Assessment of Palm Kernel Shell as Friction Material for Brake Pad Production

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ABSTRACT
The use of asbestos in brake pads and lining is being phased out due to its carcinogenic nature. This study investigated the development and assessment of asbestos free brake pad using palm kernel shell (PKS) as base material. Palm kernel shell (PKS) of three different particle sizes namely; 200µm, 400µm and 600µm were combined with other ingredients to produce brake pads following standard procedure. The performance of the produced brake pads were evaluated, and compared with commercial (asbestos based) brake pad. It was observed that PKS particle size had a significant influence on the performance of PKS based brake pads. The PKS 600µm particle size brake pad sample compared favourably with the asbestos pad in terms of wear rate, heat resistance/dissipation and braking efficiency at speed below 100Km/h.

Keywords--- Particle size, brake, efficiency, wear, fibre, lubricant, reinforcement

I. INTRODUCTION
The braking system is an indispensable component of an automobile, and is composed of many parts including brake pads, master cylinder, wheel cylinders, and a hydraulic control system (Maleque et al., 2012). The brake pad is an important part of the brake system and consists of steel braking plates with friction materials bound to the surface facing the brake disc. The brake pad generally consists of asbestos fibres embedded in polymeric matrix, along with several other ingredients (Aigbodion et al., 2010; Maleque et al., 2012; Aku et al., 2012; Idris et al., 2013). The use of asbestos in brake pads has become a source of concern due to its carcinogenic nature and problem of disposal, consequently, it is being phased out. The current trend in the automotive industry is the development and use of asbestos free brake pads.

Industrial and agricultural wastes are currently receiving attention as alternative raw materials to asbestos in the manufacture of brake pads (Leman et al., 2008). The use of suitable waste materials can provide added values and reduce environmental problems and costs associated with disposal.

Research works have been carried out in the area of development of asbestos free brake pads. The use of bagasse, palm kernel shell, coconut shell, banana peels, periwinkle shell, and palm oil clinker have been investigated (Dogwa and Ibhadode, 2006; Aigbodion et al., 2010; Idris’ et al., 2010; Zamri et al., 2011; Dagwa et al., 2012; Aku et al., 2012; Fono-Tamo and Koya, 2013; Onyeneke et al., 2014). Friction materials and especially brake pads are made up of essentially four groups of material which include binders, fillers, reinforcing fibres and friction modifiers. Combined together, these groups of materials provide the developed brake pads with the necessary properties needed for it to perform effectively. Therefore, in the choice of materials for brake pads, the following should be considered; stable friction coefficient, and a lower wear rate at various operating speeds, pressures, temperatures and environmental conditions (Wannik et al., 2012; Adebisi et al., 2011). Nigeria is blessed with palm trees and enjoys large benefits of palm resources of which palm kernel shell (PKS) is one of the waste products. The objectives of the study were to formulate asbestos free brake pad using PKS as base material, and to investigate the effect of PKS particle on brake pad performance.

II. MATERIALS AND METHOD

Material Preparation
3kg of palm kernel shell was obtained from a palm oil processing mill in Owerri, Imo State, Nigeria.
The shells were thoroughly washed with small quantity of detergent to remove residual oil and extraneous materials. Thereafter, the shells were sun dried for 72hrs. The dried shells were pulverized using a hammer mill, and the desired particle size was obtained after 3 passes. The pulverized shells were classified into three different particle sizes using sieves of mesh 200µm, 400µm, and 600µm respectively.

**Brake pad formulation**

Each of the three PKS grit sizes was used to formulate brake pad by mixing with brass chips, steel fibre, graphite, latex rubber, calcium carbonate, resin binder and carbon black powder. The proportions and functions of the ingredients are described in Table1. After mixing, the mixture was compacted in a mould to assume the required shape. A compressive force of 30-40KN was applied through a punch, by a hydraulics press, for a period of 10min. The green brake pad produced was cured by heating in an electric oven at a temperature of 77°C for 1hr, and allowed to cool. The brake pad samples were subjected to performance tests.

**Performance Test**

The produced brake pad samples and a commercial brake pad (produced from asbestos) were tested for wear/application, disc temperature rise, and disc stopping time (braking efficiency) at different speeds. All the tests were carried out using test rig at National Research Institute, Umudike, Abia state, Nigeria.

**III. RESULTS AND DISCUSSION**

Assessment of the wear behaviour of the brake pad samples when subjected to different speeds is presented in Fig. 1. All the samples including the asbestos based exhibited marginal increase in wear rate with speed up to 80km/h. The asbestos brake pad had the lowest wear rate followed by the PKS samples C, B, and A. respectively. The PKS based samples showed different resistances to wear despite the fact that the same quantity of constituents was used in their formulation, the only difference being the size of PKS grits. Sample A (grit size 200 µm) had the fastest wear rate, followed by sample B (grit size 400 µm). While sample C (grit size 600µm) compared favourably with the asbestos based pad. This trend impresses the fact that grit size is an important factor that needs careful attention when wear is to be considered in the production of brake pads using PKS. The decrease in wear rate with increased grit size could be attributed to higher load capacity of formulation and better interfacial bond between the particles and the resin thereby reducing the possibility of particle pull out which may result in higher wear rate (Idris *et al*., 2013). The presence of PKS particles provides a higher thermal stability, increased abrasion and sliding wear resistance and delays the transition from mild to severe wear (Gudmand-Hoyer *et al*., 1999).

However, when the brake pad samples were tested at speeds above 80 km/h, they presented sharp increases in wear rates. It is well known that wear process involves fracture, tribochemical effects and plastic flow. Transitions between regions dominated by each of these commonly give rise to changes in wear rate. This behaviour beyond 80 km/h speed could be due to subsurface deformation of the brake pad as a result of high temperature.

The PKS brake pads generally did not show any difference in behavior in terms of disc temperature rise with speed (Fig 2). They maintained the same Temperature change. However, at speeds below 30 km/h the asbestos brake pad had a lower disc temperature rise while the PKS samples maintained lower values of temperature change. The Asbestos sample was higher beyond 30 km/h speed. Thus, the PKS brake pads are a better choice ahead of the asbestos in applications where disc temperature rise is of great concern.

At speed below 70 km/h all the PKS pads with the exception of sample A, had lower stoppage time (that is, better braking efficiency) when compared with the asbestos pad (Fig 3), beyond 70km/h and up to 100 km/h, sample C compared favourably with the asbestos sample in terms of braking efficiency.

**IV. CONCLUSION**

The Result of this study highlighted the fact that PKS particles could be effectively used in the production of brake pads as a replacement for asbestos. However, PKS particle size has a significant influence on the brake pad performance and quality, hence, the need for careful selection. Based on this study, PKS brake pad (grit size 600µm) was found to be comparable with the asbestos based brake pad in terms of such parameters as wear rate, disc temperature rise and braking efficiency at speed below 100 km/h.
Table 1: Brake pad formulation

<table>
<thead>
<tr>
<th>Material</th>
<th>Function</th>
<th>Amount (g)</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palm kernel shell</td>
<td>Base material</td>
<td>200</td>
<td>24.7</td>
</tr>
<tr>
<td>Brass chips</td>
<td>Abrasive</td>
<td>40</td>
<td>4.9</td>
</tr>
<tr>
<td>Steel fibre</td>
<td>Reinforcement</td>
<td>55</td>
<td>6.8</td>
</tr>
<tr>
<td>Graphite</td>
<td>Lubricant</td>
<td>25</td>
<td>3.1</td>
</tr>
<tr>
<td>Latex rubber</td>
<td>Filler</td>
<td>75</td>
<td>9.3</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>Hardening agent</td>
<td>220</td>
<td>27.2</td>
</tr>
<tr>
<td>Resin binder</td>
<td>Binding agent</td>
<td>180</td>
<td>22.2</td>
</tr>
<tr>
<td>Carbon black</td>
<td>Colouring agent</td>
<td>15</td>
<td>1.9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>810</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Fig. 1: Variation of wear rate/application with speed

Fig. 2: Variation of disc temperature rise with speed
REFERENCES


