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EFFECT OF MECHANICAL AND PHYSICALPROPERTIES ON BRAKE PADS PRODUCED FROM BAGASSE, BANANA PEELS AND PERIWINKLE SHELL

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ABSTRACT

The study examined the effect of some mechanical and physical properties on brake pads produced from bagasse, banana peels and periwinkle shell in order to determine the materials suitability to develop new asbestos-free brake pads.These materials were sourced locally at Ede, Osun state.Samples were produced from different mix ratios of constituents using two sieve grades of 180 and 250 µm particle sizes. The percentage weights (wt%) of bagasse, banana peels and periwinkle shells were varied while those of crystalline silica, lead sulphide and epoxy resin were constant for both sieve grades. The density of each sample decreases from 2298 - 1199 Kg/m^3 as the sieve grade increases. Also, the oil and water absorption rates increase from 0.007 - 0.022% and 0.012 - 0.037% respectively with an increase in sieve grade. Thehardness values of the brake pads produced range from 79.7 to 89.4 HRB and 77.1 to 84.8 HRB for both sieve grades, respectively. Likewise, the values of impact strength for the sieve grades ranged from 18.89 to 27.10J/mm and 17.97 to 24.85 J/mm, respectively.The samples B and C consisting of 15 wt% bagasse, 15 wt% banana peels, 30 wt% periwinkle shell, 10 wt% crystalline silica, 10 wt% lead sulphide, 20 wt% resin and 15 wt% bagasse, 30 wt% banana peels, 15 wt% periwinkle shell, 10 wt% crystalline silica, 10 wt% lead sulphide and 20 wt% resin for sieve grade of 180 µm, respectively, were regarded as the best among others because they gave the greatest properties. Therefore, the study concluded that the use of bagasse, banana peels and periwinkle shells as reinforced materials have properties suitable for the production of brake pads.

Keywords: Brake Pads, Bagasse, Banana Peels,Periwinkle Shell, Mechanical and Physical Properties.

1.0 INTRODUCTION

The brake system is a very important component in stopping and slowing down of vehicles and machinery equipment in industries (Belhocine and Nouby, 2015; Abutu *et al.,* 2019).At the moment, the demand for eco-friendly materials such as plant-based natural fiber as reinforced materials raised concerns due to ecological system.Agricultural residue has emerged as inexpensive and alternative materials which is commercially viable and environmentally acceptable in the production of automobile brake pad (Bledzki and Gassan,1999). All forms of asbestos-based brake pad materials are carcinogenic in nature. There is no full ban placed on asbestosutilizationin the production of brake pads,nevertheless industries making friction pads are making use of non-toxic material as an alternative to asbestos as reinforced material due to uncertaintiesconcerning discarding of wastes from asbestos in the manufacturing industries and flying particles (Dagwa and Ibhadode, 2006; Abutu *et al.*, 2018; Ilori *et al.*, 2021). Studiesare focusing on different ways of making use of agricultural residues and industrial wastes as source of raw materials in production of brake pad. Theexploitationof wastes will add to the realization of the local content policy enterprisein Nigeria, thereby resulting to a form of ecological control and overseasinterchangeincomes(Abutu *et al.*, 2019).Ruzaidi *et al.*, (2011) and Bashar *et al.* (2012) established asbestos-free brake pad using ofcoconut shell, palm ash and bagasse as strengtheningingredients. In their studies, they reportedthat the selected strengtheningingredients likened well with other commerciallyobtainable brake pad resources.Ikpambese *et al.* (2014) produced non-asbestosbrake pads by utilising fibers from palm kernel shell alongsideresin as binding agent. The results obtained from their study showed that with increase in speed, thewater and oil absorption rate, specific gravity, surface roughness, porosity and hardness remained steady.Also, Idris *et al.* (2015) formulated a brake pad by making use of waste of banana peels as possible substitution for asbestos-free brake padwith phenolic resin as binder. They stated that their results agreed closely with that of commercially produced brake pads, and also in production of brake pad, the particles of banana peels could efficientlybe utilised as an alternative for asbestos. Similarly, Ademoh and Adeyemi (2015) and Bala *et al.* (2016) investigated the use of banana peels, maize husk, cow hooves, bagasse and palm kernel fibers as reinforcementmaterials forthe production of brake pads using trial and error design technique. Their results showed that the performance of the non-hazardous reinforcement materials used compared closely with commercial brake pads and as a result, may serve as a replacement for asbestos-based. Ilori *et al.* (2021) utilized banana peel, bagasse and periwinkle shell as asubstitute to replace asbestos-based frictional material to produce automobile brake pad. They observed unique uniform distribution and good interfacial bonding of constituents evident from the microstructure analysis, and stated that the use of bagasse, banana peels and periwinkle shells couldbe efficiently employed asalternativematerials to asbestos in the making of automobile brake pads.

There is need to improvethe reinforced material as friction material for replacement of asbestos thereby maintaining the same engineering properties still remains a sticking point. Hence, this study examined the effect of some mechanical and physicalproperties (density, hardness, impact strength and porosity) on brake pads produced from bagasse, banana peels and periwinkle shell in order to develop new asbestos-free brake pads.

2.0 MATERIALS AND METHOD

The materials and method used are thoroughly explained in this section.

2.1 Materials

The materials used in the formulation of automobile brake pads include bagasse, banana peels and periwinkle shells. These were sourced locally at Ede, Osun state.Also, the equipment used include digital weighing balance, hammer mill, hydraulic press, and set of sieves.

2.2 Method

The bagasse, banana peels and periwinkle shells were dried and milled using hammer mill (model TRF 400 animal ration shedder) at 250 rpm to form powder at the processing laboratory, Department of Agricultural Engineering, Faculty of Engineering, Adeleke University, Ede, Osun state. 150g of the particles was sieved with two different sieve grades (180 and 250 µm respectively). The complete classification of particles in the sieve was achieved by shaken it for 15 minutes. The automobile brake pad samples were produced with varying percentages of the constituents for the two different sieves (Table 1). The formulation was properly dried mixed to achieve a homogenous mixture for the sieve size of 180 µm. It was transferred into a mould and compacted using hydraulic press for 30 minutes. Then, the formulation was treated in an oven at temperature of 200°C for 10 minutes. Four samples were produced and replicated twice making twelve samples altogether for the sieve size of 180 µm. This procedure was repeated for the second sieve size of 250 µm (Ilori *et al.*, 2021).

Table 1: The Mix Ratios of Constituents (180 and 250 µm)

Samples	Constituents					
	Bagasse (wt%)	Banana peel (wt%)	Periwinkle shell (wt%)	Crystalline silica (wt%)	Lead sulfate (wt%)	Resin (wt%)
A	30	15	15	10	10	20
B	15	15	30	10	10	20
C	15	30	15	10	10	20
D	20	20	20	10	10	20

2.3 Physical and Mechanical Test

The following are the physical and mechanical tests carried out on the produced samples.

2.3.1 Density

The Archimedes' principle was adopted to determine the density of the samplesusing equation (i) below;

Density $\rho = \frac{M}{v}$(i)

Where,

M = mass of samples (Kg),

V = volume of the samples (m^3) by liquid displacement method.

2.3.2 Porosity

The oil and water absorption rates were used to determine the pore space of thesamples produced.

- **Water absorption**

The samples were immersed in water for 24 hours in accordance with ASTM D570.Then, sampleswere removed from the water and weighed.Thiswas done to determine the amount of water the samples could absorb in a 24-hour period using equation (ii) (Smales, 1995) below;

Absorption(%) $= \frac{W_2 - W_1}{W_1} \times 100$(ii)

Where,

W_1 = weight of the sample before immersion,

W_2 = weight of the sample after immersion.

- **Oil absorption**

The samples were also soaked in SAE 20W50 oil for 24 hours. Each sample was removed, cleaned and measured.Equation (ii) was also used to determine oil absorption of the samples.

2.3.3 Hardness

The samples were tested for hardness using a Rockwell testing machine (Rockwell Testing Aids, Model: RBHT, S/N: 2011/202). The values of Rockwell hardness were recorded and average taken.

2.3.4 Impact strength

Impact test was conducted on the samples produced to determine its ability to absorb energy during plastic deformation and its behavior under actual conditions by means of an impact testing machine in

Charpy mode. Test samples were prepared in accordance with ASTM E23 test standard. The impact strength of each brake pad was calculated using equation (iii);

$$\text{Impact strength } (I_s) = \frac{\text{Energy absorbed}}{Sample\ \ thickness\ (t)}\ (J/mm) \text{(iii)}$$

Energy absorbed = MGH(iv)

Where,

M is the mass of hammer or weight dropped on sample;

G is the acceleration due to gravity (9.8 m/s^2);

H is the drop of weight on the sample.

3.0 Results and Discussion

The results of mechanical and physical properties considered are discussed below.

3.1 Effect of Density

Table 2 illustrates the average results of density test carried out on the samples for each sieve size, respectively. The densities of samples A, B, C and D (2190 Kg/m^3, 2298 Kg/m^3, 2241 Kg/m^3 and 2083 Kg/m^3) with 180 µm sieve grade are higher compared to those with 250µm sieve grade (1272 Kg/m^3, 1420 Kg/m^3, 1358Kg/m^3 and 1199 Kg/m^3), respectively; that is, as the sieve grade increases the density of each sample decreases. This implies that the entire samples with low-density were able to trap more moisture and hold more water than high-density samples. This is because the particles of the low-density composites materials (with 250 µm sieve grade) produced are loosely packed together with sufficient space between them thereby creating voids within the composites components while the particles of high-density samples are tightly packed with very little space between the particles. This was ascertained by Ilori *et al.* (2021) through microstructure analysis of the samples for adequate interfacial bonding of the composites. Also, this is in agreement with the works of Yawas *et al.*(2016) and Elakhame *et al.* (2017) who observed increase in the density of samples as the sieve grades decreased and attributed this to the increases in particles bonding attained, respectively.

Table 2: Average Density of Samples

Samples	Density (kg/m^3)	
	180 µm sieve grade	250 µm sieve grade
A	2190	1272
B	2298	1420
C	2241	1358
D	2083	1199

3.2 Effect of Porosity

The effect of porosity on the brake pad produced was determined by the results of oil and water absorption rates.

3.2.1 Oil absorption

The results of oil absorption rate of the samples A, B, C and Dproducedare 0.012%, 0.007%, 0.009%, 0.018% for sieve grade of 180 µm and 0.019%, 0.013%, 0.011%, 0.022% for sieve grade of 250 µm, respectively as shown in Table 3. It can be observed from the Table that the oil absorption rate increases with an increase in sieve grade; this could be ascribed to the increase in pores as sieve grade increases. These results obtained for the sieve grades liken well with that of Yawas *et al.*(2016) who reported decrease in the oil absorption rate as the particle size decreases from 710 to 125 µm even though their work was mainly on the periwinkle shell.

Table 3: Average Oil and Water Absorption Rates

Samples	Oil Absorption Rate (%)		Water Absorption Rate (%)	
	180 µm sieve grade	250 µm sieve grade	180 µm sieve grade	250 µm sieve grade
A	0.012	0.019	0.020	0.034
B	0.007	0.013	0.012	0.023
C	0.009	0.011	0.016	0.026
D	0.018	0.022	0.022	0.037

3.2.2 Water absorption

Table 3 depicts the water absorption rate for all the samples tested at room temperature for 24 hours. The water absorption rate ranges from 0.012 - 0.022% for sieve grade of 180 µm and 0.023 - 0.037% for sieve grade of 2500 µm, respectively. Regardless of the mix ratios of the constituents for each sample, the water absorption rate increases as the sieve grade increases. The reason for this increase is due to particle size as the sieve grade increases which creates voids and spaces within the composites components. These results are in similarity with the previous observations ofAbiodun *et al.* (2014) and Elakhame *et al.* (2017).The results show that the oil and water absorption rates increase from 0.007 - 0.022% and 0.012 - 0.037% respectively with an increase in sieve grade which determined the porosity of the samples. Hence, it can be deduced from the results obtained that the porosity effect cannot be neglected since it will contribute to the efficient performance of the brake pads produced. Also, from the results, the samples B and C for sieve grade of 180 µm, respectively, were regarded as best because the samplesprovided the best properties as a result of their good interfacial bonding established by earlier observation of Ilori *et al.* (2021) in the production of ecologically friendly automobile brake pads.

3.3 Effect of Hardness

Table4reveals the result of the hardness test carried out on all samples for each sieve grade. The average hardness values obtained on the samples ranged from 79.7 to 89.4 HRB and 77.1 to 84.8 HRB for particles size of 180 and 250 µm, respectively, as shown in the Table 4 (Ilori *et al.*, 2021).It was observed from the Table that the hardness of each sample of brake pad produced per mix ratio increases with decrease in sieve grade. The samples with 180µm sieve grade possess higher resistance to plastic deformation than the samples produced with 250µm sieve size due to the surface area and particle size of the brake pads produced. Ilori *et al.* (2021) established that the samples B and C have the best hardness value of 89.4 and 86.5 HRB for sieve grade of 180 µm, respectively, due to high percentage weight of periwinkle shell and banana peel powders in the mix ratio of the constituents andunique uniform distribution of the particles size which resulted to an improved interfacial bonding of particles in the samples. Therefore, the range of hardness values of the brake pads produced is close to the 101 HRB hardness values of commercial brake pads.

Table 4: Average Hardness Values of Samples

Samples	Hardness (HRB)	
	250µm sieve size	180µm sieve size
A	79.30	81.90
B	84.80	89.40
C	82.10	86.50
D	77.10	79.70

3.4 Effect of Impact Strength

Table 5 shows the average values obtained from an impact strength test carried out through the measure of energy absorbed per sample thickness of produced brake pads for both sieve grades180and 250µm. This reveals the amount of mechanical energy the samples were able to withstand when load was suddenly applied.It was observed that the sample with a larger particle size possessed a lower energy absorbed per unit thickness which indicates that it would fracture far ahead than the sample with lower particle size. Thus, this will make the sample material experience fracture, tear, or damage when the amount of energy surpasses that which it can withstand.This indicates that the impact strength of the material has been exceeded.The values of impact strength for sieve grades of 180 and 250 µmranged from 18.89 to 27.10J/mm and 17.97 to 24.85 J/mm, respectively (Table 5). The samples with sieve grade of 180 µm exhibit better impact strength than sieve grade of 250 µm due to the close packing arrangement of the particle size which makes it difficult for oil and water to penetrate as established from the results of porosity test. This is contrary to observation made by Mayowa *et al.* (2015) who worked on two different materials (cow bone and palm kernel shell).Therefore, it is obvious that the samples B and C for sieve grades of 180 and 250 µm have best impact strength values of 27.10J/mm and 23.58J/mm, 24.85 J/mm and 21.36J/mm, respectively.

Table 5: Average Impact Strength of Samples

Samples	Impact Strength (J/mm)	
	180µm sieve size	250µm sieve size
A	20.85	19.78
B	27.10	24.85
C	23.58	21.36
D	18.89	17.97

4. Conclusion

The studyexamined the effect of some mechanical and physical properties on brake pads produced from bagasse, banana peels and periwinkle shell in order to develop new asbestos-free brake pads. The density of each sample decreases from 2298 - 1199 Kg/m^3 as the sieve grade increases. Also, the oil and water absorption rates increase from 0.007 - 0.022% and 0.012 - 0.037% respectively with an increase in sieve grade which determined the porosity of the samples. The hardness values of the brake pads produced range from 79.7 to 89.4 HRB and 77.1 to 84.8 HRB for particles size of 180 and 250 µm, respectively. Also, the values of impact strength for sieve grades of 180 and 250 µm ranged from 18.89 to 27.10J/mm and 17.97 to 24.85 J/mm, respectively; samples with sieve grade of 180 µm show better impact strength than sieve grade of 250 µm due to the close packing arrangement of the particle size. The samples B and C consisting of 15 wt% bagasse, 15 wt% banana peels, 30 wt% periwinkle shell, 10 wt% crystalline silica, 10 wt% lead sulphide, 20 wt% resin and 15 wt% bagasse, 30 wt% banana peels, 15 wt% periwinkle shell, 10 wt% crystalline silica, 10 wt% lead sulphide and 20 wt% resin for sieve grade of 180 µm, respectively, were regarded as the best among others because they gave the greatest properties. Therefore, the study concluded that the use of bagasse, banana peels and periwinkle shells as reinforced materials have properties suitable for the production of brake pads.

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