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Analysis of The Mechanical Properties of Brake Canvas Based on Durian Fruit Skin and Teak Leaves

Masturi[1,2]✉, Suhardi Effendy[2], Afrianus Gelu[2], Hammam[2], Fianti[1,2]

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[1]Physics Department, Universitas Negeri Semarang, Indonesia
[2]Postgraduate Program of Physics Education Universitas Negeri Semarang, Jl. Kelud Utara III, Semarang, Indonesia

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Abstract

The growth of the manufacturing industry in Indonesia affects on the demand of automotive parts. This study aims see the mechanical properties of organic brake canvas made from durian fruit skin and teak leaves. Composite making was done by smoothing durian fruit and teak leaves to become powder. The resulting powder was filtered with mesh 60 so that the particle size is the same so as to facilitate mixing. After that, simple mixing with other ingredients such as magnesium oxide and polyester resin is carried out. The printing process was carried out with a hydraulic press with a load of 4 tons for 3 hours. The brake canvas produced were tested for hardness, wear resistance, and absorbency by varying the percentage composition of the powder of durian fruit fiber and teak leaves. There are five variations in the percentage of composite material composition tested. The results obtained the percentage of the most optimum composition that has a value of hardness, wear wear resistance, and absorption capacity close to the value of the Indonesian National Standard (SNI 09-0143).

INTRODUCTION

The growth of manufacturing industry in Indonesia has increased significantly. This increase also affects the demand for motorcycle spare parts it self (Udhayasankar & Karthikeyan, 2015). Brake canvas has a very important role to be a major factor in driving safety. Brake quality depends on the constituent material (Badri et al., 2016). Broadly speaking the fibers used to make brake canvas can be classified into asbestos and non asbestos fibers (Liu et al., 2006). The existing brake canvas in the market today still exists using asbestos as its constituent material, while asbestos itself can disrupt the health, especially the lung organ and is harmful to the environment in high doses (Singh & Patnaik, 2015). In addition, the production cost of brake canvas with non organic material is quite high, so that the price of friction material made brake canvas becomes expensive, while many other materials that can be used as a substitute for the manufacture of brake canvas, such as materials derived from natural fibers (Sutikno et al., 2012). Utilization of alternative materials is highly recommended given the limitations of natural resources (Telang et al., 2010).

Durian skin proportionally contains high cellulose (50-60%) and lignin content (5%) and low starch content (5%) so it can be indicated that the ingredients can be used as a mixture of processed raw materials and other compressed products. The value of firmness of the elasticity of particle board product from the durian leather waste using mineral adhesive (cement) is 360 kg /cm^2 with a modified of Rupture of 543 kg /cm^2 (Tausif et al., 2017). Dry brown teak leaf waste contains bound carbon,

✉Corresponding author:
Physics Department, Universitas Negeri Semarang, Indonesia
E-mail: masturi@mail.unnes.ac.id

Table 1 Composition Percentage of Brake Canvas Composite Material

Sample Label	Composition			
	Durian Fruit Skin Powder	Teak Leaf Powder	Magnesium Oxide (MgO)	Polyester Resin
1	60%	20%	10%	10%
2	50%	30%	10%	10%
3	40%	40%	10%	10%
4	30%	50%	10%	10%
5	20%	60%	10%	10%

water, ash, volatile, flavanoid, protein, phenolic or tannin acids and coarse-grained lignin fibers. The content of lignin from both natural materials can make the brake canvas has optimum quality according to Indonesian National Standard (Effendy et al., 2017).

Composite materials are materials made of two or more materials that remain separate and different at the macroscopic level while forming a single component. The composite consists of a main material (matrix) and a type of reinforcement added to increase the strength and rigidity of the matrix (Rao & Prakash, 2015; Hoshitha et al., 2016). In this research the researchers added magnesium oxide. Magnesium Oxide (MgO) is selected as a filler which also serves as an abrasive and reinforcing material because of its good characteristics. MgO is a very light-weight metallic material (1.74 g/cm³), melting point (650 ºC), boiling point (1097 ºC), elastic modulus (110 MPa), yield strength (255 MPa), hardness (12 VHN). MgO powder is a type of additive that is mixed in the manufacture of CMCs, but also magnesium oxide as a wetting agent that makes the bond between Alumina and Aluminum more powerful, not easily eroded surface. Composites with the addition of a small amount of MgO have a better quality. MgO powder, although a small percentage plays an important role in improving wettability by encoding solid surfaces also has the ability to fill any height difference from rough surfaces and lower interfacial stress. The wear resistance can be increased through the addition of magnesium oxide element. In addition to MgO there are several choices of materials that can be used as fillers such as AI_3O_3, SiO_2, Fe_3O_4, Cr_2O_3, SiC, $ZrSiO_4$ and cyanite/Al_2SiO_5 but the price is relatively more expensive than MgO (Rudramurthy et al., 2014; Gulhane et al., 2017).

The abundant number of durian leather and teak leaves in the natural is considered capable of being utilized as one of the composite materials in the manufacture of brake canvas, of course, combined with other reinforcing materials. Besides aiming to utilize the waste innovatively, the utilization of durian fruit skin waste as a composite material of brake canvas can eliminate asbestos contents on brake canvas causing negative impact on health (Singh et al., 2017). Mixtures of some materials can produce better quality composite materials, because they have a high enough hardness properties that increase frictional force on brake canvas (Olabisi, 2016).

The use of natural fiber as a material of organic brake canvas has its own advantages. The advantages of natural fibers include low production cost, environmentally friendly, reliable supply, and can be updated (Silva et al., 2006). This advantage makes natural fibers able to replace synthetic reinforcing fibers for polymer matrix composites (Yousif et al., 2009; Kumar et al., 2010). In addition, natural fibers are also used as reinforcement in making structural components (Jain et al., 1992).

Based on the above description the researcher wanted to do simple research to get alternative composite material in brake canvas making. Simple research is done by using durian leather and teak leaf as a composite material of brake canvas. This study aims to see the mechanical properties of organic brake canvas made from durian leather and teak leaves.

RESEARCH METHODOLOGY

Durian fruit skin fiber was made in the following way. First, the durian skin is cut into small pieces 5x5 cm. The cut of durian skin was dried in the sun for 36 hours to reduce the water content. Durian leather that had been dried and then stoved at temperature 100 ^{0}C for 1 hour so that texture of fiber become stiff, so easy to be smoothed. The second stage is to do the same treatment on the teak leaves, but the temperature used during heating

Figure 1. Sample Press Tool

Figure 2. Pressure during pressing process

Figure 3. Brinell Hardness Testing Tool

Figure 4. Wear Resistance Tool

with the oven was carried out at a lower temperature of 50 ^{0}C. After all the ingredients are dried, then the fiber was smoothed with a fining machine until it is powdered and filtered with Mesh 60 to get the same particle size.

The next step was the manufacture of brake composite material made by variation of durian leaf composition, teak leaf, Magnesium Oxide (MgO) and polyester resin as presented in Table 1.

Sample printing process was done to compact the composite material. The sample printing was done by mixing the composite material prepared by the composition in Table 1. The printing was done using a hydraulic press tool with a load of 4 tons for 3 hours. The sample is printed in cylindrical shape with diameter of 2 cm and height 3 cm.

The tests conducted in this research was aimed to determine the mechanical properties of the sample such as hardness, wear and absorption of composite materials. Violence test was done by using Brinell method. The printed sample was subjected to surface smoothness and polishing to obtain a flat surface, so that the pressure given by the test apparatus can be evenly distributed. The sample was centrally placed on the test apparatus and pressurized until the sample looks cracked and crushed. Just as the sample looked cracked and crushed, a reading and recording were performed on the Brinell scale.

The test results obtained from the Brinell hardness testing tool as illustrated in Figure 3 were then incorporated into the equation (1) to calculate Brinell hardness.

$$BHN = \frac{2P}{\pi D\left(D - \sqrt{D^2 - d^2}\right)} \quad (1)$$

with BHN : *Brinell Hardness Number*, P : pressing load (kg), D : penetrator diameter (mm), d : diameter of penetrator stamping (mm).

Wear resistance test was performed by measuring the mass of the reduced composite material during the bending process. The printed sample was perforated in the middle so it can be placed in the test kit. Samples rotated at 100 rpm for 30 seconds resulting in friction and the sample mass will be reduced.

The test results obtained from the wear resistance apparatus as shown in Figure 4 were the reduction of sample mass due to iron friction with the tested composite material.

The absorption test was done by immersing the sample for 24 hours in each liquid water and oil

Figure 5. Composite Materials Generated With Variation Percentage of Composition

alternately. Prior to soaking, the sample was then weighed to determine the weight of the sample. After soaking for 24 hours, the sample is again weighed to determine the massive change of mass. The percentage of absorption can be determined by using equation (2).

$$absorption(\%) = \left(\frac{m_1 - m_0}{m_0}\right) \times 100\% \qquad (1)$$

with m_0 = mass before immersion (kg), m_1 = mass after immersion (kg).

RESULTS AND DISCUSSION

Mechanical properties are one of the important parameters, because the mechanical properties state the ability of a material (including components made from it) to accept the load/force/energy without causing damage to the material/component. The mechanical properties of the material reflect the relationship between the load which is received by a material with the given reaction (Mohammed et al, 2015).

In this study the sample used was 5 samples with percentage of different material composition on each sample as shown in Table 1. The materials used to make the sample include durian leather, teak leaf, MgO, and polyester resin. The use of MgO is intended to add a rough texture to the composite material, so will not be easily eroded and increase the frictional force. Samples of composite materials as a result of pressing process (compaction) are presented in Figure 5.

Figure 5 shows a composite cylindrical composite sample with a specimen criterion permitted by a brinell hardness test. Each sample has a different surface structure as a result of the difference in the percentage of material composition. Sample 1 has a more rough texture due to the percentage of the durian fruit skin composition used more than other samples. Durian leather fiber skin texture is more compact compared to teak leaves as the main ingredient for the composite material. The product is not easily eroded and more rigid. Sample 5 has a finer texture due to the percentage of the durian skin fiber composition used at least compared to other samples.

The test results show that sample 1 has the highest Brinell hardness value compared to the other four samples as shown in Figure 6. The Brinell hardness values are influenced by the percentage of durian and durian leaf composition used. Sample 1 has the highest percentage of durian leaf fiber composition among 4 other samples, so it has the highest hardness value. This is due to durian fruit skin has a high content of lignin, thus making durian fruit skin is hard but elastic. Brinell hardness test is performed to see the maximum strength level of the composite material in holding the load it receives. Hardness testing is performed by measuring the loads capable of being retained by the surface of the composite material sample (Prabowo, et al., 2017). Figure 6 shows a decrease in Brinell hardness of 82, 17 kg/mm^2 - 44.09 kg/mm^2. Composite material in sample 5 with composition of 20% durian fruit skin fiber and 60% teak leaves has the lowest hardness value of 44.09 kg/mm^2. The resulting hardness value is influenced by the percentage factor of the composite material composition used. The content of lignin on the skin of durian fruit greatly affects the value of hardness, the more the use of durian fruit skin then brake canvas are getting harder and vice versa. Brinell hardness value of sample 3 with composition of 40% durian fruit skin and 40% teak leaves of 65.15 kg/mm^2. The hardness value in sample 3 is the value closest to the value of hardness on the brake canvas on the market that meets the Indonesian National Standard of 63.49 kg/mm^2 (SNI 09-0143).

The second test carried out on the composite material sample is the wear resistance test. The wear resistance test is performed to find out the composite material shrinkage when friction.

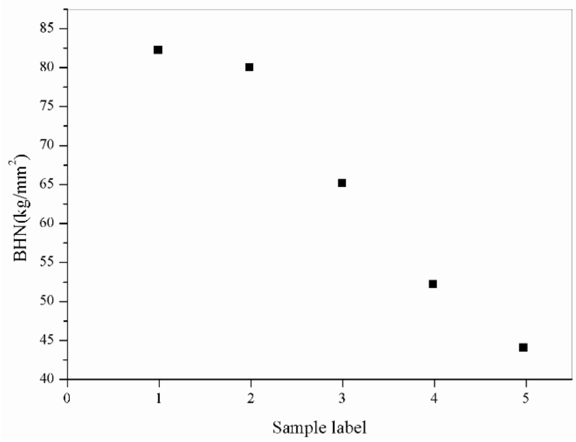

Figure 6. Brinell Hardness (BHN) of brake canvas composite for several samples. Sample label of 1, 2, 3, 4 and 5 in X-axis refers to the several compositions as described in Table 1.

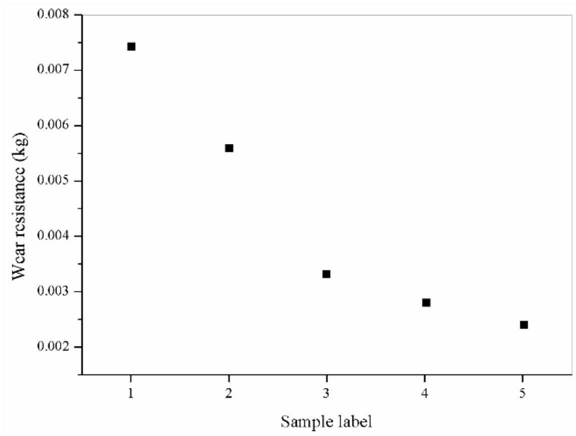

Figure 7. The wear resistance of several brake canvas samples. Sample label of 1, 2, 3, 4 and 5 in X-axis refers to the Table 1 description.

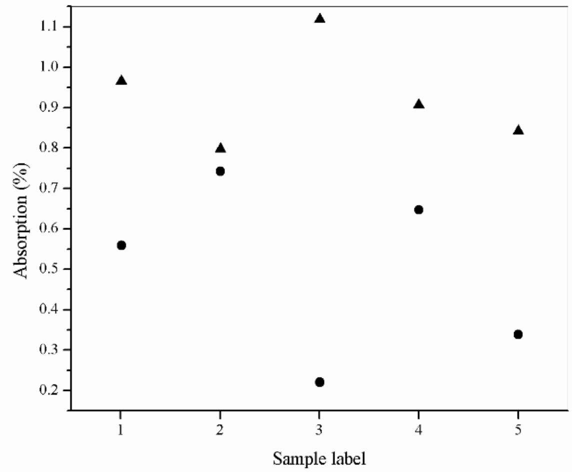

Figure 8. Media absorption of the several brake canvas samples in water (▲) and oil (●) media. Sample label of 1, 2, 3, 4 and 5 in X-axis refers to the several compositions as described in Table 1.

Testing is done by measuring the mass of composite material lost after through friction process.

The test results show that sample 1 has the highest wear resistance compared to the other four samples as shown in Figure 7. This wear resistance is affected by the percentage of the durian fruit skin composition used. Sample 1 has the highest percentage of durian leaf fiber composition among 4 other samples, so it has the highest wear resistance. The wear resistance test is performed to estimate the amount of mass of the sample lost during friction. Estimation is done by calculating the mass of the graded sample after friction (Prabowo, et al., 2017).

Figure 7 shows significant results with graphic trends experiencing a decrease in wear values on composite materials made. In sample 1 composite material consisting of 60% durian leaf fiber and 20% teak leaves have the highest wear resistance of 0.0074 kg. This is due to the main composite composite material consisting of durian fruit skin fibers that have coarse coarse texture that is easily eroded. The value of the wear resistance obtained by sample 3 is 0.0033 Kg, this value is identical with the composite material of brake canvas circulating in the market according to Indonesian National Standard which is 0.004 kg (SNI 09-0143). The amount of this wear resistance is influenced by percentage factor composite material composition. The strength of the composite material of the brake canvas, is strongly influenced by the large particles, matrix materials, and manufacturing processes (Purboputro, 2014).

The test results show that the water and oil absorption capacity of the sample varies not in accordance with the percentage of the composite material composition as shown in Figure 8. The capacity of water and oil absorption in the sample is influenced by the bond between the resin and the filler. A strong bond between the resin and its filler can decrease the porosity level of the sample (Edokpia et al, 2014). The absorption test is performed to estimate the percentage change in sample mass after immersion in water and oil. Estimation is done by calculating the change of sample mass before and after soaked in water and oil.

Figure 8 shows quite varied results not in accordance with the percentage of composite material compositions. This is due to uneven distribution of composite materials in the sample. The composite material of sample 5 consisting of 20% of durian leather fiber, 10% magnesium oxide, 60% teak leaves, and 10% polyester resin have a water absorption percentage and oil respectively of 0.832% and 0.349%. The percentage of absorption capacity obtained is identical with the composite material of brake canvas circulating in the market according to Indonesian National Standard which is 0.9% for water and 0.3% for oil (SNI 09-0143). Percentage of absorption that tends to be lower than that specified by SNI 09-0143 is considered to provide better quality on brake canvas (Ademoh, A.N, & Olabisi, A.I., 2015).

CONCLUSION

The test of hardness, wear resistance and absorption in the sample gives result that sample 3 with composition 40% of durian fruit skin fiber, 10% magnesium oxide, 40% teak leaf, and 10% polyester resin have identical with standard brake canvas that have been circulated in the market and according to SNI 09-0143 standard. Brake canvas that conform to standards have adequate hardness, not in hard or soft conditions. Brake canvas conditions that are too loud or too soft will cause problems in the braking process, so it takes a standardized hardness level of 63.49 kg/mm^2. This also applies to the level of wear mass held by the brake canvas. Brake lever wear rate affects the grip when braking is done. Good brake canvas has a high level of wear and tear is 0.004 kg, so as to make the braking process well. Conversely, if the brake canvas in the condition of low wear rate, then the braking power will be low and braking is not going well. The level of uptake of water and oil in the brake canvas also affects the performance in braking. Good brake canvass have a low tendency to absorb 0.9% for water and 0.3% for oil, thereby reducing the risk of skid during braking in wet or rain conditions. Brake canvas that have high absorption will affect the performance of brake canvas in the event of rain or wet conditions. Wet conditions will result in brake canvas loses traction and can not brake well.

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