FABRICATION AND WEAR BEHAVIOR OF PALM ASH/PHENOLIC BASED COMPOSITE

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A large quantity of palm ash by product is produced every year in Malaysia and only small quantities of palm ash are currently utilized. This paper has focused on the future potential application of palm ash as filler material to develop new composition of brake pad. The composite samples for brake pad application were developed by pre-mix the palm ash, $CaCO_3$, phenolic resins, Al_2O_3, graphite and steel fiber mill. Then, the material was compacted by using cold press/manual press machine at a pressure of 15MPa. All samples were cured at 150 °C for 5 minutes. Wear loss of the composites samples was studied by using the modified MetkonGropo V1 grinder-polisher. SEM and stereomicroscope were used to analyze the morphology of worn surface

Keywords: Wear, palm ash, $CaCO_3$, phenolic resins, Al_2O_3, graphite, steel fiber and wear

INTRODUCTION

Brake Pad

Brake pad is one of the important engineering parts in all types of the vehicle and it is used to slow down and stop moving any vehicle. Manufacturing brake pad generally has different type of materials. Its almost used 10 types of raw materials are involved in producing the brake pad [1-2].

The brake pad materials composition generally is classified into five materials, depending on the specific functional requirement. Classification is as fibers, fillers, binders, friction modifier and lubricants [3-6].The performance generally as safety, durability and comfort in various brake situations is mainly controlled by the composition and microstructure of the brake pad materials [7].The filler category divided into various functions such as to reduce thermal conductivity, to resist fade and to improve the braked pad strength.

Palm Ash

It was reported that palm ash has been used as cement replacement material and an absorbent for the removal of zinc from aqueous solution [8]. Malaysia is the largest produced palm oil in the world. Therefore, all waste produced from oil palm production has become an alternative agent in the combustion chamber to replace the fuel for generate the electric power. After burning process done the palm ash was produced and this ash cannot be used for other process.

The problem is the disposal of the palm as it requires a relatively large area to collect palm ash and affect the environment [9-11]. In 2007, the Malaysian Palm Oil Board estimated amount of Palm ash produced in Malaysia to be approximately 3 million tons [12]. One of the solutions in this case is use of palm ash as filler in a brake pad is a potential alternative to reduce the palm ash waste and reduce the costing of raw materials. However, the utilization of palm ash as filler into brake pad material has not been investigated extensively. This paper proposes the use of palm ash as filler materials in brake pad.

MATERIALS AND METHODS

Six types of raw material such as palm ash, $CaCO_3$, phenolic resin, Al_2O_3, graphite and steel fiber were used to fabricate composite samples for brake pad. Palm ash was dried in oven at a temperature of 80 °C for 24 hours to release the moisture. All the raw materials were mixed together for 15 minutes to obtain the homogeneous mixed ingredients and then compacted with the pressure of 15 MPa using cold press/manual press machine. The compacted samples were cured at 150 °C for 5 minutes and post-cured 150 °C until 6 hours. All the raw materials were mixed together for 15 minutes to obtain the homogeneous mixed ingredients. The weight percentage used in the composite mixtures is shown in Table 1.

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Table 1 Ingredients used in composites (%)

Sample / Material	A	B	C	D	E	F	G
Palm Ash	5	10	15	20	25	30	35
CaO_3	35	30	25	20	15	10	5
Phenolic	20	20	20	20	20	20	20
Al_2O_3	10	10	10	10	10	10	10
Graphite	10	10	10	10	10	10	10
Steel fiber	20	20	20	20	20	20	20

Wear test

Wear test carried out to examine friction materials with regard to their service life if they are exposed to abrasive contact. Wear loss for each sample was obtained by using the G 99-05: 2010 standard.The disk material used is stainless steel A 316. The wear test samples dimension of 10mm were put contact with the disk. The wear loss was conducted at constant load 10 N and 100 rpm (round per minute) speed, and sliding distance 1-3 km. Fig 1 shows a schematic drawing of a typical pin-on-disk wear test system.

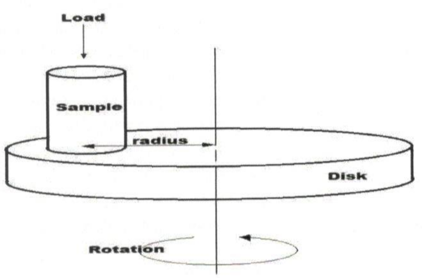

Fig.1. Diagram of Pin-on-disk

The percentage of wear loss was calculated using the following formula:

$$\text{Volume Loss} = \frac{\text{mass loss (g)}}{\text{density}\left(\frac{g}{cm^3}\right)} \times 100$$

Surface Morphology

The surface of the brake pad samples were examined using stereomicroscope to observe the surface microstructure

RESULTS AND DISCUSSION

The effects of applied at constant load and speed disk on different sliding distance.

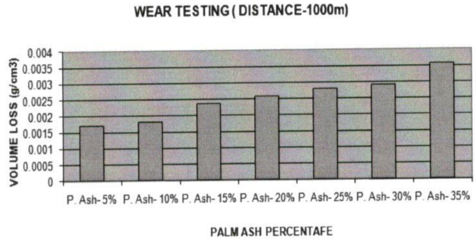

Fig.2(a) Volume loss on 1000 m sliding distance

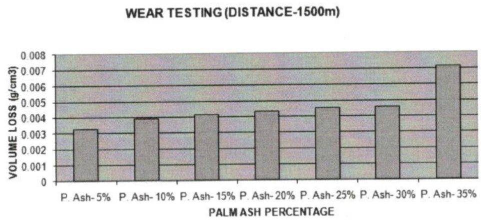

Fig.2(b) Volume loss on 1500 m sliding distance

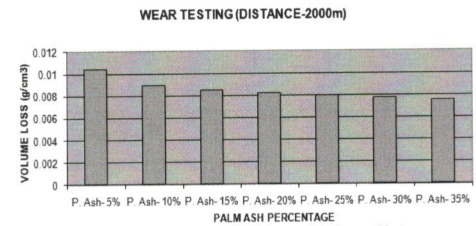

Fig.2(c) Volume loss on 2000 m sliding distance

Fig. 2 (a) and (b) is illustrates the relationship between the volume loss and percentage of palm ash loading within the brake pad samples. With reference to the Fig. (2 (a) and 2 (b), it can be seen that at lower loading of palm ash (for 5 Wt. %), the volume loss recorded are 0.00171 cm^3 and 0.00327 cm^3 for sliding distance of 1000 m and 1500 m; whereas, for samples with highest loading of palm ash, particularly at 35 wt. %, the volume loss recorded are 0.00358 cm^3 and 0.00712 cm^3 for 1000 m and 1500 m sliding distance respectively. It is obvious from these results that increasing of filler loading does not have any significant improvement on the wear resistance

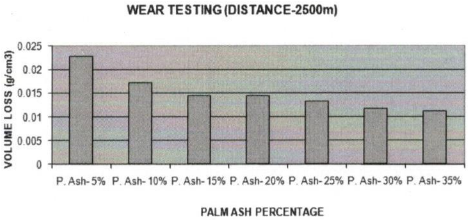

Fig 2.(d) Volume loss on 2500 m sliding distance

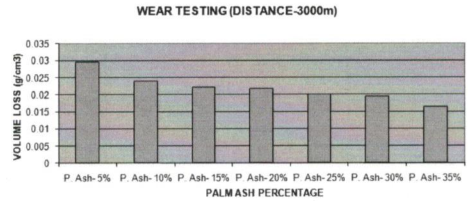

Fig.2(e) Volume loss on 3000 m sliding distance

Fig. 2(a) to 2(e) Shows the wear loss on difference sliding distance.

One of the possible reason for this phenomenon occur may be due to the effect of $CaCO_3$ particles have filled the existed pores present in the sample at lower content of palm ash. Contrarily, at higher palm ash loading, the $CaCO_3$ particles could not accommodate the resultant pores produced from palm ash during the testing due to the differences in particle size of $CaCO_3$, which generally smaller compared to palm ash. As a result, the increased in palm ash loading can have detrimental effect on the wear performance. According to Nandan Dadkar, the author suggests that any increasing loading of materials such as filler, abrasive, binder, reinforcement and lubricant material in a brake pad can also lead to a decrease on the brake pad performances [13].

Fig.2 (c) to (e), shows the volume loss decreases with increasing percentage of palm ash for 2000 m to 3000 m sliding distance. It can be observed, the above results that the volume loss was decreased at the increasing percentage of palm ash within the range of sliding distance from 2000 m to 3000 m. On lower percentage (5 Wt.%), the volume loss recorded was higher that were 0.01038 cm^3 for 2000 m, 0.02285 cm^3 for 2500 m and 0.02961 cm^3 for 3000 m. On the samples with 35 Wt. % of palm ash, the volume loss recorded were 0.007735 cm^3 for 2000 m, 2500 m is 0.01127 cm^3 and 0.01639 cm^3 for 3000 m for same sliding distance.

Based on the observation made from the trends recorded, the phenolic component was changed when the force and sliding distance are applied. The samples experienced a large shear force acting on the surface and may weaken the phenolic component thus resulting in rising of temperatures on the sample and disk. As proposed by P. Gopal et al., when a sample is subjected to a high shear force, in this case, between the interface of a sample and disk, could result in structural weaknesses of the material [14]. Therefore, the idea of incorporating palm ash is very useful to support the brake pad provided that the palm ash can stabilize at higher temperatures.

Morphology

Microstructure analysis of worn sample was done by stereomicroscope at 10x magnifications on 3000 m sliding distance. From Fig.3 (a-d), it can be seen that the steel fibers were pulled out from the samples as a result from the wear test. Moreover, the existence of pores on the sample surfaces is obvious and can be observed from the figures. This argument can be supported from the results of volume loss as a function of palm ash percentage on 3000 m sliding distance where it can be suggested that the samples underwent significant thermal changes resulted in the loss of palm ash and the steel fibers.

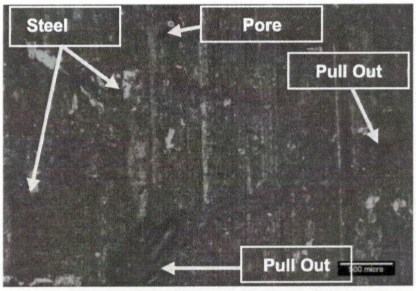

Fig.3 (a) Palm Ash 5 wt. %

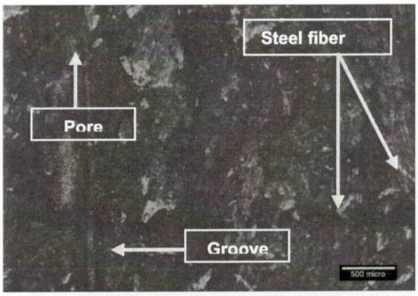

Fig.3 (b) Palm Ash 10 wt. %

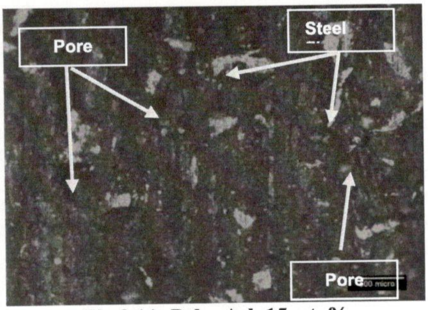

Fig.3 (c) Palm Ash 15 wt. %

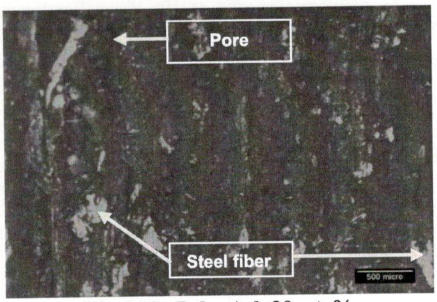

Fig.3 (d) Palm Ash 20 wt. %

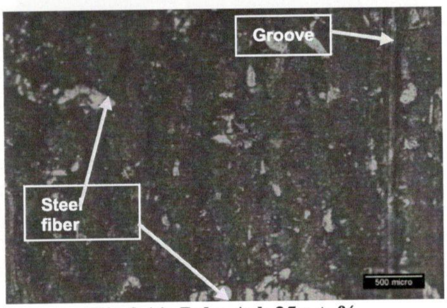

Fig.3 (e) Palm Ash 25 wt. %

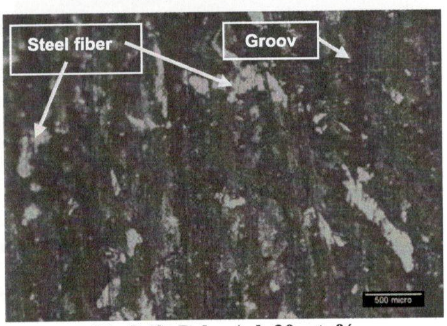

Fig.3 (f) Palm Ash 30 wt. %

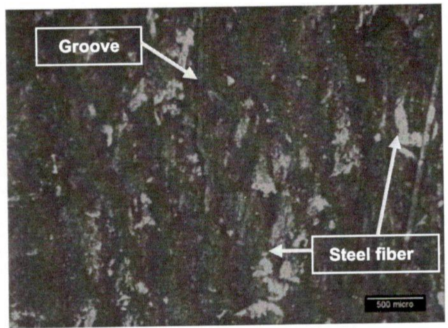

Fig.3 (g) Palm Ash 35 Wt. %

Fig.3 (a) to Fig.3 (g): Shows the stereomicroscope morphology of different percentage palm ash at 3000 m sliding distance at 35x magnification.

In relation to the samples illustrated in Fig. 3 (e-g), it can be observed that the existence of pores is less and there are evident that the presence of steel fibers is more obvious on the sample surfaces compared to the previous figures. In this regard, it can be proposed that the palm ash loading plays important role in stabilizing the heat generated within the samples during wear testing. This can be further supported from the results of wear testing where the graph of weight loss shows that within the increasing loading of palm ash resulted in improvement of wear resistance.

SEM

Morphology analysis of worn surface was done by SEM at 100X magnifications on 3000 m sliding distance for detail proof of the use stereomicroscope.

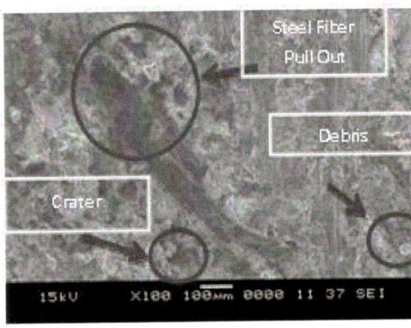

Fig.4 (a) Palm Ash 5 Wt. %

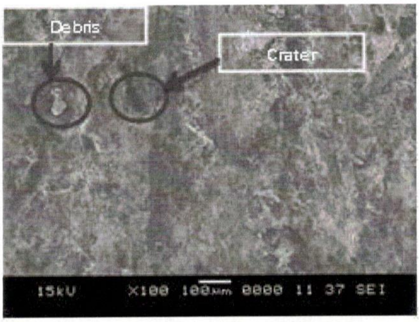

Fig.4 (b) Palm Ash 10 Wt. %

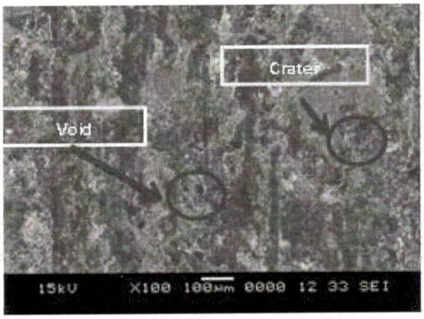

Fig.4 (c) Palm Ash 15 Wt. %

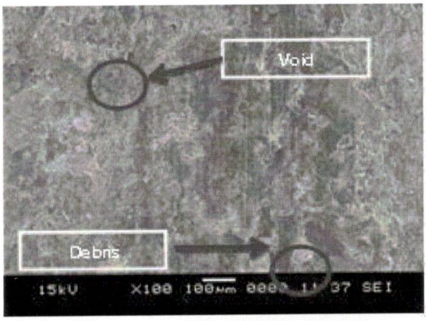

Fig.4 (d) Palm Ash 20 Wt. %

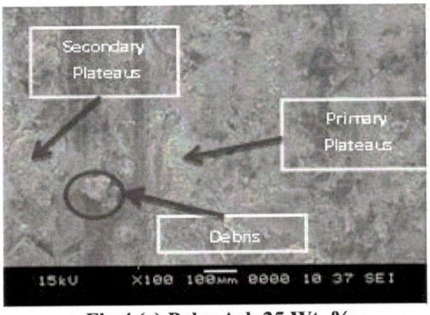

Fig.4 (e) Palm Ash 25 Wt. %

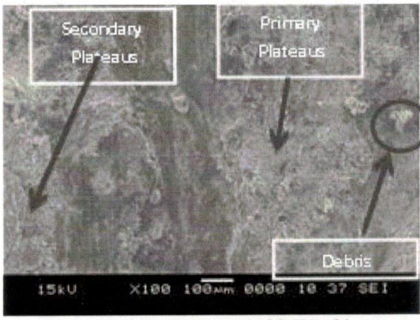

Fig.4 (f) Palm Ash 30 Wt. %

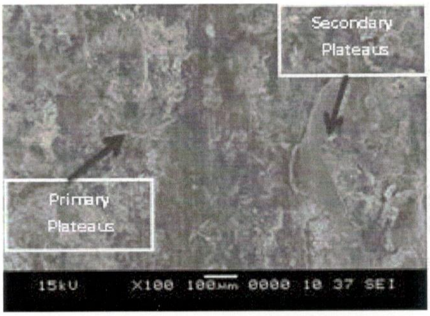

Fig.4 (g) Palm Ash 35 Wt. %

Fig.4 (a) to Fig.4(g) Shows the SEM morphology of different percentage palm ash at 3000 m sliding distance at 100X magnification.

From observation, the grooving on the surface has occurred and most of the scoring grooves showed wear surface and fine lines on the Fig.4 (a-g). At 1000 m to 1500 m sliding distance wear loss was increased when increased the palm ash content but at 2000 m to 3000 m sliding distance will change where wear loss was decreased when increasing the palm ash content.

It can be seen in Fig.4 (a), where the steel fiber has pull out and formed crater on the surface sample. It occurred due to heat generated during wear testing. In small percentage content of palm ash in sample are not effective in stabilizing the temperature at surface sample. The presence of pore/void also exists after wear sliding test and it can be seen in Fig. 4(b-d). In this figure also, it showed less plateaus and thin, it makes surface sample exposed to the stress bearing capacity between disc surface and it contributes to increase wear loss [15].

From observation on Fig.4 (e-g), grooving and crater exist after sliding wear test. Grooving and crater were reduced when increasing the percentage palm ash. In this study, palm ash can control wear loss and heat generated from wear test. From the morphology, plateaus existed where it reduces the contact surface between sample and disk surface during wear test. Also, it can reduce the mass loss of sample. In report Nidhi et al., (2006), any plateaus produced can covered the original surface and save the loss of ingredients during sliding and reduced wear lost [16].

CONCLUSIONS

In conclusion, palm ash been successfully incorporated into phenolic and improved the wear resistances of the composites.

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