Performance Testing of Motorcycle Centrifugal Clutch Lining Made from Composite Wood Powder, Coconut Fibre, and Green Mussel Shell

A Kholil¹, S T Dwiyati, Riyadi, and Randika H P
Department of Mechanical Engineering, Engineering Faculty, Universitas Negeri Jakarta, Kampus A Jl. Rawamangun Muka, Jakarta, 13220, Indonesia.
Email: ahmadkholil@unj.ac.id

Abstract. This study aims to determine the performance of a motorcycle fitted with a CVT centrifugal clutch lining made from a composite of wood powder, coconut fiber and green clam shell powder with epoxy resin as a constituent matrix. The process of making clutch lining is carried out by mixing the composite constituent materials in the form of powder. The specimens were made in two variations where clutch B was 20% wood powder, 20% coconut fibre, 10% green shell powder. Clutch C was 10% wood powder, 30% coconut fiber, and 10% green shell powder. Genuine clutch A was tested by the same method as the comparison. Meanwhile, the performance testing of automatic motorcycle was carried out by a chassis dynamometer to determine power and torque on wheels. Clutch lining with natural composite materials from a mixture of wood powder, coconut fiber, and shell powder have a greater power and torque than the genuine clutch lining. The performance of clutch B is better than C because the composition of B has 10% more wood powder which cellulose that affects the characteristics of natural fiber composites.

1. Introduction

Automatic motorcycles use a centrifugal clutch as part of the power transfer transmission. Centrifugal clutch works by centrifugal force which pushes the clutch to the drum so that the clutch is connected to the pulley. The centrifugal clutch on the automatic motor will transfer kinetic energy from the rotating crankshaft to the CVT transmission and then transmitted to the wheels. The process of merging into a power source in the clutch utilizes the frictional force on the surface of the friction material with a certain coefficient of friction. The frictional force is used to start the driven shaft from rest and gradually bring it to the proper speed without excessive slipping on the friction surface [1].

The clutch serves to disconnect and connect the engine speed to the transmission quickly and gently. The clutch must be resistant to friction and high rotation so that there is no damage when transferring power from engine speed to transmission. Some of the requirements that must be met on the clutch, among others: can continue the engine speed to the transmission; can disconnect and connect the engine speed to the transmission; and can continue the rotation of the engine to the transmission gradually, evenly, and without pounding [2].

The centrifugal clutch is usually incorporated into the motor pulley. Consists of a number of shoes on the inside edge of the pulley, as shown in Figure 1. The outer surface of the shoe is coated with a friction material. These shoes, which can move radially in guides, are held against the boss (or spider) on the drive shaft by means of a spring. The spring exerts a radial inward force which is assumed to be constant. The weight of the shoe, as it rotates, causes it to exert a radial outward force (i.e. Centrifugal force). The magnitude of this centrifugal force depends on the speed of rotation of the shoe. A little
consideration will show that when the centrifugal force is less than the spring force, the shoe remains in the same position as when the drive shaft is at rest, but when the centrifugal force equals the spring force, the shoe simply floats. When the centrifugal force exceeds the spring force, the shoe moves outward and comes into contact with the moving part and compresses it. The increase in speed causes the shoe to press harder and allows more torque to be delivered [3]. Figure 1 shows the parts of the centrifugal clutch.

![Centrifugal Clutch Parts](image)

**Figure 1.** Centrifugal clutch [3].

In general, clutch use asbestos materials which are harmful to human health and the environment [1]. Non-asbestos based friction material is a multi-material system to achieve the desired mixture of performance properties [4]. Natural composite friction material for clutches and brakes can be classified in the following groups: fibers, binders, friction modifiers, and fillers [5]. Composites are to produce better material compared to conventional materials. Composite fibers and particles are embedded in a matrix of other material. The wood powder is a waste produced by wood processing such as sawdust [6]. Wood powder is used because it has a high cellulose content [7,8]. An investigation was carried out on the use of sawdust to develop brake pads [8,9]. The composites prepared from the seashells are tested for various mechanical properties like toughness, tensile strength, impact strength, flexural strength [10]. Green mussel shell wastes consist of calcium carbonate and organic matrices, with the former accounting for 95-99% by weight. Being the richest source of biogenic CaCO$_3$, shell wastes are suitable to prepare high purity CaCO$_3$ powders [11]. The shell waste could be further processed to be the filler of polymer composites [12]. But there are limited studies in mussel shells used as filler in epoxy-based composites. In previous studies, characterization of the alloy clutch material has been carried out, especially the characteristics of hardness, coefficient of friction, wear and microstructure [1,13].

The purpose of this study is to test the performance of an automatic motorcycle using a sample of the centrifugal clutch lining made from natural fiber composites from wood powder, coconut fiber and green mussel powder. The test results are compared with genuine parts centrifugal clutch pads to see the characteristics of power and torque produced against engine speed. This will give an idea of the ability of the clutch to transmit power and torque to the wheels. This research will provide an overview for the application of the clutch lining and also for further research.

2. Materials and Methods
The material used in this study is a natural fiber composite whose ingredients are wood powder, coconut fiber, and green mussel powder which are used as a mixture with a percent by weight. Phenol-formaldehyde resin was used as a binder. The composition of the test sample can be seen in Table 1.
Table 1. The composition of sample testing.

| No | Sample for testing | Compositions                     |
|----|--------------------|----------------------------------|
| 1  | Clutch A           | Genuine clutch                   |
| 2  | Clutch B           | 20% wood powder, 20% coconut fiber, 10% green shell |
| 3  | Clutch C           | 10% wood powder, 30% coconut fiber, 10% green shell |

The process of making clutch lining samples refers to a previous study [1]. The pressed material is then prepared for the manufacture of clutch lining samples. The process of preparation of the clutch lining sample can be seen in Figure 2. The cut of the lining material is adjusted to the size of the genuine parts, centrifugal clutch shoe to facilitate assembly. The lining material that is the right size is then attached to the centrifugal clutch shoe using destine glue. Each set of automatic motorcycle centrifugal clutches for this test has three clutch shoes. The clutch that is ready for testing can be seen in Figure 3.

Figure 2. The process of preparing the test sample into a clutch.

![Figure 2](image)

Figure 3. Specimen of centrifugal clutch.

Performance testing uses test specimens that are applied to a 150 cc motorcycle engine with CVT transmission. Motorcycle performance testing is done using chassis dynamometer [14]. The testing process can be seen in Figure 4. The motorcycle performance test is carried out by varying the clutch lining material and comparing it with genuine parts, centrifugal clutch lining so that the performance characteristics of the power and torque of the motorcycle against engine speed can be seen in the form of a graph. In the performance test with the chassis dynamometer, the rear wheel of the motorcycle is raised above the dynamometer roller and the motorcycle is tied using a safety rope according to the standard operating procedure of the test. Next, the dynamometer is set up by determining the parameters to be displayed in the graph and the data to be generated by the dynamometer. The motorcycle is started and the throttle is opened to the full position until the engine reaches maximum
capacity. Torque, power, rpm, and time data from the motorcycle display in the monitor so that they can be viewed and analyzed. The testing process is the same for all clutch lining samples.

![Figure 4. Testing with chassis dynamometer.](image)

### 3. Results and Discussion

The performance of the dynamometer on the clutch lining sample produces power and torque data. From the test data, the maximum torque on the clutch pad A which is a genuine part has a value of 13.17 Nm at 4698 rpm in 1.98 seconds. While the maximum power on this clutch is 10.3 hp at 6278 rpm in 4.18 seconds. Table 2 shows the overall data obtained from the dynamometer using genuine parts centrifugal clutch pads.

**Table 2. Results of genuine parts clutch lining.**

| Engine speed (rpm) | Power (hp) | Torque (Nm) | Time (s) |
|-------------------|------------|-------------|----------|
| 4000              | 4.6        | 7.65        | 1.34     |
| 4500              | 7.9        | 12.56       | 1.7      |
| 4698              | 8.7        | 13.17       | 1.98     |
| 5000              | 9          | 12.84       | 2.38     |
| 5500              | 9.7        | 12.53       | 3.04     |
| 6000              | 9.8        | 11.63       | 3.76     |
| 6278              | 10.3       | 11.6        | 4.18     |
| 6500              | 10.2       | 11.16       | 4.5      |
| 7000              | 9.6        | 9.74        | 5.34     |
| 7500              | 9.1        | 8.62        | 6.3      |
| 8000              | 8.7        | 7.77        | 7.36     |
| 8500              | 8.8        | 7.34        | 8.52     |
| 9000              | 8.5        | 6.71        | 9.74     |
Table 3 shows the overall data using the sample clutch B. The maximum torque on the clutch B is 17.06 Nm at 4034 rpm in 1.76 seconds. While the maximum power on the B clutch is 10.6 hp at 6206 rpm in 4.42 seconds.

### Table 3. Results of the clutch lining B.

| Engine speed (rpm) | Power (hp) | Torque (Nm) | Time (s) |
|--------------------|------------|-------------|----------|
| 4000               | 9.6        | 17.05       | 1.72     |
| 4034               | 9.7        | 17.06       | 1.76     |
| 4500               | 10.1       | 15.97       | 2.24     |
| 5000               | 10.1       | 14.39       | 2.8      |
| 5500               | 10.2       | 13.19       | 3.44     |
| 6000               | 10.5       | 12.45       | 4.12     |
| 6206               | 10.6       | 12.11       | 4.42     |
| 6500               | 10.3       | 11.27       | 4.82     |
| 7000               | 10.1       | 10.25       | 5.64     |
| 7500               | 9.6        | 9.12        | 6.52     |
| 8000               | 9.4        | 8.35        | 7.5      |
| 8500               | 9.5        | 7.93        | 8.56     |
| 9000               | 9.1        | 7.2         | 9.7      |

Table 4 shows the overall data using the sample clutch C. The maximum torque on the clutch C lining is 15.81 Nm at 4391 rpm in 1.86 seconds. While the maximum power on the clutch C is 10.5 hp at 6233 rpm in 4.38 seconds.

### Table 4. Results of the clutch lining C.

| Engine speed (rpm) | Power (hp) | Torque (Nm) | Time (s) |
|--------------------|------------|-------------|----------|
| 4000               | 6.4        | 11.47       | 1.4      |
| 4391               | 9.7        | 15.81       | 1.86     |
| 4500               | 9.8        | 15.6        | 1.96     |
| 5000               | 10.1       | 14.4        | 2.54     |
| 5500               | 9.8        | 12.68       | 3.18     |
| 6000               | 10.1       | 12          | 3.88     |
| 6333               | 10.5       | 11.69       | 4.38     |
| 6500               | 10.1       | 11.08       | 4.62     |
| 7000               | 9.9        | 10.11       | 5.44     |
| 7500               | 9.6        | 9.15        | 6.36     |
| 8000               | 9.4        | 8.38        | 7.34     |
| 8500               | 9.4        | 7.89        | 8.42     |
| 9000               | 9          | 7.12        | 9.56     |

Figure 5 is a graph of power and torque against engine speed in the engine speed range of 4000-9000 rpm. This graph is a plotting of the three results of the clutch lining test using the dynamometer.
The power and torque generated from the test are the power and torque of the motorcycle wheel as the dynamometer test.

![Figure 5. Power and torque of sample test result.](image)

Clutch pads B and C with natural composite materials from a mixture of wood powder, coconut fiber and green mussel shells have higher power and torque values than clutch pads A, which are genuine clutch parts. Clutch B has a mixture of 20% wood powder, 20% coconut fiber, and 10% green mussel shells, while Clutch C has a mixture of 10% wood powder, 30% coconut fiber, and 10% green mussel shells. The power value produced in Clutch B is greater than Clutch C. Both have a different mixture of wood powder and coconut fiber. Differences in the mixture will affect the properties of the coefficient of friction, hardness, and wear. In previous studies, tests have been carried out which indicate that the friction coefficient value of the previous test results is between 0.3 - 0.4 [1] and the value is in the range of the conventional clutch bearing friction coefficient of the resin mold usually in the range of 0.3 - 0.5 [3]. The composition of the larger wood powder affects the hardness of the composite because it contains a lot of cellulose [7,13]. As research by kholil et al, the hardness value for the composite type of material used in clutch B has a higher hardness value than the type of material used in clutch C [1,13]. In addition, the coefficient of friction of clutch B is also higher than that of Clutch C, thus affecting the dynamometer results. High clutch torque at low rpm is very good for giving the motorcycle thrust so that it can increase speed. The results of this study can provide initial information for further research related to the reliability of the clutch material.

4. Conclusions
Clutch pads B and C with natural composite materials from a mixture of wood powder, coconut fiber and shells have higher power and torque values than clutch pads A, which are genuine clutch parts. The performance of the B clutch lining is better than C because the composition of the material in the B clutch has 10% more wood powder containing cellulose. Cellulose content and other material compositions will have an influence on the characteristics of hardness, coefficient of friction and wear on natural fiber composites to become friction materials for centrifugal clutches.
Acknowledgment

The author expresses his gratitude and highest appreciation to the Directorate of Research and Community Service of the Ministry of Education, Culture, Research and Technology for providing PTUPT grants. And also thanks to the National Research and Innovation Agency.

References

[1] A Kholil, S T Dwiyati, R Riyadi, J P Siregar, N G Yoga, and A I Aji 2021 Characteristics of wood powder, coconut fiber and green mussel shell composite for motorcycle centrifugal clutch pads *IOP Conf. Ser. Mater. Sci. Eng.* **1098**, no. 6, p. 062034.
[2] A Kholil and R Wirawan, Pengaruh pattern pada sepatu kopling centrifugal terhadap daya dan torsi sepeda motor matic, no. Snttm Xiii, pp. 15–16, 2014.
[3] R S Khurmi and J K Gupta, A textbook of machine design, no. I. Eurasia Publishing House (PVT.) LTD., 2005.
[4] J Bijwe 1997 Composites as friction materials: recent developments in non-asbestos fiber reinforced friction materials-a review, *Polym. Compos.* **18**, no. 3.
[5] P V Gurunath and J Bijwe 2007 Friction and wear studies on brake-pad materials based on newly developed resin, *Wear* **263**, pp. 1212–1219.
[6] O L Rominiyi, B A Adaramola, O M Ikumapayi, O T Oginni, and S A Akinola 2017 Potential utilization of sawdust in energy, manufacturing and agricultural industry; waste to wealth, *World J. Eng. Technol.* **05** no. 03, pp. 526–539.
[7] R C Pettersen 1984 The chemical composition of wood, pp. 57–126.
[8] A Kholil, S T Dwiyati, and J P Siregar 2020 Development brake pad from composites of coconut fiber, wood powder and cow bone for electric motorcycle *Int. J. Sci. Technol. Res.* **9**, no. 02, pp. 2938–2942.
[9] S S Lawal, K C Bala, and A T Alegbede, Development and production of brake pad from sawdust composite, no. 30, pp. 47–56, 2017.
[10] B V Ramnath, J Jeykrishnan, G Ramakrishnan, and B Barath 2018 Sea shells and natural fibres composites: a review, *Mater. Today Proc.* **5**, no. 1, pp. 1846–1851.
[11] S Kocaman, G Ahmetli, A Cerit, A Yucel, and M Gozukucuk 2016 Characterization of biocomposites based on mussel, *World Acad. Sci. Eng. Technol. Int. J. Mater. Metall. Eng.* **10**, no. 4, pp. 438–441.
[12] J Abutu, S A Lawal, M B Ndaliman, R A Lafia-araga, O Adedipe, and I A Choudhury 2018 Engineering science and technology, an international journal effects of process parameters on the properties of brake pad developed from seashell as reinforcement material using grey relational analysis, *Eng. Sci. Technol. an Int. J.*
[13] A Kholil, S T Dwiyati, A Sugiharto, and I W Sugita 2019 Characteristics composite of wood powder, coconut fiber and green mussel shell for electric motorcycle brake pads, *J. Phys. Conf. Ser.* **1402**, no. 5.
[14] I Wayan Sugita, D Rio Budi Syaka, and A Irianto Wahyudi 2019 Effect of pertalite – methanol blends on performance and exhaust emission of a four-stroke 125 cc motorcycle engine, *KnE Soc. Sci.* **3**, no. 12, p. 384.