Utilization of Corn Cob Waste as an Alternative Composite Material of Motorcycle Non-asbestos Brake Lining

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Abstract. One of the safety factors in riding a motorcycle is the braking system in which the brake lining plays an important role in the braking performance, therefore, application of an appropriate brake lining material which gives a low brake lining wear value is a must. The objective of this study is to evaluate the effect of brake lining material compositions on the value of brake lining wear. The brake lining was made from a mixture of corn cob powder, Al$_2$O$_3$, BaSO$_4$, and polyester resin with a certain composition. The brake lining wear value was then determined by the Ogoshi wear testing by varying the material compositions. The brake lining wear values were then compared to those obtained from the brake linings existing in the market, e.g. Texiar. The results show that the higher the concentration of the corn cob, the better the value of the brake lining wear. This is due to the nature of the corn cob that gives less wear value compared to Al$_2$O$_3$. It was found that the brake lining wear value of $2.8 \times 10^{-9}$ mm$^2$/kg, corresponding to the brake lining wear value of Texiar, was achieved at which the compositions of the corn cob powder, Al$_2$O$_3$, BaSO$_4$, and the polyester resin are 30, 30, 20, and 20 wt%, respectively. The result indicates that variations in the composition of constituent material have an influence on the brake lining wear value.

1. Introduction

Technological developments in various fields are very rapid, especially in the automotive sector. Motorcycle assembly manufacturers develop the capability of engine performance and technology to support it more rapidly in which the development is very significant in terms of aerodynamics and engine performance by increasing the power produced. With the development of vehicle performance at this time, an effective braking system is required and also as safety in driving. A good braking system must be able to support the power and speed of the vehicle where the most important part of the braking system is brake lining, which is the media that works to slow down or reduce the speed of the vehicle. To get maximum braking, brake lining is required with good and efficient braking capability, where the efficiency of the brakes is greatly influenced by the amount of friction coefficient of the brake lining. The quality of brake lining is influenced by several factors, e.g., the composition of the material, type of material, and hardness. Brake lining too hard causes the age of the drum or disc to be short, if it is too soft then the age of the brake lining will be shorter [1, 2].

The composite material is an alternative material that can be used to make brake pads. Other application of corn cobs can be found elsewhere [3-8]. In the development of composite technology, this progress has been very rapid due to the features of renewable properties as well as the strength to weight ratio which is high in stiffness, resistance to corrosion, etc., thereby reducing consumption of chemicals and environmental disturbances. The use of non-asbestos raw materials is preferred in
comparison to the use of asbestos-based materials. In addition to more environmentally friendly, non-asbestos-based raw materials also give a strong grip on braking temperatures above 300 °C and a better safety factor.

Brake linings made from non-asbestos materials usually consist of four to five types of fiber including kevlar, steel fiber, rock wool, cellulose, and carbon fiber which have long fibers, while the brake linings from asbestos only have one type of fiber, i.e. asbestos, which is a component that causes carcinogens. Since the brake linings only contain one type of fiber, it will experience a slippery effect in a wet condition. If the material uses non-asbestos brake linings that have several types of fiber, the slippery effect could be reduced. According to [9], the asbestos brake can only use a maximum of six types of material while non-asbestos using more than 12 types of material. Therefore, the asbestos brake can only be used up to 200 °C while non-asbestos last up to 360 °C.

In general, the brake friction material has, according to [10], three constituents of materials, e.g. binder, fiber material, and filler material. The binder consists of various resins including phenolic, epoxy, polyester, silicone, and rubber. The resin functions to bind various constituent substances in friction. The binder can form a matrix at a relatively stable temperature. Whereas, fiber both artificial and natural fibers serve to increase the coefficient of friction and increase the mechanical strength of the material. Artificial fibers include nylon, Cu-Zn, Al, carbon, rock wool, and glass fiber, while the natural ones include bamboo, hemp, coconut fibers, corn cobs, and many others.

Friction material in the components of motorcycle brake linings is a consumable material after use. Therefore, in making brake pads, the materials used must always be available continuously and will not be extinct. Indonesia is an agricultural country with many various plants, one of which is corn. Corn is widely used for human life, as well as its waste, which are cobs, stems, and leaves. However, the utilization of corn cobs is still very limited. Most corn cobs are used only for animal feed additives or are only used as fuel after going through the drying process under the sun, for instance. Cob has good properties such as hard and light, absorbent, inert, and decompose naturally [11]. Based on those properties, corn cobs, therefore, seem to be appropriate for making brake pads.

The objective of this study is to evaluate the effect of the brake lining material compositions made from corn cob powder, Al₂O₃, BaSO₄, and polyester resin on the value of brake lining wear. In addition, this study also attempts to utilize corn cob waste which is available in quite large amounts in Indonesia.

2. Materials and Method

2.1. Materials

The materials used in the study consist of corn cob powder, aluminum oxide (Al₂O₃), barium sulfate (BaSO₄), polyester resin, and catalyst. The corn cob powder is used as a fiber for the brake pad material, Al₂O₃ is for modifying friction levels and clean the rotor surface, BaSO₄ is used as a filler to improve the production process and acts as a lubricating oil in brake pads, the polyester resin functions as a binding agent for other ingredients, and the MEKP (Methyl Ethyl Ketone Peroxide) catalyst functions as a hardening agent in the brake pads material mixture.

2.2. Apparatus and Method

This research was conducted to determine the effect of variations in the composition of the mixture of materials on the value of brake lining wear and to evaluate the variation of the composition of the material that has a wear value that is close to that of the Texiar brand brake shoes.

In this study, specimens in the form of small blocks were made by varying the composition of the corn cob powder (10 – 30 wt%), Al₂O₃ (30 – 50 wt%), BaSO₄ (20 wt%), and polyester resin (20 wt%). The sizes of the corn cob powder, Al₂O₃, and BaSO₄ were ± 60 mesh, 75 and ± 250 μm, respectively, while the ratio of the polyester resin and the catalyst was 3:1.

To prepare the specimens, the corn cobs were first dried in an oven for a certain of time, the dried corn cobs were then crushed to powder using a milling machine. The corn cob powder, Al₂O₃, and
BaSO₄ with a total weight of 400 g were mixed and add certain amounts of the polyester resin and the catalyst in the mixture. Stir the mixture for some time to get a homogenous mixture. Pour the mixture into the mold and press with a hot press machine with a load of 2000 kg and then sinter at a temperature of 200 °C for 30 minutes. The prepared specimens were then tested for the wear test using Ogoshi High Speed Universal Wear Testing Machine (Type OAT-U) with the load of 3.18 kg, the finger plate of 14 mm, the width of the plate of 3 mm, and the distance of 100 m for 60 seconds. The revolving disc friction marks are then measured by a microscope (1 strip = 0.02631 mm).

3. Results and Discussion

As described earlier that three brake pad specimens, as seen in Figure 1, were made to be determined their brake lining wear values by use of the Ogoshi High Speed Universal Wear Testing Machine and the obtained values were then compared to the brake lining wear value of the Texiar, a brake lining brand existing in the market. The brake pad specimen compositions are presented in Table 1.

![Specimen 1](image1.jpg) ![Specimen 2](image2.jpg) ![Specimen 3](image3.jpg)

**Figure 1.** The brake pad specimens

| Specimen | Composition, wt% |
|----------|------------------|
|          | Corn cob powder | Al₂O₃ | BaSO₄ | Polyester resin |
| 1        | 10              | 50    | 20    | 20              |
| 2        | 20              | 40    | 20    | 20              |
| 3        | 30              | 30    | 20    | 20              |

From these variations, a brake pad specimen was then made through several processes with a total weight of 400 g. It can be seen that the size of each specimen is different. The difference in the size of this specimen is influenced by variations in the composition of the material. Specimen 1 is the one with the smallest size compared to the other specimens. Similarly, specimen 3 is the largest one compared to the others. This is due to the different composition of corn cobs and aluminum oxide powder. The specimens were then tested for the wear values and the results are presented in Table 2 and Figure 2. In addition to the three specimens, a similar wear test was carried out on the Texiar brand brake pad as a comparison and the result obtained was 1.50 × 10⁹ mm²/kg.

Apart from being influenced by variations in material composition, it is also influenced by the comparison of the weight of corn cobs and aluminum oxide. According to the variation in the specimen composition as in Table 2, the greater the percentage of corn cob powder and the smaller the percentage of aluminum oxide, the greater the size of the finished specimen.
Table 2. The Ogoshi wear value test results for three brake pad specimens

| Specimen | Corn cob powder (wt%) | Plate width (mm) | Plate radius (mm) | Load (kg) | Wear distance (mm) | Wear length (mm) | $W_s \times 10^9$ (mm$^2$/kg) |
|----------|-----------------------|-----------------|------------------|-----------|-------------------|----------------|--------------------------|
| 1        | 10                    | 3               | 14               | 3.18      | 100 000           | 2.16           | 8.50                     |
| 2        | 20                    | 3               | 14               | 3.18      | 100 000           | 1.84           | 5.20                     |
| 3        | 30                    | 3               | 14               | 3.18      | 100 000           | 1.50           | 2.80                     |

Figure 2. The specific wear values for the three brake pad specimens

Based on Figure 2, it can be seen that the smallest specific wear value ($W_s$) is found in specimen 3 (composition of 30 wt% corn cob powder) which is $2.80 \times 10^{-9}$ mm$^2$/kg and the largest is found in specimen 1 (composition 10 wt% corn cob powder which is $8.50 \times 10^{-9}$ mm$^2$/kg. The specimen 3, therefore, shows the best performance in comparison to the others and quite close to the Texiar wear value. The greater the addition of corn cob powder and the reduced percentage of aluminum oxide, the smaller the wear value. It can be concluded that corn cob powder has better wear resistance than aluminum oxide. Variations in the composition of constituent materials greatly influence the wear value.

4. Conclusion

The effect of brake lining material compositions made from a mixture of corn cob powder, Al$_2$O$_3$, BaSO$_4$, and polyester resin with a certain composition on the value of brake lining wear has been conducted. The results show that the specimen 3 with the composition of 30 wt% corn cob powder offers the lowest brake lining wear value and close to the wear value of Texiar.

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