iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** V **Month of publication:** May 2023

DOI: https://doi.org/10.22214/ijraset.2023.51673

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue V May 2023- Available at www.ijraset.com

Experimental Investigation on the Frictional Behaviour of Banana Peels Composites for Brake Pad Applications

P Sai Pranay[1], S Dhanush[2], P Charan Teja[3], D S Kumar[4]
[1, 2, 3]B.Tech Students, Department of Mechanical Engineering, MVGR College of Engineering, Vizianagaram, Andhra Pradesh, India, 535005
[4]Assistant Professor, Department of Mechanical Engineering, MVGR College of Engineering, Vizianagaram, Andhra Pradesh, India, 535005

Abstract: Asbestos is used in the manufacture of automobile brake linings, which has negative effects on both people and the environment. As a result, organic brake lining without the use of asbestos material evolved. Asbestos-free brake lining materials come in a variety of forms, and these novel formulations offer excellent performance too. The material used to replace it ought to maintain qualities of standard brake pad risks. A new brake pad was produced using banana peels waste to replace asbestos. The produced composites were mixed with carbon powders, epoxy and hardener in predetermined ratios. The current study is being conducted to create three different samples of brake pads by altering the combination of carbon powder and banana peel powder. The banana peel was varied from 35 to 25 wt. % with a 5 wt. % interval to create test samples. Morphology, physical, mechanical and wear properties of the brake pad were studied. The results showed that the produced banana peel composite of composition carbon 35% and banana peel powder 25% gives better properties compared with other compositions. According to the findings of this study, banana peel particles may be utilized efficiently as a replacement for asbestos in the fabrication of brake pads.
Keywords: Banana Peel, Carbon Powder, Epoxy Binder and Frictional coefficient.

I. INTRODUCTION

Brake pads are important parts of braking system for all types of vehicles that are equipped with disc brake. Brake pads are steel backing plates with friction material bound to the surface facing the brake disc. The brake pads generally consist of asbestos fibres embedded in polymeric matrix along with several other ingredients (U.D. Idris, V.S. Aigbodion, 2013). Asbestos is carcinogenic in all forms. The use of asbestos fibre has been avoided due to its carcinogenic nature. Much research had gone into finding a non-asbestos alternative for manufacturing brake pads. A new asbestos free friction material and brake pads have been developed. However, due to the inability to find a replacement for asbestos brake pads in 1991, the existing law was overturned (Melkamu Yigren, O. Fatoba, 2022). Asbestos brake pads are still permitted for existing use, but new applications of this type of brake pad are prohibited.

Asbestos, ceramic, semi-metallic, organic, and other materials are all utilized in the production of brake pads. Due to its capacity to dissipate heat, asbestos was once a widely used material. Finding a substitute material with the same mechanical qualities represents the biggest difficulty for researchers. The first generation of composite materials mainly relied on composites with asbestos reinforcement, therefore for many years, the dangers of asbestos brake pads to human health and the environment have been of great concern (Melkamu Yigren, O. Fatoba, 2022).

The replacement of asbestos brake pads is with Natural fibres. Natural brake pads are made from organic and natural materials such as fibres, resins, and minerals.

Compared to conventional brake pad materials like asbestos and heavy metals, which can be dangerous to human health and the environment, these substances are often less damaging to the environment. Natural brake pads have several advantages over traditional brake pads. For example, they tend to produce less dust and reduce wear on the rotors and other parts of the brake system. They also tend to be quieter and provide better stopping power than traditional brake pads.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue V May 2023- Available at www.ijraset.com

This project aims to develop composite materials with base banana peel combined with carbon powder and other reinforcements (O. Fatoba, Sheferaw Tensay, 2022). Banana peel brake pad material is an innovative and environmentally friendly material that has been developed as an alternative to traditional brake pad materials. The material is made by converting banana peels, which are usually discarded as waste, into a usable material. The process of making the banana peel brake pad material involves drying and grinding the banana peels into a fine powder, which is then mixed with other natural fibres and resins to create a composite material that is strong, durable, and effective for use as a brake pad. One of the advantages of using banana peel brake pad material is that it is a sustainable and eco-friendly alternative to traditional brake pad materials such as asbestos and heavy metals, which can be harmful to the environment and human health. Additionally, the material is lightweight, which can help to improve fuel efficiency and reduce the wear and tear on other parts of the vehicle. Overall, banana peel brake pad material is a promising new innovation in the field of sustainable materials, and has the potential to significantly reduce the environmental impact of transportation while still maintaining high levels of safety and reliability.

II. EXPERIMENTAL PROCEDURE

A. Materials/Equipment

The materials and equipment used during the course of this work are: Epoxy resin with hardener, Banana peel powder, Calcium Carbide, Aluminium Oxide, Brass chips, Glass Fibre and Carbon Black Powder, Hardness tester, Water, Digital Weighing Machine, Sieving machine, Hydraulic press, Brake pad mould.

B. Method

The Banana peel (waste) was dried under the sunlight for 3-4 weeks to lose all its water content. The colour of the waste material should change to black due to direct sunlight as shown in Fig.1. Ball milling is necessary to mix the fine banana peel powder with the carbon powder in order to attain a homogeneous mixture. The ball milling speed was set to 250 rpm (O. Fatoba, Sheferaw Tensay, 2022).

Figure 1: Banana Peel

The wastes were subjected to ball milling in order to reduce the banana peel waste to a fine powder form as seen in Fig2. According to BS1377:1990, the measurement of banana peel particle size was done. Particles with a size of less than 100 µm were employed for this study, therefore they were loaded onto a set of sieves that were organized in descending order of fitness and shook for 15 minutes. The variation of different compositions produced can be seen in Table 1. However, in the past, some of the researchers used a Hardener/resin ratio of 1:10 or 1:11 in the literature. The weight percentages of carbon black and banana peel powder are varied to create the brake pad material using the compression moulding technique. For 15-20 minutes, the additional items listed in 2.1 are mixed. After cleaning the mould with a dry cloth, the surface of the Mould was rubbed with release agent. The use of a releasing agent is required to avoid sticking. Silicone Spray was used as a releasing agent for this experimental work as seen in figure3.

Figure 2: Banana Peel Powder

Figure 3: Silicone Spray

By using hydraulic press, a punch with a compressive force of between 30 and 40 KN was performed for 24 hours to prepare the samples as shown in figure 4 (U.D. Idris, V.S. Aigbodion, 2013). Three different samples of brake pads by altering the combination of carbon powder and banana peel powder were prepared. Also, the produced composite samples were heated for one hour at a temperature of 100 degrees Celsius in an electric oven (O. Fatoba, Sheferaw Tensay, 2022).

Wear testing is essential for the samples produced in order to show the applicability of the materials produced. Under ambient conditions, a wear test machine was used to measure wear resistance in accordance with the ASTM G99-17 standard of disc hardness value 62 HRC, 80mm track diameter and 8mm dia (Melkamu Yigrem, O. Fatoba, 2022). The pin-on-disk test is a tribological test used to assess the friction and wear properties of materials. It is a simple and widely used test method in which a pin is slide against a rotating disc while friction and wear are measured as shown in figure5. The samples (pin) initial weight was determined using a single pan electronic weighing machine with an accuracy of 0.0001 g. At a load of 20 N, a sliding speed of 5.02 m/s, and a sliding distance of 5000 m, the pin was pressed against a rotating disc with a counter surface roughness of 0.3µm (Dagwa and Ibhadode, 2005). A strain gauge-connected friction detecting arm held and loaded the Pin samples vertically into the rotating hardened cast iron disc. The samples were removed after running through a fixed sliding distance and weighed to determine the weight loss due to wear. The weight differences measured before and after tests which indicate the wear of the samples. The formula used to convert the weight loss into wear rate is (Aigbodion and Akadike, 2010):

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

S. No	Epoxy	Carbon Powder	Brass	Banana powder	$CaCO_3$	Al_2O_3	Glass Fibre
Sample 1	20%	25%	2%	35%	10%	6%	2%
Sample 2	20%	30%	2%	30%	10%	6%	2%
Sample 3	20%	35%	2%	25%	10%	6%	2%

Table 1: Banana Peel Composites Composition

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

Figure 4: Test Samples Figure 5: Wear Test Equipment

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue V May 2023- Available at www.ijraset.com

Water Absorption test is carried out for all the three samples in order to determine the absorption behaviour of the asbestos free brake pad (M. Amutha Surabhi, P. Baskara Sethupathi, 2021). The samples were weighted in the air followed by dipping in water for 24hrs as seen in Figure 6. The absorption percentage is tabulated for every two days as seen in table 2. The specimens were weighed after the excess water had drained off. Eq. (1) was used in calculation of the percentage of water absorption (Dagwa and Ibhadode, 2006):

$$\text{Absorption} = \frac{W1-W0}{W0}\times 100 \qquad \text{Eq. (1)}$$

W1 = is the final weight of sample after absorbing the water.
W0 = is the initial weight of sample before absorbing the water.

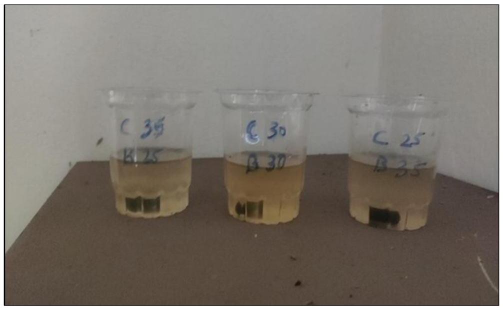


Figure 6: Water Test Samples

The Vickers hardness values were obtained using digital hardness tester as shown in figure 7. VH-1000 model is adapted to test metal structure of the samples. Hardness test is carried out according to ASTM (American Society for Testing and Materials) standards. The test is performed in two steps. First, the diamond indenter is driven into the surface of the tested material by applying a known load. Second, the user measures the diagonal(s) length of the resulting indentation and input the measured length of diagonal(s) to the integrated calculator, by which hardness value is obtained.


Figure 7: Vickers Hardness Test Equipment

III. RESULT & ANALYSIS

A. *Wear Test*

The wear test is carried out on a pin-on-disc machine by using fabricated brake pad material. The comparison between the fabricated samples is important for indicating the effect of the variation of carbon and banana peel powder percentage on the friction material properties. The three samples are tested to measure the wear rate. The weight loss of the pin and the volume loss of the disc can be used to assess wear. To evaluate the effect of these factors on the friction and wear characteristics of the material, the test can be repeated under different test conditions, such as varying loads, speeds, and lubrication conditions. We used a commercial brake pad to compare the wear rate analysis of three samples. From the fig 8, it can be seen in the sample 3 has near wear rate with commercial brake pad compared with other two samples. The values of obtained wear rate are tabulated in table 3 for all the samples. The composition carbon 35% banana 25% has similar wear with commercial brake pad up to150 sec. Because as carbon% increases to the composite can increase the stiffness and strength of the material, which can reduce the amount of material removed from the surface during wear. The other two compositions have higher wear rate than sample 3 with respect to time.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue V May 2023- Available at www.ijraset.com

B. Co-efficient of friction and frictional force test:

The coefficient of friction (COF) and frictional force test is conducted for all the three samples and the values are tabulated. The tabulated COF and frictional force test values showed that sample 3 containing 25%banana and 35 % carbon shows least value compared with other samples because of the uniform distribution of banana powder and epoxy binding leads to better hardness value, which gives better COF and frictional force. The least co-efficient of friction value (0.10) and frictional force was found for the sample containing carbon 35% and banana 25%.

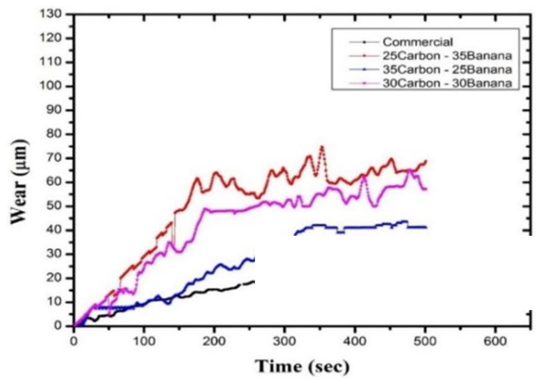
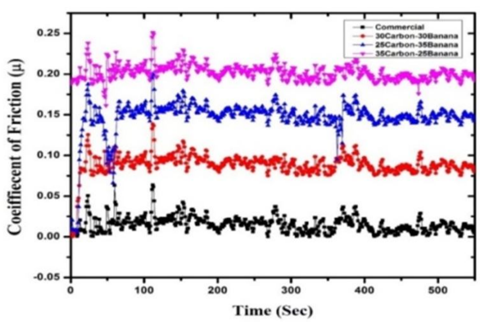


Figure 8: Wear Test Analysis



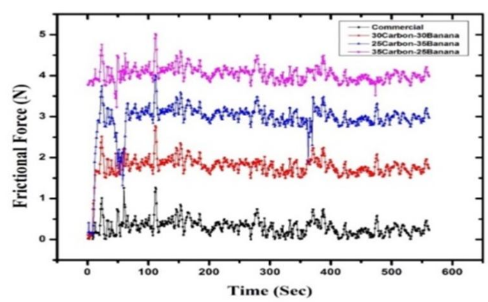


Figure 9: Coefficient of Friction Analysis Figure 10: Frictional Force Analysis

C. Water Absorption Test

Water absorption test for samples containing varied percent distribution of carbon and banana peel is carried out by weighing the sample in the air followed by dipping in water for interval of three days about ten days, and absorption percent is calculated. Banana peel-based composites may have a higher porosity. This could be due to the natural structure of the banana peel material, which contains voids and channels.

The presence of porosity can increase the surface area of the composite and make it more prone to water absorption. The hydrophilic nature of banana peel has tendency to attract and absorb water.

From the figure 11, we observe the carbon 35% and banana 25% composition sample, the rate of absorption on the first four days was 26.76%, then after 7 days the rate is 29.58% and after 10 day the rate of absorption is 31.69%. In the second sample carbon 30% and banana 30% composition sample, the rate of absorption on the first four days was 31.03%, then after 7 days the rate is 34.48% and after 10 day the rate of absorption is 36.55%. In the third sample carbon 25% and banana 35% composition sample, the rate of absorption on the first four days was 47.95%, then after 7 days the rate is 49.32% and after 10 day the rate of absorption is 50.00%.

Once the sample reaches its saturation point the water absorption rate becomes constant as the capacity to intake reached the limit. As the banana percentage decreases the porosity nature decrease which leads to absorb low amount of water. So, the sample 3 which low percentage of banana shows better water absorption rate than other two samples.

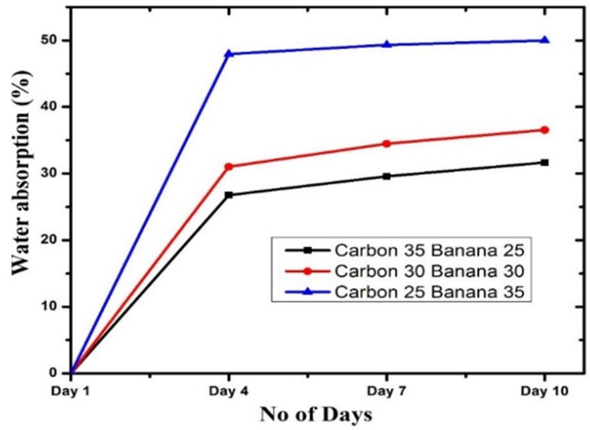


Figure 11: Water Absorption Analysis

D. Hardness Test

The results of hardness value are shown in fig 12. The combination of banana peel and carbon fibres in a composite can result in a material with improved hardness due to the enhanced interfacial bonding, high-strength carbon fibres, high cellulose content of banana peel fibres, and tailored properties of the composite. From the fig12, it can be seen that the sample 3 composition has uniform distribution with epoxy which gives better hardness value than other two samples. The hardness of the sample carbon 25 banana 35 compositions is 140.2 hv. The hardness of the brake pad improved by 14.4% when the amount of carbon increased by 5%, and the hardness value of the carbon 30 banana 30 composition is 160.4 hv. When the carbon percentage is increased by 5%, the hardness of the brake pad increases by 27.28%, and the hardness value of the carbon 35 banana 25 compositions is 178.45 hv.

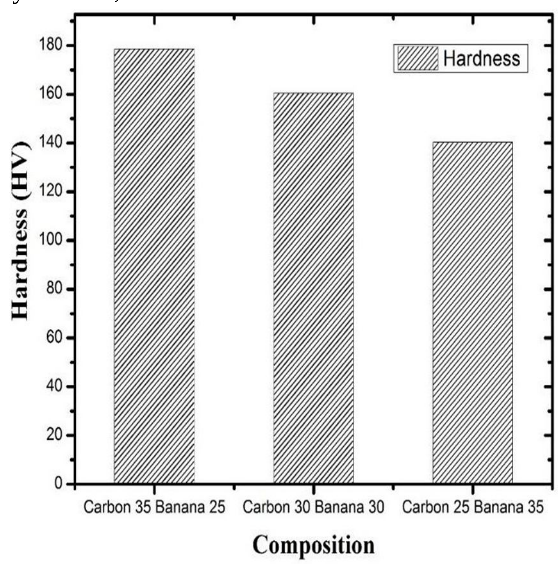


Figure 12: Vickers Hardness Values

Table 2: Water Absorption Test Value

No. of Days	Composition		
	Carbon 25% Banana 35%	Carbon 30% Banana 30%	Carbon 35% Banana 25%
Day 1	1.46 gm	1.45 gm	1.42 gm
Day 4	2.16 gm	1.90 gm	1.80 gm
Day 7	2.18 gm	1.95 gm	1.84 gm
Day 10	2.19 gm	1.98 gm	1.87 gm

Table 3: Vickers Hardness Test Values

S.no	Composition	D1	D2	Load	Dwell Time	HV
1	Carbon 25% Banana 35%	43	49	10gm	10 sec	140.2hv
2	Carbon 30% Banana 30%	43	43	10gm	10 sec	160.4hv
3	Carbon 35% Banana 25%	51	52	10gm	10 sec	178.45hv

IV. CONCLUSION

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

1) Increase in the percentage of Carbon Powder compound in the composition gives more Strength and Stiffness to material which reduces the wear rate. As a result, the Sample 3 containing Carbon 35% and Banana 25% shows low wear rate than other two Samples.
2) The Wear rate is directly proportional to Coefficient of Friction and Frictional Force. The least co-efficient of friction value and frictional force was found for the sample containing carbon 35% and banana 25% which has low Wear rate.
3) From the water absorption results, we can say that as the sample 3 which contains low banana peel powder percentage has low water absorption rate. Because of porosity and hydrophilic nature of banana peels which has the tendency to absorb and attract the water.
4) From the Vickers Hardness test, the sample with the composition of Carbon 35% Banana 25% compositions has the hardness value of 178.45 hv. It shows the highest hardness because of the high carbon percentage which enhances the interfacial bonding, high-strength carbon fibres in the composition.

REFERENCES

[1] U.D. Idris a, V.S. Aigbodion b, I.J.Abubakar c, C.I. Nwoye d, "Eco-friendly asbestos free brake-pad: Using banana peels", Journal of King Saud University, 11 June 2013.
[2] Melkamu Yigren, O. Fatoba, Sheferaw Tensay, ''Tensile strength, wear characteristics and numerical simulation of automotive brake pad from waste-based hybrid composite", Materials Today: Proceedings 62 (2022) 2954-2964.
[3] Melkamu Yigren, O. Fatoba, Sheferaw Tensay, ''Tribological and mechanical properties of banana peel hybrid composite for brake-pad application", Materials Today, Elsevier, volume-62, 2829-2838,2022.
[4] J. Chandradass, M. AmuthaSurabhi, P. Baskara Sethupathi, P. Jawahar, "Development of low-cost brake pad material using asbestos free sugarcane bagasse ash hybrid composites", Materials Today: Proceedings 45 (2021) 7050–7057.
[5] Dagwa, I.M. and Ibhadode, "A.O.A, 2005. Design and Manufacture of Experimental Brake Pad Test Rig Nigerian Journal of Engineering Research and Development," Basade Publishing Press Ondo, Nigeria, vol. 4(3). 15-24.
[6] Aigbodion, V.S., Akadike, U., Hassan, S.B., Asuka, F., Agunsoye, J.O., 2010. "Development of asbestos – free brake pad using bagasse." Tribol. Ind. 32 (1), 45–50.