

Wear Behavior of Basalt Powder Reinforced Phenolic Resin Matrix Composites Brake Lining Pads

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Abstract. This paper explain the wear behaviour of composites phenolic resin with basalt powder reinforced on brake lining pads. Composite brake has been manufactured use compaction and sintering steps. The research aims to investigate wear characteristic of composite that tested using the Pin-on-disk according to standard ASTM G 99-95a. The weight fraction ratios are 30:70%wt; 60:40%wt, and 80:20%wt were carried out. The basalt wear characteristic is compared between with and without treatment using the 5% NaOH. The experiment result reported that the rate of wear durability of the composite was 10.9% and 11:38% of composite each composition. In conclusions, basalt has better environment characteristic than asbestos.

Introduction

Brake is one important component which is installed on all types of vehicle. Braking system is consisting of many parts like cylinder, disk rotor, master cylinder, pads and etc. Technically, the brake lining pads is an important part which mounted on a brake disk rotor for making friction with the wheel disc [1-3]. In other words, brake pads that installed on each brake set has function to absorb kinetic energy through friction between the disk and pad until vehicle stop. Lining brakes is composite material due to consist of the strengthening (i.e. fibers or powders) and polymers (thermoplastics or thermosetting) [4]. Presently, asbestos has widely applied and become the main material used as reinforcement of lining brake pads blended with other ingredients, which embedded in matrix of polymer. The positive characteristics of asbestos are water resistant, resistant on high temperature, and good friction. On the thermal characteristics, asbestos have higher thermal compared with silicates is stable up to 500°C. Additionally, it is inexpensive price. Contrary, asbestos is dangerous for health and no environmental friendly. Here asbestos during friction produces much poisonous dust and it made cancer disease on humans because of asbestos dust tends to be mild, soft and easy to stick that would be making asbestosis and carcinogen. Consequently, international countries have been prohibiting use asbestos material. Besides that, all international standards like ECER 90, JASO, SAE also recommend have to use a non-asbestos material on lining brake pads.

Hereinafter, lining brake produced was generally developed through trial and error process, coupled with prior experience of manufactures, especially when government prohibits lining brake pad use asbestos [5]. Several Scientifics have carried out study for material that can substitute asbestos as lining brakes pads for all type of vehicles. Xin et al. [5] developed sisal fiber reinforced brake composites for study wear characteristic and friction. Their results, organic fiber is difficult to maintain in high temperature ranges of friction, even though its clean materials. Ikpambase et al. [6] have reduced contents of asbestos on lining brake pads of vehicle by using palm kernel fibers. Idris et al. [7] developed lining brake pads material using an organic material such banana peel. In addition, lining brake pad without metal material (i.e. copper, lead, tin, antimony trisulfide, and whisker materials) for developing an environmental friendly friction pads have studied by Yun et al. [8]. Other

material for friction brake from hybrid composite reinforced with combination of potassium titanate whisker and aramid fibers have conducted by [9], and combination of ceramic and aramid fiber reinforced hybrid phenolic composites was developed by Patnaik et al. [10]. Moreover, Singh, et.al [11] designed brake pad hybrid phenolic composites based on the lapinus and aramid fibers reinforced. The result is enhancement of μ -performance caused by increased lapinus contents with corresponding decrease in aramid fiber content. The wear characteristics and frictionless of newly design lining brake pad material was reported by [10, 12-15]. The optimization friction and wear for non asbestos lining brake pads also studied by Balaji, et.al [16]. In addition, Gultekin, et.al [17], reported the friction and wear characteristics influenced by applied loads on the sintered copper matrix composite brake pads against cast Al-Si/SiCp brake disc. Their results is the friction coefficient and wear characteristics was stable in all of applied load varieties generally depended on many factors i.e. the graphite content, applied normal load, and sliding distance.

In the context in order to develop newly material for lining brake pads, basalt as new member of organic material was introduced. Basalt is the sediment rock of volcano that contain chemically compound such as: magnesium, calcium, sodium, potassium, silicon and iron, along with traces of alumina [18, 19]. Basalt has been widely applied on engineering products due to of their mechanical and physical characteristics few last ten years. Specifically, the strength and modulus of elasticity of basalt has a highest than glass, also it has better environment behavior compared with glass and asbestos. In particular, basalt has good advantages in mechanical properties and physical, thus widely applied on engineering products. Here basalt materials have properties more better than asbestos and environmental-friendly as reported by Kogan et al. [20].

The present study, in order to develop the brake lining pad that free of asbestos, the composite phenolic resin with basalt powder reinforced have been manufactured using the three kinds of weight fraction ratios. This research aims investigate the wear characteristic of composite that tested using the Pin-on-disk. This test is accordance standard ASTM D3171-09 for specimen production and ASTM G 99-95a for wear test.

Experiment Procedure

Basalt powder has been implemented as a strengthening of phenolic resin composites material of the vehicle brake linings. Basalt and Phenolic resin were used respectively produced by Reade International Corp and co. USA and Indopherin Jaya, Indonesia. The grain size of basalt is 0.074 millimeter. NaOH was employed for basalt powder treatment. A list of basalt material characteristics are presented as Table 1.

Table 1. Basalt characteristics.

Data fisik Basalt	Nilai (unit)
Density	2600-2630 (kg/m ³)
Tensile strength	500k-550k (psi)
Temperatur sintering	1050 (°C)
Temperatur operasi	-265-+700 (°C)
Modulus of elastisitas	9100-1100 (kg/mm ³)
Mohs Hardness @20°C	5-9
Melting point	1170(°C)
Heat resistance	700-1000 (deg.C)
Elongation at break	3.15(%)
Modulus elastik	89 (kg/mm ³)

In this work, three weight fraction composition ratio had been conducted such 30:70%wt; 60:40%wt and 80:20%wt, which is produced accordance four phases i.e. blending, compaction, sintering, and cutting, respectively (see Fig. 1). Presently, mixture was pressured at loads 3 tons as long as 30 minutes under the room temperature. Then, the specimens are sintered at constant temperature of 200°C at least as long as 2h for each ratio. Afterwards, specimens for each variant were cut according to standard ASTM D3171-09 with geometry as shown on Fig. 2a. Pin on disk test [21]

was carried out accordance ASTM G 99-95a standard as exhibited on Fig. 2b. Table 2 shows the composition of every weight fraction ratio composite.

Composition	Non Treatment		Treatmen 5% NaOH	
	Basalt powder	Phenolic Resin	Basalt powder	Phenolic resin
I	60	40	60	40
II	70	30	70	30
III	80	20	80	20

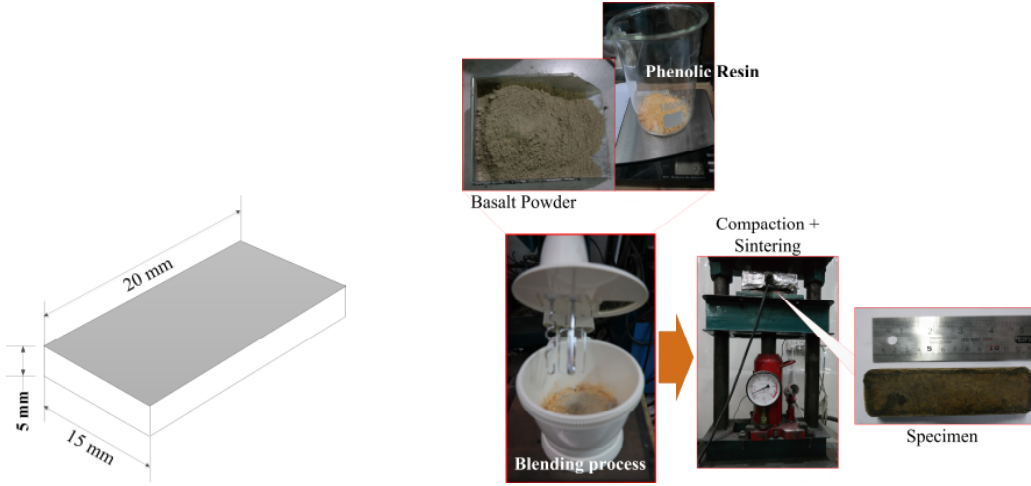


Fig. 1 a. Specimen geometry; b. Composite manufacture process.

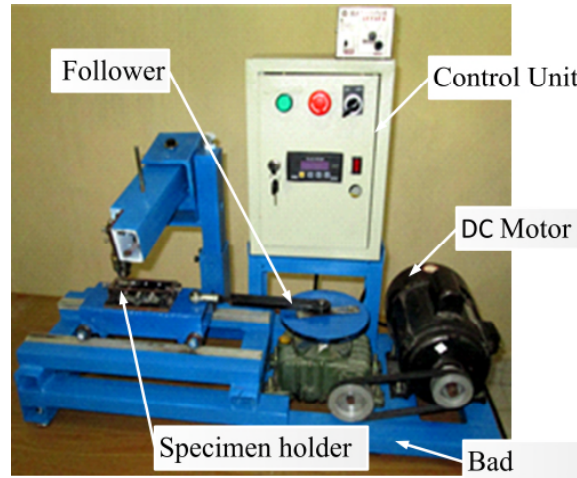


Fig. 2 Pin-on-disk Setup.

According to the traditional concept and following the composite rule was determined by as below:

$$\omega_c = \omega_m + \omega_f$$

$$W_m = \frac{\omega_m}{\omega_c}, W_f = \frac{\omega_f}{\omega_c}$$

$$W_m + W_f = 1$$

(1)

In the formula ω_c is total weight of composite, ω_f is indicating total reinforcement weight, ω_m is weight of matrix, and W_f is indicate weight fraction of reinforcement, W_m is weight fraction of matrix.

The wear measurement of composite phenolic resin matrix with basalt fiber reinforced can be reported following equation for conversion of mass lost to volume loss as below;

$$V_{loss} = \frac{m_{loss}}{density} \times 1000 \quad (2)$$

then, the friction factor could be determined according to the Eq. 3

$$\text{Wearing factor} = \frac{V_{loss}}{P.L} \quad (3)$$

In this test, semi-spherical surface friction was conducted, so the surface wearing of composites is calculated following equation;

$$P = a.l \rightarrow l = \frac{\pi r \phi}{180^\circ} \quad (4)$$

then, the mass loss per cross-section area of composite determined following the equation below:

$$z = \frac{m}{P} \left(\frac{g}{cm^2} \right) \quad (5)$$

The average results of wear resistance calculation basalt reinforced phenolic resin composite are shown in Fig. 4.

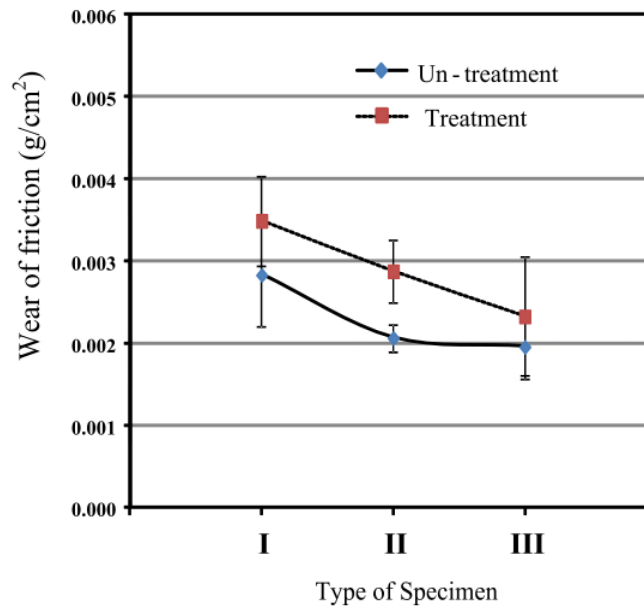


Fig. 4 Wear friction of the composite.

Test Results

Fig. 4 shows the wear friction diagram of brake lining pads using composite phenolic resin with basalt powder reinforced. It was seen for comparison between the treated and without treated of basalt powder was examined. The composite with treatment by 5% NaOH has increased the toughness of wear friction for all variation weight fractions. However, increasing of basalt powder values had decreased significantly the wear friction of composite. Particularly, the highest wear friction toughness was shown by composite with weight fraction ratio 60% wt basalt; 40% wt phenolic resin, and the lowest value is shown by weight fraction ratio 80% wt:20% wt. The decreasing wear friction toughness is caused by decreasing bounded of matrix to the powder. Here, powder diameter also influences the toughness of wear friction. According to the result the conclusion is the composition of

the number of grains and the amount of matrix has a significant influence on the rate of wear caused by friction of basalt epoxy composite material. Besides, basalt is a natural alternative material that can be used as an alternative material for asbestos brake pad replacement.

Conclusion

This study concludes that the wear friction toughness of basalt powder reinforced phenolic resin composite was increase significantly. The increasing of wear friction toughness effect of 5% treatment by NaOH is 18.75%. Additionally, powder diameter significantly influences the wear friction of composite. Besides that, basalt is good natural material that can used to substitute of asbestos because basalt has environmentally friendly

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