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Testing of mechanical characteristics of coconut fiber reinforced for composite brake pads for two-wheeled vehicles

Testing of mechanical characteristics of coconut fiber reinforced for composite brake pads for two-wheeled vehicles

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Abstract. Brake pad is the most important part of the braking system as a vehicle safety feature, which functions to slow down or stop the motorized vehicle. Generally, brake pads are made of non-asbestos and asbestos materials that contain carcinogens. Non-asbestos brake pads have several advantages, which are environmentally friendly, not noisy, and have a good temperature resistance and friction resistance. Brake pads must qualify the value of the coefficient of friction (μ) dan has low wear also to qualify braking system requirements on motorized vehicles. Hardness values also need to be studied further, because if the brake pads very hard it will affect the disk rotor's performance. Furthermore, the density and porosity of the brake pads also need to be known to get brake pads that qualify the properness of motorized brake pads. This is to determine the ability of brake pads made from natural fiber composites based on test standards for motorized brake pads. The composition of manufacture of composite brake pads consists of coconut fiber which is given alkaline treatment as reinforcement then mixed with an epoxy resin as a matrix and the filler addition of alumina and magnesium oxide as a friction modifier. The composite brake pads then tested for hardness, wear rate, coefficient of friction, density and porosity to determine the mechanical characteristics. The results of the tests between composite brake pads with comparative brake pads with successive values for hardness (97.27 HD and 99.05 HD), specific wear rates (2.99 x 10-7 cm^3/Nm and 1.77 x 10-7 cm^3/ Nm), coefficient of friction (0.41 and 0.43), density (1.93 gr/cm^3 and 2.42 gr/cm^3), porosity (19.72% and 11.89%). The result show that the composite brake pads with the coconut fiber as reinforcement are comparable with brake pads on the market.
Keywords. brake pads, composite, mechanical characteristic.

1. Introduction

The braking system is one of the most important safety features in motorized vehicles. Brake pads is the most important part of the braking system which functions to slow down or stop the vehicle. Brake pads must have good wear resistant, stable coefficient of friction during service life. Brake pad materials must have a high wearing resistance, light weight and high strength/density (specific strength) in order to reduce the costs of technological applications and fuel consumption [1].

Brake pad are generally made of asbestos materials that are subjected to changes and substitutions due to environmental and legislative demands. These demands have resulted in the removal of asbestos materials and producing pads without asbestos, based on metal-matrix composites, polymer matrix composites, organic, semi- and low-metallic compounds. In the next few years, legislation will require the replacement of copper constituents of pads. This has led to several attempts in the past few years to find proper substitution options and to develop other eco-friendly materials [2].

Brake pads with polymer matrix composites with natural fiber as reinforcement has several advantages, namely environmentally friendly, doesn't show any noise, heat resistant and has a good coefficient of friction [3]. Coconut (coir) fiber is one of environmentally friendly material that may be decomposed in 20–30 years in the nature. The brown coir fiber had a high resistance to abrasion [4]. Coconut fiber as reinforcement for composite clutch have a near value of hardness and wear rate with existing clutch [5]. The aim of this study is to investigate the mechanical characteristics of coconut fiber reinforced on composite brake pads for two-wheeled vehicles.

2. Experimental details

Composite brake pads are manufactured from a mixture of coconut fiber as reinforcement with epoxy resin as a matrix and additional fillers of aluminum oxide and magnesium oxide as friction modifiers. The composite brake pad specimens were tested for mechanical characteristic and compared with commercial brake pads that usually used in motorized vehicles.

2.1. Sample preparation

Firstly, coconut fibers were immersed in 5% NaOH alkaline solution for an hour in order to reduce the content of lignin and hemicellulose from the fibers, so that the bonding strength of the fiber-matrix interface increased [6]. Then the fiber was washed with distilled water and followed by drying process. The dried fiber was cut for ±7 mm of length and stored in a container with silica gel.

2.2. Manufacturing process

Composite brake pad made from volume fraction of 20% chopped coconut fiber, 46% of epoxy resin, 28% of aluminum oxide and 6% of magnesium oxide. Composite brake pads were manufactured by open molding process that was performed under 24 kgf.m compression load at temperature of 180°C with holding time for 40 minutes in the furnace. The next step was decreasing the temperature to the room temperature and keeping the compression load for another ± 6 hours. Composite material of brake pads specimen (Figure1) molded with dimension 10 mm (length) x 10 mm (width) x 7 mm (thickness) in square shape, was then cut according to the testing requirement.

Figure 1. Composite specimen for brake pads material

2.3. Testing of the mechanical characteristics

Composite brake pads and commercial brake pads specimens were tested to determine their mechanical characteristics such as: hardness based on ASTM F 1957-99. Wear rate determination was carried out based on ASTM G 99-95a. Furthermore the coefficient of friction based, density, and porosity were investigated according to ASTM D 1894–001, ISO 15484:2015, and ISO 15484:2015 methods, respectively.

3. Result and discussion

Composite brake pads specimens and commercial brake pads specimens were tested for hardness, wear rate, coefficient of friction, density, and porosity based on ASTM and ISO standards to determine each mechanical characteristic. Then the test results were compared to determine whether composite materials have mechanical characteristics that comparable to commercial brake pads. Test details and the result of the test are described in the following sub-section which consist of:

3.1. Hardness

The material hardness was obtained from hardness testing based on ASTM F 1957-99, with shore D durometer which was used for hardness tester. Each specimen consist of the composite material and the commercial brake pads material was carried out the same hardness test. Based on the results of the hardness test using durometer shore D, the test results are as shown in Figure 2. The hardness value of composite material reached 97.27 HD with a hot press process of 24 kgf.m, which was approaching the hardness of commercial brake pads material (99.05 HD).

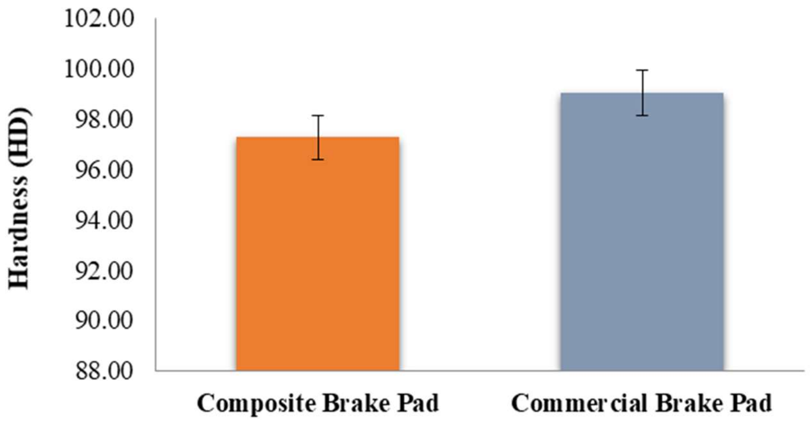

Figure 2. Hardness of material

3.2. Specific wear rate

Specific wear rate material was obtained from wear testing based on ASTM G 99-95a used a Pin-on-Disk Tribometer wear tester. Parameters of the test consists of a compressive load of 60 N, a disk rotational speed of 60 rpm, a tracking pin 1000 m. Composite brake pads and commercial brake pads materials were carried out the same test and obtained the test results as presented in Figure 3.

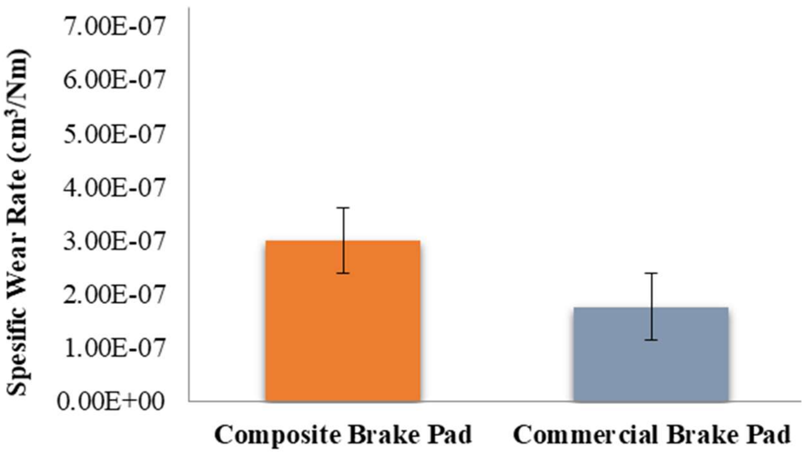

Figure 3. Spesific wear rate

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Determination of the specific wear rate shown that composite brake pads material has lower value compared to commercial brake pads material, this is proportional to the hardness value of each materials.

3.3. Coefficient of friction

Coefficient of friction material was obtained from kinetic coefficient of friction testing material based on ASTM D 1894–001. The material of composite brake pads and commercial brake pads were carried out the same test and obtained results the coefficient of friction value showed in Figure 4. Semi-metallic commercial brake pads has a coefficient of friction value greater than composite brake pad made from natural materials. However, the value obtained from the results of testing the friction coefficient are equivalent, the friction modifier in the form of aluminum oxide and magnesium oxide has a good effect on the coefficient of friction.

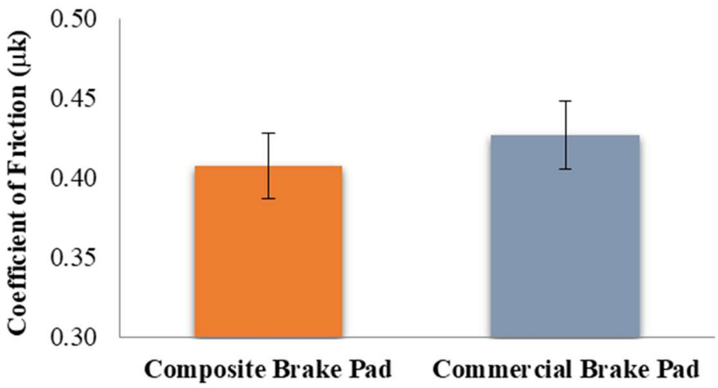

Figure 4. Coefficient of friction

3.4. Density

The density of brake pad material was obtained by weighing the specimens in the air and immersed in water at a temperature of 27 ºC. Based on ISO 15484:2015, Figure 5. showed that composites brake pad has density lower than those commercial brake pad. Density of material was depending on the material constituent, as in considering without metal contained.

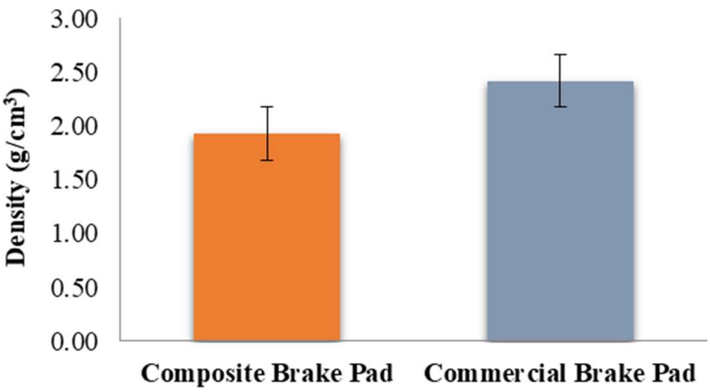

Figure 5. Density

3.5. Porosity

Porosity is proportional to the percentage of oil content absorbed relative to the material. In this research, determination of porosity in brake pad specimens was conducted based on the standard document ISO

15484: 2015. The material of composite brake pad and commercial brake pads were carried out the same test methods. Brake pad specimens were immersed in oil and stored at a temperature of 90 ± 10 ºC for 3 hours holding time. The initial weight before immersed and the final weight of the specimen after immersed were determined, then the porosity values are obtained as shown in Figure 6. The percentage of composite brake pads porosity is greater than the commercial brake pads, this value indicates that there are voids in composite brake pad specimens.

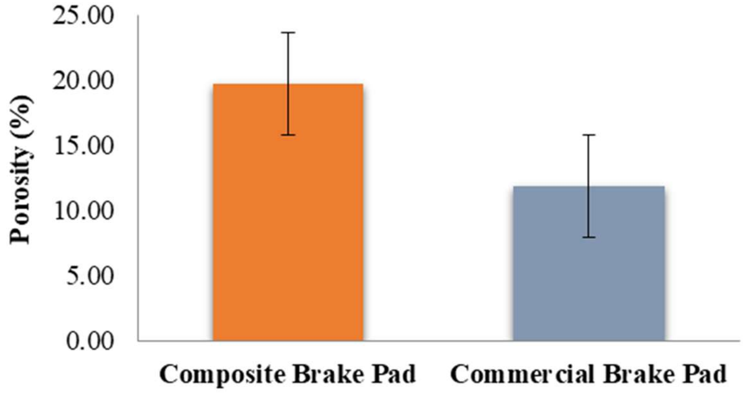

Figure 6. Porosity

Based on these five tests of composite brake lining specimens, there are several characteristics that migh be influenced by the void in the specimen. According to the result as can be shown in Figure 7, the presence of voids in the specimen need to be minimized by improving the manufacturing process such as adding compressive loads during the hot press process.

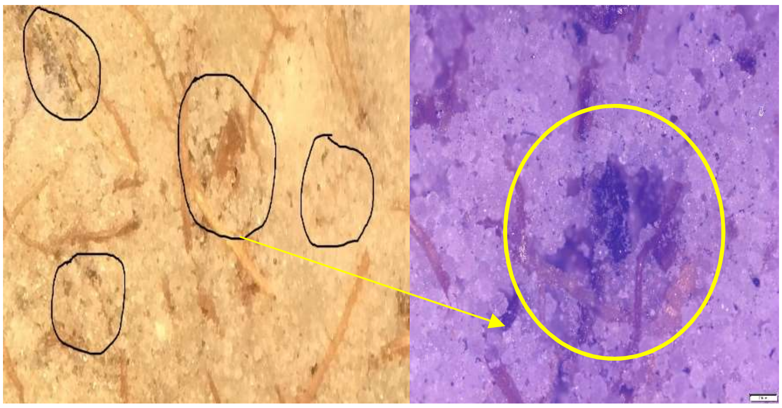

Figure 7. Void in specimen

4. Conclusion

The mechanical characteristics of composite brake pad with reinforced coconut fibers were alkalized, providing sufficient test results to be considered as alternative friction material for brake pads. The manufacturing method can be improved to get better mechanical characteristics which was equivalent to the commercial brake pads.

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