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Utilizing Cotton Bud Sticks as a Sustainable Sound Absorber

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Abstract: Sustainable products, such as recycled material, may also be deemed a renewable substitute due to a lower level of waste generation and raw material dependency. Cotton buds plastic stick should be placed in the dustbin after being used, but several are flushed down the toilet and then enter the beaches through the sewage pipe. Such problems offer an incentive for recycled material, which is a cotton bud plastic sticks to be reused and produced as a substitute material for sound absorption. This study focuses on the comparison of sound absorption performance of cotton bud sticks with and without the cotton layer in different thickness. This study involves sound absorption of cotton bud sticks on the low and high-frequency region using Impedance Tube following ISO 10534-2 (2001). The cotton bud sticks was cut into 2 cm and 3 cm thickness. The cotton bud sticks handled in 4 conditions for every thickness, which is cotton bud sticks without cotton layer, with cotton layer at front, with cotton layer at the back, and cotton layer at the front and back of the sample. For sample 3 cm thickness with cotton at the front, the highest sound absorption coefficients of 0.902 is obtained at high frequency area and the optimum frequency is 3150 Hz. This indicates that the sound absorption for samples with cotton has a high-frequency range than the sample without the cotton layer. The findings revealed that by adding fibrous material (cotton layer) at the front surface of sample, improvements in sound absorption coefficients of cotton bud sticks are achieved. Therefore, cotton bud sticks covered with cotton layer has the potential to become one of the sound absorption materials for high frequency region for acoustics used.

Keywords: Recycle Material, Cotton Bud Sticks, Absorption Coefficient

1. Introduction

Sound absorption is one of the most significant needs for human comfort today. It can be described as an incident sound wave that strikes a surface of the material and is not reflected [1]. An absorption substance is added to the reflecting surface to remove energy and the absorption of air [2]. Over the past few years, more considerable attention to the environment and public health has stimulated the research and development of new noise control materials as alternatives to traditional material [3].

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These materials divided into two main categories which is natural material and recycle material as sound absorber.

Natural material includes fibers produces by animals, plants, and geological processes [3]. Previous studied by Putra, Khair, & Nor [4] studied the usage of bamboo by using its hollow form to absorb sound energy. The standard absorption coefficient calculated based on the length and diameter of bamboo, as well as the different configuration of the bamboo structure, which is axial and transverse structure. This study found that the absorption coefficient trend appears in highs and dips at an equally spacing frequency range. In both structures, the absorption rate can be above 0.8. The usage of natural resources shall lead to the greater sustainability of buildings. Still, the natural elements have disadvantages, which are broad tolerance to fungal parasites, and general understanding to fire relative to other natural, human-made materials [5][6]. Among these purposes, in certain instances, natural materials need chemical treatment that reduces their sustainability value.

Sustainable development addresses the desires of the present by undermining the potential of future generations to fulfill their desires. Product may only be called sustainable because the expansion allows the materials from which it has been produced to be accessible to future generations and has the lowest potential effect on human health and the atmosphere [7]. Sustainable materials can play an essential role since these materials require less energy for their production than conventional materials.

The use of recycle materials for sound absorption is applied extensively in the construction industry. Recycled products, such as recycled plastic fiber and rubber granules, may also be deemed a renewable substitute because they lead to a lower level of waste generation and a lower level of raw material dependency [8]. Therefore, the focal point of this project is to utilize the disposal of a cotton bud stick, which is made from synthetic polymer, and reused them as the sound absorber. Cotton bud stick is simple to reach and low priced. The waste output of synthetic polymer may decrease by utilizing it. The results from this study expected the cotton bud stick to presents a good alternative as a sound absorber. Next, a maximum sound absorption coefficient and optimum frequency of the cotton bud stick will be determined.

1.1 Problem statement

Due to noise pollution in our environment, it is essential to find alternative materials capable of limiting noise pollution at different frequency ranges. Ballagh, [9] stated that the sound absorption material structure is typically based on porous synthetic media (rock wool, glass wool, polyurethane, and polyester). The disadvantages of applying this material have costly manufacturing processes, significant energy use, and a high environmental impact. Recycled materials are becoming an attractive alternative because of their stable acoustic behavior. They are also similar to conventional porous materials that require a low cost of production impacts [10].

Similar studies on recycling material have also been conducted by Fazlin et al,. [11] regarding the potential of plastic material from wasted lollipop sticks. Lollipop sticks in axial arrangement are good in absorbing sound. The analysis showed that the absorption coefficients were nearly constant for a material thickness of 4 cm to 5 cm. The overall absorption coefficients were 0.6 beyond the highest frequency.

In this paper, the same hollow tube-like structures were studied, which is utilizing plastic material from cotton bud sticks in 2 cm and 3 cm thickness. According to Ghayebzadeh, Taghipour, and Aslani [12], cotton buds stick made from plastic was one of the most common plastic material found on Malaysia shores in 2016. Cotton buds stick should be placed in the dustbin after being used, but several are flushed down the toilet and then enter the beaches through the sewage pipe. Such problems offer an incentive for recycled material, which is a cotton bud stick to be reused and produced as a substitute material for sound absorption.

1.2 Objective

The objective of this study is to compare the sound absorption performance of cotton bud sticks for 2 cm and 3 cm thickness in four condition which is cotton bud sticks without cotton layer, with cotton layer at front, with cotton layer at back and lastly sample with cotton layer at front and back.

2. Materials and Methods

2.1 Materials

Plastic is the most common choice for cotton bud sticks. Plastic is a material used in industry because of its lightweight, flexible, and sound absorption properties. Samples used in this study are those hollow tube-like structures from cotton bud plastic sticks. The outer diameter of the stick was 0.10 cm, the inner diameter was 0.05 cm. The cotton ends on cotton bud sticks are removed, and only the excellent condition stick will be used. The gathered sticks must be cleaned in running water to wash the sticks from any dust and all other particles. Then, the cotton bud sticks must normally dry for 24 hours. Once the cotton buds were fully dry, the sticks will cut into 2 cm and 3 cm in thickness. The material preparation process is, as shown in figure 1.

Figure 1: Material preparation

The sample was prepared in 4 conditions for every thickness, which is cotton bud sticks without cotton layer, with cotton layer at front, with cotton layer at the back, and cotton layer at the front and back of the sample. For the cotton layer sample, cotton with a thickness of 2 mm used. Figure 2 shows the four condition of samples.

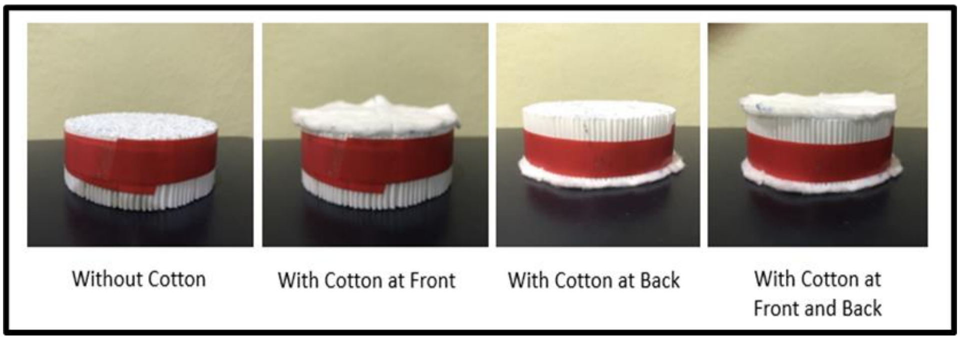

Figure 2: Condition of samples

2.2 Methods

The experimental configuration using the impedance tube is shown in figure 3. It is conducted according to ISO 10534-2 (2001) [13]. The study involved the calculation of sound absorption, which refers to the ability of the material to absorb, reflect, and dissipate acoustic energy. The apparatus consists of two 100 mm and 28 mm tube arrays. A small tube with a diameter of 28 mm used for acoustic measurements in the high-frequency range from 1600 to 5000 Hz. A large tube with a diameter of 100 mm is used for measurements in the low-frequency range from 315 to 1500Hz. The absorbency value will be combined (low and high) for final analysis. The study was conducted with a frequency value of a third-octave band.


Figure 3: Impedance tube

The cotton bud sticks was arranged inside the tube in axial arrangement. At the end of the tube, the sample was placed, while at the other end of the tube was a speaker which produced noise as shown in figure 4. Sound absorption was determined when the sound source produced the signal, and the incident with the reflecting components resulted from the relationship between the pressures measured by the microphone at two positions on the wall of the tube.

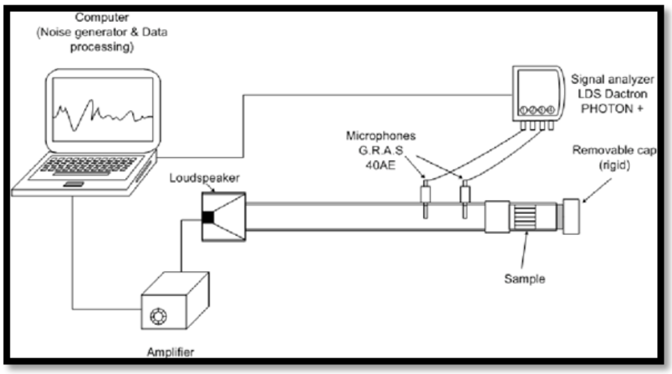

Figure 4: Schematic diagram of experimental set-up

3. Results and Discussion

As stated earlier, sample consisted of 2 cm and 3 cm thickness of cotton buds sticks are used to obtain the final result of sound absorption coefficient. The samples are tested in 4 conditions for every thickness, which is cotton bud sticks without cotton layer, with cotton layer at front, with cotton layer at the back, and cotton layer at the front and back of the sample. According to Azma, [14], it is possible to increase the value of absorption coefficient by providing porous materials in front of the sample, while absorption at lower frequency can be increased with porous material at the back of the sample. Measurements of the absorption coefficient for each sample were taken three times. The samples were detached and placed back into the place holder to ensure the repeatability of the results. The final result is the averaged absorption coefficient from all the measurements. The result shows the sound absorption coefficient (α) values are tested at low and high frequencies.

3.1 Sound absorption performance of sample with 2 cm thickness

The sound absorption performance of sample with 2 cm thickness in four condition is shown in figure 5. The results clearly show that the cotton layer has affected the sound absorption process. The sample without cotton layer is considerably a good sound absorber for the higher frequency ranges while for the other samples with cotton layer are a good sound absorber with a wider-frequency range which is above 1000 Hz. The sample without cotton was found not able to absorb much sound below 1500 Hz, where the sound absorption coefficients are below 20%. The highest peak of sound absorption is shown by the sample with cotton layer at front and back with α > 0.83 at 3150 Hz. The other samples that having cotton layer at front show nearly the same performance throughout the tested frequencies with peak α > 0.7 in between 3150 Hz to 4000 Hz.

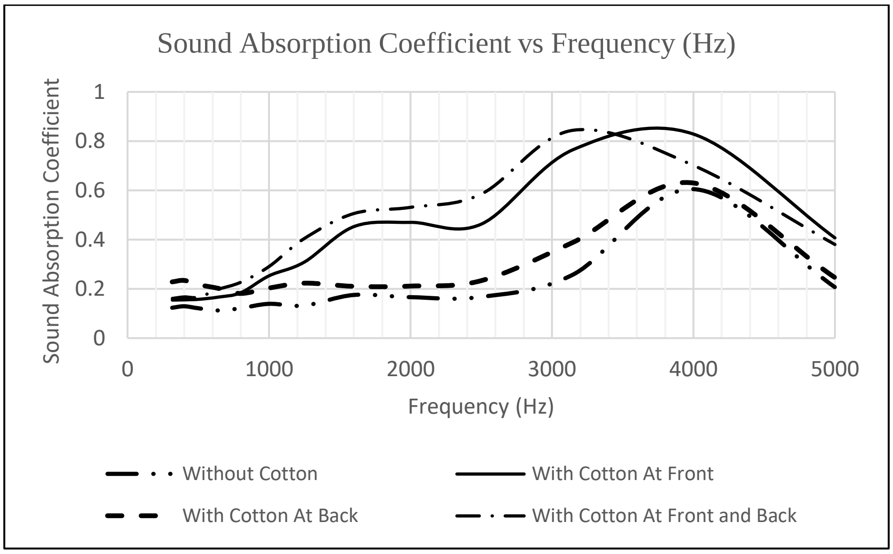

Figure 5: Sound absorption performance of sample with 2 cm thickness in four condition

3.2 Sound absorption performance of sample with 3 cm thickness

The sound absorption performance of sample with 3 cm thickness in four condition is shown in figure 6. The combination of the cotton with the hollow tubes not only improves the level of the absorption coefficient but also widens the frequency of the absorption bandwidth. For the low-frequency region, the sample with cotton at front and back shows the higher value of sound absorption coefficient, α where recorded, 0.573 at 1250 Hz. Followed the second-highest sound absorption coefficient for sample with cotton layer at front with 0.475 at 1250 Hz. The third sample with cotton at the back shows sound absorption, 0.238 at 1250 Hz. Lastly, sound absorption of 0.177 at frequency 1250 Hz for sample without cotton. The sample with cotton at the front achieved a slightly high absorption value for high frequency, which is 0.902 at frequency 3150 Hz. The second highest is for sample cotton bud sticks with cotton layer at front and back with an absorption coefficient of 0.754 at 3150 Hz. The third sample with cotton at the back has sound absorption of about 0.645 at 3150 Hz, and lastly, for sample without cotton 0.618.

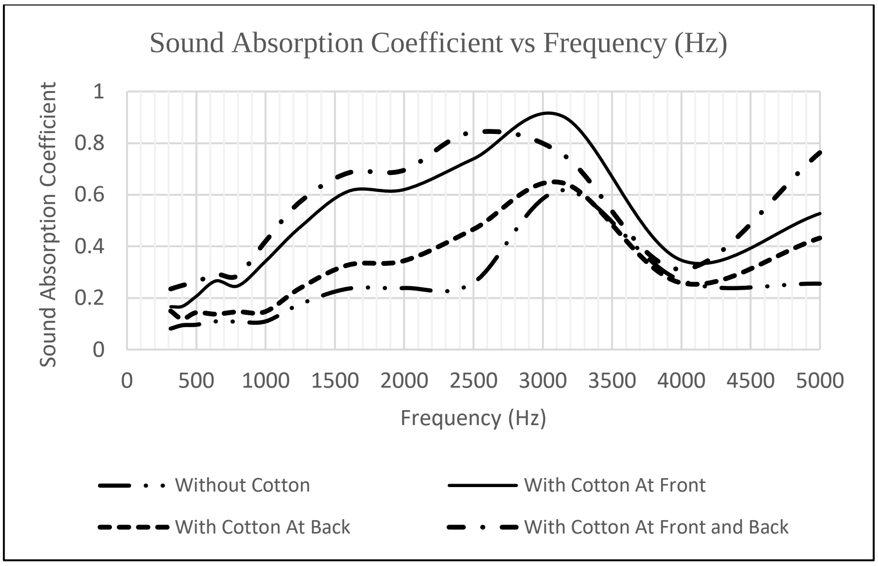

Figure 5: Sound absorption performance of sample with 3 cm thickness in four condition

3.3 Comparison on sound absorption performance of 2 cm and 3 cm cotton bud sticks absorber based on conditions.

In addition, for cotton bud sticks samples, analysis of sound absorption efficiency is achieved by comparing the absorbency between different thicknesses in the same condition. The thickness of cotton bud sticks used is 2 cm and 3 cm. Many factors affect the absorption of sound, but the thickness is the main factor analyzed in this study. The final result is the averaged absorption coefficient from all the measurements.

The results of cotton bud sticks sample in 4 condition is shown in figure 6 (a) to (d). In figure 6(a), it is clear that the sample thickness has affected the sound absorption process. The 3 cm sample is more effective in absorbing sound at 3000 Hz, while the 2 cm sample is more effective for higher frequency at 4000 Hz. The sound absorption coefficient reached 0.618 and 0.605 respectively for 3 cm and 2 cm thick sample without cotton layer.

Based on figure 6(b), the highest peak sound absorption is shown by the 3 cm sample with $\alpha > 0.9$, at 3150 Hz, while the 2 cm sample is more effective for higher frequency at 4000 Hz. The sound absorption coefficient reached 0.829.

Figure 6(c) shows that the 2 cm sample layer slightly improved the low-frequency absorbent than the 3 cm sample. The sample with 3 cm was found not to absorb much sound below 2500 Hz, where the sound absorption coefficients are below 20%. The highest sound absorption coefficient value for the 3 cm sample reached 0.645 at frequency 3150 while 0.63 at frequency 4000 Hz for sample 2 cm thickness.

Based on figure 6(d), a sample with a thickness of 3 cm is more effective in absorbing sound at 2500 Hz, while the 2 cm sample is more effective for higher frequency at 3150 Hz. However, the performance of the 3 cm sample decreased slightly in the middle frequency range (between 3150Hz to 4150Hz). The sound absorption coefficient reached 0.842 and 0.844 respectively for 3 cm and 2 cm thick sample with a cotton layer at front and back.

From all analysis in figure 6, it clearly shown that the thickness of the sample allowed the respective frequency to be absorbed. The relationship is shown by the frequency-wavelength relationship $\lambda = c/f$ where λ is the wavelength, c is the sound speed, and f is frequency. Indicates that the thicker the sample, the greater the potential for sound absorption.

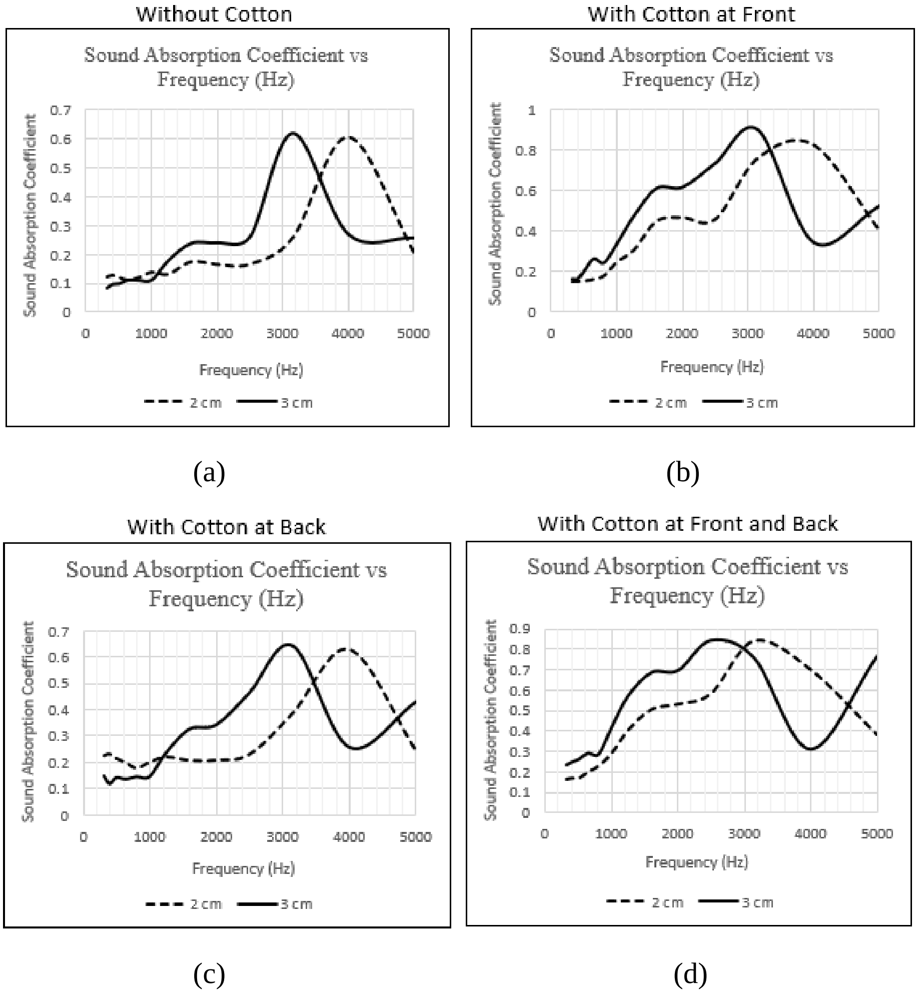

Figure 6: Sound absorption coefficient of cotton bud sticks in (a) without cotton, (b) with cotton layer at front, (c) with cotton layer at back, (d) with cotton layer at front and back

4. Conclusion

Cotton bud sticks waste if not been recycled or manage properly could lead to environment problems issues to this country. This study has proven that cotton bud sticks can be a good sound absorber for high frequency region. By looking to thickness comparison, sample with 3 cm shows great sound absorption in high frequency than the sample with 2 cm thickness. Cotton bud sticks without a cotton layer are a weak absorber at low and high frequencies than samples with a cotton layer regarding the various conditions of cotton bud sticks for this analysis. However, for samples of cotton bud sticks with a cotton layer, the absorption coefficient increased from frequency 315 Hz to 5000 Hz. It does not matter if the cotton layer is on one or both sides of cotton bud sticks. Still, the sound absorption for samples with cotton has a high-frequency range than the sample without the cotton layer. It can be seen from the outcomes of application to noise enclosures and barriers that the sample with cotton layer as sound absorber can effectively reduce the reflection of noise. Compared to the standard high-cost absorption material, the absorbent material made of cotton is inexpensive and effective without any harmful effects.

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