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The effect of hardness on bending value in manufacturing brake pads from shell and palm fiber

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Abstract: Motorbikes are one of the primary needs for many people because they are more effectively used to carry out community activities than public transportation. Because motorbikes are used so frequently, the braking system is one of the parts that must be updated. Brake pads are motorbike equipment that function to slow and stop the vehicle comfortably. The research aims to determine the characteristics of brake linings and the optimal composition of brake linings that are good for use. Brake pads are a component of motorcycle vehicles that are useful for slowing down and stopping the speed of the vehicle comfortably. The purpose of this study is to find out how the characteristics of palm shells and fibers if used as material for making brake linings. The method used is direct experimentation with a qualitative approach. The results obtained are the characteristics of brake pads made from filler palm shell powder and palm fiber with polyurethane matrix have a hard texture, solid brown, if viewed from the surface of the brake lining is a little rough because the fiber is too long. The test results showed the best hardness value of 91 R and the best bending test with a value of 10.21 kgf/mm^2.

Keywords: Hardness; bending value; brake canvass; palm shells and fiber

1. INTRODUCTION

With the development of increasingly sophisticated science and technology, there have been many significant developments and changes, especially in the field of motorbikes, the number of users of which is increasing rapidly in Indonesia every year [1][2]. Motorbikes are one of the primary needs for many people because they are more effectively used to carry out community activities than public transportation [3].

Because motorbikes are used so frequently, the braking system is one of the parts that must be updated. Previously, asbestos was used to make brake lining material. As environmentally friendly technology advances, non-asbestos materials are starting to replace asbestos-containing materials. This is caused by several variables that pose serious risks to both the environment and human health. Exposure to asbestos in humans can cause lung, throat, ovarian and other cancers. Brake pads are motorbike equipment that function to slow and stop the vehicle comfortably [4]. The component that has the highest level of load is up to 90% compared to other components in the vehicle. Brake pads on the market generally use steel fiber, cellulose, rock wool, granite, kevlar, and asbestos materials [5]. The asbestos raw material used in motorbike brake linings has several weaknesses, namely that the hard material can cause the brake discs to wear out [6]. Apart from that, asbestos is also not environmentally friendly because it produces compounds that are dangerous for human breathing. Asbestos materials must be avoided by using non-asbestos materials. This non-asbestos material uses non-hazardous materials such as corn cob waste, teak wood waste, coconut shell waste, and palm oil shell waste [5].

In perfect condition, brake linings must have a high and consistent coefficient of friction, resist fading (loss of braking power), recover quickly (force produced after braking), be wear-resistant, not damage the disc, and be environmentally friendly. The purpose of the braking system is to reduce or stop wheel motion, thereby making the wheels move more slowly [8]. Friction causes moving objects to lose kinetic energy which is then converted into heat.

This palm oil shell is often found and is usually used as fertilizer and boiler fuel to produce steam during palm oil processing. Silicon oxide (SIO2), which has highly reactive properties and can react to produce a hard and stiff material, is the majority of palm oil shells. When used in the manufacture of composite materials with a resin matrix that has thermosetting resin qualities that are resistant to high temperatures, palm oil shells are an excellent source of small particles. If processed, palm oil shells can be made into a product with more economic value [7].

Motorcycle brake linings made from palm frond fiber can be made by adding the right amount of alumina powder to meet certain requirements. After a series of level experiments, the A2 (6% Alumina) treatment produced the highest and best Rockwell hardness level, with a weight of 52.75 kg. Next, brake lining extraction was carried out from palm oil fronds using alumina powder which had the lowest coefficient value of 0.000765 N/mm2 and was best obtained in the A2 (6% Alumina) treatment, after carrying out a Pin on Disk type friction coefficient test [10].

Based on this, research will be carried out on motorbike brake linings made from variations of 60%, 65%, and 70% palm oil shell filler, palm fiber with 40%, 35%, and 30%, polyurethane matrix material. The characterization in this research uses bending (strength) tests and hardness tests.

2. METODE

This research was conducted using a quantitative approach and an experimental approach. The research samples were brake linings made from shells and palm oil originating from Paluta. The place of research was carried out at the Industrial Chemical Technology Polytechnic Laboratory (PTKI) Jalan Medan Tenggara No. VII, Southeast Medan, District. Medan Denai, Medan City, North Sumatra 20228.

The equipment used in this research is a container, spoon, scissors, blender, 100 mesh sieve, gloves, digital balance, beaker glass, brake lining mold, hydraulics, sandpaper, vernier caliper, Rockwell, universal wear machine, universal testing machine. The procedures carried out in making brake linings are as follows:

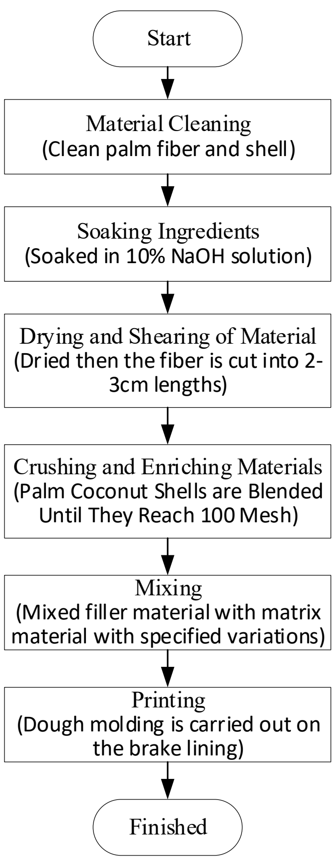

Figure 1. Procedure for making brake linings.

Figure 1 you can see the steps in the process of making brake linings. The next step after the process of making brake linings is the testing process to identify the characteristics of the sample results, and whether they are suitable for use or not.

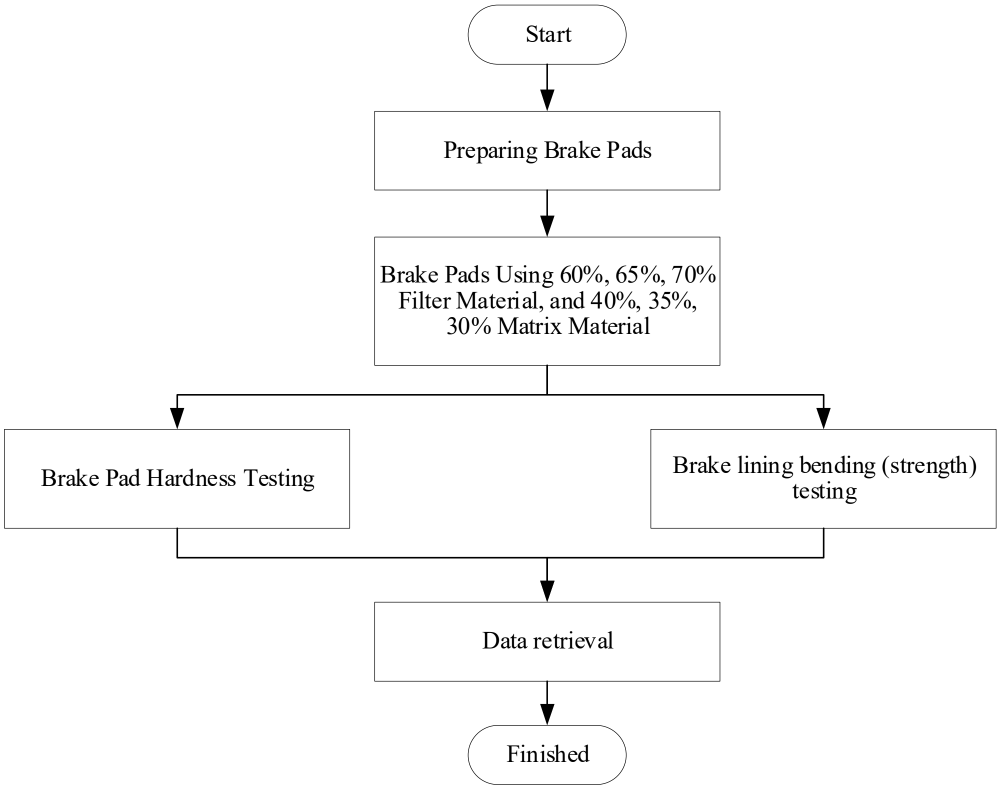

Figure 2. The brake lining testing process.

In Figure 2, a hardness test is carried out to determine the resistance of a material to permanent deformation due to freezing. This mark is caused by the mark itself which almost does not change shape and is an object that is harder than the material being examined. Hard-coated steel bullets or diamond cones of predetermined sizes are used as pressing objects to determine hardness by the Rockwell method. Rockwell's violence was formulated:

$$\text{HRC} = \frac{a+b+c}{3} \tag{1}$$

Where:
HRC = Rockwell hardness
a = hardness 1
b = hardness 2
c = hardness 3

Strength is defined as the ability of a material to withstand stress without breaking. Depending on the type of load acting on it, there are several types of strength. Example of bending strength. Materials that can stretch under a certain load or pressure are said to be flexible, not rigid. The ductility of a material is a mechanical parameter that shows the amount of plastic deformation that occurs before a material breaks or fractures. Flexural tests can be carried out on a material to ensure its flexural strength. The maximum bending stress that may arise due to external loading without causing significant deformation or failure is called bending strength, also called bending strength [11]. The type of material and stress determine how much bending strength is present.

Measurement of the strength that occurs in the test specimen can be done using the following calculations:

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$$S = \frac{3PL}{2b\ ^{2}} \tag{2}$$

Where:
S = bending strength (kgf/m^2)
d = thick (m)
b = width (m)
P = maximum load (kgf)
L = lengthy (mm)

3. RESULTS AND DISCUSSION

The indicator used on the surface of the specimen (test object) is done by hardness testing. The results of the Rockwell hardness test type N4 are shown in Table *1*.

Table 1. Rockwell hardness test of brake pads

Sampel	HRC (R)	SAE J661
A	53,33	
B	61,33	68 – 105 R
C	91	

Based on Table *1*, it can be seen that the test results show different average HRC (Rockwell Hardness) values for each sample and its variations. Sample A with a variation of 60%:40% has the minimum average HRC value, namely 53.33%. Sample B with a variation of 65%:35% has an average HRC value of 61.33 R. Sample C with a variation of 70%:30% has the maximum average HRC, namely 91 R.

Meanwhile, bending testing is carried out by pressing on the surface of the brake lining using a universal testing machine type ASTM E384. From the bending test, test results can be obtained as in Table *2*.

Table 2**.** Bending tests on brake pads.

Sample	Filter: Matrix	P maks (kgf)	Bending Strength (kgf/mm^2)	Information	SAE J661
A	60:40	42	7,75	Broken	
B	65:35	44	8,28	Broken	4,8 – 15 kgf/mm^2
C	70:30	54	10,21	Broken	

Based on Table *2*, it can be seen that the bending test results from the brake lining research were the maximum, namely with a bending strength reaching 10.21 kgf/mm^2 on the brake lining with a comparison of 70% filler and 30% matrix. Brake lining bending test 8.28 kgf/mm^2 for variations of 65% filler and 35% matrix. Bending tests of brake linings from composite materials obtained a minimum of 7.75 kgf/mm^2 from a ratio of 60% filler and 40% matrix.

For both safety and comfort when driving, vehicle brakes are very important. The braking system has to work harder as the car goes faster [12]. Common brake lining combinations contain asbestos, but because asbestos is dangerous to health, its use is not environmentally friendly. In this case, a bending test on the brake lining is needed in this research because it can determine whether the brake lining is suitable and suitable for use or not [13].

The brake lining with bending strength testing obtained had a bending strength of 6.4 kgf/mm^2. This indicates that the bending strength of the research was lower. Based on the results of this research, the bending strength is around 10.21 kgf/mm^2, this shows that the bending strength value in this study is higher than in previous research. The hardness testing graph can be seen in Figure *1*.

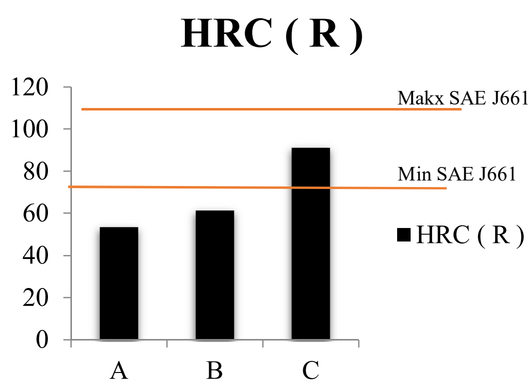

Figure 3. Brake lining hardness testing graph.

According to Figure 3, sample A, sample B, and sample C have increasing HRC values, this is due to the higher concentration of filler with the addition of less matrix, so the hardness value of the brake lining tends to be higher. Hardness testing used the Rockwell method in this study, sample A brake lining had the lowest hardness with an average HRC value of 53.33 R with a variation of 60% filler and 40% matrix resulting in the most brittle brake lining, and did not meet SAE brake lining standards J661. Sample B has a hardness with an average HRC value of 61.33 R with variations in filler of 65% and matrix of 35%, which does not meet the SAE J661 standard. Sample C has the highest hardness with an average HRC value of 91 R, with a filler variation of 70% and 30% matrix producing very hard brake linings, and meets SAE J661 standards. Sample C can meet the standard because of the filler-strengthening material, if there is more filler than the matrix, the resulting sample will be harder. If the filler mixture is less, it can cause the brake pads to become more brittle.

The sample hardness value is strongly influenced by the compaction pressure. Greater plastic deformation between powder particles due to greater compaction pressure will increase volumetric density, or bulk density, which in turn increases hardness. The results of the bending test can be seen in Figure 4.

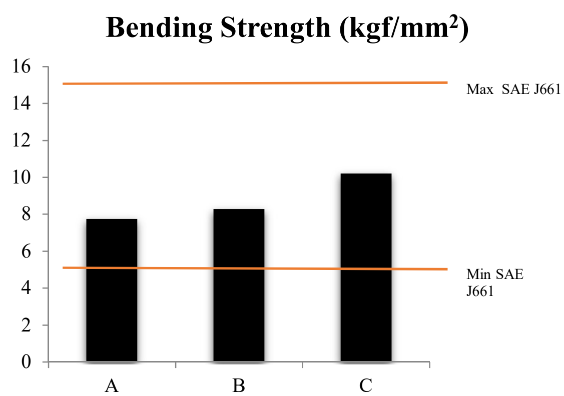

Figure 4. Brake lining bending test graph.

Based on Figure 4, it can be seen from the fracture strength of the brake lining that comparing variations in filler from palm oil shell powder and palm fiber with variations in the matrix from polyurethane can influence different bending strength values. Sample C has the maximum level of strength with a variation of 70% filler and 30% matrix, achieving a bending strength of up to 10.21 kgf/mm^2 with a maximum load of 54 kgf. Sample B with a variation of 65% filler and 35% matrix produces a bending strength value of 8.28 kgf/mm^2 with a load of 44 kgf. Sample A obtained the minimum bending strength value because it only reached 7.75 kgf/mm^2 from a variation of 60% filler and 40% matrix with a maximum load of 42 kg. It is known that the maximum bending strength test is sample C, this is because the hardness value is the highest, so the higher the hardness value of the material, the better the resulting bending strength. Samples A, B, and C in the bending test for filler for palm shell powder and palm fiber with a polyurethane matrix can meet SAE J661 standards, the test value increases for each sample.

Based on the intended use of brake linings, very high or very low hardness levels do not effect their quality [14]. However, further mechanical testing is still required to ascertain which features the brake pads require to reduce wheel speed. The purpose of brake linings is to reduce and ultimately stop the rotation speed of the shaft [15].

The hardness value of each sample that has been tested using a Rockwell hardness tool before and after undergoing heat treatment up to 600°C should be cooled with water or oil cooling media so that the material becomes softer. The maximum results obtained from testing were 55.16 R, which did not meet the standard, while the researchers tested some that met the standard, namely up to 91 R.

4. CONCLUSION

Based on the research that has been carried out, it can be concluded that the characteristics of brake linings made from palm oil shell powder filler and palm fiber with a polyurethane matrix have a hard, dense brown texture, if you look at the surface of the brake lining it is a little rough because it is made from fiber. which is too long. In the HRC (Rockwell Hardness) test measurement, sample A was obtained with a variation of 60%:40% and had an average HRC value of 53.33%. sample B with a variation of 65%:35% has an average HRC value of 61.33 R and sample C with a variation of 70%:30% has an average HRC of 91 R. Bending test results from research on the maximum brake lining namely with bending strength reaching 10.21 kgf/mm^2 on brake linings with a filler ratio of 70% and matrix 30%. Brake lining bending test 8.28 kgf/mm^2 for variations of 65% filler and 35% matrix. Bending tests of brake linings from composite materials obtained a minimum of 7.75 kgf/mm^2 from a ratio of 60% filler and 40% matrix. Test results show that the optimal hardness value is found in sample C, namely 91 R, and the optimal bending test is in sample C with a value of 10.21 kgf/mm^2.

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