Hardness Characteristics of Hybrid Composite Brake Lining on Olie's Absorption Media

I Ketut Adi Atmika[1*], IDG.Ary Subagia[2], I Wayan Surata[3] and I Nyoman Sutantra[4]

[1]Doctoral Study Program of Engineering Science, Faculty of Engineering, Udayana University
Kampus Sudirman, Denpasar-Bali, Indonesia.
[1,2,3,4] Study Program of Mechanical Engineering, Faculty of Engineering,Udayana University
Kampus Bukit Jimbaran, Badung-Bali, Indonesia
tutadi2001@yahoo.com
[4] Study Program of Mechanical Engineering, Institut of Sepuluh Nopember, Surabaya-Indonesia

Abstract – Brake lining technology is developing rapidly to adjust the absorption media in which the vehicle's braking system is operating. Material commonly used as a brake lining is asbestos and its alloys, but this material is very dangerous to the environment and health. This research was developed to overcome these problems, namely finding alternative brake lining pads material that has good mechanical and physical properties. Brake lining material is made from a hybrid composite reinforced basalt, shellfish, alumina, and phenolic resin (PR-51510i) as a binding matrix. This brake lining material is produced through a process of sintering at a temperature of 150 ° C with a load of 2000 kg for 30 minutes. These hybrid composites are made in as many as three variations, each of which is tested for olie absorption at several variations of immersion time. Immersion 3 days hardness of hybrid composite and asbestos brake lining material is still quite high between 24-28 HVN. The highest hardness at that time was an H1 specimen of 28.00 HVN. Then the hardness of the brake lining material decreases with the addition of immersion time and is close to stable at the 24-day immersion time between 5.48-7.12 HVN.

Keywords: hybrid composite, sintering, olie absorption, hardness.

I. INTRODUCTION

The braking performance of a vehicle is very dependent on the reliability of the brake lining material as the main component of the system, both the disc type and drum system. Previously, brake lining materials were mostly made of asbestos materials because their performance was still good until high temperatures reached 800˚C [1], [2]. However, asbestos material has been discontinued because it has bad properties or has a negative impact on the environment and human health [3], [4].

Then many researchers developed asbestos-free brake lining material. In 2014, C. O. Mgbemena et al. Palm kernel shell (PKS) based non-asbestos material for friction plates especially for brake lining material. This material is produced containing fibrous reinforcing constituents, additives, and elastomeric additives, flame retarding components and thermosetting resins. The results showed that there was a temperature degradation in the Palm kernel based friction coating material obtained at 53.84°C with a final degradation temperature of 634.87°C [5].

Then other researchers also developed a shell-based brake pad material with a grit size of 600 µm. The material was tested still at speeds below 100 km/h [6]. Yawas et al conducted a morphological test of shellfish granules for friction plate material. The development of asbestos-free automotive brake linings using periwinkle shell particles as friction filling material is presented. The research aims to obtain the characteristics of the periwinkle shell, which is largely obtained from waste, to replace asbestos which has been found to be toxic and carcinogenic. [7], and the thermal test of shell material for rubbing material has also been carried out and has quite good properties [5]. Research to review the ability of brake lining pads to absorb fluid has also been carried out [8].

However, the results achieved at this time have not been able to maintain mechanical properties, especially on wear resistance and material performance against fluid absorption.

This paper presents the characteristics of hardness of brake lining material on olie absorption media. The brake lining material developed was made from a hybrid composite reinforced with basalt, shellfish, alumina and bonded using a polymer matrix phenolic resin (PR-51510i).

Basalt is material obtained from volcanic eruptions. This material has heat resistance up to 1500^{0}C [9], has very good corrosion resistant physical properties, low in fluid absorption and resistant to chemical and non-toxic treatment [10]. Properties of basalt have excellent physical and mechanical properties, high ductility, and high wear resistance [11], and can replace glass fibers [12]. Then the most important characteristic of this material is that it has low thermal conductivity and good fluid absorption.

II. METHOD

This research was conducted by mixing or hybridizing 3 types of material as reinforcement and one material as matrix. The reinforcing material is basalt powder, shellfish powder, and alumina powder in the form of solid particles with a size of 60 mesh, then as a composite matrix material used phenolic resin (PR-51510i). Basalt properties are shown in table 1, while the shell powder content is shown in table 2.

Table 1. Mechanical properties of basalt material

Element	**Percentage**
SiO_2	48.59 – 60.49
TiO_2	0,48 – 1.00
Al_2O_3	16.47 – 21.76
MnO	0,11 - 0,19
MgO	2.37 – 8.84
CaO	5.57 – 11.47
Na_2O	1.83 – 3.32
K_2O	0.31 – 1.67
P_2O_5	0.14 –1.21

Tabel 2.Element of shellfish

Element	Percentage
CaO	66.70
SiO_2	7.88
MgO	22.28
Fe_2O_3	0.03
Al_2O_3	1.25

The process of making a specimen is done by mixing reinforcing material and matrix material in the dry phase. The variation of weight fraction of brake lining material studied is shown in table 3.

Table 3. Weight fraction ratio of hybrid composite

Variation	Basalt powder (%)	Shellfish powder (%)	Alumina powder (%)	Phenolic resin (%)
HC1	30	40	10	20
HC2	40	30	10	20
HC3	50	20	10	20

The stages of making composite hybrid material systematically are shown as in Figure 1. Figure 1 (a) shows the equalization and measurement of basalt powder, shellfish powder and alumina powder. Then the three powders were mixed with the composition in Table 3, by mixing the reinforcement and phenolic resin matrix in Figure 2 (b). After that the mixture is manufacturing using a hot press machine with a constant temperature of 150^{0}C for 30 minutes and a pressure of 2000 kg. After that, dry the brake pad composite at room temperature for + 24 hours, after it is completely dry, separate the composite from the mold slowly.

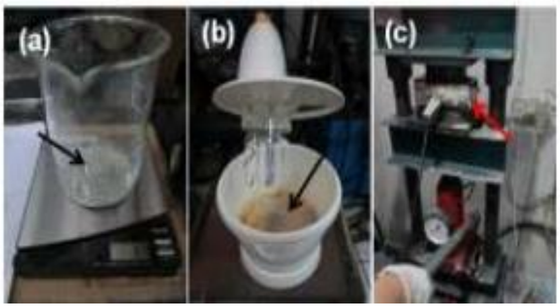


Fig 1. The process of making hybrid composite materials

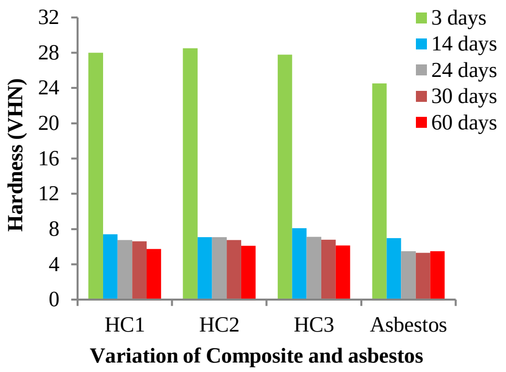
This test method includes the hardness of the specimen to withstand the load using the vickers method using ASTM e384-99, while the olie absorption ability is tested based on ASTM D 570-98.

III. RESULTS

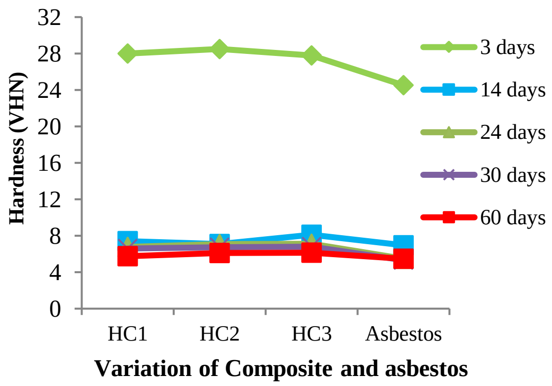
The results of the hardness test with the variation of immersion length are shown in Table 4. Then a comparison of the amount of olie absorption for the three variations of hybrid composites being developed and the asbestos brake pads material is shown in Figure 2 and Figure 3.

Table 3. Hardness after olie absorption

Variation of Composite	Hardness (VHN)				
	3 days	**14 days**	**24 days**	**30 days**	**60 days**
HC1	28.00	7.41	6.77	6.61	5.74
HC2	28.50	7.09	7.09	6.75	6.10
HC3	27.78	8.11	7.12	6.80	6.14
Asbestos	24.52	6.96	5.48	5.32	5.47

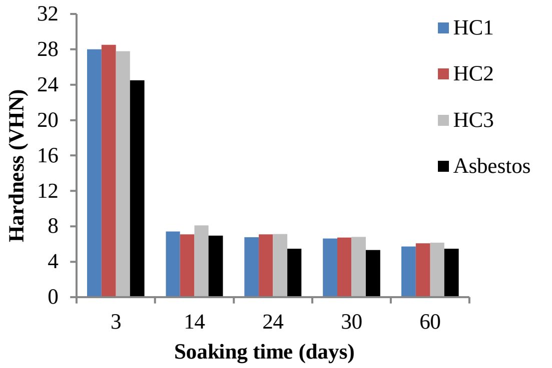


(a)

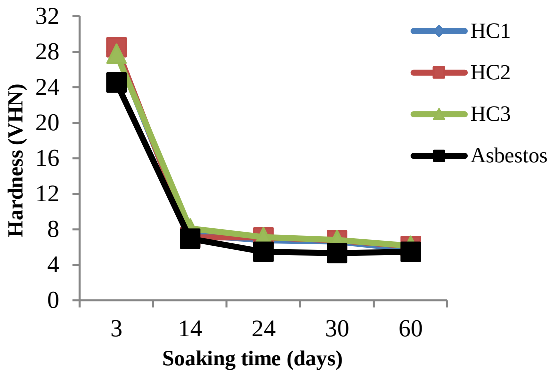


(b)

Fig 2. Hardness vs Specimen variation



(a)



(b)

Fig 3. Hardness vs immersion time

The micro-morphological structure of hybrid composite brake linings is shown in Figure 4 and Figure 5.

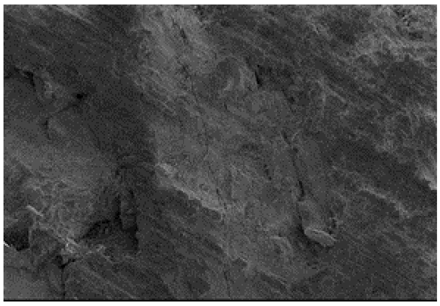


Fig. 4. Micro structure before immersion

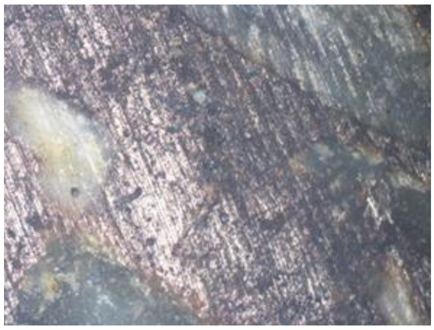


Fig. 5. Micro structure before immersion

IV. DISCUSION

Figure 2 shows a diagram of the hardness of hybrid and asbestos composite brake linings material on the variation of immersion time in olie media. From the figure, it appears that in the immersion time of 3 days the hardness of hybrid and asbestos composite brake linings is still quite high between 24-28 HVN [13], [14]. The highest hardness at that time was an H1 specimen of 28.00 HVN. Then the hardness of the brake lining material decreases with the addition of immersion time and is close to stable in the 24-day immersion period between 5.48-7.12 HVN [12], [15], as shown in Figure 3. Then from Figures 2 and 3 it is illustrated that the increase in the percentage of basalt almost does not affect the hardness of the break lining material hybrid composite brakes were developed, but still higher than the hardness of asbestos brake linings.

From the results of SEM observations, Figure 4 is a photo of SEM specimens before immersion and Figure 5 shows micro structure photographs of HC3 specimens after immersion in SAE 90 oil. In the figure above, it can be seen that all the constituent particles are completely mixed, but there is still dislamination on the surface of the specimen.

V. CONCLUSIONS

The hardness of the brake lining material decreases with the addition of immersion time and is close to stable at the soaking time of 24 days and the increase in the percentage of basalt has almost no effect on the hardness of the hybrid composite brake lining material developed, but is still higher than the hardness of asbestos brake lining.

ACKNOWLEDGMENT

The author thanks the DRPM Ministry of Research, Technology and Higher Education for the research funding provided in accordance with Research Contract No. 171.18 / UN 14.4.A / LT / 2018, dated February 19, 2018. Thank you also goes to the Institute of Research and Community Services at Udayana University for facilitating this research activity.

REFERENCES

[1] M. A. Sivarao, M. S. Rizal, and A. Kamely, “An investigation toward development of economical brake lining wear alert system,” *Int. J. Eng. Technol. IJET*, vol. 9, no. 9, pp. 251–256, 2009.

[2] N. M. Kinkaid, O. M. O’Reilly, and P. Papadopoulos, “Automotive disc brake squeal,” *J. Sound Vib.*, vol. 267, no. 1, pp. 105–166, 2003.

[3] M. G. Jacko, P. H. S. Tsang, and S. K. Rhee, “Automotive friction materials evolution during the past decade,” *Wear*, vol. 100, no. 1–3, pp. 503–515, 1984.

[4] L. St, “US Survey shows imports of asbestos brake materials increasing,” *St. Louis*, 2004.

[5] C. O. Mgbemena, C. E. Mgbemena, and M. O. Okwu, “Thermal stability of pulverized palm kernel shell (PKS) based friction lining material locally developed from spent waste,” *ChemXpress*, vol. 5, pp. 115–122, 2014.

[6] P. C. Olele, A. C. Nkwocha, I. C. Ekeke, M. O. Ileagu, and E. O. Okeke, “Assessment of Palm Kernel Shell as Friction Material for Brake Pad Production,” *Int. J. Eng. Manag. Res.*, vol. 6, no. 1, pp. 281–284, 2016.

[7] D. S. Yawas, S. Y. Aku, and S. G. Amaren, “Morphology and properties of periwinkle shell asbestos-free brake pad,” *J. King Saud Univ. Sci.*, vol. 28, no. 1, pp. 103–109, 2016.

[8] U. D. Idris, V. S. Aigbodion, I. J. Abubakar, and C. I. Nwoye, “Eco-friendly asbestos free brake-pad: Using banana peels,” *J. King Saud Univ. Sci.*, vol. 27, no. 2, pp. 185–192, 2015.

[9] V. Dhand, G. Mittal, K. Y. Rhee, S. J. Park, and D. Hui, “A short review on basalt fiber reinforced polymer

composites," *Compos. Part B Eng.*, vol. 73, no. December, pp. 166–180, 2015.

[10] V. Fiore, G. Di Bella, and A. Valenza, "Glass–basalt/epoxy hybrid composites for marine applications," *Mater. Des.*, vol. 32, no. 4, pp. 2091–2099, 2011.

[11] A. A. Dalinkevich, K. Z. Gumargalieva, S. S. Marakhovsky, and A. V Soukhanov, "Modern basalt fibrous materials and basalt fiber-based polymeric composites," *J. Nat. Fibers*, vol. 6, no. 3, pp. 248–271, 2009.

[12] V. Lopresto, C. Leone, and I. De Iorio, "Mechanical characterisation of basalt fibre reinforced plastic," *Compos. Part B Eng.*, vol. 42, no. 4, pp. 717–723, 2011.

[13] C. Jiang, K. Fan, F. Wu, and D. Chen, "Experimental study on the mechanical properties and microstructure of chopped basalt fibre reinforced concrete," *Mater. Des.*, vol. 58, pp. 187–193, 2014.

[14] I. K. A. Atmika, I. D. G. A. Subagia, I. W. Surata, and I. N. Sutantra, "Study of the mechanical properties of hybrid composite basalt/alumina/shells for brake lining pads," in *IOP Conference Series: Materials Science and Engineering*, 2017, vol. 201, no. 1, p. 12009.

[15] I. Suriadi and I. K. A. Atmika, "Mechanical properties and fluid absorption at the brake lining of hybrid composite," in *IOP Conference Series: Materials Science and Engineering*, 2019, vol. 539, no. 1, p. 12015.