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Asbestos-free Brake Pad Using Composite Polymer Strengthened with Rice Husk Powder

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Abstract – Indonesia is one of biggest country with agricultural product and its very abundant. Agricultural product would give effect on an agriculture waste. For the example of agricultural waste is rice husk (RH). RH is the outer layer of the paddy. RH as an organic waste is obtained from the outer covering of rice grains during the milling process. The mechanical properties of RH is low combustion value and potential damage to the environment. The recent uses of RH are as a fertilizer additive, animal food, stock breeding rugs, cooking fuel, paving applications, filling materials, and energy generation. RH is composed of lignin, cellulose, and SiO₂, therefore it can be considered as a natural organic-inorganic composite material. In the other hand, as the enormous spare part development nowadays, the use of asbestos-based materials in the manufacture of vehicle brake pad is considered to endanger health, especially brake pad. Asbestos-based materials are used because of their temperature resistance. However, the use of asbestos has been banned due to carcinogenic substances and substances that are harmful to the environment. Asbestos-based materials can also endanger respiratory health because they can endanger the lungs if inhaled. The objective of this study is to add value to rice husk by developing a sustainable material composite. The rice husk was combine with biodegradable polymer as matrix. This study aims to determine the effect of particle size of rice husk powders, and structural mechanisms on non-asbestos brake composites. The ratio of reinforcement and matrix as follows 20:80; 30:70; 40:60 with carbonized and uncarbonized condition. The expected result is the best wear properties conducted from rice husk powder composites brake pad are in close with commercial asbestos based brake pad.

1. Introduction

Indonesia is one of the biggest country for agricultural production, such as rice, corn, sugar cane, etc. Annual rice production worldwide is over 700 million tons per year [1]. It means that agricultural waste produced very abundant. Rice Husk (RH) is one of the agro-industrial waste products that is most abundantly accumulated. The mechanical properties of RH is low combustion value and potential damage to the environment [2-5]. RH as an organic waste is obtained from the outer covering of rice grains during the milling process [6]. The recent uses of RH are as a fertilizer additive, animal food, stock breeding rugs, cooking fuel, paving applications, filling materials, and energy generation [7]. The uses of is waiting to be elevate. In the other hand the development mechanical spare part production has occurred enormous nowadays, The use of asbestos-based materials in the manufacture of vehicle brake pad is considered to endanger health [24]. Brake pads that are commonly used are composites of asbestos-based materials bound by a polymer-based and some other materials [8]. Asbestos-based materials are used because of their temperature resistance [9]. However, the use of asbestos has been banned due to carcinogenic substances and substances that are harmful to the environment [10], since January 1, 1997 in France [11]. Asbestos-based materials can also endanger respiratory health because they can endanger the lungs if inhaled [9].

Physical, mechanical, and thermal properties of low strength concrete containing different amount of original rice husk [12]. RH is composed of lignin, cellulose, and SiO₂, therefore it can be considered as a natural organic-inorganic composite material [13]. The composition of RH as follows cellulose (50%), lignin (25-



30%), silica (15-20%), and moisture (10-15%). Carbonization of RH in inert atmosphere yields highly porous carbons with large specific surface area [14-15]. RH was obtain from burning of rice husk at around 600 °C, leading to CO₂ release and energy consumption [16]. Recently, porous carbons prepared from rice husk attracted attention in the field of energy storage [17], solar technology [18], and environment mental protection [19]. There are several application of RH such as activated carbon. In physical activation, carbonization and activation occur separately but in chemical activation both the process of carbonization and activation occur simultaneously by using a chemical agent [20-21]. Process of physical activation is very useful in the generation of activated carbon, which have low specific surface area [21]. The objective of this study is to add value to rice husk by developing a sustainable material composite with improve combustion conditions and the ratio of fabrication composite. The rice husk was combine with biodegradable polymer as matrix. The ratio of reinforcement and matrix as follows 20:80; 30:70; 40:60.

2. Materials and Methods

2.1 Materials and Equipment

The materials used are rice husk, epoxy resin, and rubber silicon along with their catalyst. The equipment used in this study are electric furnace, electric blender , a set of sieves of 297, 177, and 149 μm (50,80, and 100 mesh respectively) , digital weighing balance, 1 inch diameter PVC pipe, polishing machine along with abrasive paper grit size 600, ruler, vernier caliper, and vacuum cleaner.

2.2 Methods

Rice Husk were collected from some rice field area in Bali after sun dried within 3 days. To ensure the moisture was decrease towards zero percent, rice husk dried in the electric furnace using temperature 70°C within 3 hours. Dried rice husk was charged into electric blender to reduce the particle size to form rice husk powder. Rice husk powder sieve manually to get rice husk powder of 250, 177, 149, and 125 μm . The oversize rice husk powder return to electric blender for regrinding process to get the finer particle. To form carbonized rice husk powder (Figure 1b), the uncarbonized rice husk powder (Figure 1a) packed using aluminium foil and charged into electric furnace within 30 minutes in 500°C. Each variant size of particle mix with epoxy resin and its catalyst using variant volume percentage composition. Samples were produced by varying rice husk powder added from 20–40 Vt% with interval of 10 Vt% in. Two set of samples were produced using the uncarbonized and carbonized rice husk powder.

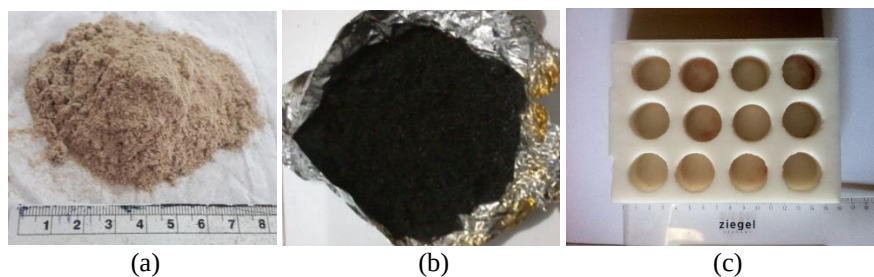


Figure 1. (a) uncarbonized rice husk powder (b) carbonized rice husk powder
(c) Mold of brake pad polymer composite model

Before casting the mixture, mold made using rubber silicon and 1 inch diameter PVC pipe as a pattern (Figure 1c). Mixture for each composition was blended manually for a period of 2 minutes and assumed homogeneous then cast inside the dies and let them dry in room temperature through agitation and vacuum process before. Model of brake pad polymer composite asbestos free shown in Figure 2a. Besides the model, the prototype of brake pad polymer composite asbestos free was also produced shown in Figure 2b.

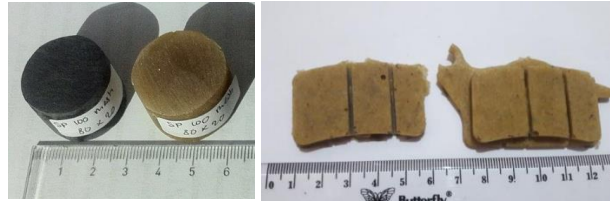


Figure 2. Brake pad polymer composite asbestos free specimen (a), prototype (b)

Polishing machine used for wear resistance characterization and the test sample was placed in the test setup, with following parameter, measuring period occurs for 10 minutes, velocity used equal 300 RPM, clockwise rotation, and 600 grit size abrasive paper drop of water needed along the wear resistance characterization procedure. To give the composite specimen well distributed load, 200 gr specimen dummy placed above the specimen while the procedure occurs. The principle idea doing wear resistance characterization using polishing machine was adopted from wear resistance characterization using Ogoshi method [22], whom use abrasive media to mention the wear resistance properties. Samples were weighed and height measured before and after the experiment to get weight and height loss. Figure 3 shown the process of wear resistance characterization. Wear resistance value provided with calculation using equation below:

$$W_s = \frac{\Delta V}{F_n \cdot L} = \frac{\Delta m}{\rho \cdot F_n \cdot L} \quad [23], \dots \dots \dots (1)$$

Where:

W_s : Wear resistance specific properties of samples

ΔV : Volumetric material loss (m^3)

Δm : Weight loss (kg)

F_n : Normal force applied ($kg \cdot m/s^2$)

L : Total distance travelled (m)

ρ : Density (kg/m^3)

Wherefore the samples are tube then the volumetric material loss (ΔV) equal with volume of tube with height of difference of initial and final height of samples. Total distance travelled (L) got from amount of abrasive disc rotation on the procedure multiply with it circumference.



Figure 3. Wear resistance characterization using polishing machine

3. Results and Discussion

The results obtained from the wear resistance tests conducted in this study are given below for all samples with 3 times repetition for carbonized and uncarbonized particle described in Table 1 and Table 2 respectively. Wear properties expressed as velocity of consuming composite brake pad per kilograms. As higher the value stated lower wear resistance express.

Table 1. Wear resistance properties for carbonized particle

Particle Size (mesh)		50					80					100				
Carbonized Particle	Composition (Matrix : Filler) %Vt	Repetition Number	ΔW (gr)	ΔH (mm)	Wear Resistance Value (Ws)	Wear Resistance Value Average (Ws)	ΔW (gram)	ΔH (mm)	Wear Resistance Value (Ws)	Wear Resistance Value Average (Ws)	ΔW (gram)	ΔH (mm)	Wear Resistance Value (Ws)	Wear Resistance Value Average (Ws)		
		1	0,67	0,7	0,00074	0,00085	1,12	1,05	0,0011	0,0015	0,25	0,61	0,00065	0,00058		
		2	0,4	0,9	0,00096	±	1	1,8	0,0019	±	0,24	0,55	0,00058	±		
		3	0,67	0,8	0,00085	0,00011	1,02	1,4	0,0015	0,0004	0,31	0,48	0,00051	0,00007		
		1	1	1,2	0,00128	0,00090	0,42	2	0,0021	0,0021	1,04	2,7	0,00287	0,00283		
		2	0,47	0,65	0,00069	±	0,3	2	0,0021	±	1,11	2,75	0,00292	±		
		3	0,67	0,7	0,00074	0,00032	0,36	2,05	0,0022	0,0000	1,92	2,55	0,00271	0,00011		
		1	1,33	1,2	0,00128	0,00094	1,19	1,8	0,0019	0,0017	0,12	1,25	0,00133	0,00128		
		2	0,67	0,75	0,00080	±	1,17	1,3	0,0014	±	0,13	1,2	0,00128	±		
		3	0,67	0,7	0,00074	0,00029	1,06	1,6	0,0017	0,0003	0,2	1,15	0,00122	0,00005		

Table 2. Wear resistance properties for uncarbonized particle

Particle Size (mesh)		50				80				100				
Uncarbonized Particle	Repetition Number	ΔW (gr)	ΔH (mm)	Wear Resistance Value (Ws)	Wear Resistance Value Average (Ws)	ΔW (gram)	ΔH (mm)	Wear Resistance Value (Ws)	Wear Resistance Value Average (Ws)	ΔW (gram)	ΔH (mm)	Wear Resistance Value (Ws)	Wear Resistance Value Average (Ws)	
Composition (Matrix : Filler) %Vt	80:20	1	0.33	1,2	0,00128	0,0011	0.95	2,7	0,0029	0,0028	1.72	2,7	0,0029	0,0031
		2	0.62	1	0,00106	±	0.96	2.45	0,0026	±	2.11	2,2	0,0023	±
		3	0.33	0.8	0,00085	0,0002	0.61	2.85	0,0030	0,0002	2.42	3.9	0,0041	0,0009
	70:30	1	1.33	0.75	0,00080	0,0007	2.54	3.35	0,0036	0,0029	1.71	2.4	0,0026	0,0022
		2	0.67	0.67	0,00071	±	2.3	2.5	0,0027	±	1.82	1.75	0,0019	±
		3	0.34	0.5	0,00053	0,0001	2.28	2.35	0,0025	0,0006	1.69	2.1	0,0022	0,0003
	60:40	1	0.67	0.6	0,00064	0,0009	0.32	1.7	0,0018	0,0014	1.96	1.51	0,0016	0,0016
		2	0.34	0.8	0,00085	±	0.33	1	0,0011	±	1.83	1.49	0,0016	±
		3	0.67	1.1	0,00117	0,0003	0.49	1.35	0,0014	0,0004	1.9	1.45	0,0015	0,0000

Unseen the big difference in wear properties of carbonized and uncarbonized filler in Figure 4, then the carbonizing process in rice husk filler not give a significantly increasment of wear resistance. Finer size particle not give a better wear resistance. Unlike composite with corn cob powder filler [24] or other natural fiber, mostly 297 μm particle of rice husk powder (50 mesh) filler gift the best wear resistance in composite brake pad either in carbonized or uncarbonized condition. The best wear resistance provides from adding 20% filler carbonized in 100 mesh size of particle.

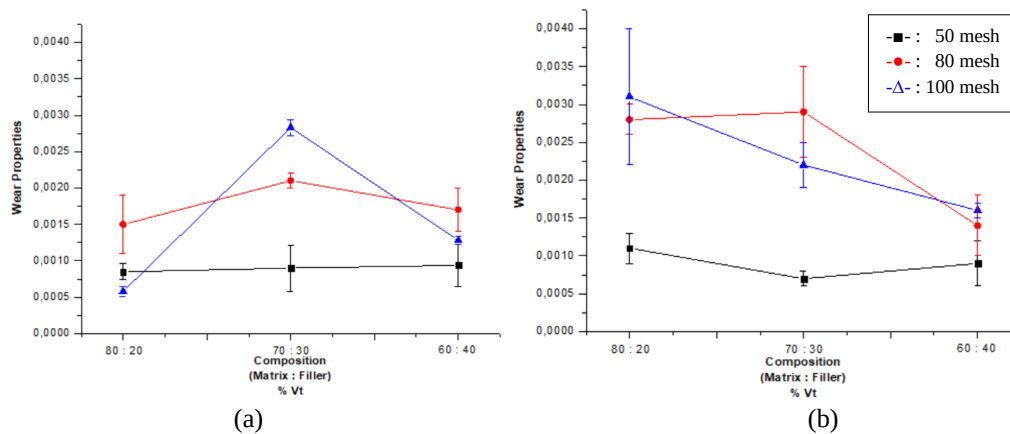


Figure 4. Wear properties' graph of samples (a) carbonized and (b) uncarbonized filler.

Carbonized filler gift better bind ability in the mixing protocol, while the uncarbonized particle have tendency to coagulate as the increasing of particle size number. Effect of carbonize filler in wear properties value clearly shown in 80 mesh samples data. Found a similar trend among 2 set of data with better wear resistance for carbonized filler, also be in effect for other particle size in different filler condition. An addition of filler amount in carbonized filler decrease the wear resistance of the composite brake pad, in the opposite, in uncarbonized filler wear resistance indicates increase. An optimum result for carbonized filler conducted from composites with composition with the lower contain of filler. In the other hand, in uncarbonized filler optimum result shown from composite with higher contain of filler. The presence of high amount of uncarbonized rice husk particle in composite gift a harsh surface roughness and it gift they better wear resistance. Hence asbestos free brake pad can be produced using rice husk powder as the filler, the best wear properties conducted from rice husk powder composites brake pad are in close with commercial asbestos based brake pad.

4. Conclusion

From result and discussion in this work the following conclusions can be made: Rice Husk composite's wear resistance value shows where rice husk powder can be used for filler element in polymer epoxy composites. It provide better wear resistance value than asbestos brake pad in 20% filler carbonized in 100 mesh size particle, means it can replace the asbestos contained brake pad. Carbonized process gives slight increasing of wear resistance value for the composite.

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