The Development of Vehicle Brake Pad Using Local Materials - (Palm Kernel, Coconut And Cashew Shells As Base Materials).

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Abstract: The development of motor vehicle brake pad using locally available raw material is presented. The disc brake friction lining with the geometrical specifications of a Toyota Camry 2000 model was produced using palm kernel and coconut shells powder as base materials, epoxy resin (araldite) as binder materials and carbon as fibre reinforcement, aluminum, copper, zinc and cashew nut shell were used as abrasives rubber dust from shoe as filler. The experiment conducted, it was revealed that the co-efficient of friction of the pad material ranged from 0.4-0.65, scratch hardness of 80-85, bonding strength of 25-27Kg/cm² and wear rate of 0.025mm/min to 0.06mm/min as compared to the conventional brake pad material that has hardness of 80-85, bonding strength of 25-27kg/cm² and wear rate of 0.03-0.08mm/min

Keywords: Brake Pad, Local Materials, Wear Resistance, Strength, Friction

I. INTRODUCTION

There are desired mechanical properties, and chemical properties which some materials possesses that make them suitable for brake pads and brake lining. Examples of such properties are hardness, resistance to abrasion, environmental friendliness, Rabinowioze (1956) reported that friction arises from surface interactions between two contacting material and is affected by volume and surface dependent properties. Volume dependent properties are elastic and it modifies the hardness and thermal characteristics, Iloeje et al. (1989). Surface properties of importance are the chemical reactivity, surface energy, tendency to absorb molecules from the environmental and compatibility of the contacting surface forces which causes friction due to adhesion, local fusion asperity and interlocking, Iloeje (1989). Any or all of these forces can cause fracture of the surface material, which implies the occurrence of wear. Therefore, a friction material needs to have shear strength. The hardness of a material particularly its scratch hardness, is an indication of its resistance to wear, however hardness decrease with temperature and since friction linings attain elevated temperature during operations their production materials should have high hot hardness.

II. MATERIALS SELECTION

The materials used for the production of the brake pads were carefully selected and they include palm kernel and coconut shells powder, araldite and epoxy resin as binder materials, carbon as fibre reinforcement, aluminum, copper and zinc were used as abrasives, rubber dust from shoe as filler. Important factors considered in selecting these materials include high coefficient of friction, low wear rate, good heat dissipation while retaining the mechanical strength, ability to dry, up as quickly as it passes through water. In critically analyzing the desired qualities of different forms of carbon, appropriate ratio was worked out for the basic raw materials. These include palm kernel shells, carbon dust (charcoal) rubber dust from shoe, coconut shell dust, epoxy resins, copper dust, and aluminum dust. Mild steel (plain carbon steel) plates are used for the brake pad back plate as shown in Fig.3.1.
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Figure 1: Brake pad designs

Figure 2. Moulds design

Equipment And Tools Used

After materials selection exercise, different types of processing equipment and tools were used for the preparation of the brake pad materials and testing of the mechanical properties of the materials. These include the following underneath described equipment.

Figure 3: Pie chart illustration of various brake pad constituents (Chan et al, 2004)
Equipment And Tools Used
After materials selection exercise, different types of processing equipment and tools were used for the preparation of the brake pad materials and testing of the mechanical properties of the materials. These include the following underneath described equipment.

Crushing of Materials (Hammer Mills)
A hammer mill is a machine that is universally used for the crushing of different materials to different grit sizes as desired. The palm kernel and coconut shell were crushed to powdered condition of different grit sizes.

See Fig 4. diagram of the hammer mill.

Hardness Test
The hardness of the palm kernel and coconut shells was tested using Rockwell hardness testing machine

Compression Test
The compressive strength of the palm kernel and coconut shells was tested using hydraulically operated compression testing machine and compressive strength of both materials ascertained and recorded

Abrasion Test
The abrasion resistance test of the palm kernel and coconut shells was carried out using abrasion testing machine
The values gotten are as written under.
Palm kernel shells:
Quantity charged to the machine = 4.0kg = 4000grams.
Quantity crushed to powder = 0.5kg = 500grams
Q₁ = Original quantity charged
Q₂ = Final quantity uncrushed
Q₃ = Final quantity crushed to powder
∴ Resistance to abrasion = \( \frac{Q₁ - Q₂}{Q₂} \) = \( \frac{3500}{4000} \) \times 100% = 87.5%

Coconut shell
4000grams of this material was charged into the abrasion test machine. 1500grams was crushed to powder.
∴ 4000g - 1500g = 2500g
∴ \( \frac{4000g - 1500}{250} = 0.65 \)
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\[ \frac{250}{4000} = 0.65 \times 100 = 65\% \]

**Table 1: Mechanical properties of palm kernel shell and coconut shell.**

<table>
<thead>
<tr>
<th>Material</th>
<th>Hardness in Rockwell</th>
<th>Abrasion resistance</th>
<th>Compression strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palm kernel shell</td>
<td>35kg/cm²</td>
<td>87.5%</td>
<td>30kg/cm²</td>
</tr>
<tr>
<td>Coconut shell</td>
<td>20kg/cm²</td>
<td>65.0%</td>
<td>5kg/cm²</td>
</tr>
</tbody>
</table>

Sieving operation (using sieving tray)

The crushed palm kernel and coconut shells were subsequently sieved using sieving tray of different mesh sizes to get five different grit sizes for the production of fifty (50) different samples of brake pads for comparative analysis. The grit sizes selected for the brake pad production are as written underneath: 0.25mm, 0.35mm, 0.45mm, 0.55mm, 0.65mm.

**The Binding Components**

In the sample preparation it is well understood that the quality and compactness of any lining is due mainly to the binding chemical and size of particle of raw materials. Basically the binding component has to be a thermosetting polymer resin. Epoxy-modified phenolic resin is used as a binding agent because it has better heat resistance than the pure phenolic resin.

**The Abrasive Components**

The ability of the material to clean up the surface and simultaneously dissipate heat was what informed the choice that was made while selecting the abrasive materials which include, aluminum, copper, and zirconium oxide. Since the material used need not wear out the brake drum, the need to introduce a material with relatively high strength which can protect the brake drum during use was considered. Coconut shells rubber and palm kernel shell were used for this purpose because of the high strength they possess as compared to asbestos, paper and wood.

**Mixture Composition**

As the coconut and palm kernel shell were crushed into five different grit/mesh sizes of 0.25mm and 0.35mm, 0.45mm, 0.55mm, 0.65 respectively. Then the copper and aluminum particles were produced by using electrically operated hand held grinding machine. The binder chosen was epoxy resin and other additives included are aluminum, copper, and zirconium oxide for abrasiveness, carbon black for strength and rubber dust for vibration absorption. Measured out quantities which gave a total weight of 1000g or one kilogram (1kg) of the constituent materials is shown in Table below. The internal surface of the mould and the lower surface of the brake pad backs plate were cleaned with emery cloth.

**Table 2: Showing first group of twenty five samples mixture composition of the brake pad**

<table>
<thead>
<tr>
<th>Function</th>
<th>Material</th>
<th>Amount (g)</th>
<th>% composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binder</td>
<td>Araldite</td>
<td>150g</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>Epoxy resin</td>
<td>150g</td>
<td>15%</td>
</tr>
<tr>
<td>Fiber reinforcement</td>
<td>Carbon</td>
<td>20g</td>
<td>2.0%</td>
</tr>
<tr>
<td>Abrasives</td>
<td>Aluminum</td>
<td>25g</td>
<td>2.5%</td>
</tr>
<tr>
<td></td>
<td>Copper</td>
<td>25g</td>
<td>2.5%</td>
</tr>
<tr>
<td></td>
<td>Zinc</td>
<td>15g</td>
<td>1.5%</td>
</tr>
<tr>
<td></td>
<td>Zirconium oxide</td>
<td>25g</td>
<td>2.5%</td>
</tr>
<tr>
<td>Lubricant</td>
<td>Cashew nut shell</td>
<td>10g</td>
<td>1.0%</td>
</tr>
<tr>
<td>Filler</td>
<td>Rubber</td>
<td>40g</td>
<td>4.0%</td>
</tr>
<tr>
<td>Base material</td>
<td>Palm kernel shell</td>
<td>270g</td>
<td>27%</td>
</tr>
<tr>
<td></td>
<td>Coconut shell</td>
<td>270g</td>
<td>27%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1000g</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Table 3: Showing second group mixture composition of the brake pad**

<table>
<thead>
<tr>
<th>Function</th>
<th>Material</th>
<th>Amount (g)</th>
<th>% Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binder</td>
<td>Araldite</td>
<td>100g</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Epoxy resin</td>
<td>200g</td>
<td>20%</td>
</tr>
<tr>
<td>Fiber reinforcement</td>
<td>Carbon</td>
<td>30g</td>
<td>3.0%</td>
</tr>
<tr>
<td>Abrasives</td>
<td>Aluminum</td>
<td>25g</td>
<td>2.5%</td>
</tr>
<tr>
<td></td>
<td>Copper</td>
<td>25g</td>
<td>2.5%</td>
</tr>
<tr>
<td></td>
<td>Zinc</td>
<td>15g</td>
<td>1.5%</td>
</tr>
<tr>
<td></td>
<td>Zirconium oxide</td>
<td>25g</td>
<td>2.5%</td>
</tr>
<tr>
<td>Lubricant</td>
<td>Cashew nut shell</td>
<td>10g</td>
<td>1.0%</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Filler</th>
<th>Rubber</th>
<th>30g</th>
<th>3.0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base material</td>
<td>Palm kernel shell</td>
<td>340g</td>
<td>34%</td>
</tr>
<tr>
<td></td>
<td>Coconut shell</td>
<td>200g</td>
<td>20%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1000g</td>
<td>100%</td>
</tr>
</tbody>
</table>

Fabrication Process Of Brake Pad

Selection of the Mould

In producing the mould, the shape of an already existing brake pad was used. Already existing brake pad shapes were used to facilitate quality test of the product specimen. The two arcs were cut into a curvature of 120° with a radius of about 127.5mm each. These arcs are to accommodate both leading and trailing lining of area 117mm². Similarly the two metal strips of width 45mm each were prepared from mild steel and one of these was placed between the two plates to the desired curvature of the desired pad. See table 4 below for the configuration dimension of mild steel plate

<table>
<thead>
<tr>
<th>Material</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radius of curvature of metal plate</td>
<td>127.5mm</td>
</tr>
<tr>
<td>Width of metal strip</td>
<td>45mm</td>
</tr>
<tr>
<td>Depth of mould</td>
<td>5.25mm</td>
</tr>
</tbody>
</table>

Productions of Pad Specimen and Laminating Procedure

The moulds were waxed thoroughly using mirror glaze wax, and allowed to dry for about 6 minutes. This was evenly polished using a dry towel. This was repeated three times to ensure even distribution on mould. The release agent, polyvinyl alcohol was applied on the two moulds and allowed to dry for about 30 minutes. As the drying progressed, mixing of the resin formulation was carried out as follows. Firstly, the coat resin was formulated using small qualities of the catalyst araldite. Special care was taken in mixing the gel coat in the mixing tank or mixing basin to avoid air bubbles being entrapped in the resin. This is the most vulnerable part because it gives the mixture a good surface finish and good wear properties. They are then thoroughly mixed together with the resin formulation and applied to the mould gently until the required depth of 5.25mm is covered with the material. A locally produced hydraulic press was then applied to compress the mixture together to the back plate firmly at a pressure of 250kgf/cm. This was the means of applying pressure to the mixture while still in the mould as at the time of production. The sample produced was then left to flow and harden for one hour (60minutes).

Diagnosis of Faults that Arose During the Processing

Most of the faults that arose during processing resulted from under curing of the resin. These flaws affect both the appearance and performance of the laminate. These include;
- De- laminating of gel wax
- Yield
- Cracks

Curing

This involves the process of heating the molded and compacted brake pad in a heating oven for twenty four hours at a temperature of 100°C, to ensure proper binding of the constituent material in order to obtain the required bond hardness in the brake pad.
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Table 6: Summary of bonding result

<table>
<thead>
<tr>
<th>Property</th>
<th>Specimen 1</th>
<th>Specimen 2</th>
<th>Specimen 3</th>
<th>Specimen 4</th>
<th>Specimen 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient of dynamic friction</td>
<td>0.35</td>
<td>0.4</td>
<td>0.45</td>
<td>0.5</td>
<td>0.55</td>
</tr>
<tr>
<td>Wear (mm)</td>
<td>0.05</td>
<td>0.055</td>
<td>0.065</td>
<td>0.075</td>
<td>0.085</td>
</tr>
<tr>
<td>Bonding (kg/cm³)</td>
<td>27</td>
<td>26</td>
<td>25</td>
<td>24</td>
<td>23</td>
</tr>
<tr>
<td>Scratch hardness</td>
<td>84</td>
<td>85</td>
<td>86</td>
<td>80</td>
<td>75</td>
</tr>
<tr>
<td>Coefficient of static friction</td>
<td>0.4</td>
<td>0.45</td>
<td>0.5</td>
<td>0.55</td>
<td>0.65</td>
</tr>
</tbody>
</table>

Fig. 5: The graph of bond strength and hardness number against particle size

Fig. 6 Pictures of Break Pad
III. CONCLUSION

The design and fabrication of an automobile brake pad using locally available materials have been successfully undertaken in this research work. Palm kernel shell and coconut shell were locally sourced for this project and were used as a base materials, epoxy (araldite) resin as binder material, carbon as fiber reinforcement, aluminum, copper, zinc were used as abrasives and rubber dust from shoe as filler. However, from the analysis of the experiment conducted, it was revealed that the co-efficient of friction of the pad material ranged from0.4-0.65, scratch hardness of 80-85, bonding strength of 25-27Kg/cm² and wear rate of 0.025mm/min to 0.06mm/min as compared to the conventional brake pad material that has hardness of 80-85, bonding strength of 25-27Kg/cm²and wear rate of 0.03-0.08mm/min. These results are in agreement with those of asbestos friction materials produced. It is therefore deducible that this material can be used on Toyota Camry.

The graph of wear against particle/grit size show that particle/grit size of the palm kernel shell and coconut shell influences the bond strength of the break pad. This confirms the scientific theory and practical evidence by Chapman (1979) concerning bond strength, he stated that large particle size (grit size) give open structure bond and that the particles break away easily from the bond on force or pressure application on the break pad. Small grit (small particle size) give close structure bond and enhance strength, that the particles withstand higher force or pressure before breakage. Therefore the samples with 0.25mm and 0.35mm particle/grit size give better/commendable wear resistance and enhance bond strength characteristic properties.

REFERENCES