Analysis study of nonwoven pineapple leaf fibre, nonwoven pineapple layered double weave and tricot knitting fabric as absorber material

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Abstract. Sound pollution can be minimized by noise intensity using sound absorbing material. Nonwoven fabrics are the material most widely used for acoustic applications. This research investigated about absorption coefficient of nonwoven pineapple leaf fiber (PNW), and its layered combination with double weave (PDW) and tricot knitting fabric (PTK). The variation of fabric will be tested for sound absorption coefficient using an impedance tube. Absorption coefficient test results showed there was an effect in absorption coefficient on nonwoven with layered.

1. Introduction

Sound pollution (noise) can be defined as the excessive noise that can cause an imbalance level of the humans or animals. Excessive noise will impact badly on physiological and psychological effects on humans that can cause permanent hearing damage, increasing efficiency, reducing stress in the workplace, the interference pattern sleep and disorders in communicating

The noise happens around us can come from a variety of sources. The source of this distinguished sources of static and moving resources. Examples of static is the factory and machinery construction. The example moving resource such as motor vehicles, trains and airplanes. Noise in Office buildings, schools, hospitals, etc. are sourced from the activity surrounding the building. Sound absorption is the ability of a material to muffle the sound of coming, calculated in percent or fractional value 0 ≤ α ≤ 1. A value of 0 means there is no attenuation sound (the whole sound comes reflected perfectly) whereas a value of 1 means the sound came completely absorbed (Nothing reflected back).

Porous materials absorbed the most commonly used as sound absorbent fibrous material is usually in the form of boards (composite), foam, fabric, rugs, pillows, etc. According to Padhye and Nayak, structure of textile fibrous materials is a great example of a porous material used for sound absorption. There are a number of textile material which can be used for sound absorbent. The material can be classified as a nonwoven fabric, woven and knitted.

Soltani and Zarrebini are conducting research on sound absorption coefficients and characteristics on a woven fabric with a variation of the plain weave structure, twill 2/1, 3/1 2/2, ribs and satin. Tang
et al.\textsuperscript{6} analyzes woven fabric corduroy against the absorption of sound by performing experiments and simulations. Mankondi and Mistry\textsuperscript{7} conducts research on the combination of jacquard woven fabric with nonwoven fabric against the absorption of sound. Monaragala\textsuperscript{8} and Ozturk, et al.\textsuperscript{9} using fabric knit spacer for sound absorption.

The use of natural fibers as sound absorber has been done, including hemp, coconut, and abaca. Natural fibers are made in the form of composites\textsuperscript{10}. Pineapple leaf fiber as a textile material has also been previously studied\textsuperscript{11}. Pineapple leaf extract has been studied as a sound absorber in a composite form\textsuperscript{12}. In this study, pineapple leaf fiber will be made nonwoven as sound absorber material.

2. Method research
This research uses experimental methods. The study begins by make a sample pineapple leaf fiber nonwoven fabric, double weave fabric\textsuperscript{13}, and tricot knit fabric\textsuperscript{14}. Sample fabric that has been created is then tested with absorption coefficient of a tube impedance\textsuperscript{15}. Absorption coefficient testing performed on sample of nonwoven fabric, nonwoven layered of double weave, nonwoven layered of tricot knitted fabric. Thickness, weight per meter square and density are calculated to support the results of the study\textsuperscript{16,17}.

3. Result and Discussion
Nonwoven fabric made using a thermal bonding method with low melt polyester as a fastener by a ratio of 75\% comparison of pineapple leaves fiber and 25\% low melt polyester. Type double weave made that kind of a double weave with a bond, the composition of warp and weft threads 1a1. Top side weave is twill 1/3 and bottom weave is twill 3/1. Double weave is made from 100\% cotton. Figure of top and bottom weave can see in figure 1, and weaving plans of double weave can see in figure 2.

![Figure 1](image1.png)

\textbf{Figure 1.} (a) top side weave is twill 1/3, (b) bottom side weave is twill 3/1

![Figure 2](image2.png)

\textbf{Figure 2.} Weaving plans of double weave

Tricot knit fabric made of 100\% polyester yarn using a double needle machine with 22E gauge. Guide bars are used as many as four of the total guide bar that is installed seven pieces. Lapping diagram of the tricot fabric used is shown in figure 3. Guide bar used is guide bar numbers 1,2,4 and 5. Lapping diagram of each bar is shown in figure 4.
Figure 3 Lapping diagram Tricot knit fabric

Figure 4 (a) Lapping diagram guide bar number 1, (b) Lapping diagram guide bar number 2, (c) Lapping diagram guide bar number 4, (d) Lapping diagram guide bar number 5
The results of the absorption coefficient test of the fabric variations made are shown in table 1. The absorption coefficient test is carried out twice for each sample. Tests are carried out at low, normal and moderate frequencies at frequencies 100 - 5000 Hz. In figure 5 the frequency ranges are listed according to ISO 11564[18]. Based on these graphs all materials used can absorb sounds with different absorption coefficients.

Absorption coefficients in all samples increase at frequencies of 1000-5000 Hz. At low frequencies the absorption coefficient is relatively low. This is because porous material can absorb sound at high frequencies. Sound absorption in fabrics is caused by the morphology of the fabrics that have cavity so that when sound passes through the material, the sound will be absorbed by the porosity in the fabrics.

The addition of layer to nonwoven fabric has an effect on sound absorption. Especially at high frequencies. This might be due to the addition of sample thickness which affects the density. At low frequency the nonwoven sample of pineapple fiber layered with double weave absorbs less sound so that more noise is transmitted. Conversely at high frequencies the nonwoven layered double weave absorbs the most sound. This is possible because of the influence of the porosity by the woven structure on the top and bottom for double weave fabric. Tricot upholstery has less influence on sound absorption compared to double weave, this is because the characteristics of the tricot that are made that have many open voids compared to the double weave so that they cannot absorb much sound.

The highest sound absorption coefficient at the frequency of 5000 Hz based on the graph above is equal to 0.70760 in the nonwoven layered double weave, while the lowest absorption coefficient on the double fabric material is 0.05252 on the same fabric combination at the frequency of 100 Hz.

| Frequency (Hz) | Nonwoven pineapple leaf fiber | Nonwoven Pineapple + Double weave | Nonwoven Pineapple + Tricot Knitted Fabric |
|---------------|-------------------------------|----------------------------------|------------------------------------------|
| 100           | 0.1407                        | 0.05252                          | 0.099389                                 |
| 124           | 0.1672                        | 0.07188                          | 0.112073                                 |
| 160           | 0.1334                        | 0.07233                          | 0.121352                                 |
| 200           | 0.1307                        | 0.06346                          | 0.140659                                 |
| 250           | 0.1330                        | 0.08702                          | 0.121732                                 |
| 314           | 0.1230                        | 0.10024                          | 0.12389                                  |
| 400           | 0.1649                        | 0.09920                          | 0.112567                                 |
| 500           | 0.0638                        | 0.10674                          | 0.066939                                 |
| 630           | 0.1474                        | 0.12513                          | 0.149091                                 |
| 800           | 0.1510                        | 0.16461                          | 0.135188                                 |
| 1000          | 0.1697                        | 0.18907                          | 0.132164                                 |
| 1250          | 0.2282                        | 0.21595                          | 0.160132                                 |
| 1600          | 0.2102                        | 0.27801                          | 0.229578                                 |
| 2000          | 0.2388                        | 0.29391                          | 0.248456                                 |
| 2500          | 0.2590                        | 0.35791                          | 0.237869                                 |
| 3150          | 0.3062                        | 0.45641                          | 0.330113                                 |
| 4000          | 0.3254                        | 0.57728                          | 0.441594                                 |
| 5000          | 0.4589                        | 0.70860                          | 0.481594                                 |
Factors that affect sound absorption are fabric density. The higher the fabric density, the higher the sound absorption. Material that has a high fabric density has good sound absorption at high frequencies. Data density of each sample are shown in table 2. The relationship between fabric density and absorption coefficient is shown in Figure 6.

| Tabel 2 density of sample | Nonwoven pineapple leaf fiber | Nonwoven Pineapple + Double weave | Nonwoven Pineapple + Tricot Knitted Fabric |
|---------------------------|--------------------------------|-----------------------------------|---------------------------------------------|
| Density (g/cm³)           | 0.514                          | 0.674                             | 0.554                                       |

The density of pineapple leaf fiber nonwoven fabric layered with tricot knit fabric is higher than the nonwoven fabric layered with double weave. This is because the tricot fabric has the highest thickness compared to the double weave fabric. So that when the nonwoven fabric is layered with tricot, the thickness exceeds the thickness of the nonwoven fabric layered double weave.
5. Conclusion

Cavities in the fiber are able to absorb sound at low and high frequencies. Thickness and weight in square affect the fabric density which can increase sound absorption. In this study, nonwoven layered with double weave fabric and tricot fabric is increases sound absorption at high frequencies. Morphological analysis can be done next to see more clearly the influence of porosity. Nonwoven layered using double weave fabric and tricot fabric can be tried to determine the effect on sound absorption and become a solution to add aesthetics.

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