

EFFECT OF THE VOLUME OF BANANA FIBER AS A POLYMER COMPOSITE AMPLIFIER WITH POLYESTER RESIN MATRIX ON THE SOUND ABSORPTION OF ACOUSTIC MATERIALS

Rizka Fauziah¹, Ramli^{1*}, Yenni Darvina¹, Ratnawulan¹

¹ Department of Physics, Universitas Negeri Padang, Jl. Prof. Dr. Hamka Air Tawar Padang 25131, Indonesia
Corresponding author. Email: ramli@fmipa.unp.ac.id

ABSTRACT

Research has been carried out on the banana fiber effect as a polymer composite amplifier with polyester resin matrix on the sound absorption of acoustic materials. Sound Absorber material is made with a variation in the volume of banana fiber that is different from polyester resin. The volume of banana fiber and polyester resin used is 15% Fiber: 85% Polyester Resin, 20% Fiber: 80% Polyester Resin, 25% Fiber: 75% Polyester Resin, 30% Fiber: 70% Polyester Resin, 35% Fiber: 65% Polyester Resin. So when made composite then the amount of banana fiber used and polyester resin is 100%. Research methods are carried out in the collection of banana fiber, composite manufacturing and testing of sound absorption properties using impedance tubes. The testing of coefficient sound reflection and also sound absorbance coefficient testing is done using sound level meter and signal generator by reference to principle the method of tube impedance via approach to the acoustic box. The banana fiber composite result and polyester resin are able to reflect the sound of highest which is 0.44 in a frequency 500 Hz with fiber 15%. While lowest sound reflection coefficient is 0.06 at a frequency of 8000 Hz and fiber 35%. While in the test the highest value absorbance coefficient that absorbs sound is = 0.94 at fiber volume 35%, and frequency 8000 Hz, while the lowest sound coefficient is 0.56 in fiber 15% and frequency 500 HZ.

Keywords : Banana Fiber, Polyester Resin Composite, Acoustic Material Sound Absorber



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I. INTRODUCTION

Banana trees are one kind of the plants which we can easily find in community areas. One part of the banana tree is the banana fiber. Banana fiber is a porous material used as one of the alternative ingredients in silencers. Banana fiber is also an agricultural waste that has not been widely used as an acoustic sound absorber [1]. Banana fiber own cellular networks with interconnected pores but if the banana fiber is dried it will be better because it will become solid so that it makes it an ingredient that has a fairly good absorption. The porous fibrous and very reliable material capable of dissipating sound energy hitting the field surface. Sound absorption of the acoustic material of banana fiber using polymer composite material that is polyester resin [2].

Composites are materials formed by the compound two or a lot of materials having mechanical properties stronger than the constituent material [3]. In composites manufacture there are several main components, namely reinforcement that serves as a reinforcement material in composites and matrices as binders on composites. Polyester resin is a polymer matrix material that is widely used in the manufacture of fiber composites. The most widely used fibers include glass and carbon fibers. Polyester resin is the most widely used resin, especially in the marine industry [4].

Waves are defined as vibrations that propagate through the medium, in the form of solids, liquids, and gasses. Waves are divided into several types, namely based on the direction of propagation of waves distinguished into

two types, namely longitudinal waves and transverse waves [5]. The general definition of sound is that of a longitudinal wave in a medium. The simplest sound wave is a sinusoidal wave, which has a frequency from 20 to 20,000 Hz, which is called the audible range (audio sonic). Also used as a term for waves that cannot be heard by humans, namely waves similar to the above frequency or high frequency called ultrasonic ($>20,000$), while with a low frequency called infrasound (<20 Hz) [6].

Noise is defined as unwanted noise that is made like the sound of a machine. Sound is considered as very relative noise for example, the sound that is in places where discotheques, for people who have never been to the place will feel that it is a disturbing noise, but that can often be in the place it is not a noise [7]. Noise can cause noise or hearing system loss due to noise: Temporary hearing loss, can recover if the noise can be avoided, Ears buzz, People become immune to noise, permanent hearing loss / deafness (unable to recover) [8].

SWR is a measurement of the ratio of coming waves and bounce waves. SWR meters serve as signal gauges of signal sources at frequencies emitted through transmission lines and antennas. The working principle of SWR is based on a power meter whose SWR value can be calculated from the coming wave. To determine the value of SWR, namely with the amplitude of maximum pressure and amplitude minimum of pressure. To represent the amplitude of maximum pressure used $(A+B)$ and $(A-B)$ represents the amplitude of minimum pressure. The maximum and minimum pressure amplitude this namely as standing wave ratio [9] using the formula number (1):

$$SWR = \left(\frac{A+B}{A-B} \right) \quad (1)$$

The word acoustic comes from the Greek *acoustics*, which means everything related to hearing in a space condition that can affect the quality of sound. The phenomenon of sound absorption by a surface occurs due to the presence of sound beams that meet or pound the surface plane of the material, then the sound will be reflected (*reflected*), absorbed (*absorbed*), and transmitted (*transmitted*) or transmitted by the material. Medium sound waves can be solids, liquids, or gasses. The frequency of human acceptable sound waves ranges from 20 Hz to 20 kHz, or referred to as *audible range* [10].

The material of acoustic is a technical material which mainly functions to permeate sound or noise. An acoustic material is a material that can absorb the sound energy that comes. But basically all materials can absorb sound, but the amount of energy absorbed varies for each material [11]. Sound absorption materials and constructs used in the acoustic design of an auditorium or used as sound controllers in noisy spaces can be classified into: panel absorption, cavity resonators, and porous materials [12]. Acoustic materials can be separated into three types, sound absorbent material, sound barrier material, sound damper material. The absorption coefficient (α) the state amount of sound absorption in the absorbing material. The absorption coefficient is expressed as a number among 0 and 1. No energy absorbed is an event where the absorption coefficient value is 0 while coefficient value is 1 then indicates if absorption perfected [13].

If a sound wave propagates from one medium to another, it will be reflected and transmitted by the boundary plane of the second medium. *Sound Reflection* is the re-reflection of a sound wave that collides on a surface, where the angle comes as large as the angle of the bounce [14].

The coefficient of sound reflection can be identified using equations number (2):

$$R_{\Pi} = \left| \frac{B}{A} \right|^2 \quad (2)$$

The definition of sound absorption is the change of sound energy into other energies, generally heat, when passing through a material or when pounding a surface [15]. The efficiency of sound absorption is expressed in α . The α can be between 1 and 0. The absorption of sound on a surface is measured in units of cabins. There are several methods of measuring sound absorption, namely the method of impedance tube, the method of echo chamber, the method two microphone far fields and method in situ. The Common used method is the impedance tube method and the echo chamber method. In order to measure coefficient of the sound absorption, the method of impedance tube is used of acoustic materials practically because of the small size of the sample. Sound waves propagate perpendicular to the surface of the material with varying ranges of frequency as needed [9].

The method of impedance tube coefficient sound absorption is determined by finding the ratio of the amplitude maximum and minimum of pressure. This Ratio of amplitude pressure it's called the *Standing Wave Ratio (SWR)*. Value of mathematically the upright wave ratio can be expressed in the following equation (1):

$$SWR = \frac{A+B}{A-B}$$

(A + B) represents amplitude maximum of pressure and the amplitude minimum of pressure represents by (A-B). While the coefficient of sound absorbance (α) can be determined from the following equation [16] using number (3) :

$$\alpha = 1 - \left(\frac{SWR-1}{SWR+1} \right)^2 \quad (3)$$

II. METHOD

In this study, the type of research conducted at this time belongs to the category of experimental research on a laboratory scale by making several kinds of composite panels by varying the volume of fiber used. The goal of this study is to find out the volume fibers effect used in composite manufacturing panels on acoustic sound absorption properties to determine the characteristics resulting from acoustic properties. This study is the volume variation of the fiber used in composite manufacture. Bananas fiber ratio and polyester resin is 15%:85%, 20%:80%, 25%:75%, 30%:70%, 35%:65%. So that the amount of banana fiber and polyester resin used is 100%.

The methods carried out in this study are Material Preparation, Mold Making, Composite Manufacturing and Acoustic Nature Testing Process. The preparation of the ingredients that will be done is to prepare banana fiber taken from the trees that have been cut down then washed thoroughly and dried for about 1-3 days. Banana fiber is brushed and cleaned using wire brush then it is decomposed and fibrous and cut into pieces with size of 3 cm .Then banana fiber is soaked using *NaOH* 5% for 2 hours Banana fiber weighed according to calculation and can be used. Then make a print of circle-shaped iron with 8 cm in diameter and 2 cm in thickness.

The next process is the manufacture of composites with the hand lay-up method, which is to determine the volume of the first mold used using the tube volume formula, namely πr^3 so that the tube volume is 100.48 ml. Then determine the volume for each fiber and also the resin used. Making composites from samples is done after getting the value of the volume of banana midrib fiber with the volume of resin used. The polyester resin is stirred using a catalyst in a container. Then put it into the mold periodically. Then the banana midrib fibers that have been cut are arranged evenly and parallel. Then put the resin into a container that has been arranged into 3 layers. After that the print is pressed using a tool, namely a hot press until the mold has a thickness of 2 cm.

Acoustic testing is performed using impedance tubes. The impedance tube to be used is loaded with iron assembled in such a way. Impedance tubes are equipped with several tools including: microphones, amplifiers, power supplies, oscilloscopes, generator signals, loudspeakers, scales and samples arranged at the end of the tube. Loudspeaker is connected with the generator as a sound generator with a regulated frequency. At the end of the tube is placed a loudspeaker whereas the other side tube placed a sample. In the middle of the tube is placed the microphone and is directed towards the sample. The end of the wire attached microphone in order to slide to find the amplitude position and to determine maximum pressure of the amplitude and the minimum pressure of the amplitude. The impedance tube is equipped with several tools, including: microphone, amplifier, power supply, oscilloscope, signal generator, loudspeaker, scale and samples which are arranged as shown in Figure 1.

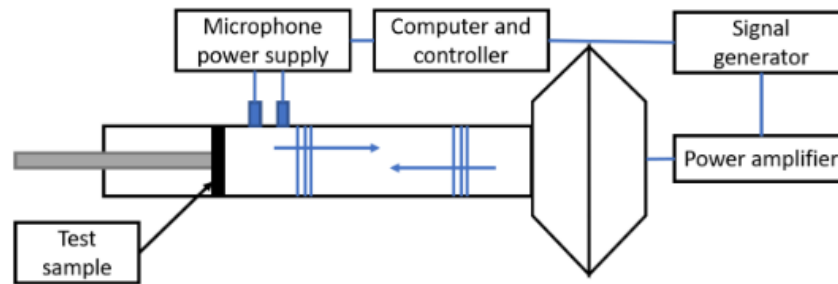


Fig. 1 Impedance Tube Circuit [17]

Amplifier will be used to amplify the microphone and connected to an oscilloscope to display the waveform. The quantities measured are amplitude maximum of pressure ($A+B$), the amplitude minimum of pressure ($A-B$), and sample distance is first minimum amplitude (d_1), the distance from second minimum amplitude (d_2). In this research usage frequency range 500, 1000, 2000, 2500, 3000, 4000, and 8000 in units of frequency hertz (Hz).

Next determine the value of the reflection coefficient of sound using the formula using equation number (2):

$$R_{\Pi} = \left| \frac{B}{A} \right|^2$$

And determine the value of the coefficient of sound absorption using the formula using equation number (3):

$$a = 1 - \left(\frac{SWR-1}{SWR+1} \right)^2$$

III. RESULTS AND DISCUSSION

The results of study are value coefficient the sound reflection and value coefficient sound absorption the banana fiber acoustic material obtained from the results of impedance tube testing. Variations in fiber volume used are 15%, 20%, 25%, 30% and 35% based on maximum pressure amplitude values and minimum pressure amplitude values with frequency ranges of 500, 1000, 2000, 2500, 3000, 4000, and 8000 in units of frequency hertz (Hz).

On the sound reflection coefficient test and the sound absorbance coefficient carried out at the Materials Physics Laboratory, Andalas University. From the measurements results that have been done to specify the reflection coefficient of banana acoustic material with variations of banana fiber, banana fiber has a different sound reflection coefficient value of each frequency. The coefficient of sound reflection will be small when the material has a small cavity and a little so that sound waves are difficult to enter and reflect in acoustic materials, while the absorbance coefficient drops it is because the material is a little cavity so that sound waves will be difficult to enter the material, resulting in more incoming sound reflected [18]. Based on the data obtained, the sound reflection coefficient value can be seen in table 1.

Table 1. Sound Reflection Coefficient

Frequency	Sound Reflection Coefficient				
	15% Fiber	20% Fiber	25% Fiber	30% Fiber	35% Fiber
500	0.44	0.42	0.39	0.35	0.34
1000	0.43	0.39	0.35	0.31	0.28
2000	0.37	0.31	0.25	0.23	0.16
2500	0.30	0.28	0.21	0.17	0.12

3000	0.27	0.23	0.18	0.15	0.10
4000	0.25	0.21	0.17	0.12	0.08
8000	0.22	0.18	0.15	0.10	0.06

Based on table 1, it can be seen that the highest sound reflection coefficient value is 0.44 at a frequency of 500 Hz and the sample with banana midrib fiber volume is 15%. While the lowest sound reflection coefficient is 0.06 at a frequency of 8000 Hz at a volume of 35% banana sheath fiber. The following is a graph of the sound reflection coefficient value of each sample. Here is the relationship of the coefficient of sound reflection to frequency, as shown in Figure 2:

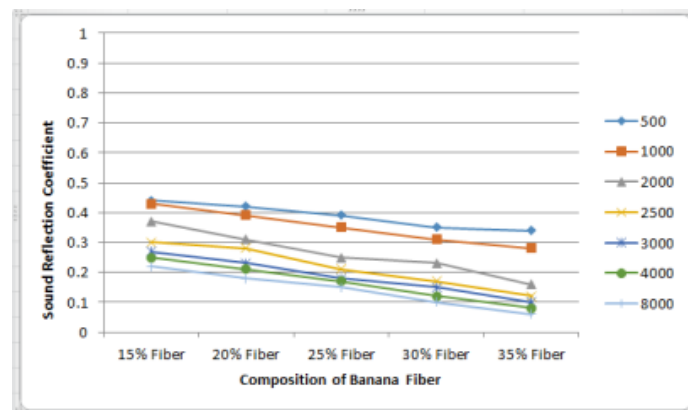


Fig. 2 The relationship of the sound reflection coefficient in the banana smelter to the frequency.

At 500 Hz a frequency reflection coefficient the highest sound is 0.44 by 15% fiber presentation used. The lowest sound reflection coefficient is 0.06 in 8000 Hz frequency at fiber presentation by 35% according to the ISO 11654:1997 standard [19]. This is because the less volume of banana fiber used, the coefficient of reflection will also rise. This is because the volume of fiber used is less so that it forms fewer pores as well. This makes the wave more difficult to absorb and will be reflected by materials that can increase the value of its reflection coefficient.

From the measurement results that have been carried out, the relationship between the sound absorption coefficient of the acoustic material of the banana midrib with the variation of the banana sheath fiber has a different sound absorption coefficient value for each frequency [20]. Testing on the first sample of the sound absorption coefficient on acoustic material, namely the frequency relationship of banana sheath fiber 500Hz, 1000 Hz, 2000 Hz, 2500 Hz, 3000 Hz, 4000 Hz, 8000 Hz. Based on the data obtained, the sound absorption coefficient value can be seen in table 2 below.

Table 2.Sound Absorption Coefficient					
Frequency	Sound Absorption Coefficient				
	15% Fiber	20% Fiber	25% Fiber	30% Fiber	35% Fiber
500	0.56	0.58	0.61	0.65	0.66
1000	0.57	0.61	0.65	0.69	0.72
2000	0.66	0.69	0.75	0.77	0.84
2500	0.7	0.72	0.79	0.83	0.88
3000	0.73	0.77	0.82	0.85	0.9

4000	0.75	0.79	0.83	0.88	0.92
8000	0.78	0.82	0.85	0.9	0.94

Based on table 2, it can be seen that the highest sound absorption coefficient value is 0.94 at a frequency of 8000 Hz and the sample with banana midrib fiber volume is 35%. While the lowest sound absorption coefficient is 0.56 at a frequency of 500 Hz at 15% banana sheath fiber volume. The value of the sound absorption coefficient meets the requirements as a sound absorbent material according to the ISO 11654 standard. The following is the relationship between variations in the volume of banana sheath fiber and the value of the sound absorption coefficient, which can be seen in Figure 3.

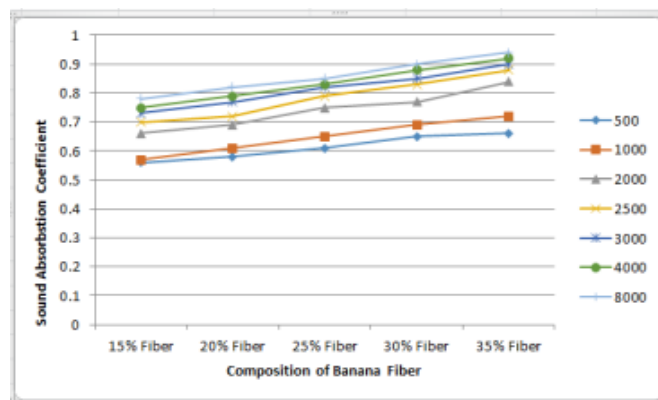


Fig. 3 The relationship of the sound absorbance coefficient in the banana fiber with respect to frequency.

The highest coefficient of sound absorbance is 0.94 in the frequency of 8000 Hz with the fiber presentation used being 35%. The sound absorption coefficient lowest value is 0.56 in frequency 500Hz with a 15% fiber volume presentation, according to the ISO 11654:1997 standard. This is because the greater the volume of banana smelter fibers used, the absorbance coefficient will also be large. This is because the volume of fiber used is more so as to form more pores. This causes the wave to be more easily absorbed by the material which can increase its absorbent coefficient value. Based on the data analysis, the composite sample that has been made has a decrease in the reflection coefficient as seen in figure 4.

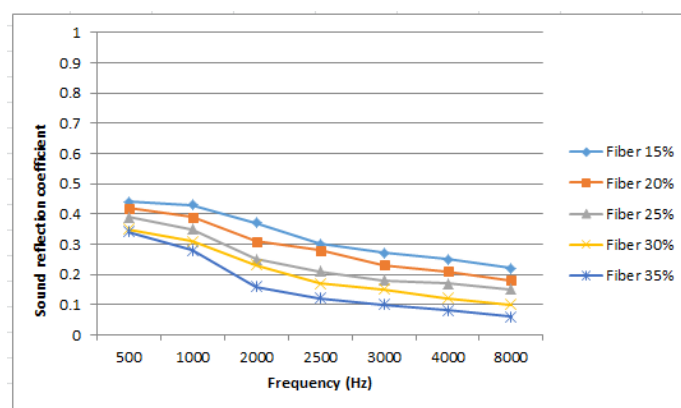


Fig. 4 The relationship between the reflection coefficient of sound and frequency

Based on Figure 4, it can be seen that the composite sample has a decrease in frequency from 500 Hz – 8000 Hz. The composite sample has the highest coefficient value at a low frequency of 500 Hz. It can be seen that the value of the sound reflection coefficient decreases with the amount of frequency used. So the relationship between the reflection coefficient value of banana sheath fiber and frequency is inversely

proportional. From the data analysis that has been carried out on the banana sheath fiber composite that has been made, it has an increase in the absorption coefficient as seen in Figure 5.

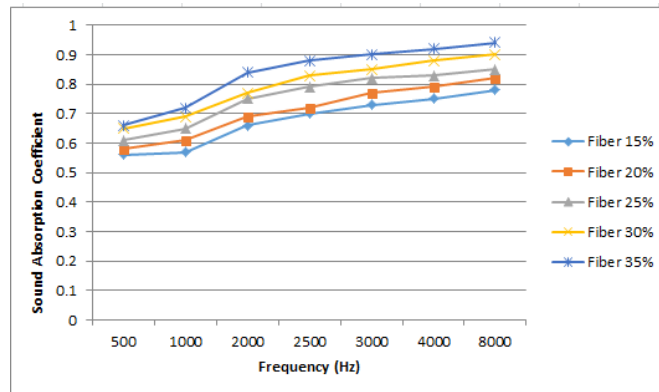


Fig. 5 The relationship between sound absorption coefficient and frequency

Based on Figure 5, it can be seen that the composite sample of banana sheath fiber has an increase in frequency from 500 Hz – 8000 Hz. The composite sample has the highest absorption coefficient at a frequency of 8000 Hz, and has a low absorption coefficient at a frequency of 500Hz. The highest sound absorption coefficient is 0.94 at a frequency of 8000 Hz on 35% fiber. The lowest absorption coefficient is 0.56 at a frequency of 500 Hz and 15% fiber. It can be seen that the value of the sound absorption coefficient increases with the frequency used. So the relationship between the sound absorption coefficient of banana sheath fiber and the frequency is directly proportional.

In testing the value of the sound reflection coefficient and the value of the sound absorption coefficient using an impedance tube, the value varies for each sample used. In this study, it was not possible to test the value of the sound transmission coefficient due to the limitations of the equipment used. The impedance tube device at Andalas University can only test the reflection and sound absorption coefficients through the value approach of the maximum pressure amplitude and minimum pressure amplitude values obtained from the oscilloscope.

IV. CONCLUSION

Based on the study that has been completed it can be concluded that: Coefficient of sound reflection highest is 0.44 in the frequency of 500 Hz at 15% fiber. The lowest coefficient of reflection is 0.06 in the frequency of 8000 Hz at 35% fiber. The highest coefficient of sound absorption is 0.94 in the frequency 8000 Hz at 35% fiber. The lowest coefficient of absorbance is 0.56 in the frequency of 500 Hz and fiber 15%. So it can be concluded that the greater the value of the frequency and volume of the fiber used, the greater the absorbance coefficient value (absorption) and the smaller the coefficient of reflection (reflection). If the smaller the value of the frequency and volume of the fiber used, the smaller the absorbance coefficient and the greater the coefficient of reflection.

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