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Use of bamboo fiber as a brake pad lining material and the influence of its portion on hardness and durability

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Abstract. This study aims to optimize non asbestos brake pad lining component to find their dynamic characterization. The brake pad component material was made from bamboo fiber, aluminum powder, fiber glass and polyester as matrix. The initial characterization consists of its hardness and wearness in the water and dry condition. The result is highest hardness 14.47 BHN more than existing brake pad 13.7 BHN. Wearness on Ogoshi in dry condition is lowest 0.00041 mm²/kg, while on water wearness variation 1 has lowest wearness 0.0062 mm²/kg, whether in oil wet condition variation 2 has lowest wearness 0.0003 mm²/kg. The characterization shows that the brake pad lining that we were made are close to existing characterization.

1. Introduction
This research was dominant to use natural fiber as green technology that recently issues, to substitute asbestos fiber that can cause lung disease. This research that using bamboo fiber, glass fiber and aluminum powder, and polyester as matrix, its wide to use natural fiber to substitute the asbestos component.

These materials were tested on strength with friction Ogoshi wear test method, and Wipro wear test Method. Its hardness tested with Brinell Hardness Test, followed by macro photographs, and testing of braking dynamics characteristics.

The strength of the composite material of these brake particles, greatly influenced by particle size, matrix material and the manufacturing process. Strength of the particle composite is obtained maximally in sizes from 0.01 to 0.1 mm, and also depend on the strength of surface bonding, pressing, and sintering [1]. The process is very rarely exposed to the producers of brake lining, so the need for research on materials and processes are need scientifically standard for brake lining. We hope this field of studying composite base natural fiber can be developed continuously.

The use of brake lining is usually no more than 10,000 contacts, especially for braking in daily use in city travel may be no more than 6 months [2]. In other uneven wear may result from less uniform pressure, due to improper mounting [3], so we hope to find materials that better on breaking characterization and healthy environment in this study.

2. Research purposes and virtue
The purpose of this research is to study on brake pad lining material, using variation of composition from bamboo fiber, glass fiber, aluminum powder, with polyester as matrix, for fair result of its hardness and wear and to characterize prototype of motorcycle brake lining by dynamometer test, to
obtain the parameters of braking, absorption of braking, braking time, temperature of braking, and also coefficient of friction brake pad in the variation of dry and wet condition (water and oil). The variation of composition is:

a. 40% bamboo fiber + 10% fiber glass + 10% aluminum (Al) + 40% polyester, as variation 1.
b. 30% bamboo fiber + 15% fiber glass + 15% aluminum (Al) + 40% polyester, as variation 2.
c. 20% bamboo fiber + 20% fiber glass + 20% aluminum (Al) + 40% polyester, as variation 3.

The virtue of this research are conducting applied research for the same field study using natural fiber on brake pad lining materials. Giving alternative of material using natural fiber for better health and environmental consideration and supports local contain materials and home industries among Surakarta.

3. Literature review

The research on friction brake pad by giving sintering time at compaction pressure of 10 minutes is conducted by [4]. Wear of a composite material is getting bigger or more easily worn can be affected by the amount of time given in the compaction process. When the emphasis time is greater than the wear rate is also getting bigger. The hardness value of a material is also affected by the amount of time the compression stresses are given in the process of making the brake lining materials. In making the brake pads, the value of the hardness of the canvas also affects the greater the compaction charged the harder the composite. Composite itself is influenced by several factors in the process of making from material to composite and several causes are: material variation, compaction load given and duration of compaction load, and sintering.

Low wear and high Brinell Hardness Number (BHN) are obtained by providing relatively lower formation pressures than other specimens. This is due to two possibilities [5]:

a. The separation of the resins as the binder of the composite mixture.
b. The resin bond strength is less than the formation pressure applied to the specimen at the time of the specimen preparation process.

The research on friction brake pads by providing improved sintering is conducted by [6]. With the higher sintering temperatures affect the wear rate. High temperature sintering causes the value of wear increases. Then the wear is higher. Increased sintering temperature also affects the hardness of the canvas. The higher the sintering temperature the hardness value will decrease.

Composite material is actually a lot in use of nature fiber, because the composite material can consist of organic and inorganic such as bamboo, wood, leaves, and so on [6]. We are unconsciously familiar with various types of composites.

4. Method

The tools that used in this research are measuring cup, electrical mixer, pressing load machine, thermometer, electrical oven, stopwatch, hardness tester, Ogoshi wear tester, Wipro wear tester and microscopic structural photograph. The procedure of the proposed method is explained as follow:

a. Bamboo fiber cut into less than 2 mm in order make discontinuous fiber.
b. Aluminum powder would be 60 mesh.
c. Fiberglass are also cut for 2 mm length.
d. Preparing mixing specimen conduct based on variation in table 1.
e. Mixed specimen pressed under 2.000 kg load, then sintered among 180°C.
f. Tested on Brinell.
g. Tested on Wearness.
h. Find friction coefficient.
### Table 1. Variation of mixing specimen.

| Bamboo fiber | Fiber glass | Aluminum Powder | Polyester 157 BQTN/ Phenolic |
|--------------|-------------|-----------------|-----------------------------|
| 40%          | 10%         | 10%             | 40%                         |
| 15%          | 10%         | 15%             | 40%                         |
| 20%          | 15%         | 20%             | 20%                         |
| 20%          | 15%         | 20%             | 20%                         |
| 25%          | 20%         | 25%             | 20%                         |
| 30%          | 20%         | 30%             | 20%                         |
| 20%          | 20%         | 40%             | 20%                         |
| 25%          | 25%         | 20%             | 40%                         |
| 30%          | 30%         | 30%             | 20%                         |

5. **Result and discussion**

#### 5.1. Hardness test

Figure 1 shows that variation 1 (40% bamboo fiber + 10% fiber glass + 10% aluminum (Al) + 40% polyester) is the highest hardness of Brinell Number. This variation is 7.4% harder than exiting material that we find. It tends have good wearness resistance, high hardness materials tend more less in wearness. It shows, that bamboo fiber is good contributed in hardness for this material. The material will be more using time in braking operation, but severe in temperature rising. Variation 2 (30% bamboo fiber + 15% fiber glass + 15% aluminum (Al) + 40% polyester) is also higher than existing part, although more aluminum, it tends good in heat reducing during friction.

\[
BHN = \frac{2P}{\pi D(D - \sqrt{D^2 - d^2})}
\]

Where BHN is the Brinell Hardness Number, \(P\) is the load (15.625 kg) and \(d\) is the penetrator diameter (2.5 mm).

![Figure 1. Variation of Brinell Hardness Braking Lining.](image-url)
5.2. Oghosi wear test

Figure 2 shows that variation 1 is the best in wearness on dry condition, but less than existing material. It not more than 0.0002 mm³/kg, so the breaking lifetime is not to different. Variation 2 shows better in water and oil wet condition. It shows that bamboo fiber is not affected in wet condition breaking operation, because of Ori bamboo fiber is solid and harder than other natural fiber. Variation 3 is less in hardness and wearness.

![Figure 2. Oghosi wearness for braking wet and dry condition.](image)

5.3. Wipro wear test

Figure 3 shows that the best wearness is variation 3 (20% bamboo fiber + 20% fiber glass + 20% aluminum (Al) + 40% polyester). It is more in fiber glass and aluminum, make more tight in compaction load and shearing force resistance. Variation 3 is not wide difference with existing breaking properties.

![Figure 3. Comparison of Wipro wearness test for braking wet and dry condition.](image)
Figure 4 shows that high power has high torsion resistance. It means high torsion has high coefficient of friction on these braking pad materials. Furthermore, all of these variation is not wide difference on coefficient of friction.

![Electrical Power needed for braking](image)

**Figure 4.** Electrical Power needed for braking.

6. **Conclusion**

From the discussion in section 5, we can conclude that for Brinell hardness, the material of brake lining with the composition of Variation 1 is the hardest, with hardness price of 14.47 BHN harder than the product on the market with the value of hardness 13.7 BHN, although for Ogoshi Wear Testing on dry conditions, the brake lining material with Variation 2 has the lowest wear value of 0.00041 mm²/kg, which is slightly larger than the product on the market with 0.00014 mm²/kg wear.

For Ogoshi wearing tests wet conditions with water, it is found that, brake lining material with the lowest Variation 1 of its wear is equal to 0.0062 mm²/kg, but still slightly higher than the brake lining of the market that is equal to 0.0032 mm²/kg Waste Testing Ogoshi Wet condition with oil, it is found that, the material of brake lining with the lowest 2 of its wear is 0.0033 mm²/kg, but still slightly higher than the brake lining material of the market that is equal to 0.00014 mm²/kg.

In Wipro Wear Tests on dry conditions, the brake lining material with Variation 3 has the lowest wear value of 0.0014 mm²/kg, which is the same from the product on the market with 0.00014 mm²/kg wear. For Wipro Wear Tester Wet condition with water, it was found that the brake lining materials with the lowest 2 and 3 variations were 0.144 mm²/kg, but still slightly higher than the brake pads of the market at 0.0007 mm²/kg. Wipro Wear Testing Wet condition with oil, it is found that, brake lining material with the lowest 3 of its wear is 0.0011 mm²/kg, but still slightly higher than the brake pads material of the market that is equal to 0.00014 mm²/kg.

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