Effect of Volume Fraction Filler on Sound Insulation in Oil Palm Fronds Fiber Composite Polyester Matrix

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Abstract. In this study, the effect of adding palm fiber rods to the polyester matrix for sound insulation purposes was investigated. The type of fiber used is short fibers with random orientation with the percentage difference in the amount of fiber in the composite as a comparison. Testing loss of voice transmission using impedance tube method is done to know the ability of material to reduce or prevent sound. The data obtained from the TL test results were analyzed and the STC (sound transmission class) values were calculated on each sample. The best results obtained are in the first and second samples with the percentage of fiber 0% and fiber 30%. The calculated results of the STC values in samples one and two each have 32.1 dB and 31.6 dB which indicates sufficient ability to defeat the loud noise. Based on these results, a composite with a 30% fiber content can be used as a sound insulation material and can reduce waste of palm oil that is underutilized.

Keywords: Sound Insulation, Impedance Tube, Composite, Oil Palm Frond

INTRODUCTION

Noise pollution is an important and serious issue. In developed countries like America alone is still far behind from the European countries that make noise pollution a serious problem. High pollution noise is also a parameter of the quality of life of residents in Europe (Rwawiire, Tomkova, Militky, Hes, & Kale, 2017). Due to high noise pollution conditions will cause other related problems. In connection with the problem, noise control in a room needs to be done.

Noise control can be done with two techniques. The first technique deals with the sound control of a building better known as the sound absorption that appears in the room, and the second technique with the isolation from the sound source (Sistiani Departemen et al., 2011). The commonly used synthesis material is able to withstand sounds but the largest source of raw material from fossils. A comparison between conventional and natural sound insulation materials indicates that natural fibers are more energy efficient in the production process and reduce the greenhouse effect (Asdrubali, 2006). So much of the development of natural fiber based materials that are more environmentally friendly.

The use of natural fiber composite fibers as sound insulation has been largely done for several products such as, low cost product yield, has good acoustic and thermal characteristics, low energy use and environmentally friendly and safe in sustainable use (Setyanto, Priyadithama, & Maharani, 2011). Natural fibers used in this research is organic waste of palm stem. This fiber has several advantages such as economic value is high enough, easily available, available in large quantities, not dangerous to health, and is a waste that is rarely used. Previously, palm fiber has also been used in research for noise control and the results have a good value of 0.96 absorbent coefficient. While the composite matrix in this study uses polyester because it has several advantages in heat retention, easy fabrication and can Insulated sound well. According to (Zhu, Kim, Wang, & Wu, 2013) in his study shows the acoustic characteristics of natural fiber recognized effectiveness and controlled based on the density that causes different behavior on noise reduction.

Based on the above data, this research is focused on knowing the sound insulation capability of fiber palm fiber composite material with polyester matrix with variation of fiber volume fraction to sound transmission loss in some frequency of environment standard. Frequencies heard by humans generally consist of many low, middle and high

frequencies. The standard frequency normally indicated under environmental conditions is selected in the range of 125 Hz up to 4000 Hz to calculate the average value of sound transmission loss.

MATERIALS AND METHODS

Materials and Tools

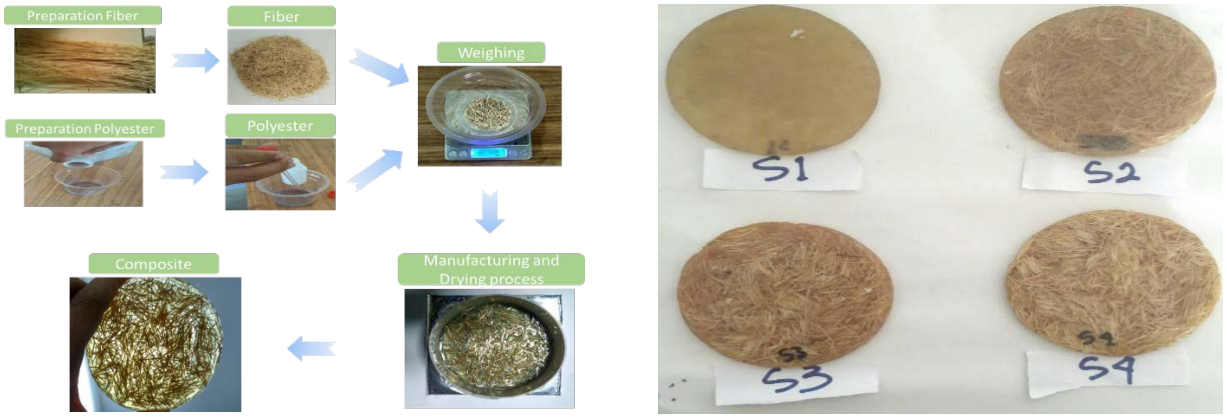
Materials and tools used in this research are palm fiber Species E. Guineensis Jacq type Nigrescens, polyester resin and polyester resin hardener, cutting tool, wire brush, digital scales, aluminum foil, receptacle, specimen mold, spatula, drop pipette, 100 grade grinding sand paper with grinder, and a set of transmission loss testing equipment with impedance tube method.

Sample Preparation

The fiber preparation process begins with the removal of palm stem fiber which will then be immersed in water for a week of purpose in order to facilitate the separation of the fiber. The result of fibers that have been done separation and has dried and then cut the fiber 1 cm. The polyester is weighed in accordance with a predetermined composition and mixed with a polyester resin catalyst or hardener of 1% of the volume of the polyester.

Composite Manufacture

Figureure 1 (a) shows the composite-making process from scratch to being a sample ready for the test in Figure 1 (b). The manufacturing process begins by weighing the fiber and polyester materials according to the desired persetase. The mixture is then stirred on the receptacle and ready to use. The prepared fibers and polyesters are then molded and dried for a day and a night for conditioning. The subsequent process of removal from the mold and sanding to conform to the sound transmission loss test dimensions.



(a) (b)

FIGURE 1. (a) Manufacture process of oil palm fronds composite, (b) Sample sound insulation and young modulus test

Sound Transmission Loss Testing

Sound transmission loss testing was carried out by using 2 pieces of microphone, in different to the test of absorption coefficient. Schematic and set up tools for transmission loss testing are shown in Figure 1 according to ASTM standard 1050-98 using impedance tube. The sample size for TL test is a circle with a diameter of 98 mm with a thickness of 5 mm.

Sound Transmission Class

STC (Sound Transmission Class) is a value that indicates the ability of the material to hold the sound or isolate the sound in each frequency in a single value unit that is calcified. The value of STC is determined based on the quality standard issued by ASTM which is determined by comparing the TL curve versus curve standard STC at a frequency of 125 Hz - 4000 Hz and based on the requirements that satisfy the STC value determination of the material.

Test procedure:

1. Material cut 98 cm according to the size of the impedance tube.
2. After the cut, the specimen is inserted into the impedance tube for measurement.
3. Compilation of impedance tubes, amplifiers, NI as in Figureure 2.
4. Then opened the application labview STC Measurement.vi in C: \ Users \ ASUS \ Desktop \ desktop contents 2 \ STC Measurement which has been connected with NI consisting of 2 microphones inserted into hole number 2 in room 1 and hole number 2 room 2.
5. After that, measurements are made by generating a 1/3 octave noise signal (frequency 125 Hz- 4000 Hz) and measured [in (dB)] using a microphone connected to NI and labview.
6. The measurement results on each microphone are inserted and processed using excel and matlab program to find out the STC value of the specimen

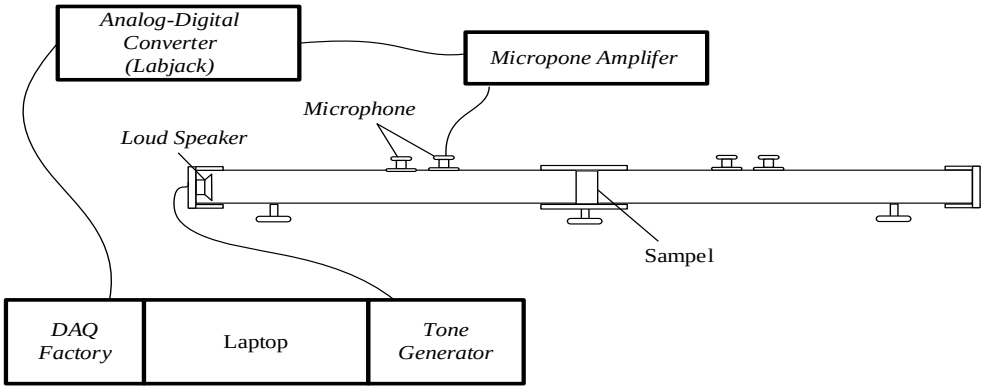


FIGURE 2. Schematic and set up tools for transmission loss testing

RESULT AND DISCUSSION

Effect of Fiber Volume Fraction on Sound Insulation Characteristics

Sound transmission loss test is intended to obtain the value of voice transmission loss, the value of voice loss is indicated by the TL value (transmission loss). Table 1 shows the data of measurement of loss of voice transmission. In the table it can be seen that from the results of composite testing of palm fiber fibers, the value of the sound transmission of each specimen against the frequency is different from 125 Hz to 4000 Hz and decreases as the addition of fiber fraction. This is influenced by several factors that cause the value of loss of transmission is getting down.

Based on the above results the best loss transmission at low frequencies at 125 Hz frequency of 67.1 dB in sample 1 without the fiber mixture whereas the lowest transmission loss value was obtained at the frequency of 250 Hz 11.1 dB in sample 4 with the highest percentage of fiber volume fraction. However, if viewed from the four materials in general the value of transmission loss decreases as the percentage increase of fiber in polyester as shown in Figure 4 which shows the transmission loss versus frequency.

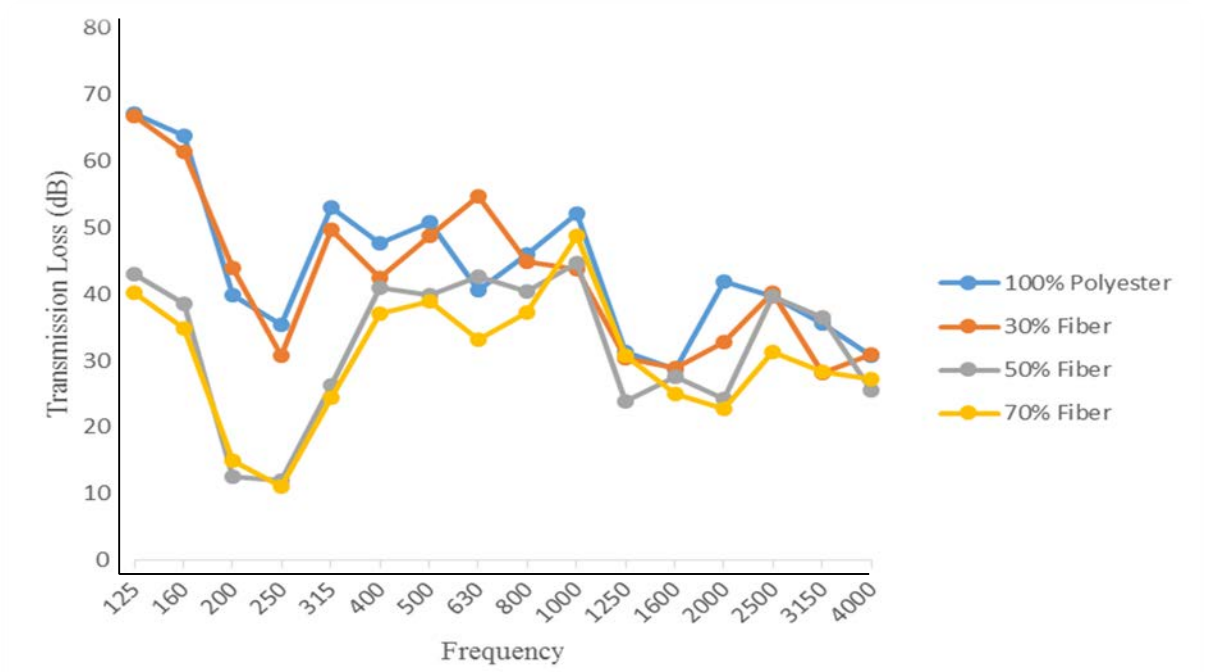


FIGURE 3. Graph of sound transmission loss testing

TABLE 1. Sound transmission loss test results

Frequency (Hz)	Transmission loss (dB)			
	100 % Polyester (S1)	30% Fiber + 70% Polyester (S2)	50% Fiber + 50 % Polyester (S3)	70% Fiber + 30% Polyester (S4)
125	67,1	66,6	42,9	40,1
160	63,7	61,3	38,6	34,8
200	39,8	43,8	12,5	14,9
250	35,3	30,7	12,1	11,1
315	52,9	49,7	26,3	24,4
400	47,6	42,4	41	37
500	50,8	48,7	39,9	38,8
630	40,5	54,6	42,6	33,2
800	45,9	44,9	40,4	37,2
1000	52	43,7	44,7	48,7
1250	31,3	30,4	23,8	30,7
1600	28,7	28,9	27,5	25
2000	41,9	32,7	24,3	22,8
2500	39,6	40,2	39,6	31,3
3150	35,5	28,1	36,4	28,4
4000	30,7	30,9	25,5	27,3

The comparison effect of addition fiber volume friction to sound insulation based on sound transmission loss can also be seen from STC (Sound Transmission Class) value. This value indicates the material properties to hold the sound or isolate the sound at any standard frequency in a single unit of value that the consonant corresponds to (Everest & Pohlmann, 2009) is as follows:

a). 50-60 is very good, loud noises sound weak or unheard
b). 40-50 is very good, sounds weak
c). 35-40 is good, the voice must be heard further
d). 30-35 is enough, loud enough to sound
e). 25-30 bad, normal voice is easy or clear sounding
f). 20-15 is very bad, a soft voice can be heard

Table 2 shows the calculated data of STC values on the four samples that have been tested in its transmission loss indicating that the highest STC value is found in the material without adding fiber as much as 32.1 dB while the lowest STC value is present in the sample with the addition of fiber at most 25,1 dB. The value obtained is influenced by several factors such as thickness, density, sample surface, cavity in the sample and modulus of elasticity. These factors influence the level of material in holding the sound. So if you want to have a material that has good properties in holding the sound by raising several factors by not lowering other factors. In this study the results decreased due to the decreasing density value and the number of cavities formed due to the amount of fiber addition.

From the calculation of STC values, samples one and two shows the STC number of 32.1 dB and 31.6 dB that indicates the noise damping is still not good or enough because of the loud noise can still be heard, while in samples 3 and 4 show the value of each STC Is 25.9 dB and 25.1 dB of the value says that poor sound damping due to normal sound is clearly heard. These results show that samples one and two can be applied because they have a material value to insulate sound so that the composite with a 30% fiber percentage is able to isolate the sound and reduce waste of palm stem.

TABLE 2. Sound transmission loss test results

No.	Sample	STC (dB)
1.	Sample 1 (100% polyester)	32.1
2.	Sample 2 (30% fiber + 70% polyester)	31.6
3.	Sample 3 (50% fiber + 50% polyester)	25.9
4.	Sample 4 (70% fiber + 30% polyester)	25.1

CONCLUSION

Based on the result of the transmission loss test, the addition of volume fraction resulted in the decrease of material ability in insulating sound. The highest sound insulation value was obtained in the S1 sample with a value of 32.1 dB and the lowest value in the S4 sample with a value of 25.1 dB. Based on the ability of the material to insulate the sound of sample 1 and sample 2 can be used because it can inhibit the sound. Therefore, composites with a 30% percentage of palm stem fiber can be used as sound insulation and can reduce waste of palm oil waste that is underutilized.

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