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Sound Absorption Coefficient Value test on Bagasse Fiber and Empty Palm Fruit Bunches as an Effective and Environmentally Friendly Sound Absorbing Composite Material Using a Simple Impedance Tube

Chandra Halim.M, S.Si[1]
[1]MAN 1 Subulussalam
Corresponding E-mail: chandra.halim.m@mail.ugm.ac.id

Abstract
Recently, the development and use of sound-producing tools is increasing and some people are annoyed by these sounds. Besides that, a sound suppressor was created to reduce the noise generated by sound-producing devices, one of which is a porous Absorber which is most widely used by the community because it is relatively light and cheap. Meanwhile, on the other hand, there are many natural fibers that generally cannot be utilized significantly, two of which are oil palm empty bunches and bagasse fibers which are hard and strong. Based on data from the Directorate General of Plantations at the Ministry of Agriculture, Indonesia's palm oil land area reached 14.23 million hectares (ha) with production reaching 48.68 million tons in 2018, this also has an impact on the number of empty palm fruit bunches. Palm empty bunches are a natural material that contains thick and coarse filaments so they can absorb sound. Meanwhile, Indonesia's sugarcane production reaches 34.9 million tons per year with an area of about 750,000 hectares (ha). The high productivity of sugarcane in Indonesia has resulted in many sugar cane processing factories which have resulted in a lot of bagasse as well. Bagasse has a carbon and silica content of about 90% and 10%, respectively. This carbon plays an important role in sound-absorbing materials because it is very suitable for converting energy waves into heat energy. The research method are literature study which used as the fundamental comprehension to do the bagasse fiber, empty palm fruit brunch and composite material research also an experimental method by making five types of panel samples. Variation will be tested at sound frequencies 400 Hz, 600 Hz, 800 Hz, 1000 Hz, and 1200 Hz. From all calculation, All variation works perfectly in range frequency 400 – 600 Hz. For 800, 1000 and 1200 there are mines coefficient that informs the increasing of sound intensity level instead of reducing noises. The best variation is obtained by variation 1:1. It is proved by all coefficient of sound absorption is positive integer. The condition is totally opposite with control bagasse and variation 2:1. Both fibers have the ability to absorb the sound. All fibers work well if the composition is proportional and balance. The size of bagasse fiber are quite big compared to control empty palm fruit brunch. Therefore, control bagasse does not work well since the fibers are not stick densely. On the other hand, control empty palm fruit brunch has smooth fiber and bind each fiber easier rather than control bagasse. It can be proved by the value of coefficient of sound absorption for control empty palm fruit brunch is more positive than control bagasse. As the conclusion, variation 1:1 is the best variation for applying bagasse fiber and empty palm fruit brunch composite material. It also strongly proves that bagasse fiber and empty palm fruit brunch can be one of the material composite by applying variation 1:1 around of frequency 400-600 Hz.
Keywords: *Bagasse fiber, coefficient of sound absorption, empty palm fruit brunch, sound level intensity*

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INTRODUCTION

Sound is a form of energy like electricity and light. Sound is a wave that has wave characteristics in general, that is, when it meets a surface it can be reflected, absorbed, or transmitted. Over time, the use and development of sound tools that produce sound has increased. The voices gave a lot of reactions ranging from being attracted and enjoying to those who were annoyed by noise. To help those who feel disturbed by these sounds, a Absorber is now created that can reduce the noise that appears. Of the several types of

Absorbers that have existed, Absorbers with porous materials are the most widely used, especially in narrow spaces such as housing and offices[1]. This is because the porous material is cheaper and lighter than other types of Absorbers[2].

On the other hand, many natural fibers that generally cannot be utilized significantly, two of which are oil palm empty bunches and bagasse fibers which are hard and strong. Indonesia itself is one of the largest oil palm and sugarcane producing countries in the world. Based on data from the Directorate General of Plantations at the Ministry of Agriculture, Indonesia's palm oil lands reached 14.23 million hectares (ha) with production reaching 48.68 tons in 2018 (Saragih, et.al., 2021). Meanwhile, Indonesia's sugarcane production reached 34.9 million tons peryear with an area of around 750,000 hectares (ha) (Guo, et.al., 2015)

In fact, the use of empty oil palm bunches and bagasse cannot be optimized by the wider community due to a lack of understanding of this. Empty bunches of palm oil and bagasse are generally only disposed of and become waste in the community. Therefore, in this study, an experiment will be carried out that combines the empty palm oil bunch fiber and bagasse fiber to be used as an effective sound suppression tool, as well as an alternative to reduce empty bunches and bagasse waste itself.

LITERATURE REVIEW

Absorber

In principle, Absorber works by applying an acoustic system in the room. Acoustics itself is a sound arrangement principle that preserves and absorbs sound in a closed room. This material has a destructive function from one room which affects another room. With sound waves, the sounds produced in the room will sound more natural and clear. There are many types of materials that can be used as sound absorbers, such as cloth, gypsum, egg foam, polyester, rockwool, and soft board (Neri, et.al., 2021). Sound absorbers function to dampen the incoming soundso that it doesn't reflect into an echo or dull so that any sound will sound clear. Absorbers, alsoknown as Absorbers, Absorbers or sound moderators, when a weapon is fired, by modulating the speed and pressure of propellant gas from its muzzle and the blast muzzle blast (Zohuri, 2020)

Bagasse

Bagasse is one of the potential for natural fiber with an abundant amount of about 30% of the weight of the sugarcane plant[3]. Bagasse has a carbon and silica content of about 90% and 10%, respectively[4]. This carbon plays an important role in sound-absorbing material because it is very suitable for converting wave energy into heat energy[5]. Fibrous and porous materials have so far been accepted as sound-absorbing materials. Fiber surface area and fiber size have a strong influence on sound-absorbing properties. The higher the surface area and the smaller the fiber size will increase the absorption coefficient[5]. Bagasse content consists of cellulose (52.42%), hemicellulose (25.8%), lignin (21.69%), ash (2.73%) and ethanol (1.66%)[6]. The fiber content in bagasse is quite high, around 44% -48%, so this material can be used as an additional material to provide strength to other materials (Dhawan, et al., 2021).

Empty Palm Bunches

Empty palm bunches are the fibers that remain after separating the fruit from the bunches. Empty palm bunches are a natural material that contains thick and coarse filaments. This makes oil palm empty bunches more effective than non-renewable industrial materials, harmful to health and the environment (Khoshnava, et al, 2017). Oil Palm Empty Bunches is one of the materials that has good sound absorption capability, so it has a high potential to be used as an absorbent base material. sound replaces synthetic materials. In oil palm empty bunch microfibrils, cellulose, lignin and hemicellulose are the main components (Sukmawan, et.al., 2022). The most common compounds in palm fiber are cellulose, lignin, hemicellulose, and holocellulose. Holocellulose and hemicellulose have the same chemical structure as cellulose but have the same properties as lignin (Le Floch, et.al. 2015).

METHODOLOGY

Tools and Materials

a) Tools.Tools which have been used within this research are 50 inch PVC pipe, analytical balance, gloves, speaker and frequency generator apps and sound level meter apps.
b) Materials. For the material, this research requires materials like empty bunches, bagasse, and PVC pipe glue.

Research Steps

This research was conducted in three stages, with the first stage being the preparation stage. The second stage is the stage of absorbing material and finally, the third stage, which is the testing phase by using simple impedance tube. The following is a description of the stages of the assessment.

a) Preparation Stage. The details of the research stage are described as follows oil palm empty bunches and bagasse fibers are prepared. Then both fibers are cleaned (soak or boil). Both fibers are dried until they are completely dry.
b) Stage of Absorber Manufacturing. The details of the research stage are described as follows, tools and materials are prepared. Oil palm empty bunches and bagasse fibers combined according to predetermined variations (1:1, 1:2, 2:1, control oil palm empty bunches fibers and control bagasse fibers). The fibers are glued together so that they are sticky and dense. Fiber is formed into a round and adjusted in size with the pipe that has been prepared.
c) Testing Stage. The details of testing stages are described as follows absorber, pipe, speaker and sound meter are prepared.The absorber is placed in the center of the pipe, with the speaker on one side and the sound meter on the other. Assessment is carried out for all variations of absorbers. The speaker is turned on and measured the sound with an Aabsorber and without an absorber. The research data for each absorbers variation were obtained and statistical tests were performed.

Formula

To obtain the result, the data will be analyzed by using fundamental sound intensity level equation below.

$$I = I_0 e^{-\alpha x} \quad (1)$$

Equation (1) can be derived to this equation below.

$$\alpha = -\frac{1}{x} \ln\left(\frac{I}{I_0}\right) \quad (2)$$

With :
α = Sound Absorption Coefficient (m^{-1})
x = thickness of sample (uniformly 1 cm)
I = Sound intensity Level (dB)
I_0 = Initial Sound Intensity Level (dB) (Campillo-Davo, et.al., 2013)

By applying this formula to this research, coefficient of sound absorption will be obtained as the result also the effective interval of frequency range of plastic waste packaging food composite absorbing material. To determine the best absorption composite material, the interval of sound absorption coefficient is ranged by 0 – 1. If the sound absorption coefficient reaches zero, the material will not absorb the sound at all vice versa. As the coefficient of sound absorption increases, the better quality of composite material gained.

RESULTS AND DISCUSSIONS

Research Data

Data collection for each variation was carried out once for one minute at each frequency. The testing process is carried out by testing each sample at a sound frequency of

400 Hz, 600 Hz, 800 Hz, 1000 Hz, and 1200 Hz. In this study, the measurement of sound volume from the effect of 5 variations of absorbers was carried out. The sound produced will be the data to obtain the volume value of the sound produced after using an absorber made from bagasse fiber and empty palm fruit brunch fiber which will be used as test parameters. The measurement result data is shown by the following data table:

Table 1. Data Measurement Results of Each Sample

NO	Frequency (Hz)	Initial Sound Intensity (dB)	Sound Intensity Level (dB) variation				
			Control Bagasse	Control Empty Palm Fruit Brunch	Variation 1:1	Variation 2:1	Variation 1:2
1	**400**	83,3	77,8	82,9	81,6	79,3	78,6
2	**600**	82,2	80,5	81,5	82	81,6	80,8
3	**800**	81,5	81,6	77,7	80	82,4	81,5
4	**1000**	80,9	81,5	79,2	77,9	81,5	81,4
5	**1200**	80,8	81,4	81,2	80,5	81,4	81,7

This data will be examined by applying the formula (2) to gain the best coefficient of sound absorption among all variations. This result will be explained further in result and discussion section.

Result and Discussion

This study aims to determine the most appropriate and effective variations of absorbers made from sugar cane and empty palm fruit brunch fibers in reducing sound and to determine the effective interval frequency for applying this material. In determining the best variation of the damper for the sound level intensity using the sound level meter application for 20 trials. The data collection process was taken by entering each variation in turn into a 4-inch pvc pipe. Then, insert the sound source into one end of the pipe hole and on the other hand, use the frequency generator application which has function to be sound source. Data were collected once a minute for each sample at each frequency. The testing process is carried out by testing each sample at a sound frequency of 400 Hz, 600 Hz, 800 Hz, 1000 Hz, and 1200 Hz.

This research resulted in 5 mixing variations between sugarcane fiber and palm oil fiber. Variation 1 is mixing sugarcane fiber: Empty palm fruit brunch fiber with a size of 1: 1, variation 2 is 1: 2, variation 3 is 2: 1, variation 4 is sugarcane fiber control (without mixing the palm empty palm fruit brunch fiber) and the last variation is control of the palm empty palm fruit brunch fiber. (without mixing sugarcane fibers). Each variation is formed in a circle that is the same size as a 4 inch diameter pvc pipe hole having a thickness of 3 cm. By applying the formula (2), the coefficient of sound absorption is appeared as the table 2.

Table 2. Data Measurement Sound Absorption Coefficient of Each Sample

NO	Frequency (Hz)	Initial Sound Intensity (dB)	Sound Absorption Coefficient (1/m) variation				
			Control Bagasse	Control Empty Palm Fruit Brunch	Variation 1:1	Variation 2:1	Variation 1:2
1	**400**	83,3	2,2746	0,1602	0,6866	1,6387	1,9339
2	**600**	82,2	0,6959	0,2847	0,0811	0,2439	0,5720
3	**800**	81,5	-0,040	1,5900	0,6185	-0,365	0
4	**1000**	80,9	-0,246	0,70721	1,2583	-0,246	-0,205
5	**1200**	80,8	-0,246	-0,16444	0,1238	-0,246	-0,368

Table 2 shows that for variation 1:2 has zero coefficient which leads to unchanged condition between before and after applying the material. All variation works perfectly in range frequency 400 – 600 Hz. For 800, 1000 and 1200 there are mines coefficient that informs the increasing of sound intensity level instead of reducing noises. This table also provides the information that the best variation is obtained by variation 1:1. It is proved by all coefficient of sound absorption is positive integer. The condition is totally opposite with control bagasse and variation 2:1. Both fibers have the ability to absorb the sound. All fibers work well if the composition is proportional and balance. The size of bagasse fiber are quite big compared to control empty palm fruit brunch. Therefore, control bagasse does not work well since the fibers are not stick densely. On the other hand, control empty palm fruit brunch has smooth fiber and bind each fiber easier rather than control bagasse. It can be proved by the value of coefficient of sound absorption for control empty palm fruit brunch is more positive than control bagasse. As the conclusion, variation 1:1 is the best variation for applying bagasse fiber and empty palm fruit brunch composite material. It also strongly proves that bagasse fiber and empty palm fruit brunch can be one of the material composite by applying variation 1:1 around of frequency 400-600 Hz.

CONCLUSION

The best variation is variation 1:1 for bagasse fiber and empty palm fruit brunch and is effective to be applied at the frequency around of 400-600 Hz.

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