Development of Acoustic Absorption Composite with Application of Coir and Viscose

V Thamaraiselvan, N Mekala and G Dhanapriya
Faculty of Fashion Technology, Bannari Amman Institute of Technology, Sathyamangalam, Erode, Tamilnadu, India.
mekalan@bitsathy.ac.in

Abstract. In the current scenario the industry looking for good quality products at low cost as well as recyclable ones. The non-woven products, especially reclaimed nonwoven manufacturing cost is very low when compared to other fabric manufacturing cost and it can be recyclable & attractive too. The sound absorption property is very essential in recent years. So it is very advisable to manufacture the sound absorption material with the help of non-woven fabric. This study speaks about the improvement in sound absorption characteristics of the non-woven composite. To improve the acoustic property of the composite the natural fiber coir has been blended with recycled viscose fiber in six different ratios using a needle-punching technique. The six different (in %) blend ratios of coir and reclaimed viscose is 70:30; 60:40; 50:50; 40:60; 30:70& 20:80. The composite has been introduced at a minimum of 200 grams so that adequate acoustic property is achievable. The composites are examined with GSM, Abrasion Test, Moisture test, and Acoustic coefficient. The GSM of the composite increases, when the viscose ratio increases in the sample. The abrasion-resistant decreases when the viscose increases. The moisture regains increases when the viscose content increases in the composite. The values of the sound absorption coefficient are high in sample 6 (Coir: reclaimed viscose, 20:80) when compared to other samples, it reflects that the reclaimed viscose has higher acoustic property than coir.

Keywords: Coir, Reclaimed viscose fiber, Non-woven, Acoustic property, Needle Punching machine.

1 Introduction:

Undesirable and potentially hazardous noises cause side effects, due to the wide scope of the present-day building structure and different procedures. The continued advancement of innovations has brought about the natural effect of commotion to turn into a significant concern. The expanding interest for quietness in building and assembly halls has animated the utilization and improvement of powerful methods for commotion decrease.

Sound absorption characteristics of nonwoven materials have been the subject of several works nowadays related to research. Many researchers have explained the dissipation mechanism of sound in fibrous materials. Faulkner proved that when sound passes through porous materials, acoustic energy loss takes place due to frictional losses, momentum losses, and temperature fluctuations. Experimental data indicate that the fiber mass, thickness, and porosity of the nonwoven fabrics seem to be the most influential factors in this respect. It was found that nonwovens with a higher proportion of fine fibers dissipate more sound. This causes more resistance due to frictional viscosity as a result of air vibration. It
was also established that the sound absorption coefficient of the absorptive system incorporating with anisotropic nonwovens is marginally higher than the systems containing isotropic webs in their structure.

Nonwoven structures contain pores in the micron and submicron scale, making them the preferred medium for sound-insulating and sound-absorbing applications. Moreover, their sound absorbency is the principal controlling factor in environmental sound pollution. Nonwoven fabrics can serve as noise absorption elements in a wide range of applications including acoustic ceilings, noise-reducing quilts, and noise proof barriers.

Coir fiber from coconut husk is a vital rural waste in Malaysia. The acoustic ingestion coefficient of the fiber is taken as a permeable material and it’s considered in this paper for proceeding. Sound absorption characteristics of non-woven materials concerning fabric thickness have been thoroughly discussed in the literature. Two investigative models are followed to test the fiber’s acoustic property. They are Delany– Bazley, and Biot– Allard is utilized for examination. Test estimations in impedance tubes are led to approve the scientific results. Results demonstrate that new coir fiber has a normal ingestion coefficient of 0.8 at f > 1360 Hz and 20 mm thickness [14]. Expanding the thickness has moved forward the sound ingestion in lower frequencies, having a similar normal ingestion coefficient at f > 578 Hz and 45 mm thickness. These results show a poor acoustic property in low frequencies.

Therefore, the fiber must be blended with another material to upgrade its qualities, like sound absorption, firmness, and combustibility. Consequently, different methodologies such as including air holes or punctured plates are to be utilized to enhance the acoustical properties of modern treated coir fiber [6]. Coir is blended here with viscose and made into a non-woven composite, and then tested for its acoustic properties.

2 Materials and Methods

2.1 Materials

2.1.1 Coir

Coconut coir fiber was utilized as the main raw material which is prepared from the coconut husk. The coir fiber is the thickest and most resistant of all commercial natural fibers. Low decomposition rate is the key advantage of making durable products. The visual analysis results and cross-section shows there are a lot of cavities inside the fiber, and roughly one-third of the bulk of fiber is filled by air. This entrapped air gives rise to the pronounced springiness (resilience) of the fiber, its buoyancy in water, and increases the time water takes to penetrate the fibers. The properties of coir are less affected by wet conditions than other hard fibers. The thickness of coir fiber limits the products made by coir being coarser and heavier.

2.2.2 Viscose

Viscose is one of the regenerated fibers in textile phenomena. Here the fibers are used from recycled viscose fiber. Viscose fibers are prepared from cellulose from wood pulp. Wood pulp cellulose is reacted with caustic soda, after a matured waiting period, the developing process will take place. During that time, depolymerization occurs and carbon disulphide will be added. It forms a yellow crumb, called Xanthate which can be easily dissolved in more caustic soda to give a viscous yellow solution.

2.2 Methodology

2.2.1 Manufacturing non-woven

The fibers (Coir & Recycled viscose) need individualization before the non-woven fabric manufacturing process called carding. First, coir is processed and lay of two varying proportions are made. Then, viscose is processed and lay of two varying proportions are made. The two fiber lays are blended then applied with a needle punching process.
2.2 Sampling

The non-woven composite should be prepared about 200 grams and this is the minimum thickness required to attain the acoustic properties of the particular application to attain the same minimum 30% of viscose needs to blend with coir fabric.

The samples (non-woven composites) are prepared with six different ratios of coir & viscose is 70:30; 60:40; 50:50; 40:60; 30:70; 20:80 respectively.

2.3 Material preparation

The pre-process of the fibers and the needle punching process are shown. The conversion of the fibre into the lay form using a miniature carding machine. The Carding machine operated with 0.61 feeder roller, 394rpm & Doffer 4.14 settings. The web coming out a form that machine is processed again with a cross lapper machine to form the lap. The various proportionated weight of coir and viscose fibre is blended thoroughly and given as input for the machines. Then the lap is subjected to a needle punching machine operated under 20 mm/stroke speed to get a composite layer.

![Figure 1. Miniature Carding M/C (conversion of fiber into lay form)](image1)

![Figure 2. Feeding blended fibres fed into the needle punching machine.](image2)
2.4 Testing

The developed non-woven composite undergoes a Sound absorption test, Abrasion test, and moisture test to identify the sound absorption (acoustic) property.

2.4.1 Sound absorption coefficient

The sound absorption coefficient of materials is correlated with frequency, and it varies with different frequencies. The sound absorption coefficient frequency characteristic curves can be used to illustrate the sound absorption properties of different frequencies exactly. It is not convenient to compare and state, so the average sound absorption coefficient, which is the average of an acoustic material's absorption coefficient at a specified set of frequencies, is used for simplification. The average sound absorption coefficient is represented by $\alpha$. The sound absorption coefficient of the material is measured using an impedance tube. The results will be in the form of a graph.

2.4.2 Abrasion test

Abrasion is just one aspect of wear and is the rubbing away of the component fibers and yarns of the fabric. It is a series of repeated applications of stress; therefore a capacity to absorb punishment is required to the fibres. Inherent fibre properties such as work of rupture may give a high resistance to abrasion. This test is done to test the resistance of the material to other materials in the process of repeated friction between the materials.

2.4.2.1 Procedure

The samples are weighed before testing then kept in an abrasion tester. Then the material was subjected to rotation about 50 times. Once the process is done the samples are taken out from the machine and weighed again to measure the resistance of the composite using the following formula:

\[
\text{Abrasion} \% = \left( \frac{\text{Loss in weight}}{\text{initial weight}} \right) \times 100
\]

Where Loss in weight = initial weight - final weight.

2.4.3 Moisture test (hot air oven)

This test is done to analyze the moisture content absorbed by the material, by comparing its weight before evaporation of water till those get dry.

\[
\text{Moisture} \% = \left( \frac{\text{Loss in weight}}{\text{initial weight}} \right) \times 100
\]

Where, Loss in weight = initial weight - final weight.

3. Results and Discussion

3.1. Sound Absorption test

Table 1 shows that as the content of viscose fiber in the nonwoven composite increases from 30% to 80% (from Sample 1 to sample 6). When there is an increase in areal density there is an increase in sound absorption coefficient for reclaimed viscose and coir nonwoven composites. This shows that coir has less sound absorption coefficient when compare to viscose since it is a synthetic fibre.
Table 1. Sound absorption test: (Co efficiency value of the material)

| Sample. No | Frequency (in Hz) |   |   |   |   |   |
|------------|------------------|---|---|---|---|---|
|            | 1000            | 2000 | 3000 | 4000 | 5000 | 6000 |
| Sample 1   | 0.09            | 0.1  | 0.13 | 0.15 | 0.35 | 0.40 |
| Sample 2   | 0.10            | 0.19 | 0.35 | 0.38 | 0.42 | 0.45 |
| Sample 3   | 0.19            | 0.25 | 0.38 | 0.42 | 0.45 | 0.49 |
| Sample 4   | 0.22            | 0.29 | 0.40 | 0.46 | 0.53 | 0.58 |
| Sample 5   | 0.35            | 0.39 | 0.45 | 0.57 | 0.68 | 0.75 |
| Sample 6   | 0.45            | 0.53 | 0.64 | 0.75 | 0.81 | 0.89 |

Figure 4. Graph - Sound absorption test: (Co efficiency value of the material)

3.2 Abrasion Test

Table 2 shows that as the content of viscose fiber in the nonwoven composite increases from 30% to 80% (from Sample 1 to sample 6). When there is an increase in areal density there is an increase in abrasion, which means the coir has higher abrasion resistance than viscose it leads to the better acoustic property of the product.

Table 2. Abrasion test

| Sample.no | Initial weight | Weight after abrasion | Change in weight | Abrasion (%) |
|-----------|----------------|----------------------|------------------|--------------|
| S1        | 8.730          | 8.38                 | 0.35             | 4.0          |
| S2        | 8.930          | 8.460                | 0.47             | 5.26         |
| S3        | 8.980          | 8.450                | 0.53             | 5.90         |
| S4        | 9.050          | 8.550                | 0.55             | 6.07         |
3.3. Moisture Test

Table 3 states that when there is a higher percentage of viscose in composite material the moisture content of the product is when compared to less percentage of viscose in the non-woven composite. So it's clearly said that the viscose has higher moisture regain than coir fiber. So the same reflects in the acoustic property of that particular composite. The acoustic property increased when the viscose proportion increased in the composite.

**Table 3.** Moisture Test

| Sample.no | Weight before moisture absorption (in gms) | Weight after moisture absorption (in gms) | Change in weight (in gms) | Moisture (%) |
|-----------|------------------------------------------|-----------------------------------------|--------------------------|--------------|
| S1        | 8.610                                    | 8.42                                    | 0.19                     | 2.20         |
| S2        | 8.675                                    | 8.425                                   | 0.25                     | 2.88         |
| S3        | 8.690                                    | 8.3                                     | 0.39                     | 4.48         |
| S4        | 8.750                                    | 8.24                                    | 0.51                     | 5.86         |
| S5        | 8.790                                    | 8.21                                    | 0.58                     | 6.59         |
| S6        | 8.808                                    | 8.178                                   | 0.63                     | 7.79         |
3.4 GSM Test

Due to the compact structure of the viscose, sample 6 has high GSM when compare to other samples. Table 4 shows the nonwoven composite GSM for different samples. It clearly states that when the viscose content increases then GSM increase respectively.

Table 4. GSM Test

| Sample. No | GSM (Average) in grams |
|------------|------------------------|
| S1         | 180                    |
| S2         | 205                    |
| S3         | 212                    |
| S4         | 223                    |
| S5         | 230                    |
| S6         | 234                    |

![Figure 7. Graph - GSM of the Fabric in gms](image)

4 Conclusion

This paper shows the acoustic property of the product is increasing, concerning the thickness of the end product. If the viscose percentage increases in the product, the quality of the product i.e., acoustic property (Acoustic coefficient) of the product will improve when compared to others. Since the higher in proportion viscose leads to higher moisture, weight addition, and more abrasion weight loss. This is due to viscose is a very light fiber that can make a compact object and not resistant to abrasion due to its friction property. Since the presence of coir fiber makes air porosity due to denser fiber which leads to avoiding echo in frequency application. The concept behind the thickness of the layer is to enhance the incident sound waves to lose more energy as they take a longer path through the material.
References

[1] Nor M J M, Jamaludin N and Tamiri F M 2004 A preliminary study of sound absorption using multi-layer coconut coir fibers Electronic Journal Technical Acoustics 3 1-8.
[2] Shahani F, Soltani P and Zarrebini M 2014 The analysis of acoustic characteristics and sound absorption coefficient of needle punched nonwoven fabrics Journal of Engineered Fibers and Fabrics 9(2)
[3] Barron R F 2003 Industrial Noise Control and Acoustics, New York: Marcel Dekker.
[4] Delany M E Bazeley E N 1970 Acoustic Properties of Fibrous Absorbent Materials Applied Acoustics Vol 3 No 2 105-116.
[5] Gopalakrishnan D Processing and characterization of nonwoven structured coir and palmyra for acoustic application.
[6] Majid Ali 2010 Coconut Fibre – A Versatile Material and its Applications in Engineering, Second International Conference on Sustainable Construction Materials and technologies Universitapolitecnicadelle Marche Ancona Italy.
[7] SurajitSengupta 2010 Sound Reduction by Needle-punched Nonwoven Fabric Indian Journal of Fibre & Textile Research Vol. 35 pp. 237-210.
[8] Mamta H, Fouladi M H, Al-Atabi M and Narayana Namasivayam S 2016 Acoustic absorption of natural fiber composites. Journal of Engineering 2016.
[9] Yang W D and Li Y 2012 Sound absorption performance of natural fibres and their composites, Science China Technological Sciences vol. 55 no. 8 pp. 2278–2283.
[10] Shahani F, Soltani P and Zarrebini 2014 The analysis of acoustic characteristics and sound absorption coefficient of needle punched nonwoven fabrics Journal of Engineered Fibres& Fabrics vol. 9 no. 2 pp. 84–92 2014.
[11] Allard F 1993 Propagation of Sound in Porous Media: Modelling Sound Absorbing Materials Elsevier Application Science. NewYork. NY. USA.
[12] Ingard K U 1994 Notes on Sound Absorption Technology Noise Control Foundation, Poughkeepsie, NY, USA.
[13] Coates M and Kierzkowski M 2002 Acoustic textiles-lighter, thinner and more sound-Absorbent Technical Textiles International vol. 11 No. 7 pp. 15–18.
[14] Soltani, P and Zarrebini M 2013 Acoustic Performance of Woven Fabrics In Relation To Structural Parameters and Air Permeability, Journal of the Textile Institute, Vol. 104 No 9 1011–1016.