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TEACHING THE CONCEPT OF BRAKE PADS BASED ON COMPOSITES OF PALM FRONDS AND RICE HUSKS TO HIGH SCHOOL STUDENTS

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Abstract

This study aims to demonstrate teaching the concept of brake pads prepared from biomass composition (i.e., palm fronds (PF) and rice husks (RH)). We also showed the mechanical properties of composite-based brake pads (CBP) as a function of PF and RH that were bound in a polyester resin matrix (a step-growth mechanism reaction with the addition of a methyl ethyl ketone peroxide (MEKP) catalyst). In the teaching process, students are given pretest and posttest questions to determine the effect of learning on student understanding. The ratio of PF and RH made it possible to obtain different mechanical properties, and specifically, RH (due to the high lignocellulosic component) made the brake pad strong, having low wear values. All obtained information and knowledge have been transferred to students to make them understand the concept. The results showed that the learning method improves students' understanding in the medium category.

Keywords: Composite-based brake pad, Mechanical properties, Palm frond, Rice husk, Teaching.

1. Introduction

The practice of converting biomass into environmentally friendly material in Indonesia as a part of Sustainable Development Goals (SDGs) needs to start with the students' understanding (as the nation's successors), specifically teaching in vocational schools [1]. One of the needed teachings is delivering the concept of a brake pad as a part of vehicle components to slow down or stop the movement of [2]. Making brake pads is easy to do from existing biomasses, embedded into a polymer matrix. This understanding can be obtained by students from the learning process. The learning process requires methods and media that are appropriate to the needs of students [3].

Indeed, it will be more effective when we combined it with an experimental demonstration during the teaching and learning process [4-8]. This can make it easier for students to understand the material being taught. This method prioritizes the provision of material by means of demonstrations that make students directly observe and engage in learning [9]. Demonstrations are carried out by demonstrating the sequence of activity, either directly or using teaching media that are relevant to the subject presented [10].

To produce the brake pad, asbestos is usually employed [2]. Asbestos-based brake pads only survived at 200°C, while brake pads supported by composites can withstand temperatures up to 360°C [11]. Table 1 shows some reports [10-20] on the development and utilization of alternative materials using biomass as a natural reinforcing agent.

This study aims to demonstrate teaching brake pads prepared from rice husk (RH) and palm frond (PF) as the reinforcing agents. This study was also accompanied by an analysis of the level of students' understanding of briquettes which was assessed through a short survey using 10 questions pretest-posttest. The systematics carried out started by assessing students' abilities (pretest), delivering teaching about making briquettes supported by theoretical explanations through learning media in the form of videos, and reassessing students' abilities (posttest). The analysis is supported by direct evaluation (through assessment).

In the experiment, the composite-based brake pad fabrication method, in summary, involved polymerization reactions and was performed at room temperature without the influence of pressure. Brake pad fabrication has been well-documented in our previous studies [21-30].

To create brake pads that are more environmentally friendly, this study explains how to use and maximize the potential of biomass, particularly RH and PF. Although RH and PF have been reported to be used. The primary ingredient of biomass waste, such as RH and PF, has not been widely used as the major component for the creation of the ecologically friendly non-asbestos brake pad, which is a shortcoming of the current research. RH and PF are widely available and abundant in agricultural nations like Indonesia.

It, therefore, has the potential to be put to use. Since they include lignocellulose, RH and PF have promise for better performance. Table 2 provides an overview of RH and PF's chemical makeup.

Table 1. Various types of biomass as alternative materials in the production of composite-based brake pads.

Type of reinforcement component from agricultural waste	Type of supporting components	Results	Ref.
Bamboo	• Aluminum oxide • MgO • Epoxy resin	The asbestos-based brake pad may eventually be replaced by brake pads composed of bamboo fiber. The best brake pad samples had an 810-day heat resistance at 280°C, a wear rate of 0.9612×10^{-8} g/mm^2, and a hardness of 91.8 HRR.	[10]
Coconut and Bamboo	• MgO • Al_2O_3 • Epoxy Resin	• A bamboo composite with a composition of 29% coconut, 40% epoxy, 6% magnesium oxide, and 25% aluminum oxide has a temperature resistance of 251.53°C, a hardness of 37.14 HRB, a wear rate of 0.323 mm^3/N.mm, and a friction coefficient of 0.454. • The coconut fiber-reinforced composite has a temperature resistance of 250.56°C, a hardness of 44.10 HRB, a wear rate of 0.242 mm^3/N.mm, and a coefficient of friction of 0.46. It is composed of 20% natural fiber, 46% epoxy, 6% MgO, and 28% Al_2O_3. • Two composite brake pads have a lower hardness rating than traditional brake pads. However, the wear rates and coefficient of friction of the brake pads made from the two composite materials are nearly identical to those of commercial brake pads.	[11]
Coconut Fiber	• Aluminum Graphite • Zirconium Oxide • Silicon Carbide • Titanium Oxide • Aluminum Oxide • Hexamethyltetramine • Phenolic resin	Due to correct homogenization of composition, material particle size, distribution of the fill material across the matrix, and an ideal ratio of the amount of metal and other components, the brake pad has superior physical and mechanical properties. The density and strength of the composite-based brake pad increase with the amount of coconut husk used.	[12]

Type of reinforcement component from agricultural waste	Type of supporting components	Results	Ref.
Banana Peel	• Phenolic Resin	Due to the strong link between the peels and the resin created by the high microstructure of the packaging, the wear rate of the brake pad decreases when more binder material is added. The extra binder wears out more quickly than the brake pad. The tight bond between the peels and the resin boosted composition, resulting in a high microstructure for the packaging. The strength, hardness, and friction coefficient of the brake pad rose along with an increase in the resin content of banana peel particles.	[13]
Palm Kernel Fiber (PKF)	• Epoxy Resin	The sample experiences an increase in wear due to the presence of PKF and a minor amount of epoxy resin as a binder. This indicates a low wear rate for the brake pad. But the addition of the reinforcing material composition (PKF) boosts the brake pad's compressive strength.	[14]
Maize Husk	• Epoxy Resin	The wear rate, hardness, compressive strength, thermal conductivity, and tensile strength can all be improved by adding maize husk as a filler.	[15]
Rice Husk	• Epoxy Resin	It may be possible to use rice husk instead of asbestos as a strengthening component in brake pad friction.	[16]
Cocoa Beans Shells (CBS)	• Epoxy Resin	CBS has the potential to be employed as a reinforcing material to replace asbestos in brake pad material friction by increasing the compressive strength and hardness of the brake pad by decreasing the composition of the material.	[17]
Palm ash	• Polychlorinated Biphenyls • Phenolic Resin	The compressive strength and wear characteristics of the brake pad increase with the addition of more palm ash.	[18]
Saw-Dust	• Epoxy Resin	Reduced brake pad density, compressive strength, and hardness are the results of	[19]

Type of reinforcement component from agricultural waste	Type of supporting components	Results	Ref.
		improved sawdust composition. Potentially, brake pads made of sawdust with a 100 m particle size could replace asbestos-based brake pads.	
Groundnut Shells	• Phenolic Resin	The compressive strength of the brake pad increases with an increase in the phenolic resin content. The compressive strength density of the brake pad increases as the groundnut shell content is reduced.	[20]

Table 2. Chemical composition of RH and PF. The table was adopted from the literature [2].

Type of biomass	Chemical content (%)			
	Cellulose	Hemicellulose	Lignin	Silica
RH	34.4	24.3	19.2	22.0
PF	31.5	19.2	14.0	12.3

2. Materials and Methods

The primary components utilized in creating the composite-based brake pad are polyester resin, the catalyst methyl ethyl ketone peroxide (MEKP), RH, and PF. RH (Bandung, Indonesia) and PF (Bangka Belitung, Indonesia) were used as matrix-reinforcing materials, and polyester resin (Tokopedia, Indonesia) served as the matrix-forming material. The brake pad's primary reinforcement came from RH and PF. Both materials were divided into little pieces and allowed to dry for three days in the sun. The sieving technique was used to achieve the precise particle size of RH and PF, and as a result, particle size in the range of 250-500 m was obtained. The composition of the reinforcing ratio for PF/RH used to make the brake pad varied as follows: 10/90; 30/70; 50/50; and 70/30. The PF/RH combination was then mixed with 100 mL of polyester resin acting as a matrix and 10 mL of MEKP catalyst. The polyester to reinforcing fiber ratio is 4 to 1. After that, the prepared brake pad mixture was placed into a silicone mold (2 x 2 x 2 cm) and allowed to cure for a day at room temperature without exposure to sunlight. The brake pad was sanded to smooth out the uneven surface when the drying process was complete. Figure 1 depicts the experimental method's flowchart. Detailed experiment is reported in our previous study [2].

The subjects in this study were vocational students in Bandung and Cianjur, Indonesia. To determine the level of understanding of students, three processes were given to them. In the first step, students were given a pretest of 15 questions to find out students' knowledge about water pollution and the process of water purification. After that, the students were given a learning video containing an explanation of the purification of water contaminated with zinc waste by the electrolysis method, the bad effects of liquid waste containing zinc, and the effect of concentration and voltage on the purification process using the electrolysis method.

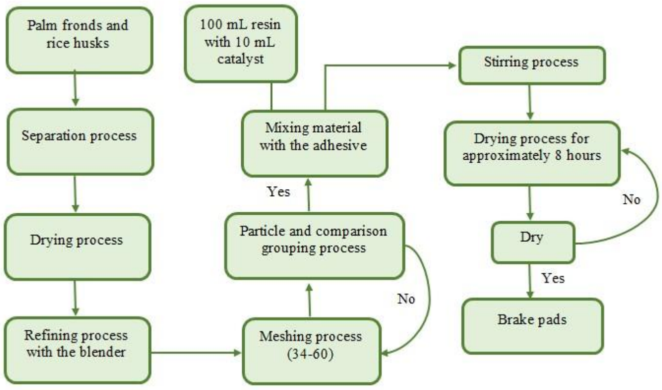

Fig. 1. The flow chart of the experimental method.

Then, the posttest was given to find out whether there is an increase in student understanding. The pretest-posttest analysis was carried out using a score scale of 0 (if false) and 1 (if true). The mean score of each question was converted into a percent (%). To see an increase in student understanding, the n-gain value is calculated using the following Eq. (1).

$$Normalized\ gain\ (g) = \frac{Postest\ Score - Pretest\ Score}{100 - Pretest\ Score} \tag{1}$$

Determination of the category of the effect of the learning method on increasing student understanding is presented in Table 3.

Table 3. Effect size category.

N Gain	Category
$g \geq 0.7$	High
$0.7 > g \geq 0.3$	Moderate
$g < 0.3$	Low

3. Results and Discussion

Figure 2 shows a photograph of the composite-based brake pads used for the teaching and learning process. Students tried to make their brake pads. The composite-based brake pads were different colours as different PF/RH compositions were used. The existence of this colour difference is mainly due to the difference in the ratio of the composition of PF and RH. All composite-based brake pads had a rough and tough texture.

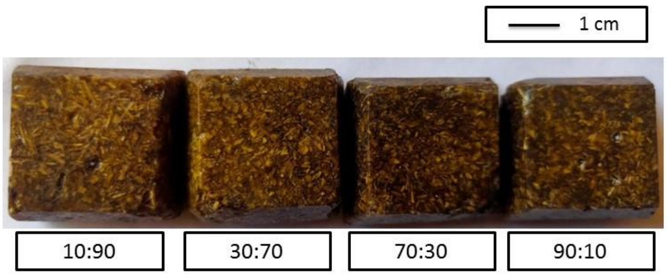

Fig. 2. The photograph of the prepared composite-based brake pad. The figure was adopted from our previous study [2]

The study results indicated that composite-based brake pads have good mechanical characteristics if they contain high RH content. Detailed information is explained in our previous study [2]. There are variations in the composition of cellulose and hemicellulose and lignin in RH and PF that affect the mechanical properties of composite-based brake pads. The content of cellulose, hemicellulose, and lignin which is the highest in the reinforcing agent contributes most to the improvement of the mechanical properties of composite-based brake pads [2].

Table 4 shows students' demographics of the average score in science subjects (mathematics, chemistry, physics, and biology), and Bahasa Indonesia. There was no significant difference between the subjects' scores. Therefore, the students' mastery of each subject was mostly similar. The data also informed that the students have sufficient skills in science subjects.

Table 4. The average score of students in mathematics, biology, chemistry, physics, and Bahasa.

Subject	Average Score
Mathematics	85.2
Biology	86.5
Chemistry	84.1
Physics	84.5
Bahasa Indonesia	87.4

Table 5 presents the acquisition of pretest and posttest scores of 11 senior high school students as a whole. The level of students' mastery of the material regarding the concept of brake pads based on composites of palm fronds and rice husks increased after the experimental demonstration method was carried out.

Table 5. The results of the students' pretest and posttest.

No	Question	Pretest (%)	Postest (%)
1	The high accident rate is one of the problems in the transportation sector	100	100
2	The contours of the region in Indonesia cause many traffic lanes that are prone to accidents	90.9	100
3	61% of the causes of traffic accidents in Indonesia are due to human negligence	90.9	90.9
4	Biomass cannot be used as the brake lining material	81.8	81.8
5	Biomass is material derived from living things, including plants, animals, and microbes	90.9	100
6	The amount of catalyst added for the correct polyester resin mixture in the manufacture of brake linings is as much as 1%.	72.7	100
7	Brake pads from palm fronds are very expensive and damage the environment	72.7	90.9
8	Natural resources such as oil palm in Indonesia are very few	100	90.9
9	A good brake pad has a wear value of about 5×10^{-4} - 5×10^{-3} mm^2/kg	72.7	100
10	Biomass is a non-renewable material	90.9	100

Table 6 shows the comparison of the student's scores on the pretest and posttest. This is shown in the pre-test average value of 86.36% and the average increase after the post-test was 95.45%. Because the average value of N gain is 0.44, the increase in student understanding is in a moderate category. This is because students' basic skills in science were adequate but learning with short videos and in a pandemic situation that requires studying from home causes the increase in student understanding is not optimal [30]. Therefore, further learning about the teaching and learning process about brake pads students needed to be done to increase students' knowledge and understanding. This study is in line with previous reports [31-39].

Table 6. Student score for pretest and posttest.

Subject	Pretest	Postest	N-Gain
Student 1	100	90	0
Student 2	80	100	1
Student 3	90	100	1
Student 4	100	100	0
Student 5	40	80	0.67
Student 6	100	100	0
Student 7	100	100	0
Student 8	80	90	0.5
Student 9	100	100	0
Student 10	70	90	0.67
Student 11	90	100	1
Average	86.36	95.45	0.44

4. Conclusion

The effect of RH and PF amount on the quality of composite-based brake pads has been carried out. Composite-based brake pads with more RH contents have the best strength, which is durable, having the lowest wear value, as well as excellent performance in braking. This is because of the high content of cellulose, hemicellulose, lignin, and silica which is the major influence on the mechanical characteristics of composite-based brake pads. The teaching method with experimental demonstration can improve the understanding of high school students in the medium category.

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