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Resin-based Brake Pad with Fleece Fiber and Its Mechanical Properties

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Abstract

Fleece has strong and good fiber characteristics, which are needed to manufacture brake pads. This study aims to analyze the fleece performance as a friction component material in brake pads. The fleece was initially pre-treated by heating for 4 hours at 150°C and cut into 2 mm sizes. The epoxy resin and hardener were mixed with a ratio of 1:1. The 0.5 g pre-treatment fleece was added to the resin mixture, so the total mass of the resin-fleece mixture was 12.5 g. The mixture was then molded into a cube mold (dimensions of 2.5 × 2.5 × 2.5 cm). The brake pad was dried at room temperature for a day. The characterizations were done using the compressive strength and puncture strength test. The results showed that the fleece brake pad has good mechanical characteristics, demonstrated by the pressure of 215 MPa, which can still be held by the surface of the fleece brake pad. The puncture test showed an average puncture of 76.43%. Overall, the fleece shows good performance on the brake pads. Fleece has many minerals that make it as powerful fiber characteristics and prospective as a friction component material on the brake pads. This research is expected to provide new information about organic materials for friction materials in brake pads.

Keywords

Brake pad; Fleece; Friction material; Resin.

1 Introduction

A brake is a system that regulates, slows down, and stops a rotating machine inside a vehicle [1]. The brake works by rubbing the disc (brake disc) with brake pads when two components come into contact, turning kinetic energy into heat. The brake pad is crucial when the vehicle is moving at high speed to protect the safety of drivers and passengers. Depending on the material used in their production, brake pads are particle composites made of a binding substance and a friction material that will influence the brake pad strength in the end. Hence, the friction material comprises evenly distributed particles in a matrix and serves as a binder to create a compact structure [2].

Regarding brake pad characteristics, friction material significantly affects fade resistance, friction coefficient, porosity/noise, and strength [3]. In the past few years, asbestos has been the friction material utilized in brake pads. However, it was already banned due to its dangerous and carcinogenic characteristics [4]. Thus, researchers have recently developed safe and environmentally friendly friction materials using non-asbestos organic materials (NAO) [5]. The high fiber content in NAO materials has improved the mechanical properties, friction coefficient, and brake linings' water absorption [6].

Several organic materials used as friction materials in brake pads include seashells [7], rice husk [8], areca sheath fibers [9], palm kernel shell [10], sawdust [11], cow bone [12], banana [13], periwinkle shell [14], and many more. All those organic materials contain much fiber, either in the form of lignin, cellulose, or other fibers type. In addition, the silica content in some organic materials can also improve the performance of brake pads.

Fleece is one of the unique materials found among the organic materials used for friction material in the brake pad. In general, fleece is widely used in the textile industry and has never been used in the manufacture of brake pads, despite having strong and good fiber [15]. Therefore, the innovation of fleece fiber used in the brake pad would be the originality of this research. This study aimed to analyze the performance of fleece as a friction material in brake pads. The fleece fiber would be used in a resin-based brake pad. The resin was made from bisphenol A-epichlorohydrin and cycloaliphatic amine, and the resin-based brake pads were manufactured at room temperature without additional heat or pressure. Then, compressive and puncture tests

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were used to investigate the mechanical properties. Additionally, microscopy imaging was done to assess the fleece brake pad surface. This study shows the potential of fleece fiber as a friction material in brake pads.

2 Method

The resin components utilized in the brake pad production were cycloaliphatic amine and bisphenol A-epichlorohydrin. Those two components were carefully blended in a 1:1 ratio. The fleece was obtained from sheep raised in Kuningan, West Java, Indonesia. The fleece was cleaned, dried in an oven (150°C for four hours), and cut into 2 mm sizes to make it smaller. Then, 0.5 g of fleece was mixed with 6 g of epoxy resin and 6 g of hardener to produce a cube (dimensions of 2.5 × 2.5 × 2.5 cm) of brake pads. For one day, the dough was dried at room temperature. The ready-made brake pad was chopped into a precise size for the characterizations.

The brake pad's mechanical properties were evaluated using compression and puncture strength tests. For the compressive test, a Screw Stand Test Instrument (Model I ALX-J, China) with a digital force gauge instrument (Model HP-500, Serial No. H5001909262) was utilized with a constant displacement rate of 2.6 mm/min. From the simultaneous recording of the compressive force, a compressive stress-strain curve was generated to illustrate the textural profile. Then, the peak of the curve was taken as the compressive strength.

Furthermore, the amount of force (measured in Newton (N) units) exerted at its maximum was utilized to determine the sample's hardness. The piercing or puncture strength test was done using shore durometer equipment (Shore A Hardness, In size, China). During the test, a 1 mm diameter probe was utilized to penetrate the brake pad [3,17], and a scale of 0 - 100 was used to calculate the hardness. The probe will pierce the sample of the brake lining and show a value as the brake lining strength.

3 Results and Discussion

Figure 1 is the photograph of a resin-based brake pad reinforced with fleece. This brake pad has a brownish yellow color with an inhomogeneous, porous, and rough surface. This is because the fleece contains many minerals that cause the fleece to be rough and hard [15].

Figure 2 is the result of the structural morphology of the brake pad surface made of resin and reinforced with sheep's wool or fleece. Figure 2(a) depicts the morphology of an inner brake pad surface structure. The outer brake pad has a surface with a porous structure and unequally distribution of fleece. The non-uniformly distribution of fleece in forming bonds with the resin can be indicated by the horizontal and vertical positions of the fleece in forming crosslinks with the resin [16]. Figure 2(b) depicts the morphology of an outer brake pad surface structure, which also has a porous structure on the surface but not as much as the outer surface.

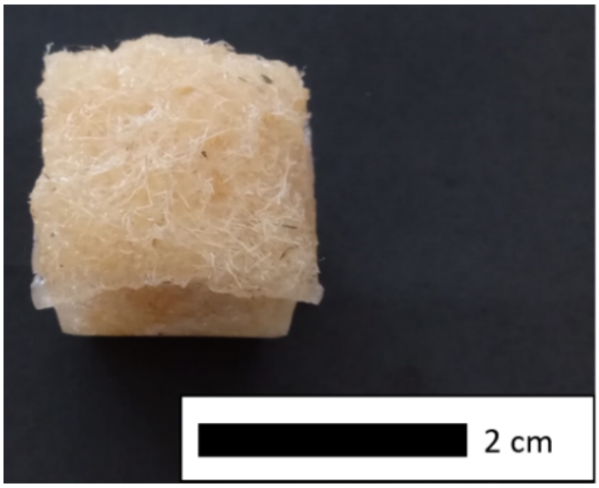

Figure 1 Brake pad prepared from fleece-based resin

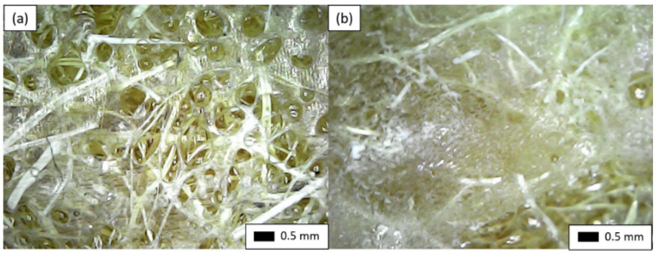

Figure 2 Microscope image of fabricated brake pad (a) inner and (b) outer morphology structure

The compressive test results of the brake pad are shown in Figure 3 to be analyzed for the mechanical properties. The compressive strength reaches peaks at 215 MPa and reaches steadier at 80 MPa. For those achieved values, the fleece brake pads can still withstand the applied force, the brake pad cube remains solid, and no crack occurs. The reason is predicted by the compressive load that is held collectively by the fleece fiber, resin, and interface. This indicates that the fleece brake pads have good mechanical characteristics.

The above brake pad characteristic was obtained from the binding of fleece fibers that involves a polymerization of an epoxy resin at room temperature. The co-reactants such as polyfunctional amines, acids (including acid anhydrides), phenols, alcohols, and thiols (sometimes referred to as mercaptans) can be used to react epoxy resins (crosslinked) with themselves to make poly epoxy [3].

Figure 4 shows the result of fleece brake lining strength by puncture test. The test was carried out seven times to generate more accurate results. As shown in the graph, the values obtained during the puncture test were between 89 and 77% with an average of 76.43%.

Fleece fiber has several characteristics such as elasticity, hard to break, and fire-resistant due to having high-water content, moisture absorbing capability, and high ultraviolet (UV) protection. In addition, fleece fiber includes natural fibers with intrinsic properties, namely mechanical strength. When mixed with resin, the characteristics of the fleece can form a very strong polymer that can improve the performance of brake pads. Thus, these results confirm the potential of fleece to be added as a friction material in brake pads.

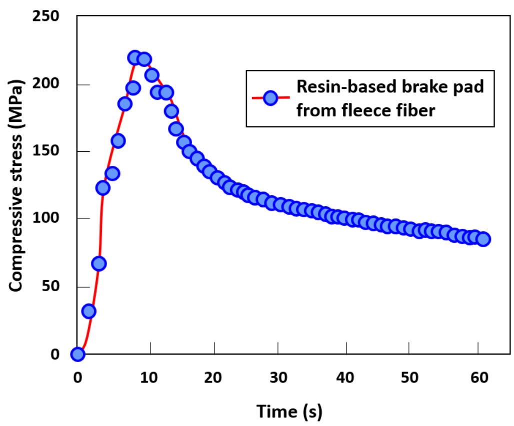

Figure 3 The compressive test results

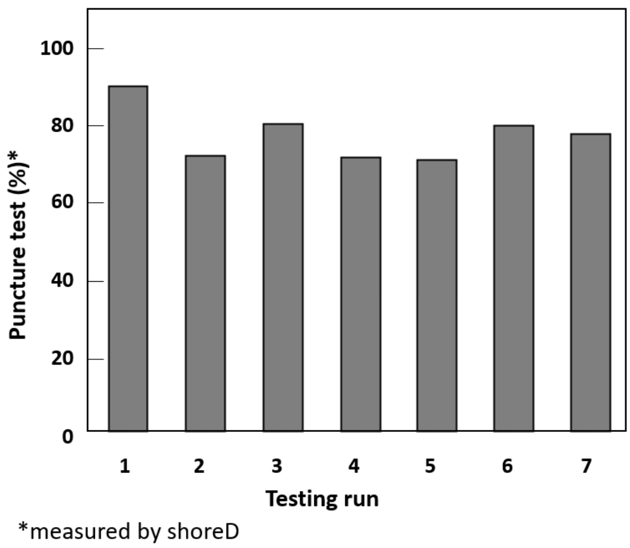

Figure 4 The puncture test results

4 Conclusion

This study has evaluated the fleece's performance in brake pads as a friction material. The results show that the fleece brake pads have good mechanical properties. The surface of the fleece brake pad was still capable of holding 215 MPa of pressure. The result of the puncture test revealed a value averaging 76.43. The fleece performs well on the brake pad properties. Moreover, fleece has many minerals, which gives it a very robust fiber quality and can act as a brake pad friction material. This study offers recent details regarding organic materials for friction material in the brake pads.

Acknowledgments

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