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Determination of Acoustic Characteristic of Rice Bran Composite as a Material to Control Noises

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Abstract

The examination of the acoustic characteristic of rice bran has been performed. The materials are the alternative materials of the noise controller from the use of synthetic fiber materials like *glasswool.* The examination is completed by using tube impedance method. The result of the examination reveals that the natural fiber materials that have been mixed with glue have a good value of sound absorption at frequency 400-1200 Hz whereas at frequency 200 Hz, its value does not change significantly. The high value of the sound absorption is owned by materials with the bigger porous. Beside the coefficient of the absorbtion, the examination of the value of acoustic impendence is also performed. The result shows that the similar composition between natural fiber and glue has a bigger value of impendence compared to the lower composition of glue. It is caused by the fulfillment of the bigger amount of the porous by glue.

1. Introduction

Noise is a pollution that tends to increase time to time. There are so many sources of noise caused by sounds from vehicles, industries, airplanes and so on. This noise can be controlled, among others, by absorbing the noise with a variety of acoustic material that is absorbing or muffling the sound so that the noise can be reduced (Suhada, 2010; Hansen, 2015). Materials of natural fibers such as coconut fiber and hemp fibers show good acoustic performance, a sound absorption that is not much different from synthetic fiber materials such as glass fiber and rockwool (Sabri, 2005; Asdrubali, 2006; Berardi & Iannace, 2015; Mueller & Krobjilowski, 2003).

Composite is a material structure that can use fiber as its basic material. This natural fiber is used as a reinforcement material, which serves to increase strength and stiffness in receiving the desired load. The fibers contained in nature have characteristics that are suitable as a reinforcing base material on the composite. Natural fibers have random and unruly fiber directions. If the natural fibers are used as a composite base material, then it is likely that the composite material will have an isotropic characteristic, which has the same characteristic in all directions. In addition, natural fibers in general have the ability to absorb sounds quite well (Berardi & Iannace, 2015, 2017; Samsudin, Ismail, & Kadir, 2016; Tomyangkul, Pongmuksuwan, Harnnarongchai, & Chaochanchaikul, 2016; Zheng, Wang, Zhu, & Wang, 2015; Wirajaya, 2007)

Some researchers have made new breakthroughs in developing natural fibers and wood as a new sound absorber. Bamboo fibers are developed as a sound absorbent whose quality is as good as glasswool (Koizumi, Tsujiuchi & Adachi, 2002). Natural fibers such as coconut fibers (Kartikaratri, Agus & Hendri, 2012; Rozli & Zulkarnain, 2010; Fouladi, Nor, Ayub, & Leman, 2010; Kim, Cho, Min, & Park, 2015; Mahzan, et.al., 2010; Nor, Jamaludin, & Tamiri, 2004; Zulkifli, Nor, Tahir, Ismail, & Nuawi, 2008) banana stalk fiber (Dewi & Elvaswer, 2015; Bin Bakri, Jayamani, Heng, Hamdan, & Kakar, 2017; Jayamani, Hamdan, Ezhumalai, & Bakri, 2016; Tholkappiyan, Saravanan, Jagasthitha, Angeswari, & Surya, 2016), bagasse (Ridhola & Elvaswer, 2015; Doost-hoseini, Taghiyari, & Elyasi, 2014; Trindade et al., 2005), okra (Khan, Yilmaz, & Yilmaz, 2017; Santulli, Sarasini, Fortunati, Puglia, & Kenny, 2014), tempeh pulp (Wijaya & Elvaswer, 2015), tofu (Rizal, Elvaswer & Fitri, 2015) and pineapple fiber (Bahri et al., 2016; Asim et al., 2015) are also used as a base for absorbing noise.

In this research, the coefficient of sound absorption and the acoustic impedance of rice bran material with PVAc glue was determined. The acoustic characteristic of a material can be known by acoustic testing. Acoustic testing can be distinguished based on the place of testing ie testing inside the tube and testing in a hum room (Doelle & Prasetyo, 1993). This research apllied tube method. The tube method is chosen because it is simple, practical and the material required is relatively small compared to the humming method. The sound absorption coefficient is expressed in numbers between 0 and 1. The absorption coefficient value 0 states no absorption of sound energy and the absorption coefficient value 1 denotes perfect absorption (Doelle & Prasetyo, 1993). In the tube method, the determination of sound absorption coefficient (α) is done by calculating the ratio of maximum pressure amplitude (A+B) with its minimum pressure amplitude (A-B). The ratio of the maximum pressure amplitude with minimum pressure amplitude is called the standing wave ratio (SWR).

The coefficient of sound absorption is calculated by measuring the sound pressure coming on the surface of the material and reflected by the surface of the material. Russell (1999) stated that the coefficient can be calculated using the following equation:

$$\alpha = 1 - |R|^2 = 1 - \frac{(SWR-1)^2}{(SWR+1)^2}$$

where R is the sound reflection coefficient, which is defined as the ratio of the sound pressure of the reflected sound to the incoming sound wave pressure. The equation uses the assumption that no sound is transmitted.

2. Method

This research begins with the manufacture of composites with basic materials. Composite acoustic dampers are made from a blend of rice bran with PVAc glue matrix. After the manufacture of composite materials is completed, then proceed with the testing process. For testing, It first conducted the assembly and calibration of tools for testing of the impedance tube and other supporting tools. After the assembly and calibration of the tool are completed then testing of the test material that has been made is done. The work flow diagram of this study is shown in Figure 1.

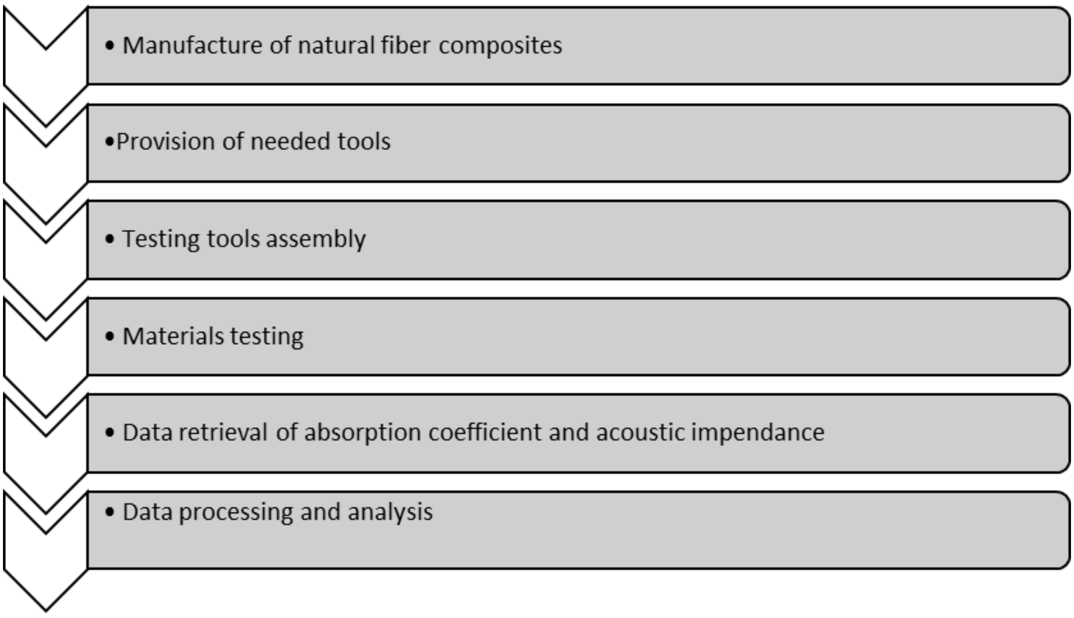

Figure 1. Workflow Diagram

In manufacturing the composite materials, the rice bran is first cleaned from other impurities. To determine the number of matrices and fibers, it is used the ratio of mass between fibers with the matrix used. The mass ratio used in the manufacture of this test material is obtained based on several experiments using different mass ratio. From these experiments the corresponding mass ratio was determined based on the results obtained in terms of weight, and density. The mass ratio is determined between rice bran and PVAc glue. is 1: 1 (40 gr: 40 gr.) and 3: 2 (45 gr: 30 gr). At the time of manufacture, the rice bran which has been mixed with the glue is pressed in such a way as to satisfy the volume of the mold used. The mass ratio based on the volume of rice bran after mixing with glue and pressed will have 3 times volume compared to the volume before it is mixed. This pressure is aimed at obtaining greater stiffness and stronger adhesion among the fibers.

The form of test material made is adjusted to the size required by the tester, ie the impedance tube. The form used is a cylinder or disc, with a diameter of 8 cm, for its thickness in accordance with the thickness used, which is equal to 1 cm. The result is silenced in the mold for 1 day. After that, just released from the mold by ensuring the glue has dried and adhered well, as in figure 2.

Figure 2. Resulted in composite structure

The impedance tube used is an impedance tube made of a PVAc pipe set up in such a way as shown in Figure 3. In the operation, the impedance tube is connected to some other means of ampilifier, oscilloscope, signal generator, adapter, loudspeaker, and microphone.

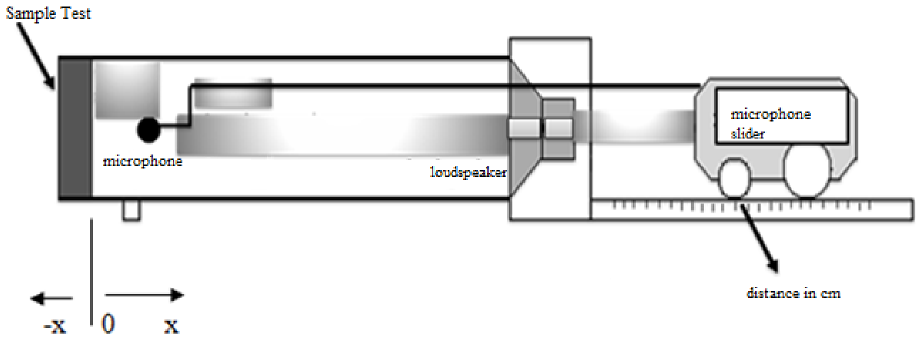

Figure 3. Impedance tube circuit

The data retrieval is done by shifting the microphone away from the sample so that the display on the oscilloscope shows the minimum pressure amplitude (A-B). Then the microphone is shifted again so that the oscilloscope display shows the maximum pressure amplitude (A + B).

At the edge of the tube, there is a loudspeaker as a source of sinusoidal waves and the material of the test can be at the other edge of the tube. The microphone contained in the tube is connected to the amplifier. Then the amplifier is connected to the oscilloscope. The loudspeaker is used as the sound source associated with a frequency generator that can be varied. The frequency used in the study is in accordance with the frequency response of the microphone used, ie the frequency range of 200 Hz, 400 Hz, 600 Hz, 800 Hz, 1000 Hz and 1200 Hz.

3. Result and Discussion

3.1 Sound Absorbtion Coefficient

The measurement data of the absorption coefficient of the material test is done by the variation of mass material ratio and the matrix. The results of data analysis of measurement coefficient of absorption of test material that has been done with the ratio of mass material and 1: 1 matrix can be seen in table 1.

Table 1. The result of coefficient value test of absorption materials with 1:1 mass ratio

f (Hz)	A+B (cm)	A-B (cm)	SWR	Absorption Coefficient (α)
200	53.2	1,12	9,523	0,354
400	61	44,7	1,365	0,976
600	47,6	30,24	1,580	0,950
800	31,32	24,14	1,298	0,983
1000	27,7	18,06	1,540	0,955
1200	21.34	13	1,682	0,940

Table 1 shows that the sound absorption coefficient with a mass ratio of 1: 1 for low frequency, ie 200 Hz of the material absorption coefficient value is 0.354. Whereas for high frequency 400-1200 Hz, the value of absorbtion coefficient of *barada* material test in more than 0.9. This indicates that the material is a better absorption material in absorping sound waves with high frequency or short wavelength.

The result of measurement data of absorption coefficient of material test that has been done with mass material ratio and 3: 2 matrix can be seen in Table 2.

Table 2. The result of coefficient value test of absorption materials with 3:2 mass ratio

f (Hz)	A+B (cm)	A-B (cm)	SWR	Absorption Coefficient (α)
200	24,6	1,22	20,379	0,180
400	63,8	45,58	1,401	0,972
600	46,7	32,54	1,437	0,967
800	34,16	22,66	1,509	0,959
1000	28,76	19,36	1,493	0,960
1200	23,64	16,12	1,460	0,964

From Table 2, it can be seen that the sound absorption coefficient value with 3: 2 mass ratio for low frequency, ie 200 Hz of material absorption coefficient value is 0.180. As for high frequency, the value of absorbtion coefficient of *barada* material test in more than 0.9. This study, either with a mass ratio of 1: 1 or a mass ratio of 3: 2, found characteristics that are in principle the same as previous studies conducted by Leslie L. Dolle for plywood material that shows greater sound absorption at high frequencies compared to low frequencies.

The largest absorption coefficient value is generated at 400-1200 Hz at values greater than 0.9 This is in line with Rizal et al. (2015) the largest value is generated at high freqency, that is 0.87 to 0.99. Similarly, for the lowest value produced at low frequencies. In this study either with a mass ratio of 1: 1 or a mass ratio of 3: 2, it was found that characteristics were similar in principle to those of Doelle & Prasetyo (1993) previously for plywood material which exhibited greater sound absorption at high frequencies compared to low frequencies.

3.2 Acoustic Impedance

The data of the acoustic impedance measurements using the three material tests performed with the ratio of mass material and matrix can be seen in Table 3. Based on Table 3, the impedance value with the lowest 1: 1 mass ratio at a frequency of 200 Hz increases at a frequency of 400 Hz to a frequency of 1200 Hz. Meanwhile, for materials with a mass ratio of 3: 2, the impedance value of the material decreases at high frequency. This happens because of the comparison between mass ratio of material and glue (matrix). Comparison of mass materiales and the same matrix results in an increasing impedance values at high frequencies.

The more the ratio of the mass material than the glue, the impedance value decreases at a higher frequency.

Table 3.The result of material acoustic impedance value test with mass ratio

Frequency (Hz)	Impedance Accoustic (Zs/ρc)	
	Ratio 1:1	Ratio 3:2
200	0,338	0,403
400	0,677	0,069
600	0,665	0,070
800	0,680	0,071
1000	0,667	0,071
1200	0,661	0,070

The acoustic impedance value on the material mass ratio with 1: 1 glue was obtained at a frequency of 800 Hz of 0.68 compared with the ratio of material mass to 3: 2 glue. This is in line with Rizal et al. (2015) which suggests that a slight composition of the glue will provide better acoustic impedance than a large amount of glue composition because the incoming sound waves will be absorbed by the pore-rich material.

4. Conclusion

The composite material of rice bran is potential to be used as a noise controller because it has a high sound absorption coefficient value. The highest sound coefficient value is 0.983 at a frequency of 800 Hz with a ratio of mass material and 1: 1 glue. Meanwhile, the lowest noise coefficient value is 0.183 at a frequency of 200 Hz with the ratio of mass material with 3: 2 glue. The acoustic impedance value in the ratio of mass material with 1: 1 glue is obtained better than the ratio of mass material to the 3: 2 glue. This suggests that a slight gluing composition will provide better acoustic impedance than many glue compositions because the incoming sound waves will be absorbed by the pore-rich material.

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