Effect of operation conditions to rice plant fiber reinforced composite on coefficient of friction and wear rate of brake lining

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Abstract. Composites made from a combination of rice plant fiber, fiberglass, aluminium powder and polyester resin are potential materials to be used as brake lining. In addition to the properties of the composite material itself, operating conditions also affect the performance of the brake lining. Therefore, this study is aimed to investigate the effect of operating conditions on the coefficient of friction and the wear rate of the composite when used as brake lining. The coefficient of friction and the wear rate tests were carried out on composites made of 40% fiber rice plant, 40% polyester resin, 10% fiberglass and 10% aluminium. The tests were carried out at a pressure of 30 kg/cm² and a speed of 2000 rpm. The operating conditions applied in this study were dry, water, salt water and brake oil. The test results show that the highest coefficient of friction was the dry operating conditions of 0.643 and the lowest coefficient of friction was the operating condition using brake oil of 0.586. While the wear test results showed the highest wear rate in dry operating conditions of 81.25 mm³/hour and the lowest wear rate in operating conditions using brake oil of 68.34 mm³/hour.

1. Introduction

Composite materials defined as a combination of two or more phases in a macroscopic and microscopic manner in order to obtain the desired combination of properties. To achieve the required properties, various combinations of metals, ceramics and polymers are mixed. This will produce various types of composite materials. In general, composite materials are made to improve the predominance of mechanical properties such as strength, toughness, stiffness at room temperature and at high temperatures [1-3].

Composite materials play an important role in industry. For example, composites are widely used in the fields of aerospace applications [4, 5], aircraft and military [6, 7], the automotive industry [8, 9], sports equipment [10] and packaging materials [11].

Nowadays, natural fiber reinforced composites developed by numerous industries are utilized in various applications [12-15]. In order to find new possibilities, the natural fibers have been recently studied as a reinforcing material in automotive brake friction composite materials and showed significant potential. The researchers highlighted that apart from tribological properties, the economic and ecological benefits of natural fiber reinforced friction composites helps them to be utilized in automotive braking systems.
Brake lining is a friction material made from a mixture of materials that serves as a barrier to friction between two plates. The main function of the brake lining is to reduce or even stop the rotational speed of an object. One of potential material to replace common material is natural composite that help protect the environment and human health [16, 17].

Matějka et al. [18] investigate effects of silicon carbide particle sizes on friction and wear properties of composites. The composite is applied for brake lining of car. The coefficient of friction is significantly increased with the presence of SiC. Increasing of particle size caused decreasing of specific wear rate.

The coefficient of friction and the rate of wear become important properties to be investigated when composites are used as components that experience friction with other components. One of its uses is as a material for brake lining. Therefore, this research is intended to investigate the effect of brake lining operating conditions on the coefficient of friction and corrosion rate of the composite

2. Materials and Methods
In this study, composite materials are used as alternative materials for brake lining. This composite is a combination of 40% polyester resin, 40% of rice plant fiber, 10% fiberglass and 10% Aluminum powder.

The first step of this research is to weigh material for composites. Furthermore, rice plant fiber, fiberglass and aluminum powder are mixed until blended. Then the steel brake lining mold is mounted on the plate. In the second step, polyester resin is placed in the mold. Then the other material that has been mixed is put into the mold.

After all components of the composite were mixed in the mold, the mold is then pressed using a pressing machine. During the compression process, the composite mixture was given heat at a temperature of 90 °C. Furthermore, the composite was sintered at a temperature of 180 °C for 15 minutes. After the composite in the mold has cooled, the brake lining is then removed from the mold.

Metallographic testing is conducted by taking micro photos of brake lining, and then proceeds with friction testing to get the coefficient of friction. The coefficient of friction testing is carried out at a pressure of 30 kg/cm² and a speed of 2000 rpm. The operating condition for the coefficient of friction test and wear rate test were dry, water, salt water and brake oil.

3. Results and Discussions
Figure 1 shows a photo of a brake lining made of composites as a product of this research. This composite is a combination of metals, ceramics, polymers and natural materials. The composition of this composite is 40% polyester resin, 40% of rice plant fiber, 10% fiberglass and 10% Aluminum powder.

![Figure 1. Brake lining from composite materials](image)

Micro photo of brake linings made of composites are shown in figure 2. Aluminum powder with a size of 3 μm, fiberglass and rice plant fiber is surrounded by polyester resin matrix. Aluminum
powder, fiberglass and rice fiber plant have a function as composite reinforcement and transferring the load received by the component.

![Figure 2](image-url)

**Figure 2.** Photo micro of brake lining from composite materials.

The coefficient of friction of composite at various operating condition is shown in figure 3. The coefficient of friction of the composites under dry, water, salt water, and brake oil operating conditions is 0.643, 0.631, 0.603 and 0.586, respectively.

The coefficient of friction of the composites under dry, water, salt water, and brake oil operating conditions is 0.643, 0.631, 0.603 and 0.586, respectively. Compared to other operating conditions, the coefficient of friction in the brake oil operating conditions has decreased the greatest coefficient of friction by 9.7%. This is due to the function of the lubricant from brake oil which reduces friction.

![Figure 3](image-url)

**Figure 3.** Coefficient of friction of composite at various operating condition.

The wear rate test shows a similar tendency to the results of the friction coefficient test (figure 4). The wear rate of the composites under dry, water, salt water, and brake oil operating conditions is 81.25 mm³/hour, 78.66 mm³/hour, 72.38 mm³/hour and 68.34 mm³/hour, respectively. The highest decrease in wear rate also occurs in brake oil operating conditions by 16%. Figure 5 shows the surface
of the former wear test on composite materials. It can be seen in the picture that the wear on the composite material is caused by a cohesive failure on the composite

![Figure 4. Wear of composite at various operating condition](image)

![Figure 5. Cohesive failure](image)

4. Conclusions
From the results of the study it can be concluded that operating conditions affect the coefficient of friction and the rate of wear. The highest coefficient of friction of 0.643 occurs in dry operating conditions and the lowest coefficient of friction occurs in operating conditions using brake oil of 0.586. In the wear test it was found that the highest wear rate occurred in dry operating conditions of 81.25 mm$^3$/hour, while the lowest wear rate occurred in conditions using brake oil of 68.34 mm$^3$/hour.

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