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Friction and Braking Application of Unhazardous Palm Slag Brake Pad Composite

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Abstract. This paper reveals new alternative friction materials for brake pads. Palm slag was studied as new friction materials in brake pads but its much harder made it difficult to be applied. As a way to reduce the hardness, tire dust was including as purpose on stabilizing the hardness of brake pads. The palm slag was sieves to get desired size that is 150 µm, 300 µm and 600 µm. The percentage weight of materials used are 20% graphite, 20% aluminium oxide, 20% steel fiber, 20% polyester resin and another 40% are varied between tire dust and palm slag. All of materials were blend and compress by using hot pressed machine. The composites properties that were examined are density, porosity, hardness, compressive strength, microstructure analysis and wear rate. The composition of 30% palm slag, 10% tire dust and larger size of filler give better result of mechanical properties and less wear rate of brake pads composites. Then, palm slag can be used in producing of non asbestos brake pads.

1. Introduction

Utilization of friendly materials into production of brake pads was discovered since 117 years ago [1]. The friction materials in pads of brake has important impact to the performance in system of brake and also on health [2]. The reason of replacement ingredient in existing brake pad is the disease that afflicts humans as example cancers, mesothelioma and asbestosis. One of the materials which cause the disease is asbestos. Theoretically, asbestos was chosen once time ago because of its goodness in frictional properties and thermal resistance [1, 3]. Asbestos was blend with other ingredients in the matrix. The use of asbestos was banned caused by its carcinogenic nature give harmful to human health [4].

Besides that, to develop better qualities for new brake pad comparable with existing brake pad, there are government rules that restrict to use materials in brake pad for application on road [1]. Generally, filler in brake pad has significant in plays a role which provide an optimization of friction, stabilization and minimization of wear, under operating variable such as sliding speed, braking force, braking duration and temperature [5]. Nowadays, brake pad was made from aramid [6], palm ash [7], coconut [8, 9], banana peel [10], ceramic [5] ,copper [11] and others.

In this paper, the physical, mechanical and wear test of variation percentage to weight ratio and size of filler for brake pad composites were studied experimentally.

2. Materials and Methods

2.1 Experimental Procedures

In this study, palm slag is use together with tire dust in brake pads composites. Five different compound were produced which contain of phenolic resin as binder, Graphite as lubricant, alumina as abrasive, steel fiber as reinforcement, palm slag and tire dust as filler. Weight balance was used to weight the materials. Dry materials were mixed in pulverizer to obtain homogeneous mixture. The mixture was mixed with polyester and put into hot pressed mold. The composites were pressed at 150^{0}C with pressure 30 MPa.

Table 1. The ingredients used in palm slag composite.

Materials	C1	C2	C3	C4	C5
Phenolic resin	20%	20%	20%	20%	20%
Palm slag	-	10%	20%	30%	40%
Tire Dust	40%	30%	20%	10%	-
Graphite	10%	10%	10%	10%	10%
Steel fiber	20%	20%	20%	20%	20%
Alumina	10%	10%	10%	10%	10%

2.2 Characterization of palm slag composites

The measurement of density was carried out by using pycnometer equipment. The porosity test using sample dimension of 25mmx25mmx7mm and was left in desiccator for a day. The weight of sample was taken before it was test in oil at 90^{o}C temperature for 8 hours. Then, the sample was left in oil until the oil was cool down to room temperature.

Hardness test was conducted by using shore D hardness Test. The dimension of samples is 15mm diameter with 6mm thick. The measurement penetration of a specified indentor into the materials was under specified conditions of force and time.

Compression Test of the composites were conducted according to ASTM D695 standards The result of compressive strength was obtained from universal testing machine that retrieves data through software of Test Expert II. There are three variation sizes: 150µm, 300 µm and 600 µm of composites that was tested. The sample with dimension 25mm x 7mm x 7mm were subjected to compressive force, loaded continuously until failure.

Microstructure analysis was carried out using SEM instrument model JEOL JSM-6460LA. Composite samples that have been tested on friction test were observed.

Wear Test on brake pad composites were conducted by using polisher machine with applied 10N load. The samples have dimensions 15 mm in diameter and 6 mm in height. The sample was set up on pin on the surface of stainless steel wheel and a wheel speed of 100 rpm. The weight loss of the composites was measured after friction test with sliding distance of 1 km. The samples were weighed before and after testing to determine weight loss within an accuracy of 0.0001 mg. Wear rate for the brake pad composites were determined by dividing wear volume and sliding distance. Calculation of the wear rate was listed in equation (1) and (2) below:

$$\text{Wear Volume, } m^3 = \frac{\text{Weight Before-Weight After}}{\text{Density, } \rho} \tag{1}$$

$$\text{Wear Rate} = \frac{\text{Wear Volume, } m^3}{\text{Sliding distance, } m} \tag{2}$$

3. Result and Discussion

The brake pad composites which have more tire dust show lowest density than brake composites with more palm slag as shown in Table 2, Table 3 and Table 4. Figure 1(a) and Figure 1 (b) indicates that formulation C5 has the highest porosity and density properties which mean that there should be high stability to the higher temperature because of its attribution to hydrophobic nature of the pores presented in the matrix of the composite through lubricious effect in hydrophobic group [12]. Porosity in composites will absorb energy and heat. Basically, low percentage of porosity will result in higher wear rate. Brake pad composites must contain at least small amount of porosity as an advantage to reduce the effect on the wear rate by water and oil [1].

Table 2: Density and Porosity for 150µm size of filler

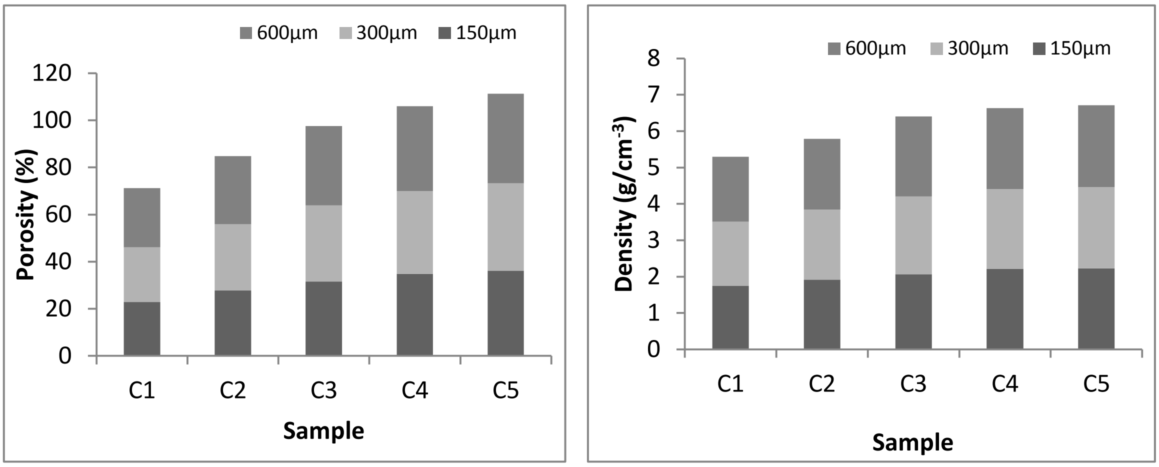
Physical Properties	C1	C2	C3	C4	C5
Density (g/cm^{-3})	1.7527	1.9166	2.0667	2.2159	2.2231
Porosity (%)	22.94	27.82	31.61	34.87	36.23

Table 3: Density, Porosity for 300µm size of filler

Physical Properties	C1	C2	C3	C4	C5
Density (g/cm^{-3})	1.7612	1.9311	2.1421	2.1922	2.2413
Porosity (%)	23.21	28.06	32.34	35.18	37.08

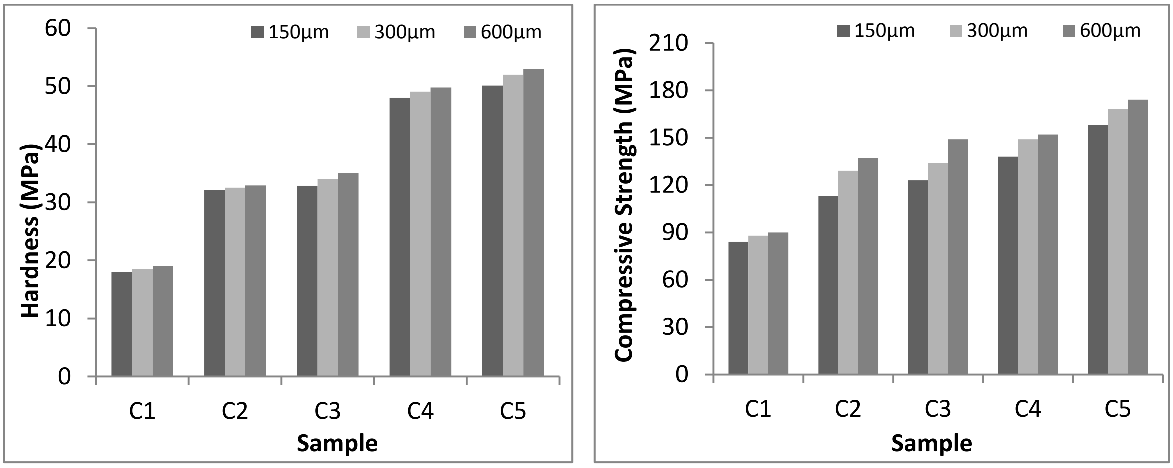
Table 4: Density, Porosity for 600µm size of filler

Physical Properties	C1	C2	C3	C4	C5
nsity (g/cm^{-3})	1.7817	1.9402	2.1931	2.2232	2.2513
:osity (%)	25.02	28.89	33.67	35.98	37.97



(a) (b)

Figure 1.Physical properties of different size of filler brake pad composites (a) Density analysis of the samples (b) Porosity analysis of the samples



(a) (b)

Figure 2. Mechanical properties of different size of filler for brake pad composites (a) Hardness properties (b) Compressive strength

In this study, the hardness properties of composites shows increase in value when the percentage of palm slag was increase. It was observed that the composites have more palm slag materials will result in higher hardness as shown in Figure 2 (a). The correlation between size of filler and hardness shows that the larger size of filler will increase the value of hardness. The size of filler, 600µm gives higher value of hardness than 150µm and 300µm.

Figure 2(b) shows the result of compressive which correlate with size of filler. The formulation C5 exhibits higher strength to resist applied load and more capability to hold compressive force. Formulation C5 have higher compressive strength caused it contain more palm slag materials.

Surface of friction composites was analyzed through scanning electron microscope to view scratched on surface after friction test. Figure 3 shows SEM micrograph of worn surface. Some materials from the composite have come out of the composites. Figure 3(i) illustrate the brake pad

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composite with 150µm size of palm slag and tire dust which shows more depth of scratch than other size of filler. It also can be seen that all of the ingredient such as, graphite, aluminium oxide, steel fiber, tire dust and palm slag have been distributed well in the matrix binder. The existence of Al and O have given part of formation of aluminium oxide [12].The worn surface of brake pad composite in Figure 3(ii) have less materials come out and more scratch on surface. The brake pad composites Figure 3(iii) have greater size of filler than others, 600µm, has some tiny plateaus on the surface which responsible to low wear rate [1]. The wear debris that stick on surface of composites (Figure 3) showed the platelets in microstructure which can be form during the materials transfer from composites to disc or disc to composites.

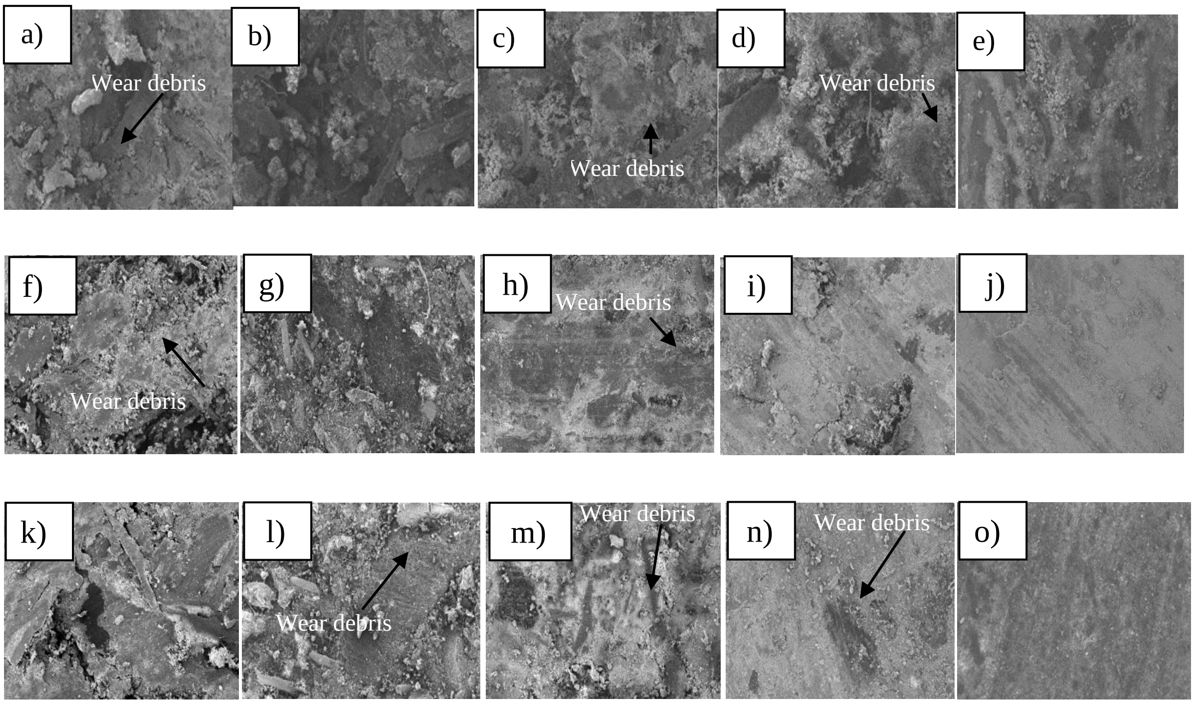

Figure 3. Surface Morphology of Brake Pads of (i) 150µm (a-e) ,(ii) 300µm (f-j) and (iii) 600µm (k-o).

Figure 4 shows wear rate of palm slag composites which varied with percentage and size of filler. Composites of formulation C5 have higher wear rate because it does not have tire dust. After addition tire dust into the composite, formulation C2, C3 and C4 have achieved low wear rate. It can be seen that formulation C4 contributed to higher wear resistance.

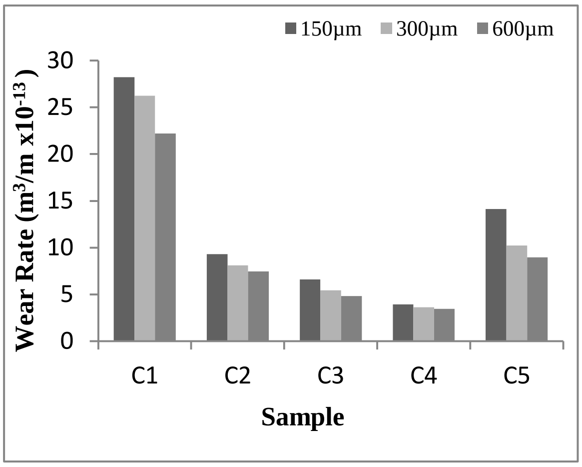

Figure 4. Wear Rate of brake pad composites with variation in size of filler.

4. Conclusions

Palm slag and tire dust can be used as friction materials in brake pad composites reinforced with palm slag and tire dust causing its properties below:

i. Brake pad composites reinforced with palm slag and tire dust show better properties. Hardness and compressive strength is in stability range.
ii. Morphology on surface composites shows hard bonding properties between matrix and filers. The worn surface indicates that the increasing in size of filler will result in low formation of wear debris.
iii. Formulation of composites with tire dust has less wear rate than composites without palm slag. The larger size of filler also decreases the wear rate of the brake pad composites.

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