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Analysis of Bast Fibre Acoustic Properties with Speciality Fibre Properties

S. Rajesh Kumar[1], G. Shubha Shree[2*], S. Dakshata[3], M. M. Barath[4]

[1]*Assistant Professor II, Department of Textile Technology, Bannari Amman Institute of Technology, Erode, India*

[2,3,4]*Student, Department of Textile Technology, Bannari Amman Institute of Technology, Erode, India*

***Abstract*: This paper explores about the acoustic properties of bast fibers in combination with speciality fibers. Through a comprehensive analysis, we examine the unique characteristics that make these fibers ideal for use in sound absorption. By analyzing the physical and chemical properties of these fibers, we can understand how bast fibers in combination with speciality fibers interact with sound waves and how they can be optimized for acoustic performance. This study focuses on the combining of flax fiber and glass fiber using needle punching method to produce non-woven acoustic panel.**

***Keywords*: bast fibres, speciality fibres, flax fibres, glass fibres, acoustic properties, sound absorption capacity.**

1. Introduction

Acoustic panels are an essential component of sound management in any space. It is designed to absorb sound waves and reduce echoes, reverberation, and other unwanted noise. This improves the overall sound quality and clarity of a room, making it more comfortable and functional for its intended purpose. Acoustic panels come in a variety of shapes, sizes, and materials, allowing them to be customized to fit the specific needs and aesthetic of a space. They can be made from materials such as foam, fiberglass, and natural fibres and can be covered in fabric or other decorative finishes to blend seamlessly into the surrounding environment. Incorporating acoustic panels is a crucial step in achieving optimal sound quality and creating a comfortable and functional environment. The goal of this project is to develop a non-woven composite acoustic panel using bast fibre and speciality fibre with needle punching technology which contributes in enhancing the sound absorption.

A. Bast Fibres Properties

A class of natural fibers known as bast fibers is produced from the inner bark (phloem) of some plants, including flax, hemp, jute, ramie, and kenaf. These fibres have been found to possess excellent noise reduction properties. These fibers have a porous structure that can absorb sound waves, reducing the level of noise in a room or building. These fibers have a high sound absorption coefficient, which means they can absorb a lot of sound energy and reduce the amount of noise that passes through them. Additionally, bast fibers have a low density and a high stiffness, which allows them to vibrate at certain frequencies and produce unique acoustic effects. The noise reduction properties of bast fibers make them ideal for use in soundproofing and acoustic treatment applications. The acoustic properties of bast fibres depends on various factors such as density, fiber length and porosity. Through a complete analysis it is found that flax fiber has several characteristics that makes it suitable for developing non-woven composite acoustic panel.

1) Flax fibre

Flax fiber has good acoustic properties, making it suitable for certain applications. Due to its natural structure and composition, flax fibers have a low density and high stiffness, which can contribute to effective sound absorption and dampening. Flax-based composites are gaining popularity in the acoustic industry due to their eco-friendly nature and desirable acoustic characteristics.

Fig. 1. Flax fibre

B. Speciality Fibre Properties

Specialty fibers are fibers that are engineered for specific applications. These fibers are designed to have unique properties such as high strength, durability, and resistance to chemicals and heat, low weight and high durability and it can be utilized in variety of applications such as sensing, communication, and noise reduction. Specialty fibres possess sustainability benefits such as reduced environment impact and biodegradability. Through complete research it is found that glass fibre has better sound absorbing capacity as it has less density and low cost.

1) Glass fibre

Glass fiber acoustic panels can be used to absorb sound and

*Corresponding author: shubhashree.tx20@bitsathy.ac.in

reduce echo in places like auditoriums, recording studios, and generator rooms. Glass fibre has high stiffness, but it has high strength, relatively low cost, and high chemical resistance and also gives better aesthetic.

Glass fibers have a low density, making them lightweight and ideal for applications that require acoustic insulation without adding significant weight. Glass fiber is non-corrosive, making it suitable for use in environments with high humidity or chemical exposure without degrading its acoustic properties.

Fig. 2. Glass fibre

2. Literature Review

The literature survey conducted during the development of an acoustic panel using flax and glass fibers is a critical component of the research process. This survey involves a comprehensive review of existing academic papers, patents, and industry reports related to acoustic panels, natural fibers like flax, and synthetic fibers like glass.

According to Yang Wei Dong & Li Yan (2012), Natural fibers such as ramie, jute, kenaf, etc. reinforced composites have drawn a lot of attention from material scientists and engineers in recent years due to their good mechanical properties, light weight, environmentally friendly and biodegradable. It was concluded that multifunctional composite materials can be made by natural fibers so that both the mechanical and acoustical functions can be achieved. The sound absorption coefficients of flax fibers are about 0.8 at frequencies above 800 Hz, respectively. It is found that NRC of flax is 0.65.

Adarsh Kumar; Pankaj Kumar Shah; Ritwik Singh; Ayush Chand; Siddharth Yadav; S.C. Ram (2022) The final structures of hybrid laminated composite have excellent chemical resistance, better mechanical properties, low density, and low cost. The glass fibre and flax fibre reinforced laminate offer exceptional strength with reduced weight because structural components require light materials. The glass fibre and flax fibre reinforced laminate offer exceptional strength with reduced weight because structural components require light materials.

With reference to Parikshit Paul, Meenakshi Ahirwar, B.K. Behera (2022) Porous materials are an excellent example of passive materials, which reduces sound energy by dissipating heat energy due to the presence of a void structure. In textiles, nonwovens are highly porous and less expensive materials compared to woven and knitted structures. The present research investigates the effect of fiber type fiber fineness, fiber cross-sectional shape, and fabric areal density on the acoustic properties of needle punched nonwoven fabrics produced from flax comber noil and jute caddies and polyester staple fibers of circular, hollow, and hollow conjugated cross-sections. Higher punch density results in better compactness of nonwoven fabric leading to improved sound absorption property. Layered nonwoven structures are responsible for better sound absorption properties due to the presence of an air layer.

Regarding Christoph Buksnowitz, Ramesh Adusumalli (2010) this study characterizes the acoustical behavior of natural fiber composites. Regenerated cellulose fibers (Lyocell), hemp fibers, and flax fibers were embedded in an epoxy matrix. These unidirectional composites were tested for their logarithmic damping decrement, the resonance frequency, the ultrasound velocity, the dynamic and static modulus of elasticity, and bending strength and density. Results indicate flax has good sound absorption properties and good reverberation characteristics.

3. Methodology

The nonwoven composite acoustic panel is made using needle punching method. The acoustic panel is made with the combination of flax fiber and glass fiber. The web formation of flax fiber and glass fiber is done using miniature carding machine. This web is then fed into needle punching machine to form the nonwoven. The nonwoven material is then layered using tapioca starch. This is then covered using cotton duct cloth. This acoustic panel is tested using impedance tube.

A. Miniature Carding

The web formation process for flax fiber and glass fiber using miniature carding involves several steps to create nonwoven fabrics.

1) Flax fibre web formation

Web formation of flax fiber mixed with cotton using a miniature carding machine involves a meticulous process of blending these two distinct fibers to create a homogeneous web. In this intricate procedure, the flax and cotton fibers are first opened and cleaned to remove impurities. Next, they are carded together through a miniature carding machine, which aligns and intermingles the fibers. This mechanical action helps to ensure even distribution and orientation of the fibers, resulting in a web with desirable strength and textile properties.

Fig. 3. Flax fibre web formation

2) Glass fibre web formation

The web formation of glass fibers mixed with cotton using a miniature carding machine is highly specialized and innovative process. In this intricate procedure, glass fibers, known for their exceptional strength and resistance, are combined with cotton, a comfortable and breathable natural fiber. Initially, the glass fibers are carefully prepared to remove any impurities or irregularities. Then, they are blended with cotton fibers and fed into the miniature carding machine. This machine processes the fibers, aligning and interlocking them to create a homogeneous web. The result is a unique textile blend that capitalizes on the high tensile strength of glass fibers while maintaining the softness and comfort of cotton.

Fig. 4. Glass fibre web formation

B. Needle Punching

Needle punching is a textile manufacturing technique that involves mechanically interlocking fibers using barbed needles. This process creates a nonwoven fabric, where fibers are entangled to form a cohesive material. It is a versatile method widely used in industries like textiles, automotive, and home furnishings. In needle punching, a bed of loose fibers is fed into a machine equipped with multiple needles. These needles repeatedly pierce through the fibers, pushing them through a base material and entangling them together. This action effectively binds the fibers, resulting in a strong, durable fabric with various applications.

1) Formation of nonwoven panel

Fig. 5. Formation of nonwoven panel

The chosen combination of flax and glass fibers is layered together, with different configurations depending on the desired material properties. Once the layers are aligned, they are passed through a needle punching machine. This machine uses an array of barbed needles to repeatedly pierce and interlock the fibers, mechanically entangling them. The penetration and withdrawal of the needles create a robust and integrated fabric, where the flax and glass fibers are effectively bonded. Then the formed nonwoven panel is layered to the required densities with the help of tapioca starch. Tapioca starch, which is derived from the cassava root, is a natural and biodegradable adhesive that offers several advantages such as it is environmental friendly, cost-effective, has good binding property and low emission.

4. Testing Method and Finishing

A. Impedance Tube

The developed acoustic panel is tested using impedance tube to analyses the rate of sound absorption. This equipment is particularly useful for characterizing the sound absorption coefficient and impedance of a material over a range of frequencies.

The procedure typically involves placing a sample of the composite material inside the impedance tube. Sound waves are then directed towards the sample at a known frequency and intensity. As the sound waves interact with the material, some of the energy is absorbed, and some is reflected. The impedance tube precisely measures the amount of sound energy absorbed by the composite material. This measurement is crucial in assessing the materials

Acoustic performance. By analyzing the data collected from impedance tube we can determine the absorption coefficient, which quantifies the rate at which material absorb sound energy across different frequencies.

Table 1
Test method: ASTM E1050-12

S.No.	Frequency in (Hz)	Sound absorption Co-efficient
1.	125.00	0.19
2.	250.00	0.04
3.	500.00	0.13
4.	1000.00	0.34
5.	2000.00	0.68
6.	2500.00	0.76
7.	3150.00	0.85
8.	4000.00	0.91
9.	5000.00	0.92
10.	6300.00	0.91

Sample: Flax and glass fiber needle punched

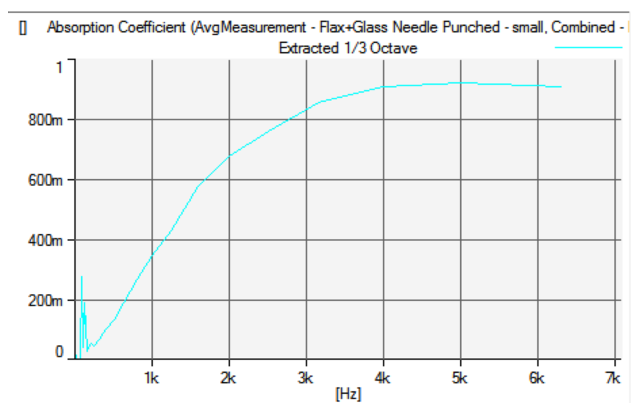

Fig. 6. Absorption coefficient

B. Finishing of Nonwoven Composite Using Cotton Duck Cloth

The finishing of a non-woven acoustic composite with cotton duck cloth involves a meticulous process to enhance both functionality and aesthetics. Initially, the non-woven acoustic composite is trimmed and sized to fit its intended dimensions. It is then carefully layered between sheets of cotton duck cloth, creating a protective envelope around the acoustic material.

5. Conclusion

Flax and glass fibers find application in the construction of acoustic panels, each offering distinct advantages in enhancing acoustic performance. Flax fibers, renowned for their Eco friendliness and biodegradability, contribute to sustainable panel designs. They possess moderate sound absorption capabilities, particularly in mid to high frequency ranges, effectively reducing noise and enhancing acoustic comfort. Their textured, natural appearance also adds an aesthetic dimension to panels. In contrast, glass fibers are chosen for their structural strength and durability. They provide critical reinforcement to panels, ensuring long-term resilience. Their fire-resistant properties make them suitable for applications prioritizing safety. In summary, the combination of flax and glass fibers allows for the creation of acoustic panels that balance acoustic performance, sustainability, and structural integrity, catering to a wide range of needs and settings.

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