International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 6, Issue 9, pp 95-99, September-2022

https://doi.org/10.47001/IRJIET/2022.609015

Composite Materials of Sound Absorption Polyurethane Foam, Pineapple Fiber and Banana Fiber

[1]Rohmat, [2]Sulardjaka, [3]Achmad Widodo

[1,2,3]Department of Mechanical Engineering, Faculty of Engineering, Diponegoro University

Jl. Prof. Sudharto, SH, Tembalang, Semarang

+62 247460059 ext. 101

***Abstract* – Research has been carried out on the sound absorption properties of sound-absorbing materials made from Pineapple Leaf Fiber, PUF, and Banana Trunk Fiber with the resin matrix. Absorbent in the ratio of 2:1, 1:1, and 1:2. The research method was carried out first by making samples by taking pineapple leaf fiber and banana fiber, and decomposing the alkaline treatment fiber with 4% NaOH for 4 hours. Rinse with aquades until clean then dry. Composite molding was carried out with a Hot Press for 240 seconds at a temperature of 1100C. Then the sound absorption test was carried out using a signal generator and sound level meter concerning the principle of the E-1050 impedance tube method, at a ratio of fiber: matrix 2:1 capable of absorbing sound at a frequency of 400 Hz at = 300 Hz.**

Keywords: Composite, Sound Absorption, Polyurethane Foam, Pineapple Fiber, Banana Fiber.

I. INTRODUCTION

WASTE is the residual waste from a production process, both from household and industrial residues, where most people live, there are various types of waste, especially in the Belik Mountains area, Pemalang Regency, there are a lot of agricultural residues namely waste pineapple leaves and banana stems. Solid waste from pineapple leaves and banana stems is known as garbage because it has no economic value. The presence of waste can harm the surrounding environment, especially human health due to noise, so it is necessary to handle the waste.

The silencer [1] is a tool to control noise generated from home and industrial activities, one way to reduce it is by emitting sound energy that hits the wall through the visco-thermal effect. Its application is commonly found in buildings to control the acoustic quality in rooms where the clarity of speech. The absorbers commonly found in their manufacture are derived from porous materials such as foam, cotton, and wool. It is known that such materials have sound absorption at low to high frequencies where the thickness of the absorber is equal to a quarter of a wavelength. In addition to dampers, resonance-based dampers are also used which are effective for reducing acoustic energy at lower frequencies with limited absorption bandwidth.

For the last decades, it has been studied with natural ingredients by researchers. Experimental products made from natural materials as noise absorbers have been published, such as cellulose tiles, mineral fiber, rock wool [2], glass wool [3], and pineapple leaf fiber [4]–[6], wood fibers, sawdust [7], felt (felt), sisal, coconut fiber and sugarcane [8]–[14], hair, carpets, cellulose , grain from tires [15], cigarette filters [16] and waste fabrics and their composites used for noise control are distinguished for their high efficiency in sound absorption.

In the study[17], the PU composite foam including CaCO3 filler after chemical treatment with oleic acid was made to check the sound absorption resulting in a high sound absorption coefficient and the highest value at 6 wt% filler content.

Pineapple leaf fiber has the highest sound absorption coefficient among other types of fiber. Smaller and uniform fiber diameter has an important role to absorb sound energy in pineapple fiber[12].

The research method was carried out by taking banana stem fibers, making composites, and testing the sound absorption properties of banana stem fiber polyester composites. The stem fiber was taken through a decomposition process with 5% NaOH solution for 14 hours and dried in the sun to dry, then chopped with a blender. The fibers obtained were then made into composites with fiber volume fractions of 30, 40, and 50%. Each fiber volume fraction in the composite was pressed until it hardened with a time of ± 5 hours. The composite attenuation test was carried out on a Kundts Tube Impedance device equipped with speakers, amplifiers, power supplies, laptops, oscilloscopes, and sound level meters, with input frequencies of 200, 400, and 600 Hz. The results of the attenuation study of polyester composites reinforced with banana stem fibers have the highest sound absorption coefficient of 0.72 at 50% fiber volume fraction with an input frequency of 200 Hz and the lowest value is 0.54 at 30% fiber volume fraction with an input frequency of 400 Hz. Overall, the specimen can be used

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 6, Issue 9, pp 95-99, September-2022

https://doi.org/10.47001/IRJIET/2022.609015

as a damping material because it has a sound absorption coefficient value > 0.30 [18].

Based on the background of various uses in the field of sound-dampening composites, it will try to make composites derived from natural fibers. Natural fibers used in the manufacture of composite materials are pineapple fiber, polyurethane foam, and banana fiber. This study used pineapple fiber and banana fiber which had been treated with a 5% NaOH solution [14]. The immersion of pineapple fiber and banana fiber using NaOH solution is intended to improve the adhesion between the fiber and the resin. In addition, the results of research with alkaline treatment can improve sound absorption. Sound attenuation testing is by the ASTM E 1050 standard. The morphology of the material was investigated and evaluated using SEM and Fourier transform infrared spectroscopy.

II. EXPERIMENT

2.1 Material

Pineapple fiber and banana fiber are easily obtained from local agricultural products in Indonesia because of the abundant ingredients. The fibers were soaked in 5% NaOH solution for 4 hours and the fibers were washed with distilled water and dried in the sun to dry. Epoxy resin brand ALF and Epoxy hardener brand ALF as adhesive for making composites. Another matrix material used is bi-component rigid polyurethane foam. The polyol component of the foam mixture includes polyol, (polyol: density = 1.09 g/cm3 at 26 °C, viscosity = 560 mPa at 26°C). The isocyanate component includes the polymer MDI (methylene diphenyl diisocyanate) (isocyanate: density = 1.24 g/cm3 at 26 °C, viscosity = 170÷250 mPa at 26°C).

In the manufacture of Polyurethane Foam, weighing 55% polyether polyol and 45% isocyanate, then the polyether polyol is stirred for 120 seconds then the isocyanate material is poured and stirred for 90 seconds, when finished pour in the container provided with room temperature 260 C. Wait until approx. of 4 hours.

2.2 Sample preparation

The tools used include molds, digital scales, calipers, and hydraulic jacks. Composite manufacture by press mold with a length, width, and width of 70 mm x 70 mm x 10 mm. Composite manufacture by coating the mold with a mixture of epoxy resin hardener placing banana fiber, and giving the surface of fibers with a mixer of resin and hardener. The next step is to put the polyurethane foam fiber, mixer of resin and hardener, and cut pineapple fiber on it while coating the resin hardener mixture to an even thickness of 10 mm. Composites using a Hot Press machine for 240 seconds at a temperature of 110 C, samples were cut with an average diameter of 40 mm and an average thickness of 10 mm. The manufacture of a sample cylinder with a diameter of 20 mm is intended so that the sample can be precisely inserted into an impedance tube to measure its absorption coefficient. An impedance tube made of aluminum pipe with an inner diameter of 40 mm was used to cover measurements in the frequency range from 200 Hz to 3000 Hz. The impedance tube is designed according to ASTM E-1050. Sound absorption test specimen is made by cutting the composite according to the tube diameter. Dimensions of the test sample and test method according to standard E-1050. [16] SEM (Scanning Electron Microscopy) to determine the composite mechanism and FTIR.

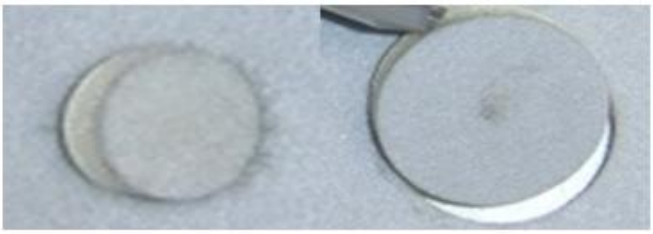

Figure 1: 20 mm diameter specimen (left) and 40 mm diameter specimen (right)

First, the impedance tube is calibrated with a density of 45 kg/m^3 and a thickness of 40mm. The sound absorption coefficient is calculated using the transfer function generated from the two microphones. The experimental set-up is illustrated in Figure 2.

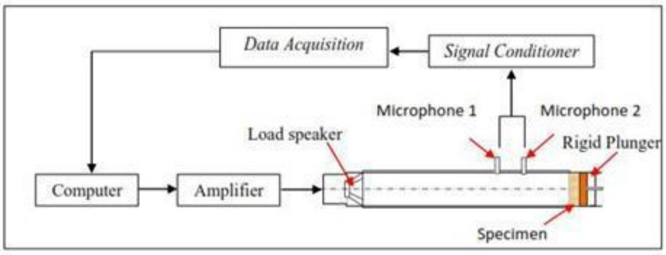

Figure 2: Impedance tube installation

2.3 sound absorption coefficient measurement

The sound absorption coefficient was tested according to the ISO 10534 standard tube impedance shown in the figure. 2. The test sample size is about 20mm & 40mm diameter for lower frequency and higher frequency respectively. In this method the speaker is used to generate the frequency and the microphone picks up the signal from the incident wave and reflected wave. The transfer function between these two signals gives you the value of the sound absorption coefficient determined using a 1/3 octave signal from a frequency of 100 to 6300 Hz.

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 6, Issue 9, pp 95-99, September-2022

https://doi.org/10.47001/IRJIET/2022.609015

2.4 Characteristics

FTIR spectroscopy with attenuated total reflection accessory was used to examine the chemical function of NaOH on the surface. FTIR spectra obtained with an average of 16 scans with a resolution of 4 cm 1. Scanning electron microscopy (SEM, SNE-3000M, SEC) was used at 15 kV to examine the filler surface and cell morphology of PU composite foam.

III. RESULTS AND DISCUSSION

3.1 Acoustic properties

Table 1: Sound coefficient test results

Frekuen si	Comparison matrix : fiber 1:2	Comparison matrix : fiber 1:1	Comparison matrix : fiber 2:1
100	0,000	0,000	0,000
125	0,075	0,075	0,075
160	0,150	0,150	0,150
200	0,200	0,200	0,200
250	0,220	0,220	0,220
315	0,250	0,250	0,250
400	0,300	0,130	0,090
500	0,400	0,200	0,400
630	0,500	0,500	0,500
800	0,600	0,500	0,300
1000	0,700	0,700	0,700
1250	0,800	0,680	0,680
1600	0,850	0,850	0,850
2000	0,870	0,770	0,870
2500	0,890	0,790	0,590
3150	0,900	0,900	0,900
4000	0,930	0,930	0,930
5000	0,950	0,950	0,950
6300	0,890	0,900	0,790

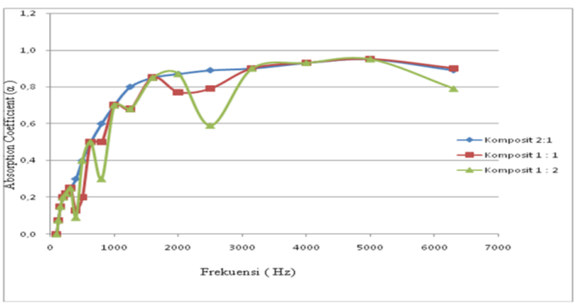

Figure 3: Frekuensi (Hz) dengan Absorption Coefficient (α)

The results of the sound absorbing test on the sample with a matrix and fiber ratio of 2:1 after the experiment showed that at a frequency of 5000 Hz with a coefficient value of 0.90 the density of the material gave a more dominant influence on the absorption coefficient compared to the thickness of the test object. Higher density and higher thickness increase the absorption coefficient. More fibers create more trapped acoustic pressure energy in the material. Material with a thickness of 10 mm and 0.1978 gr/cm^3 density can absorb sound, a maximum of 90% at 3000 Hz frequency, and may still increase at higher frequencies. In addition, other specimens also have a higher probability of sound absorption at frequencies over 3000 Hz. It is also shown that the compression of the fibrous material decreases the sound absorption properties. Under compression, various fibers in the material are brought closer to each other without deformation or change in fiber size.

3.2 FTIR

The fibers used in this study were pineapple fiber and banana fiber. The results of the FTIR test of pineapple fiber and banana fiber that have been soaked in NaOH for 4 hours. From the test results on pineapple fiber, it was found that there was an identification of stretching of the O-H bonds of the alkane group with a wave peak at 3319.26 cm-^{1} . Meanwhile, the bond between C and OH in the hydroxyl group occurs at the peak of the 572.06 cm^{-1} waves. Furthermore, at the peak of 1267.78 cm^{-1} wave absorption occurs which causes stretch deformation in the C-H bond. At the peak of the 1033.99 cm^{-1} waves, there was the absorption of the CO bond from the alkali group.

In the banana fiber test, it was found that there was an identification of stretching of the O-H bonds of the alkane group with a wave peak at 3322.07 cm^{-1}. Meanwhile, the bond between C and OH in the hydroxyl group occurs at the peak of the 557.03 cm^{-1} waves. Furthermore, at the peak of the wave at 1317.04 cm^{-1}, wave absorption occurs which causes stretch deformation in the C-H bond. At the peak of the 1034.67 cm^{-1} waves, there was the absorption of the CO bond from the alkali group.

3.3 SEM

The fibers used in this study were pineapple fiber and banana fiber. Figure 4.1 shows the results of the FTIR test of pineapple fiber and banana fiber that have been soaked in NaOH for 4 hours. From the test results on pineapple fiber, it was found that The morphology of pure polyurethane -fiber composites was demonstrated by a Scanning Electron Microscope photomicrograph. These morphological results were carried out in the Undip Terpadu laboratory. The SEM test specimen was made with dimensions of 10x10x10 mm

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 6, Issue 9, pp 95-99, September-2022

https://doi.org/10.47001/IRJIET/2022.609015

and then coated with an AuPd coating after that it was inserted into the SEM test equipment.

The SEM results with 200x magnification. From the SEM observations, it can be seen that the morphology of the composites with a ratio of Matrix: Fiber = 1:2 has a visible fiber cell structure compared to other Matrix: Fiber composites. However, the difference in pore openness between composites and the ratio of Matrix: Fiber is not too different.

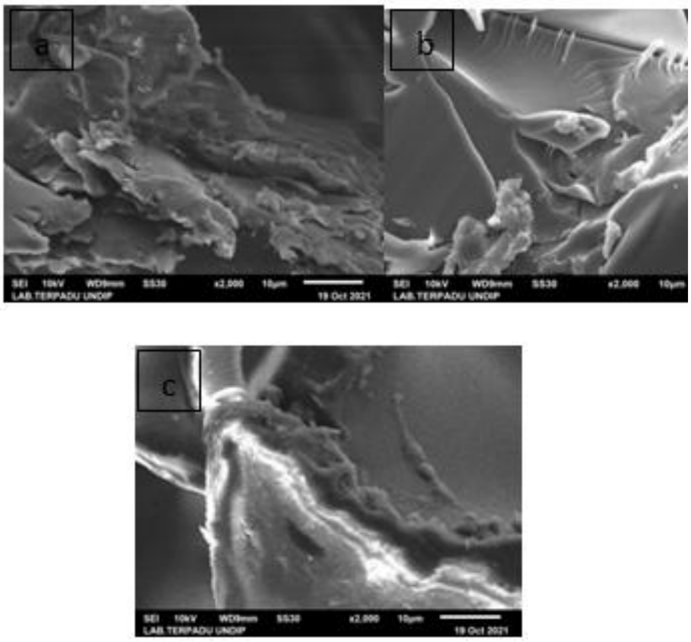

Figure 4: matrix: Fiber 1: 1 (a), SEM matrix: Fiber 1: 2 (b) and SEM matrix: fiber 2: 1(c)

IV. CONCLUSIONS

Composites can absorb sound well at medium frequencies (400 Hz), with a sound absorption coefficient value of 0.3 for composites with more fiber while at high frequencies (5000) the coefficient value is 0.95. This shows that the composite can absorb sound well for low and medium frequencies, following the E-1050 standard where the acoustic material's sound absorption coefficient is at least = 0.15.

The results of the research show that there is hope for the development of composites as sound-absorbing materials. However, it still has several more steps, further research is needed including porosity testing, and flammability resistance related to its application as a sound absorber.

REFERENCES

[1] N. C. Loureiro and J. L. Esteves, Green composites in automotive interior parts: A solution using cellulosic fibers. Elsevir Ltd, 2018.

[2] A.Katherina, Sudarno, and E. Sutrisno, "Perancangan pengendalian bising dengan pemasangan rock wool pada ruang pegawai di dipo lokomotif Semarang poncol," Tek. Lingkung., vol. 5, no. 2, pp. 1–14, 2016.

[3] H. M. dan D. F. Hasan, Akhabun Ari, "Analisa perbandingan penggunaan bahan Peredam suara glass wool, stainless wool dan fibre glass terhadap tingkat kebisingan pada sepeda motor empat langkah," 2013.

[4] N. H. N. Do et al., "Heat and sound insulation applications of pineapple aerogels from pineapple waste," Mater. Chem. Phys., vol. 242, no. October 2019, p. 122267, 2020, doi: 10.1016/j.matchemphys.2019.122267.

[5] A.Kusuma Riza Pawestri, W. Hasanah, and A. Murphy, "Studi karakteristik komposit serat daun nanas," Teknol. Bahan Alam, vol. 2, no. 2, p. 113, 2018.

[6] A.Putra, K. H. Or, M. Selamat Zulkefli, and M. Jailani Mohd Nor, "Sound absorption of extracted pineapple-leaf fi bres," elsevier, vol. 136, pp. 9–15, 2018, doi: 10.1016/j.apacoust.2018.01.029.

[7] A.E. Tiuc, O. Nemeş, H. Vermeşan, and A. C. Toma, "New sound absorbent composite materials based on sawdust and polyurethane foam," Compos. Part B Eng., vol. 165, no. November 2018, pp. 120–130, 2019, doi: 10.1016/j.compositesb.2018.11.103.

[8] E. Apriani and J. A. Malik, "Pembuatan kertas daur ulang dari limbah serat kelapa muda dan kertas bekas," Pros. Konf. Nas. Eng. Perhotelan X, vol. 2019, pp. 242–247, 2019.

[9] Y. M. Kartikaratri, A. Subagio, and H. Widiyandari, "Pembuatan komposit serat serabut kelapa dan resin," Fisika, vol. 15, no. 3, pp. 87–90, 2012.

[10] A.Kirana, "Efek penambahan serat gelas pada komposit polyurethane terhadap nilai koefisien absorpsi suara dan sifat mekanik komposit doorpanel," 2016.

[11] Y. Rianto, "Pengaruh komposisi campuran filler terhadap kekuatan bending komposit ampas tebu-serbuk kayu dalam matrik polyester," 2011.

[12] M. Rusli, M. Irsyad, H. Dahlan, Gusriwandi, and M. Bur, "Sound absorption characteristics of the natural fibrous material from coconut coir, oil palm fruit bunches, and pineapple leaf," IOP Conf. Ser. Mater. Sci. Eng., vol. 602, no. 1, 2019, doi: 10.1088/1757-899X/602/1/012067.

[13] C. C. B. Da Silva, F. J. H. Terashima, N. Barbieri, and K. F. De Lima, "Sound absorption coefficient assessment of sisal, coconut husk and sugar cane fibers for low frequencies based on three different methods," Appl. Acoust., vol. 156, pp. 92–100, 2019, doi: 10.1016/j.apacoust.2019.07.001.

ISSN (online): 2581-3048
Volume 6, Issue 9, pp 95-99, September-2022
https://doi.org/10.47001/IRJIET/2022.609015

[14] Suriadi, R. Balaka, and L. Hasanuddin, "Pembuatan komposit serat serabut kelapa Dan resin polyester sebagai material peredam akustik," J. Ilm. Mhs. Tek. Mesin, vol. 3, no. 1, pp. 1–10, 2018.

[15] K. L. Putra, R. Y. Prakoso, and Z. Muchtar, "PENGARUH PENAMBAHAN LIMBAH SERBUK BAN SEBAGAI PENGGANTI AGREGAT HALUS TERHADAP STABILITAS LAPISAN AC-WC," vol. 14, no. 01, pp. 9–14, 2019.

[16] A.I. Candra, E. Gardjito, Y. Cahyo, and G. A. Prasetyo, "Pemanfaatan Limbah Puntung Rokok Filter Sebagai Bahan Campuran Beton Ringan Berpori," UKaRsT, vol. 3, no. 1, p. 82, 2019, doi: 10.30737/ukarst.v3i1.365.

[17] H. Choe, J. H. Lee, and J. H. Kim, "Polyurethane composite foams including CaCO 3 fillers for enhanced sound absorption and compression properties," Compos. Sci. Technol., vol. 194, no. March, p. 108153, 2020, doi: 10.1016/j.compscitech.2020.108153.

[18] K. Khotimah, S. -, and H. Soeprianto, "Sifat Penyerapan Bunyi Pada Komposit Serat Batang Pisang (Sbp) – Polyester," J. Penelit. Pendidik. IPA, vol. 1, no. 1, pp. 91–101, 2015, doi: 10.29303/jppipa.v1i1.9.

Citation of this Article:

Rohmat, Sulardjaka, Achmad Widodo, "Composite Materials of Sound Absorption Polyurethane Foam, Pineapple Fiber and Banana Fiber" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 6, Issue 9, pp 95-99, September 2022. Article DOI https://doi.org/10.47001/IRJIET/2022.609015

****