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Research Article

An Effect of Biocomposite Composition and Material on Brake Pad Wear

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A B S T R A C T

Asbestos material, widely used in brake pad friction material, is carcinogenic and harmful to long-term health. The method of making brake pads is by mixing the essential ingredients of brake linings from nature in the form of bamboo powder and bagasse ash with different percentages of mixtures of 25% bamboo powder, 35% bagasse ash, and 40% polyurethane sample coded A. 35% bamboo powder, 25% bagasse ash and 40% polyurethane sample coded B. In comparison, 45% bamboo powder, 15% bagasse ash, and 40% polyurethane sample coded C. Using compression molding with a compressive force of 14.709 N. The highest average hardness, 77.4 HD, was obtained on the brake lining coded A with the ratio of a mixture of 25% bamboo powder, 35% bagasse ash, and 40% polyurethane. At the same time, the lowest average hardness value of 70.6 HD was obtained on brake pads with code C with a mixture ratio of 35% bamboo powder, 25% bagasse ash, and 40% polyurethane.

1. INTRODUCTION

The brake system is a vehicle speed deceleration mechanism so that the vehicle speed can be controlled, and the basic principle is based on changing the kinetic energy of motion to heat energy. This condition results in reduced movement of the drive wheels compared to the initial conditions due to the transfer of heat from the brake shoes to the drum. Brake pads are generally made of materials with high frictional resistance to inhibit the continuous rotation of the wheels, and these materials include asbestos fibers mixed with resins and adhesives. Currently, the use of asbestos fiber is harmful to human health because it can form carcinogenic in the long term.

Selection of other alternative materials for brake linings can use resin with health considerations and without reducing the coefficient of friction, and the temperature that arises during the braking process is not too high. The use of polyurethane resin to function as a binder undergoes deformation, which results in changes in adhesion that increase during the braking process. None of the disc brake systems meet the desired performance criteria, such as safety and durability, under different braking conditions. Brake pad materials require a stable coefficient of friction and low wear rates under different conditions. The material must be compatible with the material of the rotor or disc brake to reduce wear, vibration, and noise during braking.

In addition, a study entitled "The Effect of Composition and Temperature of Biocomposite Materials on the Performance of Non-Asbestos Brake Pads" concluded that the harder a material, the smaller the wear [2]. In a study on the hardness of the brake lining material using the fineness level

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of teak wood powder, entitled "The Making of Brake Pads Using a Variation of Aluminum Silicon (Al-Si) Mesh Grains 50, 60, 100 Mixed with Teak Wood Powder Against the Value of Hardness, Wear and Friction Coefficient." Concluding that the smaller the grains of Mesh Aluminum Silicon can affect the increase in the hardness value of brake linings made from natural teak wood powder [3]. The discussion of the wear of the canvas using areca nut skin fibers and Al2O3 powder with the title "Process of Making Fiber Polymer Biocomposites for Brake Pad Applications." It concluded that the highest wear rate value occurred in biocomposites without adding alumina, 9.065E-06 gr/mm^2. Second, the lowest wear rate value occurs in biocomposites with adding 5% alumina, 2.506E-06 gr/mm^2.seconds [4]. The aim is to compare the maximum and minimum frictional wear and tear by varying the composition of the mixture of brake lining materials. The percentages were 25% sugarcane powder, 35% bagasse ash, and 40% polyurethane for specimen number one. 35% sugarcane powder, 25% bagasse ash, and 40% polyurethane for the second specimen. 45% sugarcane powder, 15% bagasse ash, and 40% polyurethane. In a study entitled: "Experimental Study of the Effect of Particle Size of Bamboo Powder on Mechanical Properties of Composites for Motorcycle Brake Pad Applications." The composite hardness value is directly proportional to the density value [5].

2. METHODOLOGY

The method of making specimens is by mixing the brake lining material into the mold and giving a press force of 1.5 tons with a time of 15 minutes. The brake lining drying process uses room temperature. The hardness test uses a shore D durometer by pressing the durometer to the test object as much as 10 points at random with the ASTM D2240 standard, while the brake lining wear test method uses a disc that is rotated using an electric motor by placing a load on the brake pads, and determining a certain sliding distance. By weighing and comparing the weight before and after the test [2] and the method of data analysis using two-way ANOVA.

2.1. Ingredient

Ingredient maker brake lining consists of powder bamboo, gray dregs sugarcane, and polyurethane, where bamboo powder with mesh size 50 Due bamboo have level strength The average tensile strength is 107.44 MPa [5]. *Sugar Cane Ash* with *formula chemical (Silica oxygen* SiO2 comes from residue results burning dregs *)*, heavy type ash dregs sugarcane 2.25 g/cm3 [6]. *Polyurethane* (Polyurethane is an ingredient polymer containing group function urethane (NHCOO) in chain main) with a flexural strength of 44.18 MPa [7].

2.2. Specimen-Making Process

The prepared ingredients are mixed and stirred until homogeneous, then poured into the mold. The mixtures were according to their respective compositions, as shown in table 1 in terms of the weight of the specimen.

Table 1. Composition Specimen Mix

Specimen	*Bamboo Powder*	*Sugar Cane Ash*	*Polyurethane Adhesive*
A	*25%*	*35%*	*40%*
B	*35%*	*25%*	*40%*
C	*45%*	*15%*	*40%*

Specimens were made by compression molding. The material in the mold is compressed using a predetermined compressive force for 15 minutes. After removing the mold, the brake lining drying process is carried out for 2 hours at room temperature to ensure the material is dry. The brake lining specimen is then glued to the brake pad using an adhesive layer. The strength of the adhesive layer between the friction material and the plate is very important to avoid debonding. Debonding (damage in composite materials caused by non-adhesion of fibers and binders when used).

2.3. Hardness Test

The specimen brake lining was measured using a hardness tester to ensure even mixing during the hardness data collection process. Hardness value specimen obtained with the use Durometer hardness

tester. Sample with 5mm height used to test various variation compositions of different materials. Test done at 10 points other test using a shore D type durometer with test standard as per ASTM D2240.

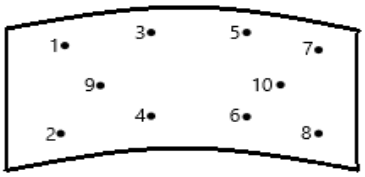

Figure 1. Point Test Violence

2.3. *Wear Test*

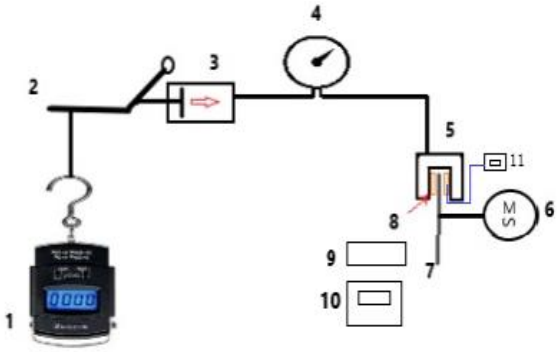

Figure 2. Setting the wear test tool

Description:

1. Digital Scale	6. Electric Motor
2. Push Lever	7. Disc Brake
3. Brake Master	8. Brake Pads
4. Pressure Gauge	9. Tacho Meter
5. Brake Caliper	10. Stop Watch

The wear rate of the specimens was measured using a disc brake simulator. The brake lining specimen is rubbed with a brake disc which is rotated using an electric motor. During the test, different compressive forces of 173.7 N, 349.5 N, and 521.5 N were applied using a time of 1 minute. The initial weight of the specimen was measured using a digital scale with an accuracy of 0.0001 g. After passing the shear distance, the specimen is removed, cleaned, and weighed to determine weight loss due to wear and tear. The difference in weight measured before and after the test gives the sample wear. The formula used to convert weight rpm to distance is:

$$S = 2\pi.r.N.t \quad (1)$$

The formula used for change drop heavy Becomes level wear and tear is:

$$WearRate = \frac{\Delta W}{S} \quad (2)$$

3. RESULTS AND DISCUSSION

3.1. *Violence*

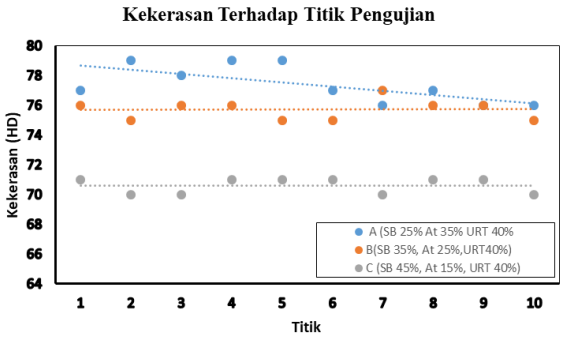

Figure 3. Hardness Value To Point Test

Figure 3 shows the X axis where testing is carried out on each sample of the brake lining at as many as ten different points, while the Y axis is where the measured value is on the shore-d durometer hardness tester. Another color marks each sample on a separate graph, shown in sample A in blue with a mixture of non-asbestos brake lining material as much as 25% bamboo powder, 35% bagasse ash, and 40% polyurethane, the highest among other hardnesses. In sample B, the color is orange with a mixture of 35% bamboo powder, 25% bagasse ash, and 40% polyurethane, as seen from the change in the graph, which has a hardness value below sample A. In comparison, sample C is gray with a mixture of ingredients. Brake lining 45% bamboo powder, 15% bagasse ash, and 40% polyurethane, when viewed from the decrease in the graph, sample C has the lowest hardness value among other samples.

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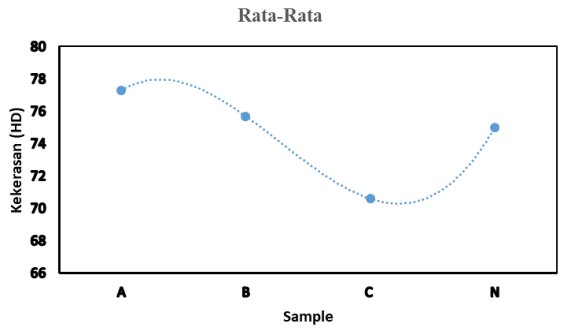

Figure 4. Average Hardness Specimen

From Figure 4, it can be seen that the average level of hardness of the brake pads of specimen A has a hardness level of 1.6 HD, the difference is higher than that of specimen B, while the brake pads of specimen C have a hardness difference of 4.4 HD below the original brake lining. And the hardness level of specimen A is above specimen B, which has a difference of 0.7 HD above the original brake lining. This is due to the percentage mixture of specimen A with a percentage of 25% bamboo powder and 35% bagasse ash. In comparison, specimen B has a percentage of 35% bamboo powder and 25% bagasse ash, and specimen C has a mixture of 45% bamboo powder and bagasse ash 15% percentage. Each material has a density difference of 1.39 gr/cm3 for bamboo powder [5]. In comparison, the density value of bagasse ash is 2.25 gr/cm3[7].

Table 2. The result of one-way Anova

Source of Variation	SS	df	MS	F	P-value	F crit
Kekerasan	244,87	2,00	122,43	160,47	0,00	3,35
Error	20,60		27,00	0,76		
Total	265,47	29,00				

Because F count > F table, then H1 is accepted and H0 is rejected, which means there is influence significant Among mix and value violence brake lining.

3.2. Wear

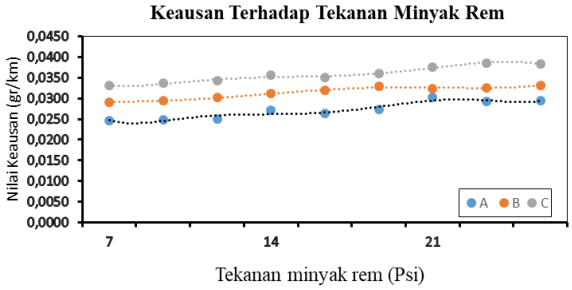

Figure 5. Wear average brake lining

Figure 5 shows the average wear swipe brake lining gets a distance of 1.153 km/m at 7 Psi pressure with code brake lining A has score wear 0.0247 gr test first, 0.0249 gr/m tests two, and 0.0250 gr/m test third. At a pressure of 14 Psi, a distance of 1.116 km/m value wear and tear gets 0.0271 gr/m tests first, 0.0264 gr/m tests second, and 0.0273 gr test third. Whereas 21 Psi pressure gets distance sliding 1.082 km/m gets a score to wear 0.0302 gr on the test first, 0.0292 gr test second, and 0.0294 gr/m test third.

Code B brake pads with pressure 7 Psi brake fluid got distance sliding 1.153 km/m has score wear 0.0291 gr/m tests first, 0.0294 gr/m tests second, and 0.0302 gr/m in the test third. At a pressure of 14 Psi, a distance of 1.116 km/m value wear and tear get 0.0311 gr/m tests first, 0.0319 gr on the test second, and 0.0329 on the test third. Whereas 21 Psi pressure gets distance sliding 1.082 km/m gets a score to wear 0.0324 g on test first, 0.0326 gr/m on test second, and 0.0332 gr/m on test third. Pressure C code brake pads 7 Psi brake fluid got distance sliding 1,153 km/m has score wear 0.0331 gr/m on test first, 0.0336 gr/m on test second, and 0.0342 gr/m on the test third.

From the result, research and testing conducted that score violence something object could influence score wear and tear. Could interpret the more tall score violent test object, the smaller the resulting wear.

Table 3. The result of two-way Anova

Source of Variation	SS	df	MS	F	P-value	$F_{crit.}$
Sample	0,00008	2	0,000038	129,75	0,00	3,55
Columns	0,00034	2	0,000168	567,35	0,00	3,55
Interaction	0,00000	4	0,000001	3,23	0,03	2,92
Within	0,00001	18	0,0000003			
Total	0,00042	26				

Because $F_{count} > F_{table}$, H1 is accepted, and H0 is rejected. It means there is a significant influence between sample source materials of brake pads and pressure brake fluid due to wear and tear average brake lining.

4. CONCLUSION

The more mixture of bagasse ash as a material for making brake pads, the harder it will be because the density value of bagasse ash is higher than that of bamboo powder.

The composition of a mixture of 25% bamboo powder, 35% bagasse ash, and 40% polyurethane has a wear of 0.0750 gr/m at 7 Psi brake fluid pressure, 0.0890 gr/m at 14 Psi brake fluid pressure, and 0.1010 gr /m at 21 Psi brake fluid pressure. This is because the effect of wear on the brake lining sample will be smaller, along with the object's hardness. The harder the brake pads, the smaller the wear value will be.

BIBLIOGRAPHY

[1] L. Rina, and Sunardi, "Study Experimental Influence Size Particle Bamboo Powder on Mechanical Properties Composite For Application Motorcycle Brake Pads." National Journal ISSN 2407-7852. Volume II, No. 2, pp.54-63, 2016.

[2] I. S. Bluedi and M. Hartono, "Influence Composition and Temperature of Biocomposite Materials Against the Performance of Non-Asbestos Brake Pads." National Journal of Energy and Technology Manufacturing, Vol. 05, No. 01, pp.29-34, 2022.

[3] I. Scout, "Brake Pad Using Variation Mixed 50, 60, 100 Silicon (Al-Si) Aluminum Mesh Granules With Teak Wood Powder Against Hardness, Wear, and Coefficient Values Swipe." Journal Scientific Mechanical Engineering Vol. 21, No. 1, pp. 35-45, 2020.

[4] Aminur and M. Hasbi, "Manufacturing Process Biocomposite Polymer Fiber For Application Brake Pads." ISSN: 2407 – 1846, pp.1-7, 2015.

[5] P. Bead, and Samuel, "Analysis of Tensile Strength and Strength flex Beam Laminate Combination of Petung Bamboo and Apus Bamboo for Component Wooden Ship." National Journal of SHIP. Vol. 13, No. 3, pp. 142-151, 2016 .

[6] H. Harianto and M. Devana, "The Effect of Sugarcane Bagasse As Pozzolan in Mixtures Normal Concrete And Concrete Uhcp To Strong Press and be strong flexible concrete. " Journal Civil Engineering Science. Vol. 22 No. 2, pp. 151-156, 2016.

[7] K. Siti and M. Farid, "Characterization of Physical Properties and Mechanical Properties Polyurethane Composite / Bamboo Powder As Car Door Panel Application." Journal of ITS Engineering, Vol.5, No. 2, pp. 153-155, 2016.

 https://doi.org/ 10.25077/metal.6.2.102-106.2022