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Characterization of Brake Pads by Variation in Composition of Teak Wood Powder and Rice Husk Ash

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Abstract

Motorcycles in Indonesia have increased. So, part of the motorcycle increases, especially for brake pads. Asbestos brake pads are prohibited because they have the potential to cause lung cancer. Therefore, alternative brake pads material is needed that are more environmentally friendly. Teak wood powder and rice husk ash are underutilized waste to be used as alternative materials for making brake pads. This research is to determine the characteristics of the mechanical properties of composite materials made from rice husk ash and teak wood powder. The research method used is experimental. The manufacture of brake pads includes mixing materials, pressing, and heating processes. Brake pads are subjected to hardness testing, heat resistance testing, density testing, wear testing, and braking distance testing. The results of this study get the highest hardness test value of 5.821 HV, the highest density of 1.32 gr/cm3, the results of the braking distance test are 4.12 m with a retarding value of 3.67 m/s2, and the wear test results are 2.22 X 10 -6 mm2/kg. Special heat resistance test that meets the SAE J7661 standard with a heat resistance of 3600C for 1 hour.

Keywords: *brake Pads; Motorcycle; Rice Husk Ash; Teak Wood Powder*

INTRODUCTION

Currently, the automotive world in Indonesia is progressing very rapidly. This progress can be seen from the number of vehicles which is increasing year by year. Based on data from the Central Statistics Agency states that the number of motorcycles in Indonesia has increased, in 2017 the number of vehicles was 118,922,708 units; in 2018, it rose 5.9% to 126,508,776 units; in 2019, it rose by 5, 3% to 133,617,012 and in 2020 it will increase to 136,137,451 (BPS, 2021). The motorcycle's need for replacement components will increase, especially brake pads. Brake pads are one of the important components in the brake system, which function as a medium that rubs directly against the disc. Because of this, the brake pad must be resistant to friction (not easy to wear), not easily deformed when working at high temperatures, and resistant to heat (Fauzan et al. 2016). In general, brake pads are made of asbestos and non-asbestos materials. Using asbestos-based brake pads causes respiratory tract diseases, such as lung cancer (Sutikno, 2008). Because of these problems, innovation is needed to replace asbestos with natural and environmentally friendly materials.

Rice husks are rice husks obtained from the rice milling process. Currently, rice husks have not been used optimally and are only used as materials for making charcoal and brick-burning materials. Some are even thrown away without being used, even though rice husks contain a lot of silica (SiO2). The silica content in rice husk is 86.7% - 97.3% SiO2 (Putro et.al, 2007). Silica (SiO2) is one of the minerals consisting of silicon and oxygen. Silica has hard properties, wear resistance,

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high stiffness, and thermal resistance (Arayapranee et al. 2005). Silica from rice husk ash can be used as a substitute for asbestos to manufacture brake linings (Prasetya, 2016). The teak tree (Tectona grandis L. F.) is one of the most widely used trees. Based on data from the Central Statistics Agency, teak wood ranks first in forest product production by type of production in Central Java in 2016-2020 (BPS, 2021). The higher the production of teak wood, the higher the waste of teak wood powder produced. Teak sawdust charcoal has rough properties. These rough properties affect the level of the coefficient of friction.

For this reason, teak powder charcoal qualifies as a material for making brake linings (Puja, 2011). This study aims to determine the mechanical properties of the brake lining composite material made from a mixture of teak wood powder and rice husk ash. The tests used in this study consisted of the Vickers hardness test, heat resistance test, density test, braking distance test, and Ogoshi wear test.

LITERATURE REVIEW

Brake pads are one component that has an important role in the braking system. Brake linings are usually made of asbestos material with the addition of SiC, Mn, or Co. The process of making brake linings is by pressing and heating, which will produce hardness, and strength and increases friction. Heating the brake pads at a temperature of 130-150 °C causes the material to change its structure, and the particles stick together and make a good solid and a strong binding matrix (Wahjudi et al., 2002). The material's mechanical properties are the material's condition or response after loading. The mechanical properties consist of hardness, wear, ductility, flexibility, and wear resistance. The material's hardness is the material's resistance to a deformation that occurs in the local area. The hardness of a material is directly proportional to its brittleness and inversely proportional to its ductility (Prasetya, 2016). Hardness testing is a material's ability to load in a constant change. The test object under pressure can be analyzed how much the hardness level of the test object. Various methods of testing material hardness include Brinell, Rockwell, Vickers, microhardness, and knob testing.

Density is a value that shows the ratio between the mass of the object to the volume of the object. Density serves to determine a substance because each substance has a different density. The density of a substance cannot be affected by the size and shape of the object. Even though it has different sizes and shapes, if it is made of the same type of material, the density value of the substance remains the same. Material wear is defined as the progressive loss of material. Wear occurs because of the mechanical interaction of two objects that move, slide and rub against each other. Wear testing is used to calculate the loss of solid surface material due to mechanical movement. One of the methods used to perform the wear test is the Ogoshi method. Composites are a new type of engineered material consisting of two or more materials where the properties of each material are different from each other both in terms of chemical and physical properties and remain separate in the final result of the material (Mukmin, 2017). Composite materials have advantages such as lighter weight, corrosion and wear resistance, and higher strength and resistance.

RESEARCH METHOD

The method used in this research is the experimental method with steps. The steps can be seen in the research diagram in Figure 1.

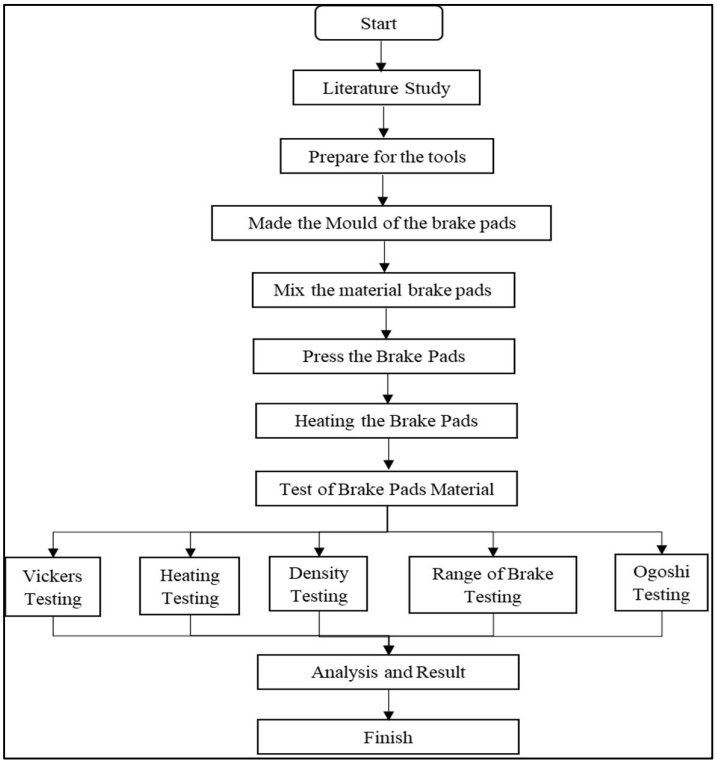

Figure 1. Research Diagram

Materials the research

This study used three samples, with each sample having a different composition. Sample 1 with 30% rice husk ash composition, 30% teak powder, 30% resin, 5% Al, and 5% MgO. Sample 2 with rice husk ash composition of 35%, teak wood powder of 25%, a resin of 15%, Al 5%, MgO 10, and Sample 3 with a composition of 25% rice husk ash, 25% teak powder, 25% resin, 15% Al, 10% MgO. Detailed materials can be seen in Table 1. Samples of the brake pads can be seen in Figure 2.

Table 1. Materials Composition

Sample	**Rice husk ash (%)**	**Teak wood powder (%)**	**Epoxy (%)**	**Aluminum (%)**	**Magnesium Oxide (%)**
Sample 1	30	30	30	5	5
Sample 2	35	25	15	15	10
Sample 3	25	25	25	15	10

Figure 2. Sample of Brake Pads

Test the Materials of brake pads

The materials of the brake pads test for to know their characteristic. Test for the materials of brake pads includes hardness materials with the Vickers test in AKPRIND laboratorium of Yogyakarta with calibration by PT Global Quality Indonesia in 2021. Heat resistance testing with Faithful furnace sx4-12 at 360^0C. Density testing with Ohaus measurement. Wear test with Ogoshi testing method—the range of brake testing on the road in motorcycle caliper brake.

Figure 3. Vickers Test

Figure 4. Ogoshi Test Method

Figure 5. Thermal

Figure 6. Braking Test

FINDINGS AND DISCUSSION

Hardness Test Results

Table 2. Hardness Test Results

Specimen	Intended	HV	HV Mean
Sample 1 (ASP 30%, SKJ 30%, Resin 30%, Al 5%, MgO 5%)	Poin 1	5.785	5.821
	Poin 2	5.838	
	Poin 3	5.838	
Sample 2 (ASP 35%, SKJ 25%, Resin 15%, Al 15%, MgO 10%)	Poin 1	4.531	4.556
	Poin 2	4.485	
	Poin 3	4.652	
Sample 3 (ASP 25%, SKJ 25%, Resin 25%, Al 15%, MgO 10%)	Poin 1	5.681	5.746
	Poin 2	5.798	
	Poin 3	5.759	

Based on the data in Table 2, sample 1 gets the highest hardness value with a composition of 30% rice husk ash, 30% teak powder, 30% epoxy resin, 5% aluminum, and 5% magnesium oxide. The result is 5.78 HV. The results of this study indicate that each addition of epoxy resin will affect the hardness of a composite material. This is shown in the variation of the use of epoxy resin, that the composition of the specimen with 15% resin produces a hardness value of 4.556 HV. Specimens with the addition of 25% resin resulted in a hardness value of 5.746 HV. The highest hardness was obtained by adding 30% resin with a hardness value of 5.821. So the use of epoxy resin can affect the hardness value of a material. The more resin composition, the harder the material. The standard of SAE J661 brake lining hardness is 68-105 Rockwell. This means that the three samples do not meet the SAE J661 brake lining standard.

Heat Resistance Test Results

The thermal resistance test was carried out using a furnace with a temperature of 360^0 C for 1 hour, and then visually viewed the condition of the material was before and after the thermal resistance test was carried out. The test results showed that all samples experienced a change in

color from silver to black. Of the three samples, sample 1 (*See Figure 7)*, with a resin composition of 30%, had the darkest color, and samples 2 (*See Figure 8)* and 3 (*See Figure 9)*, with a resin composition of at least 15% of the lightest color. It showed that adding resin could affect the specimen's color. In addition to the color change, there were cracks in samples 2 and 3. The cracks occurred on the side of the specimen surface. Samples that are not damaged are only sample 1.

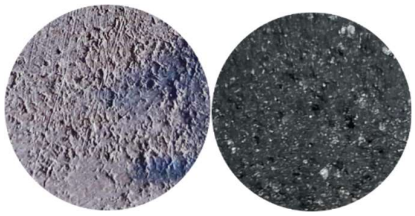

Figure 7. Before and After Heat Resistance Test sample 1

Figure 8. Before and After Heat Resistance Test sample 2

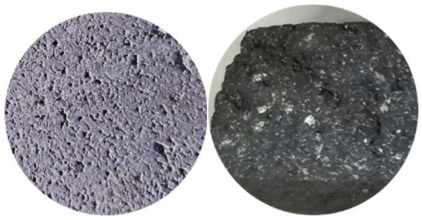

Figure 9. Before and After Heat Resistance Test sample 3

Density Test Results

The results of testing the density of brake lining samples made from rice husk ash and teak wood powder can be seen in Table 3.

Table 3. Density Test Result

Sample Composition	V1 (ml)	V2 (ml)	V2-V1 (ml)	Mass (gr)	Density (gr/cm^3)
ASP 30%, SKJ 30%, Resin 30%, Al 5%, MgO 5%	40	50	10	7.55	1.32
ASP 35%, SKJ 25%, Resin 15%, Al 5%, MgO 5%	40	48	8	8.9	0.89
ASP 25%, SKJ 25%, Resin 25%, Al 15%, MgO 10%	40	46	6	5.66	1.06

The results of the density test show that the lowest value is sample 2 of 0.89 gr/cm^3 with a composition of 30% ASP, 30% SKJ, 30% resin, 5% Al, 5% MgO, and the highest density is sample 1 of 1.32 gr/cm^3 with a composition of 25% ASP, 25% SKJ, 25% resin, 15% Al, 10% MgO. The higher

the density of a specimen, the denser the specimen, and the lower the specimen's density, the more porous/hollow the specimen is. Porous/hollow specimens have a lower hardness level than denser materials. Based on the SAE J661 brake lining standard, the density is 1.5-2.4 gr/cm^3, which means that the three samples have not met the SAE J661 brake pads standard.

Braking Distance Test Results

The braking distance test was carried out using a 2011 supra x 125 cc motorcycle with a speed of 30 km/hour, then braking and measuring the distance between the start of braking until the vehicle actually stopped.

Table 4. Brake Distance Result

Specimen	Brake Distance (m)
Standard Brake Pads	2.82 m
Brake Pads Sample 1	4.12 m
Brake Pads Sample 2	4.32 m
Brake Pads Sample 3	4.19 m

Based on Government Regulation no. 55 of 2012, the minimum deceleration value is 5 m/s2 with the formula $=\frac{V^2}{2a}$. The results of the calculation of the braking distance can be seen in the following results:

V = 20 km/hour

$= \frac{20 \times 1000}{3600}$

$= 5{,}5$ m/s^2

$$S = \frac{V^2}{2a}$$

S = braking distance (m)
a = deceleration (m/s^2)
v = vehicle speed (m/s)

Deceleration of the standard brake lining braking distance obtained a braking distance of 2.82 m.

$$2.82 = \frac{(5.5\ m/s)^2}{2a}$$

$$a = \frac{30.25}{2 \times 2.82}$$

$$a = 5.36 \text{ m/s}^2$$

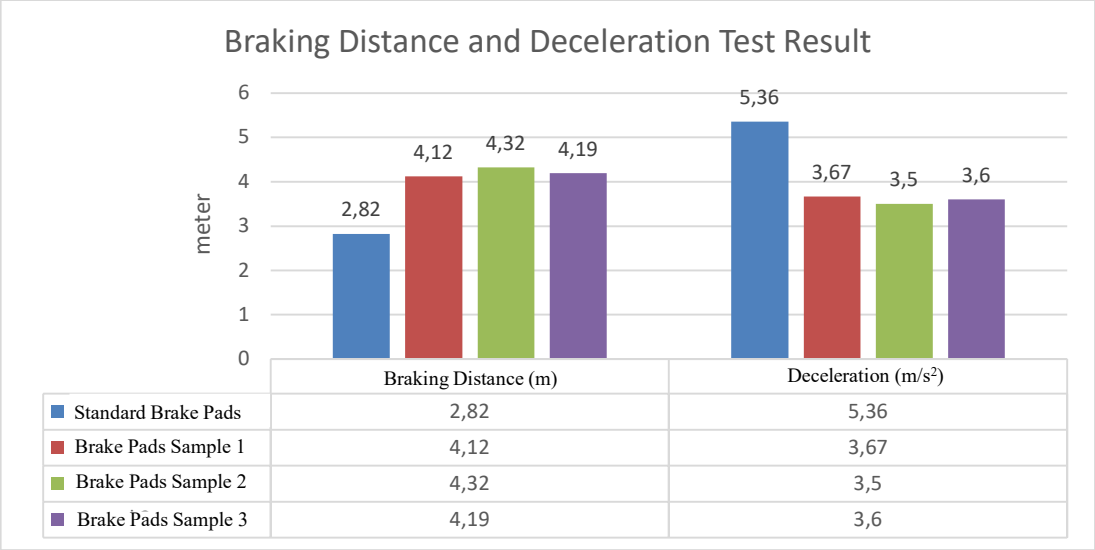

Figure 10. Braking Distance and Deceleration Test Result

The results of the braking distance are opposite to the results of the deceleration. If the braking distance is large, then the deceleration value is small. Based on Government Regulation no. 55 of 2012 Article 67, the minimum deceleration value is 5 m/s^2. If the deceleration value is below 5 m/s^2, the braking system or brake lining must be repaired or replaced because it can be fatal if operated on the road.

The data in Figure 10 shows that the braking distance using factory standard brake pads is 2.82 m with a deceleration value of 5.36 m/s^2. This indicates that the standard brake lining exceeds the deceleration threshold value, which means that the brake lining exceeds the retarding threshold value. Standard brakes can be used. While the brake pads made from rice husk ash and teak wood powder with the best braking distance obtained in sample 1 of 4.12 m with a retarding value of 3.67 m/s^2 indicate that the brake pads for rice husk ash and teak powder have not met the threshold deceleration value limit so that the brake pads of rice husk ash and teak sawdust cannot be used on vehicles because they have not met the deceleration threshold value.

Ogoshi Wear Test Results

The results of the ogoshi wear and tear of brake pads, rice husk ash, and teak sawdust can be seen in Table 5.

Table 5. Ogoshi Test Result

Specimen 1	**Wear test / WS (mm^2/kg)**
Sample 1	2,22 X 10^{-6}
Sample 2	1,24 X 10^{-6}
Sample 3	4,56 X 10^{-7}

Based on the results of the wear test in the table, it shows that the material that has higher wear resistance is obtained in sample 1 with a composition of 30% rice husk ash, 30% teak powder, 30% epoxy resin, 5% aluminum, 5% magnesium oxide, two results are obtained, 22 X 10^{-6} mm^2/kg this shows that sample no 1 has a higher wear resistance than the other samples, but the sample is still not close to the SAE J7661 brake lining standard with a value of 5 x 10^{-4} until 5 x 10^{-3} mm^2/kg. This means that the brake pads for rice husk ash and teak powder are still not in accordance with the SAE J7661 standard.

CONCLUSION

The hardness value of brake pads made from rice husk ash and teak sawdust results in a hardness value of sample 1 of 5.821 HV, sample 2 of 4.556 HV, and sample 3 of 5.746 HV. The standard of SAE J661 brake pads hardness is 68-105 Rockwell. This means that the three samples do not meet the SAE J661 brake pads standard. Condition of brake pads made from rice husk ash and teak wood powder all samples changed color but from the three samples, only sample no 1 met the standard after being tested for heat resistance at a temperature of 360^0C for 1 hour, the condition of the sample did not experience structural damage. Samples no. 2 and 3 had structural damage. The density value of sample no 1 is 1.32 gr/cm3, sample no 2 is 0.89 gr/cm^3, and sample no 3 is 1.06 gr/cm^3. The standard density value of SAE J661 is 1.5-2.4 gr/cm^3. This means that the three samples have not met the SAE J661 standard. The wear test results of sample no. 1 are 2.22 X 10^{-6} mm^2/kg, sample no. 2 is 1.24 X 10^{-6} mm^2/kg, and sample no. 3 is 4.56 X 10^{-7} mm^2/kg. All samples still do not meet the SAE J661 standard of 5 x 10^{-4} until 5 x 10^{-3} mm^2/kg.

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