Development Brake Pad From Composites Of Coconut Fiber, Wood Powder And Cow Bone For Electric Motorcycle

Ahmad Kholil, Siska Titik Dwiyati, Januar Parlaungan Siregar, Riyadi, Sulaiman

Abstract: The research aims to develop a brake pad from composite wood powder, coconut fiber, and cow bone. The characteristics of hardness, braking time, wear and coefficient of friction compared to the commercial brake pad had been studied. As a matrix was used polyester resin. Test samples were produced by varying content of coconut fiber, wood powder, and cow bone. Specimen A with a composition of 40% coconut fiber, 0% wood powder, and 10% cow bone. Specimen B with a composition of 0% coconut fiber, 40% wood powder, and 10% cow bone. Specimen C with a composition of 20% coconut fiber, 20% wood powder, and 10% cow bone. And Specimen B with a composition of 25% coconut fiber, 25% wood powder, and 0% cow bone. The percentage of polyester resin was made constant by 50% for all specimens. Commercial brake lining became the comparison of this study. Specimen C with a composition of 20% coconut fiber, 20% wood powder, 10% cow bone has closer hardness characteristics to the commercial brake pad. Braking time of specimens C is closer to braking time on commercial brakes. The brake pads of specimens C have a rough surface so the braking capability is better than the other. Specimen C is more resilient so that they have lower wear. Therefore this study prove that coconut fiber, wood powder, and cow bone can be used for motorcycle brake pad materials through the appropriate composition comparison.

Keywords: composite, wood powder, coconut fiber, cow bone, brake pads.

1.INTRODUCTION

Brakes are a vital component of a vehicle that serves to help reduce speed, stop the vehicle and maintain the speed of the vehicle when passing on a downhill road [1]. Brakes are a very important regulator of motion and vehicle safety. Brakes that do not function properly can cause accidents because they crash into a vehicle that stops suddenly. The vehicle can't be controlled and finally crashes. Crash into a vehicle when passing a downhill road or falling into a ravine. This is due to the ability of the braking force which depends on the characteristics of the brake pad material. Brake pads are steel backing plates with friction material bound to the surface facing the brake disc [2]. The test equipment used was a brake pad test rig for determining the brake pad wear, brake disk temperature rise, and braking time under different braking conditions [3]. The brake pads generally consist of asbestos fibers embedded in a polymeric matrix along with several other ingredients. The use of asbestos fiber is been avoided due to its carcinogenic nature. Therefore a new asbestos-free friction material and brake pads have been developed [2].
Coconut fiber shows a good stiffness and is used in products such as floor mats, doormats, brushes, mattresses, coarse filling material, and upholstery. Coconut fiber, obtained from unripe coconut, is a natural fiber extracted from the husk of coconut [4][5]. One coconut fruit produces 0.4 kg of husk containing 30% fiber. Coconut fiber consists of fiber and cork which connects one fiber with other fibers. Coconut fiber has the following physical properties: rough, colored, and stiff. The composition of the content of coconut husk includes hemicellulose (8.50%), cellulose (21.07%), lignin (29.23%), pectin (14.25%) and water (26.0%). Cellulose a compound like clay, insoluble in water and found in the cell walls of plant protectors [6]. Fiber an essential part of coir. Each coconut contains 525 grams of fiber (75% of coir) and 175 grams of cork (25% of coir) [7]. The wood powder a waste produced by wood processing such as sawdust [5][8]. Sawdust possesses characteristics similar to wood but due to the fact that it is in particles, some structural properties have been altered. However, in general, the wood powder has chemical compositions such as hollocellulose (70.52%), cellulose (40.99%), lignin (27.88%), pentosan (16.89%), ash (1.38%), and water (5.64%) [9]. Fig. 2 shows wood powder. An investigation was carried out on the use of sawdust to develop brake pads [5][10]. Cow bone being natural animal fiber is expected to have good surface compatibility in addition to the structural compatibility requirements as biomaterials [11]. The main content in the form of inorganic material which is hydroxyapatite $Ca_{10}(PO_4)_6(OH)_2$, calcium phosphate, carbonate and contains 1% citric acid. This composition can add strength and hardness to the composite. The combination of collagen and calcium makes complex tissues hard, strong and rigid with a melting point temperature of cow bone of 1227^oK. Cow bone resin composites as a friction material for automobile braking systems have been developed observed that increasing interfacial bonding as the cow bone particle size decreased [12]. Palm kernel fibers (PKFs) was used to produce asbestos-free automobile brake pads [13]. Similarly, the development of asbestos-free brake pad using bagasse was investigated to replace the use of asbestos whose dust is carcinogenic. The sieve bagasse was used in the production of brake pad in a ratio of 70% bagasse - 30% resin using compression molding [2]. A research was carried out on the use of banana peels [14] to replace asbestos in brake pad with phenolic resin (phenol formaldehyde) as binder. The resin was varied from 5 to 30% weight in an interval of 5% weight. Different previous studies [5] using material composite of coconut fiber, wood powder and green mussel shell. This research, therefore, aimed to develop brake pad from agro-waste material composite of coconut fiber, wood powder, and

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cow bone to investigate the characteristics of hardness, friction coefficient, braking time and wear as compared with the commercial brake pad.

2 MATERIALS AND METHODS

2.1 Materials
Materials for this test were taken from waste. Coconut fiber was taken from the peel of coconut fruit, wood powder from sawdust and cow bone is processed beef waste that is dry and not utilized. All samples used the same polyester resin composition of 50%. It is hoped that there will be an effect with changes in the composition of coconut fiber, wood powder, and cow bone on a fixed polyester resin matrix. The process of mixing ingredients started with filtering coconut fiber and wood powder using a mesh filter of size 40 µm to get fine material. Then mixing done in the container so that the mixing of coconut fiber and the wood powder was evenly mixed [5]. Mixing ingredients according to Table 1, as follows: The method of making specimens is the same as the method used by Kholil et al [5]. The formulation was mixed in a container, stirred to reach a homogeneous mixture and transferred to the mold plate with dimensions of 100 mm x 100 mm x 10 mm at a pressure of 2 tons for 60 minutes. The results were dried by the oven and naturally by sunlight. The material is cut partially with a size of 25 mm x 25 mm x 10 mm for samples of hardness testing and friction coefficient testing. The remaining part of the canvass material then cut with a saw following the size of the commercial brake lining. The lining material is glued then affixed to the bearing. The test specimens can be seen in Fig. 1.

2.2 Hardness testing
Hardness testing based on ASTM E 92 using the Vickers FV-300e test equipment [5]. Each sample was tested three times and taken data-average. For hardness testing is given a load of 3 kg.

TABLE 1
THE COMPOSITION OF SPECIMENS

No.	Composition (% weight)	A	B	C	D
1	Wood powder	0	40	20	25
2	Coconut fiber	40	0	20	25
3	Cow bone	10	10	10	0
4	Polyester resin	50	50	50	50

TABLE 2
STATIC FRICTION COEFFICIENT TEST

Spec.	Test 1	2	3	4	5	6	7	8	9	10	Average
A	25°	26°	25°	25°	26°	27°	25°	25°	26°	26°	25.6°
B	22°	23°	22°	22°	23°	23°	22°	22°	21°	23°	22.3°
C	21°	20°	21°	21°	22°	20°	21°	21°	22°	21°	21.0°
D	24°	25°	24°	24°	24°	25°	25°	24°	23°	24°	24.2°

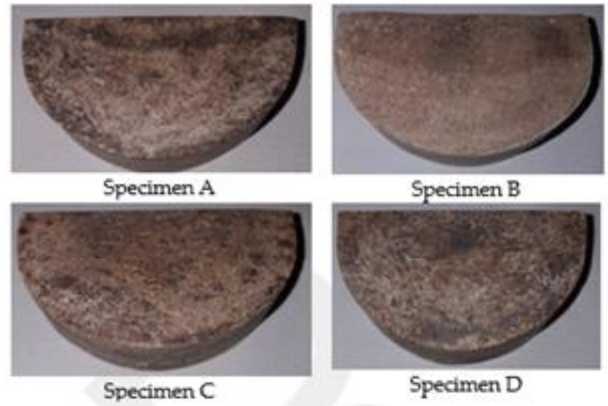

Fig. 1. Test specimens

2.3 Friction coefficient
Friction coefficient of each test specimen was determined with the aid of an inclined plane and a 90^0 wedge as illustrated in Fig. 2. Each specimen was placed on the inclined plane with the wedge in place. The wedge position was varied to increase the inclination angle until the test sample was just about to slide. down the plane. The resulting coefficient of static friction (µ) was calculated from Equation 1 [12] [15].

$$\mu_s = \tan\theta \qquad (1)$$

where θ is an angle of repose at the instant of sliding.

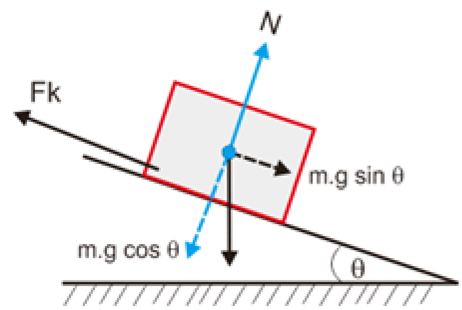

Fig. 2. Analysis of coefficient of static friction.

2.4 Braking test
The braking test is based on distance and time measured from the time of braking until the bicycle stops. Braking distance measurements are carried out using a meter. While the braking time is done with a stopwatch. Braking tests are carried out at speeds of 10 km/h, 15 km/h and 20 km/h. Measurement method by marking a line on the road as a sign of the start of braking. Then the vehicle starts at a constant speed within 200 meters. After arriving at the starting line the braking of the vehicle is braked until it stops so that the distance and time of the braking data will be obtained. This test is carried out as many as three and the average data is taken.

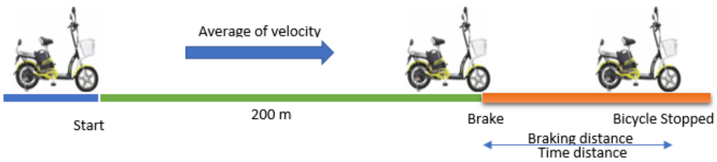

***Fig. 3**. Illustration of braking test*

2.5 Wear testing

This test aims to obtain wear data after braking testing at speeds of 10 km/h, 15 km/h and 20 km/h. Sample testing using disc brake pads. The test begins by weighing the brake pads using a digital scale to measure the initial weight of the brake pad. After braking testing was carried outweighing again to obtain the mass of disc brake pads after testing. The mass difference between the brake pads after testing with the mass of the brake pad before testing becomes the mass reduction data of the disc brake pads. For this test, the data was taken using Equation 2.

$$wear = mass\ before\ testing - mass\ after\ testing \qquad (2)$$

2.6 Manufacture brake pad

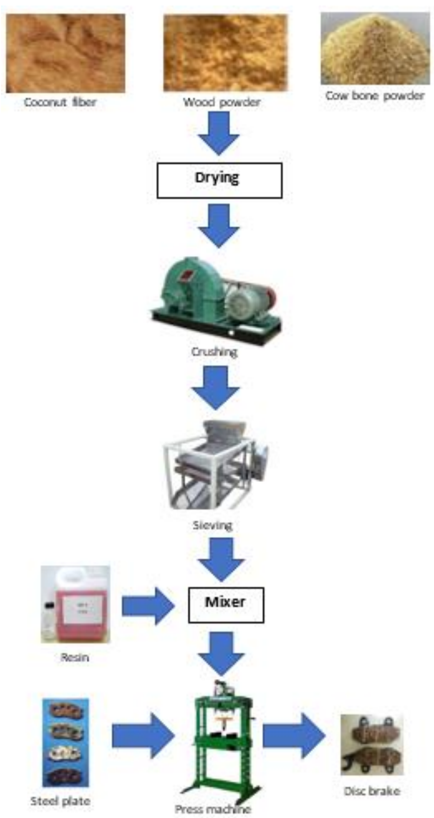

Fig. 4. Manufacture brake pad

Fig. 4 shows the manufacturing process of making a brake pad. The process starts from raw material into brake pad products. For the manufacturing process requires mold, press machine, mixer, sieving machine, crushing, and drying.

3 RESULTS AND DISCUSSIONS

The brake pads for electric motorcycle developed were subjected to various tests; these are hardness, coefficient of friction, braking test, and wear characteristics. The test results carried out were analyzed to determine the potential of the asbestos-free brake pad for application as a brake pad material. The test results were compared with the corresponding properties of conventional asbestos-based brake pads and from previous studies. The results made clear the effect of the mechanical constituent properties and braking characteristics of the developed friction material considering the manufacturing procedure employed.

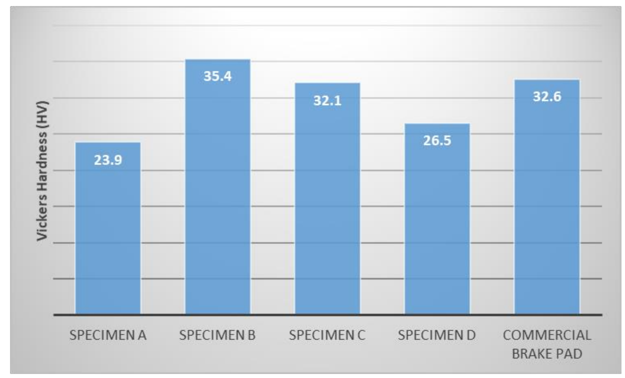

Fig. 5. *Vickers hardness of specimens*

The hardness values are shown in Fig. 5, shows variation of coconut fiber, wood powder and cow bone composition to the hardness value. The hardness of the specimens varies non-uniformly because of the percentage of coconut fiber, sawdust, and cow bones. Specimen B with composition of 0% coconut fiber, 40% wood powder, and 10% cow bone has the highest hardness value of 35.4 VHN. The hardness decreases along with increasing of composition coconut fiber or reduction of wood powder. The hardness value of specimen A with composition 40% coconut fiber, 0% wood powder, and 10% cow bone is 23.9 VHN. The hardness value influenced by lower cellulose content in coconut fiber, it is about 21.09% [6] compared with wood powder which has 40.99% of cellulose [9]. The lower cellulose content in coconut fiber brings on the mechanical properties of coconut fiber is softer than wood powder [5]. The addition of cow bone powder as much as 10% to the composite affects the value of hardness. Specimens B and C have a higher hardness value than specimen D due to the content of cow bone particles which results in increased contact surface area and increased bonding ability with resin [12]. Specimens C have closer hardness characteristics to the commercial brake than specimen A, B, and D. Table 2 shows the results of the static friction coefficient test. Tests carried out ten times and the average value is taken. The average value of the angular magnitude is then entered into equation 2, the result is the coefficient of friction values in Fig. 6. It presents the results of the average friction coefficient for each composition of brake pads made from wood powder, coconut fiber and cow bone with parameters used. The coefficient of friction is reduced due to changes in the composition of wood powder and coconut fiber. The value for brake pad with specimen A is the highest with a coefficient of friction of 0.47 while specimens B, C, and D have 0.41, 0.38 and 0.44, respectively. The coefficient of friction of conventional brake pads is usually in the range of 0.3 - 0.4[12]. It can be concluded that the developed specimen A brake lining meets the requirements above the range for conventional brake pads. By comparison, the friction coefficient of brake pads developed by specimens A, B, C, and D varies above the average value of commercial brake pads (0.35). The coefficient of friction of the brake lining developed was slightly higher than that obtained in previous studies [2][12][14]. Specimens C have closer friction coefficient characteristics to the commercial brake than specimen A, B and D.

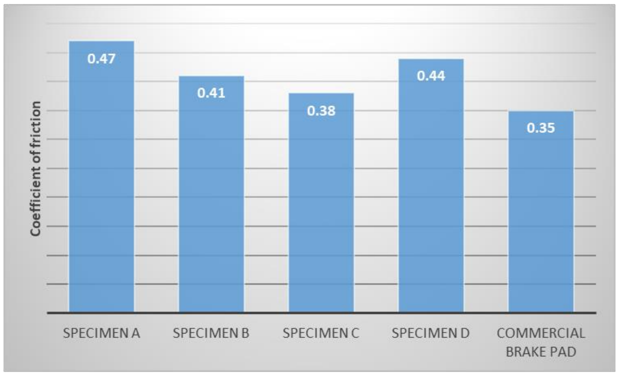

***Fig. 6**. Static friction coefficient*

The braking time was obtained from the braking test measurement. Fig. 7 shows Specimen C with a composition of 20% wood powder, 20% coconut fiber and 10% cow bone has a shorter braking time than others. Specialization C takes 1.2s to stop electric bicycles, this time is not much different from commercial brake pads. Specimen A is much longer braking time because the content of 40% coconut fiber and 10% bovine bone is softer compared to other specimens.

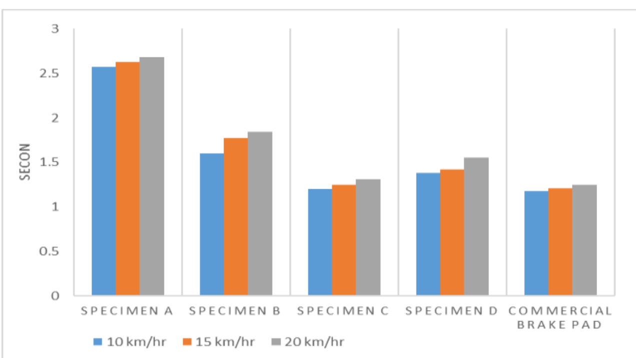

***Fig. 7**. Braking time analysis.*

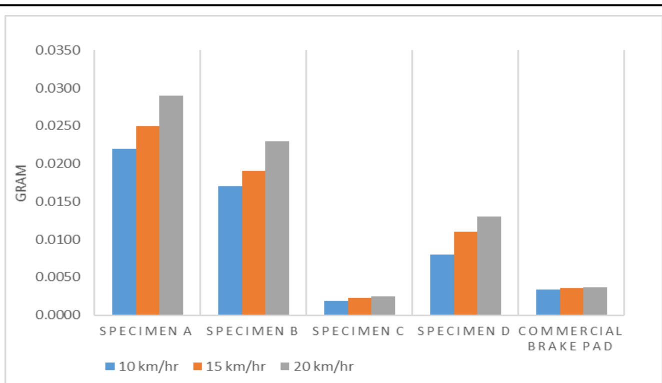

***Fig. 8**. Wear analysis.*

Fig. 8 shown relation between wear of brake pad to composition of wood powder, coconut fiber, and cow bone after the braking test. The wear varies depending on the composition of the material. This graph as a similar trend to the hardness value (see fig. 5). The increasing in composition wood powder contributed to increasing hardness value which has affected to decreasing wear of brake. From Fig. 8, it can been seen that specimens C have lower wear than specimen A, B, D, so that they have higher wear-resistant than others. The lower wear rate at a lower particle size of the brake pad formulation can be attributed to the interfacial bond between the particle and the resin, which reduces the possibility of a particle pull out [12].

Fig. 9. Shoe brake pad

Fig. 9 shows the results of manufacturing shoe brake pad for electric motorcycles. This brake pad has been tested according to the standard. The brake lining is expected to be known by the public and investors.

4 CONCLUSION

Specimens C have closer characteristics to the commercial brake than specimen A, B and D. Specimen C with the composition of 20% coconut fiber, 20% wood powder, 10% cow bone has closer hardness characteristics to the commercial brake. Specimens C contain coconut fiber composition so that they have lower hardness value because the mechanical properties of coconut fiber are softer compared to wood powder. The value for the friction coefficient of specimen C is 0.38 while The coefficient of friction of conventional brake pads is 0.35. It can be concluded that the developed specimen C brake lining meets the requirements above the range for conventional brake pads. By comparison, the friction coefficient of brake pads developed by specimens A, B and D varies above the average value of commercial brake pads. Braking time of specimens C is closer to braking time on commercial brakes. The brake pads of specimens C have a rough surface so the braking capability is better than the other. Specimen C is more resilient so that they have lower wear. Therefore the results of this study prove that coconut fiber, wood powder, and cow bone can be used for motorcycle brake pad materials through the appropriate composition comparison.

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