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ANALYSIS OF OIL ABSORPTION AND FRICTION COEFFICIENT OF BAMBOO POWDER, COCONUT POWDER, GLASS POWDER, AND COPPER POWDER COMPOSITES FOR CLUTCH PADS

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Abstract

This study aims to determine the characteristics of the absorption test with SAE 10W-30 and the friction coefficient test with the ASTM D 3702-94 test standard on composite clutch pads made from bamboo powder, coconut powder, glass powder, and copper powder. It is based on the considerations that there are abundance of natural resources of bamboo and coconut with that is still not optimally utilized as well as the discovery of several hazardous clutch lining (asbestos) basic material properties. In each test, each composition variation was tested 3 times and from the data, the average value of the composition variation was taken. Based on this research, the specimen with the highest oil absorption value is specimen combination 3 (BB20KL20CU0KC20) with an absorption value of 17.98% and the specimen with the lowest absorption value is specimen combination 2 (BB20KL20CU5KC15) with an absorption value of 4.88%, and the specimen with the highest percentage change in volume is specimen combination 1 (BB20KL20CU10KC10) with a percentage of 3.30%, and the specimen with the lowest percentage change in volume is specimen combination 2 (BB20KL20CU5KC15) with a percentage of 1.01%. From the results of the combined friction coefficient test, specimen 3 (BB20KL20CU0KC20) has the highest friction coefficient value of 0.54526 and specimen 2 (BB20KL20CU5KC15) has the lowest friction coefficient value of 0.16923.

Keywords: Clutch Pads, Composite, Absorption, Friction Coefficient

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1. Introduction

Technological advances affect various aspects of life like economic, political, social, and cultural. The automotive world, both motorbikes and cars, is always progressing[1].

Indonesia is rich in natural fibers. Some natural fibers become organic waste if not used for something that human needed. One of potential utilization is for composite material, which can be used for automotive components[2], and which has good mechanical properties.

Investigations of mechanical properties have been carried out by material researchers including metal[3,4] and composite materials[5,6,7]. Among them, there were an investigation of the effect of fiber length, fiber concentration, alkali treatment and coupling agent on the mechanical properties of composite[8], the fiber content and hardener fraction effect on the mechanical properties of epoxy resin composite materials[9], and also the percentage of oil palm fiber content effect on the Fatigue cycle of Axial Load of Resin Matrix Composites[10]. Studies related to the mechanical properties of composite materials is due to the widespread use of composite materials to replace metal materials[11]. For example, polymer composite materials have almost replaced automotive components, starting from the interior, dashboard, steering wheel, bumpers etc.[2,12].

On the other hand, glass waste is one of the solid wastes that has not been utilized properly. The availability of glass waste are 0.7 tons annually, based on estimates from 26 big cities in Indonesia which producing 38.5 million tons of waste annually[13].

Clutch is one of the components of a motorized vehicle that functions to connect or connect two shafts with machine elements that continuously or occasionally must rotate with the shaft. At this time, clutch pads on motorbikes are usually made of hazardous materials, namely asbestos, which can endanger human health. Asbestos is declared as the most dangerous industrial material because it is not environmentally friendly[14]. Asbestos dust if inhaled in high enough concentrations can cause Mesothelioma disease (malignant tumors in the lining

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of the lungs)[15]. Therefore, we need a clutch pad with not harmful material to human health, namely composite. Composite is a material that is produced from combining two or more basic materials that are arranged so as to get a new material[16].

From several previous studies of composite materials in Indonesia, the more coconut fiber, the better the mechanical properties produced, i.e.: tensile stress of 13.576 N/mm^2, tensile strain of 2.577%, impact energy value of 27.900 joules, and density of 1.356 gr/cm^3[17].

The use of bamboo fiber in the process of making composite brake pads with hazelnut shells as a base material can reduce wear rates and increase the value of the coefficient of friction compared to the use of reinforcement from coconut fiber[18]. The smaller the particle size of the glass powder increases the hardness value of the brake pads and decreases the wear value of the brake pads[13]. The addition of 40% Aluminum (Al) powder and 20% copper (Cu) powder produced a composite with a wear value of 0.14 mm/hr while the addition of 30% Aluminum (Al) powder and 30% Copper (Cu) powder produced a composite with a wear value of 0.1 mm/hour, it can be concluded that the addition of copper powder decreases the wear value[19]. The function of the resin is to bind laminate and laminate with filler (*core*). The tensile strength of the resin must be higher than the bending strength so that it is difficult for delamination to occur between the *skin* and the *core.* The resin must also have resistance to chemicals and heat so that the adhesive power is not easily damaged[20]. Therefore, the addition of copper powder in this study is expected to reduce the wear value in order to obtain a high value of the friction coefficient. This research is a continuation of several previous studies where the composites used in this study were bamboo powder, coconut powder and added by glass powder and copper powder to find out their characteristics on oil absorption, friction coefficient and microstructure of the specimens.

2. Experimental and Procedures

The method used in this research is experimental research. The stages carried out in the process of testing composite materials with the composition of bamboo powder, coconut powder, copper powder and glass powder with an epoxy resin matrix in this study are as follows:

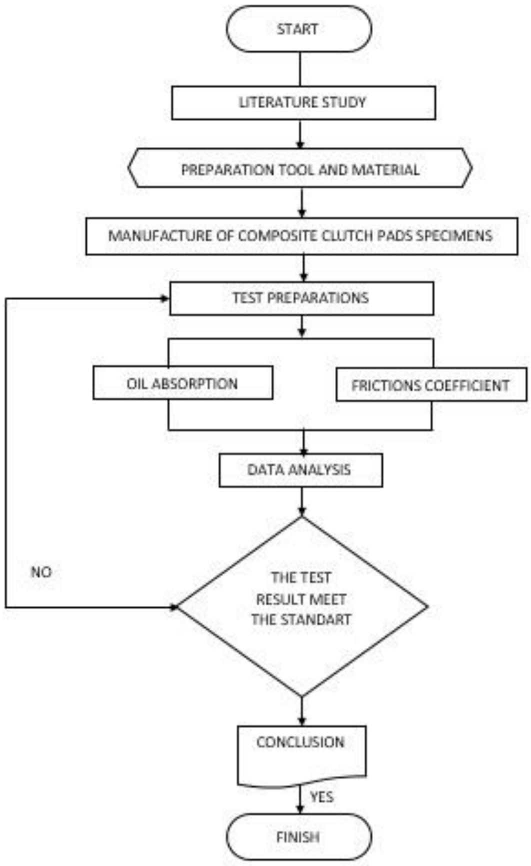

Fig. 1. Research flowchart

Fig. 1 shows a flowchart in testing composite materials made from bamboo powder, coconut powder, glass powder and copper powder to test oil absorption, friction coefficient and microstructure, the following steps are explained.

2.1 Literature Study

The initial stage was to study the literature on previous theories and calculations, in order to be able to discuss how to conduct research on the effect of composite strength based on bamboo powder, coconut powder, glass powder and copper powder from research that had been carried out by other people before.

2.2 Preparation of Tools and Materials

At this stage, tools and materials are prepared for the purposes of making specimens. The tools prepared include specimen molds according to the requirements of the test size, digital scales, calipers, mesh (100), planer machines, tribometer machines and digital microscopes. The materials prepared were bamboo powder, coconut powder, glass powder, copper powder and epoxy resin along with the hardener.

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Fig. 2. Tube specimen mold

Fig. 3. Tribometer (pin on disc)

Fig. 4. Immersion oil

2.3 Preparation of Powder Materials

All powders underwent a repeated grinding process 10 times using a blender to produce powder that could pass through the 100μ mesh process, where the maximum grain size that could pass was 0.15 mm.

a. Coconut Powder

The coconut coir, which has been separated by long fibers, is ground again using a blender repeatedly until it passes through a 100-mesh sieve.

Fig. 5. Coconut powder

b. Bamboo Powder

The bamboo powder used is apus bamboo powder (rope) which is shaved with a shaver machine. Because the bamboo powder obtained was still in the form of flakes, the refining process was repeated until the grains had a maximum size of 0.15 mm.

Fig. 6. Bamboo powder

c. Copper Powder

The copper powder to be used is obtained from the rest of the turning in the lathe workshop which is grinded repeatedly with 10 repetitions using a blender.

Fig. 7. Copper powder

d. Glass Powder

The glass powder to be used is obtained from glass waste around the residence, crushed by grinding. Then grind it repeatedly with a blender until it passes a 100-mesh sieve.

Fig. 8. Glass powder

In this study, the ratio between resin and hardener was 1:1, according to the provisions.

2.4 Specimen Preparation

The process of making composite clutch pads specimens in this research follows the powder metallurgy method. Steps that must be conducted in making the composite using this method including preparation of the composite ingredients, mixing the composite ingredients, pressing or compact on print the composite ingredients, then warming up or sintering. The effect of sintering to the properties of

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material have been conducted by many researchers, one of them is research on the magnetic properties of iron oxide[21].

The specimen preparation follows the following steps:

1. Material Mixing

The coconut powder, bamboo powder, copper powder, and glass powder which already screened are mixed up with resin according to the compositions in Table 1.

Table 1. Material composition combinations

Run	Powder Composition (%)				
	Coconut	**Bamboo**	**Copper**	**Glass**	**Resins**
1	20%	20%	10%	10%	40%
2	20%	20%	5%	15%	40%
3	20%	20%	0%	20%	40%

With reference to the composition variation in Table 1, volume fraction calculation of composite ingredient from each specimen combination is conducted to determine the weight of the material ingredient needed in accordance with the volume of the mold rectangle 112 cm^3, volume print tube 113.04 cm^3, and density of each ingredient in Table 2.

Table 2. Density composition

Material	Density (g/cm^3)
Bamboo powder	0.39
Coconut powder	1.150
Glass powder	2.579
Copper powder	8.9
Epoxy resins	1.2

To determine the weight of the material or the amount (grams) needed with reference to the composition, the volume fraction formula is used as follows:

$$\%_{Composite} \times V_{Total} = V_{Composite} \quad (1)$$

where:

$V_{composite}$ = Volume of composite required (cm^3)

V_{Total} = Required mold volume (cm^3)

From Eq. (1), the weight of the material is found as follows:

$$V_{Composite}\ x\ \rho_{\ material} = W_{Material} \quad (2)$$

2. Compaction Process

Compaction or pressing process is conducted after composite ingredients have been mixed equally and put into the print. The compaction is carried out slowly by using a 5000-psi pressure compactor for 45 minutes in room temperature. This method is called cold compressing.

Fig. 9. Compaction tool

3. Warming Up Process

After pressing, the next process is heating, i.e., the heating process at a certain temperature with a certain holding time with the aim of strengthening the bond between the compacted powder surfaces. This process is carried out by inserting the molded material that has been pressed and then heating it to a temperature of 130°C during 45 minutes. After it is heated, it is then allowed to stand at room temperature for about 3 hours and then the cutting process can be carried out.

Fig. 10. Electric oven

2.5 Specimen Testing

In this study, 2 types of testing are carried out, namely oil absorption test and friction coefficient test. Before testing, the specimen is cut and shaped in accordance with the test standards on the test equipment as depicted in Fig 11 and Fig 12.

Fig. 11. Cutting process

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Fig. 12. Sanding process

a. Oil Absorption Test

The oil absorption test in this study is the immersion method using engine oil with specification of 10W-30 for 48 hours. Before testing, a weighing process must be carried out both before and after immersion in order to know the mass changes of the tested specimens. Specimens weighing, measurement, and soaking are shown in Fig. 13, Fig. 14, and Fig. 15 respectively.

Fig. 13. Specimen weighing

Fig. 14. Specimen measurement

Fig. 15. Specimen soaking process

The oil absorption capacity of the composite is calculated using the following formula[22]:

$$\frac{(W_1 - W_0)}{W_0} x\, 100 \quad (3)$$

where:
W_0 = weight before immersion (gram)
W_1 = weight after immersion (gram)

The volume increase of the composite is calculated using the following formula:

$$\frac{(V_1 - V_0)}{V_0} x\, 100 \quad (4)$$

where:
V_0 = volume before immersion (mm^3)
V_1 = volume after immersion (mm^3)

b. Friction Coefficient Test

Friction coefficient test in this study using pin on disc tribometer, where specimen will turn and rub with pin which is given certain load. Then, sensors detect the movement of the pin to get the results of the friction coefficient test specimen. The specimen consists of five variation composition clutch pads composite. The steps of getting the pin friction coefficient on disc are as follows:

1. Prepare the specimen with cutting and sanding to get a size according to the standard of the test equipment i.e., 60 mm in diameter and 8 mm in thickness.

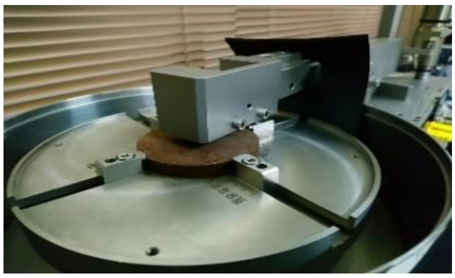

Fig. 16. Friction coefficient testing process

2. Turn on the pin on disc tribometer.
3. Do calibration by putting specimen on the test tool. The pin that has been given a load of 30 N is adjusted to the position of beginning testing and arrange the track friction pin on the diameter of 40 mm. Then, set on the test tool software to zero position.
4. Set the duration of the test to 15 minutes and the rotation speed to 200 rpm on the test tool

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software.

5. Start testing with push start on the software.
6. The specimens are tested 3 times for each composition variation and the results obtained are averaged to obtain the friction coefficient value of each compositional variations.

3. Results and Discussion

3.1 Oil Absorption Test

The oil absorption capacity which are calculated using Eq. (3) are shown in Table 3. Whereas, changes in the volume of the test specimens due to oil absorption on the composite clutch pads which are calculated using Eq. (4) are shown in Table 4.

Table 3. Oil absorption capacity

Run	Initial Weight	Average	Final Weight	Average	(%)
1A	5.8		6.4		
1B	5.8	5.90	6.5	6.56	11.18
1C	6.1		6.8		
2A	5.5		5.8		
2B	5.4	5.53	5.8	5.8	4.88
2C	5.7		5.8		
3A	3.7		4.2		
3B	3.8	3.67	4.7	4.33	17.98
3C	3.5		4.1		

Table 4. Increase in oil absorption volume

Combi-nation	Average Volume Before Immersion (mm^3)	Average Volume After Immersion (mm^3)	Volume Increase (%)
1	4070.5	4208.2	3.30%
2	4411.1	4455.8	1.01%
3	4082.2	4192.9	2.71%

This oil absorption test was carried out to determine the absorption value and percentage of volume change of composite clutch pads, data obtained was the average value of 3 test specimens in each variation of the composite composition. The effects of variations in the composition of composite clutch pads materials on the oil absorption and volume increase are shown in Fig 17 and Fig. 18.

Based on the graph in Fig 17, it is found that the specimen having the highest absorption value is Combination 3 composed of 20% coconut powder, 20% bamboo powder, 0% copper powder, and 20% glass powder, while the specimen with the lowest absorption value is Combination 2 composed of 20% coconut powder, 20% bamboo powder, 5 % copper powder, and 15% glass powder.

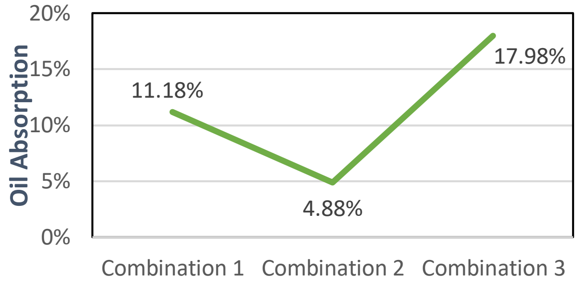

Fig. 17. Oil absorption capacity test results

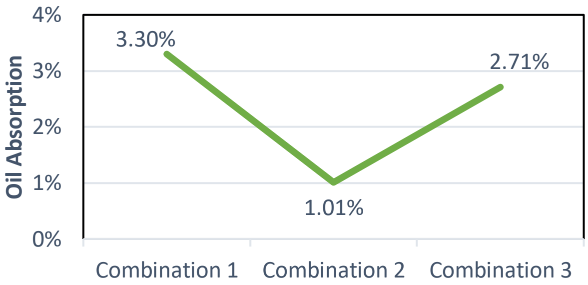

Fig. 18. Increase in oil absorption volume test results

Based on the graph in Fig. 18, it is found that the specimen having the highest percentage change in volume is Combination 1 composed of 20% coconut powder, 20% bamboo powder, 10% copper powder, and 10% glass powder with a percentage increase in volume of 3. 30%, and the specimen with the smallest percentage change in volume is Combination 2 composed of 20% coconut powder, 20% bamboo powder, 5 % copper powder, and 15% glass powder. From the data of the oil absorption test results both for the changes in size and the increase in volume due to absorption, it can be concluded that more copper powder can reduce the oil absorption capacity of a composite.

3.2 Friction Coefficient Test

The testing of friction coefficient was conducted using tribometer. Specimen testing was carried out 3 times for each variation of the composite clutch pads. The average data of the friction coefficient test results is shown in Table 5.

Table 5. Friction coefficient test results

BB20KL20 CU10KC10	BB20KL20 CU5KC15	BB20KL20 CU0KC20
0.23084	0.16923	0.54526

Friction coefficient testing is done to determine the value of the coefficient clutch pads composite friction. The graph of friction coefficient test results

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for the 3 combinations of material composition is shown in Fig 19.

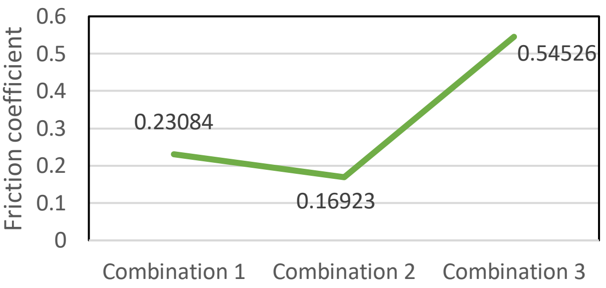

Fig. 19. Friction coefficient test results

In Fig. 19, the composite clutch lining specimen that has the highest coefficient of friction with a coefficient of friction of 0.59508 is Combination 3 with a composition of 20% coconut powder, 20% bamboo powder, 0% copper powder, and 20% glass powder. The specimen that has the lowest friction coefficient value is Combination 2 with a friction coefficient value of 0.16923 with a composite material of 20% coconut powder, 20% bamboo powder, 5% copper powder, and 15% glass powder. Based on the standard coefficient value of the Indoparts standard clutch lining, i.e., 0.498, the friction coefficient of Combination 3 is the highest and close to the standard. It can be concluded that the higher the composition of copper powder in the composite, the higher the friction coefficient value.

4. Conclusions

The conclusions of this study are as follows:

1. The material which has the highest oil absorption value (17.98%) is Combination 3, while the lowest (4.88%) is Combination 2.
2. The material which has the highest percentage of volume change (3.30%) is Combination 1, while the lowest (1.01%) is Combination 2.
3. The material which has the highest friction coefficient (0.54526) is Combination 3, while the lowest (0.16923) is Combination 2.
4. More copper powder portion in the composite material can reduce the oil absorption capacity.
5. The higher the copper powder portion in the composite, the higher the friction coefficient value.

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