the particles-resin interaction and consequently increases the ability of the brake pad formulation to restrain gross deformation.

Wear Properties

From table 1 there is a decrease in wear rate as the weight fraction of resin increases in the watermelon peels particles. This may be attributed to closer packing of the microstructure which has affected stronger binding of watermelon peels with resin. It may also be due to higher hardness values and compressive strength of the samples as the resin addition increased in the water melon peels particles.

This observation is on par with the one observed by Aigbodion et al (2010). It is well known that wear process involves fracture, tribo-chemical effects and plastic flow. Transitions between regions dominated by each of these commonly give rise to changes in wear rate with load.

The wear resistance of the brake pad formulation is improved by preventing direct contacts that induce subsurface deformation. The addition of hard watermelon peels particles improves the resistance to seizure. The presence of the watermelon peels particles provides a higher thermal stability, increased abrasion and delays the transition from mild to severe wear (Gudmand-Hoyer, 1999).

Result of this work indicates that sample containing 25wt% in watermelon peels composites gave better properties than other samples tested. Hence, the increase in

wt% watermelon peels particles, the better the properties.

Figure 3.5 shows the brake pad from water melon peels and package water sachet as a binder.

CONCLUSIONS

From the results obtained the following conclusions can be drawn:

1. Proper bonding was achieved with watermelon peels particles at 25wt% resin addition.
2. Compressive strength, hardness and specific gravity of the produced samples were seen to be increasing with increase in wt% resin addition, while the oil soak, water soak, wear rate decrease as wt% resin increases.
3. The sample containing 25wt% in watermelon peels composites gave better properties compared to others.
4. The result of this research indicates that watermelon peels particles can be effectively used as a replacement for asbestos in brake pad manufacture.

REFERENCES

- Aigbodion V. U. Akadike, S. B. Hassan, F. Asume, and J. O. Agunsoye (2010), Development of Asbestos -Free Brake Pad Using Bagasse, *Tribology in industry*, 32(1)
- Abigbodion V. S. and J. O Agunsoye (2010): Bagasse (Sugarcane waste): Non-Asbestos Free Brake Pad *Materials*. LAP Lamhert Academic Publishing Germany, ISBN 978- 3-8433-8194-9.
- Blau, P. J. (2001). Compositions, Functions and Testing of Friction Brake Materials and their Additives. Being a report by Oak Ridge National Laboratory for U.S Dept. of Energy. www.Orni.gov/-webworks/eppr/y/2001/rpt/112956.pdf
- Dagwa, I. M., and Ibadode, A. O. A. (2006) Determination of Optimum Manufacturing Conditions for Asbestos-free Brake Pad using Taguchi Method, *Nigerian Journal of Engineering Research and Development*, Basade Publishing Press Ondo, Nigeria Vol. 5, No. 4, Pp 1-8.
- Guadmand-Hoyer, L., Bach, A., Nielsen, G. T. and Morgen, P. Tribological properties of automotive disc brakes with solid lubricants. *Wear*, 1999, 232, Pp 168—175.
- Kim S.J. Kim, K₁, and Jang, H. (2003). Optimization of Manufacturing Parameters for Brake Lining Using Taguchi Method. *Journal of Material Processing Technology*. 136. Pp 2 02-208.
- Mathur, R. B. Thiyagarajan, P. and Dhama, T. L. (2004). Controlling the hardness and Tribological Behaviour of Non-Asbestos BrakeLining Materials for Automobiles. *Journal of Carbon Science*, 5(1). Pp 6-11.
- Yesnik, M. A. (1996). Friction material comprising powdered phenolicresin and method of making same. US Pat. 5529666, 1996 (United States Patent and Trademark office