Impact Strength and fluid absorption at the brake lining of hybrid composite

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Abstract. Brake lining is one of the active safety components in the vehicle that serves to reduce and stop the vehicle speed. Brake lining is arranged in brake system made of asbestos material and other materials such as metal oxide, sulphate, Mn or Co, and silikan. In research to realize the environmentally friendly brake pads have developed hybrid composite materials with reinforced basalt, clamshell and alumina as the material of brake pad. The purpose of this study was to examine sea water absorption and impact strength in brake pad and can look for alternative brake pads that are environmentally friendly. In this test obtained the value of impact strength of asbestos 0.000374867 J/mm². From the calculation of the hybrid composite test with variations in composition, the highest impact strength value is obtained on hybrid composite HC2 with a value of 0.000339547 J/mm². This is due to the hybrid composite with a variation of 40% basalt, 10% clamshells, 10% alumina and 40% resin, which has a stronger and more perfect bond between metric and basalt compared to other hybrid composite. Sea water absorption by composite materials and asbestos brake lining materials, showing that the trend after the 24th day immersion starts to be constant for each specimen. From these conditions, the sea water absorption capacity of specimen I was higher than specimen II of 0.51% and Specimen III was 1.01%, but lower than the asbestos materials at 1.14%.

1. Introduction

One of the factors of failure in braking is the loss of the ability of the brake lining to stop the vehicle. Therefore, along with the development of motor vehicle speed, it must be balanced with a higher brake system and quality. The quality of brake lining is influenced by several factors, namely the composition of the material, the type of material and the hardness of the brake lining material. The ability of brake pads has an important role in absorbing the amount of kinetic energy during braking. The problem that often occurs in brake lining is wear due to shock loads by sudden braking [1].

In general, brake lining is made of asbestos, because it has several advantages such as resistance to high temperatures reaching 800° Celsius [2], while the weaknesses in wet conditions will experience slippery effects. Asbestos brake pads are made of 60% asbestos or fiber material as the main fiber, and other additional elements such as Silicon Carbide (SiC), Manganese (Mn), Cobalt (Co), Resin, Additive Friction, Filler [3]. Brake pads from asbestos which are components that cause carcinogenic properties and are also not environmentally friendly [4].

The development of composite technology has now begun to lead to the concept of returning to nature. The composite technology has begun to shift by using natural materials such as natural fibers, natural wood, coconut shell powder, basalt fiber and waste fly ash from the combustion of coal [5], to apply powder coconut shell as friction material in which the hardness and tensile strength of the brake increases with the optimum level of 14.82% for grade resin 15%, holding time of 6 hours and the temperature of the oven 160 degree Celsius and get a hardness of 60-70 HRB. Czigany [6], has been conducting research on the characteristics of epoxy composite with basalt fiber reinforcement, in which the strength properties of the hybrid composites due to the increase of surface treatment after mechanical tests and microscopic analysis. Then the laminate characteristics of basalt fiber composite
laminates have been studied because of the imposition of tensile and flexural [7]. Liu, et al. [8] conducted a study on the mechanical properties of basalt fiber composites in vehicle components.

Based on the results of research that has been done, in this study using volcanic sediment material called Basalt. Basalt which has corrosion resistance, low water absorption, and resistance to chemical treatment and non-toxic [9]. Based on laboratory analysis, Basalt content consists of chemical elements such as: SiO, Al₂O₃, Fe₂O₃, MgO, CaO, Na₂O, K₂O, TiO₂, P₂O₅, MnO, and Cr₂O₃ [10]. Then the clamshell powder is a powder produced from the burning of crushed clamshells and based on laboratory analysis shows the chemical content of: CaO, MgO, SiO₂, Al₂O₃ and Fe₂O₃ [11]. While alumina is a lightweight metal that has good corrosion resistance and is easily formed [12]. Composite formation with basalt powder, clamshell and alumina reinforcement is carried out by hybridization method on single binder, epoxy. In the formation of the test material carried out by sintering process with temperature control 150°C which will produce strength and hardness as well as increasing frictional force.

This study used basalt powder, alumina and clamshell powder and epoxy as hybrid composite composers. The specimens tested with Charpy impact refer to ASTM D6110-04 standard, to determine the characteristics and toughness of hybrid composite materials that have been made. Analysis of surface fault characteristics using SEM test. While sea water absorption testing refers to ASTM D 570 - 98

2. Materials and Method
This research was conducted by hybridizing 3 types of material as reinforcement and one material as a matrix. Strengthening materials include basalt, clamshells and alumina. While as a composite matrix material used phenolic resin. All reinforcing materials are particles. In this study, basalt powder, alumina powder and clamshell powder with a size of 0.0074 millimeters were used. Mechanical properties of basalt are shown in Table 1. Clamshell powder material consisted of 66.70% CaO, 22.28% MgO, 7.88% SiO₂, 1.25% Al₂O₃ and 0.03% Fe₂O₃. The phenolic resin material used in this study coded PR-51 510.

This brake pad research is made by mixing, compacting and sintering. The shape and size of the specimen as shown in Figure 1. Composite composition shown in table 2 and table 3 is based on ASTM D 3171-09 standard. In the process of making brake lining material this is done with a compressive load of 2000 N for approximately 30 minutes, and a sintering process at 150°C.

| Table 1. Mechanical properties of basalt material |
|-----------------------------------|------------------|
| Properties of Basalt | Value (unity) |
| Density | 2600-2630 (kg/m³) |
| Tensile strength | 500k-550k (psi) |
| Sintering Temperature | 1050 (°C) |
| Operation Temperature | -265→700 (°C) |
| Modulus of elasticitas | 9100-1100 (kg/mm³) |
| Mohs Hardness @20°C | 5-9 |
| Melting point | 1170(°C) |
| Heat resistance | 700-1000 (deg.C) |
| Elongation at break | 3.15(%) |
Figure 1. Specimen geometry

Table 2. Hybrid composite weight fraction ratio for impact test

| Composition | Basalt powder | Clamshell powder | Alumina powder | Phenolic Resin |
|-------------|---------------|------------------|----------------|---------------|
| HC1         | 45            | 5                | 10             | 40            |
| HC2         | 40            | 10               | 10             | 40            |
| HC3         | 35            | 15               | 10             | 40            |
| HC4         | 30            | 20               | 10             | 40            |
| HC5         | 25            | 25               | 10             | 40            |

Table 3. Hybrid composite weight fraction ratio for fluid absorption test

| Composition | Basalt powder | Clamshell powder | Alumina powder | Phenolic Resin |
|-------------|---------------|------------------|----------------|---------------|
| I           | 30            | 50               | 10             | 20            |
| II          | 40            | 40               | 10             | 20            |
| III         | 50            | 30               | 10             | 20            |

3. Result and Discussion
The average result of the impact of each composition and comparison with the impact strength of the brake lining pads that asbestos material (C) are shown in figure 2 and figure 3, while the sea water absorption of brake pads is shown in Figure 4.

Figure 2. Impact strength of the hybrid composite and asbestos
Figure 2 shows the relationship of variation in impact strength specimens that experience an increase and decrease in composition variation. In this test obtained the value of impact strength of asbestos materials (C) 0.000374867 J/mm². From the calculation of the hybrid composite test data with variations in composition, the highest impact strength value is obtained on composite hybrid HC2 with a value of 0.000339547 J/mm². This is due to the hybrid composite with a variation of 40% basalt, 10% clamshells, 10% alumina and 40% resin, which has a stronger and more perfect bond between metric and basalt compared to other hybrid composites.

![Variation of Composite Impact Strength](image)

**Figure 3.** Value of energy absorbed that occurs in impact testing

From Figure 3, the comparison of energy values absorbed by specimens in impact testing occurs. It can be seen from the graph of the absorbed energy value that the HC1 absorbed energy value is 0.022012589 J, for HC2 to HC5 which is 0.023739901 J, while the energy in asbestos material (C) is 0.026656442 J. This means that the energy absorbed by the asbestos material (C) is greater than hybrid composites brake lining pads.

![Seawater Absorption](image)

**Figure 4.** Sea water absorption of the hybrid composite and asbestos

Figure 4 shows a graph of seawater absorption by hybrid composite materials and asbestos material, showing that the trend after the 24th day immersion starts to be constant for each specimen. From these conditions, the absorption capacity of specimen I was higher than specimen II of 0.51% and specimen III was 1.01%, but lower than the asbestos material at 1.14%. This shows that specimen I has a higher absorptive capacity than specimen II and specimen III but has a lower absorption capacity.
than asbestos material specimens, so that specimen I reaches a faster saturation point on day 14 compared to specimen II and specimen III which reached saturation on 24th day.

4. Conclusion
The effect of the weight fraction on each hybrid composite variation on the impact strength is a reduction in the percentage of basalt and the addition of percentage of clam shell powder, and a constant percentage of alumina which in each composition produces varying strength values. Seawater absorption in the specimens brake lining pads are strongly influenced by the basalt content, where the greater the basalt content in the specimen, the sea water absorption capacity of the specimens will be smaller.

Acknowledgment
This research is part of the PTUPT scheme research funded by the Directorate of Higher Education in 2018 with an Assignment Agreement Letter in the Framework of National Competitive Research Implementation. For this reason the author wishes to express his gratitude for the support of this research fund. Thanks are also conveyed to the Udayana University LPPM which facilitated the research activities.

References
[1] Aigbodion, V. S., Akadike, Hassan, U.S.B., Asuke, F., and Agunsoye, J.O. 2010. Development of asbestos - free brake pad using bagasse, Tribology in industry, vol. 32, No.1, pp. 12-18. 
[2] Louis St, 2004. U.S. Survey shows imports of asbestos brake materials increasing. St. Louis. 
[3] Kedar S Pandya, Ch. Veerraju, and N. K. Naik. 2011. Hybrid composites made of carbon and glass woven fabrics under quasi-static loading. Materials and Design, vol. 32 pp. 4094–4099.
[4] Ashby, M. F. and Y. J. M. Brechet.,. 2003. Designing hybrid materials. Acta Materialia, vol. 51, pp. 5801-5821. 
[5] Czigany, T. 2005. Basalt fiber reinforced hybrid polymer composites. Materials Science, Testing and Informatics Li, vol. 473-474, pp. 59-66. 
[6] Ary Subagia, I.D.G., and Y. Kim. 2013. A study on flexural properties of carbon-basalt/epoxy hybrid composites. Journal of Mechanical Science and Technology, vol. 27 (4), p. 987–992. 
[7] Qiang Liu, Montgomery T. Shaw, and Parnas, R. S. 2006. Investigation of basalt fiber composite mechanical properties for applications in transportation. POLYMER COMPOSITES, vol. 27, pp. 41-48.
[8] Atmika I.K.A, Subagia I.D.G.A, Surata I.W, Sutantra I.N. 2017. Study of the mechanical properties of hybrid composite basalt/alumina/shells for brake lining pads. IOP Conf. Series: Materials Science and Engineering 201(2017) 012009. 
[9] Singha, K. 2012. A short review on basalt fiber. International Journal of Textile Science, vol. 1 (4), pp. 19-28. 
[10] Fiore, V. G. Di Bella, and Valenza, A. 2011. Glass–basalt/epoxy hybrid composites for marine applications, Materials and Design, vol. 32, pp. 2091–2099. 
[11] Dalinkevich A.A., Gumargalieva K.Z, Marakhovsky S.S, and Soukhanov A.V. 2009. Modern basalt fibrous materials and basalt fiber-based polymeric composites. Journal of Natural Fibers, vol. 6, pp. 248-271. 
[12] Lopresto, V.C. Leone, and I. De Iorio, 2011. Mechanical characterization of basalt fiber reinforced plastic. Composites Part B: Engineering, vol. 42, pp. 717–723.