ISSN: 0974-5823 Vol. 6 No. 3 October-December, 2021

International Journal of Mechanical Engineering

Acoustic Insulation by Textile Fibres

S.VIJU

Associate Professor, Department of Textile Technology, PSG College of Technology, Coimbatore-641004, Tamil Nadu, India

***Abstract* - Noise pollution is described as unwanted sound that disrupts the activity level of human as well as animal living. Problem associated with noise pollution is rising gradually around the globe. Sound is considered to have harmful effect in several engineering applications. Now days, porous textile fibers are gaining more interest owing to its uniqueness. Porous structures in cellular or fibre form are commonly used for acoustic insulation. In this paper, various parameters influencing the sound absorption behavior of textile structures and applications of textile fibers in acoustic insulation are discussed.**

1. INTRODUCTION

Noise pollution is described as unwanted sound that disrupts the activity level of human as well as animal living. Because of the industrial revolution, noise pollution is still a growing problem around the world. This is especially concerning in poorer nations where stringent legislation is lacking. Previously thought to be harmless, noise pollution is now recognized as a major threat to people's health in the modern world, as it can cause mental disease, distract attention, and cause physical illness. Acoustic insulation materials are commonly employed to combat the adverse sound effects and, hence reducing reverberant noise levels [1].

As per World Health Organization (WHO), Noise pollution is a global issue that affects the health of many people. Noise pollution can cause a variety of issues, including hearing loss, decreased efficiency, fatigue, negative social actions, psycho physiologic issues and cardiovascular related problems. It is vital to provide a suitable environment for individuals to live in their houses and for people to work in industries efficiently. Depending on the speed and surrounding conditions, automobiles emit a variety of noises. The goal of automotive noise reduction is to keep tyre, engine, and exhaust noise from entering the cabin. Vehicle noise can be reduced by changing the road's surface roughness, regulating vehicle speed, erecting barriers, lowering the number of heavy trucks, and selecting the best tyre design. Other areas where emphasis should be paid include noise barriers, surface pavement selection, truck restrictions and improved road design [1].

2. PARAMETERS INFLUENCING THE SOUND ABSORPTION BEHAVIOR OF TEXTILE STRUCTURES

The following section discusses the parameters influencing the sound absorption behavior of textile structures [1]. Table 1 shows the factors influencing acoustic insulation [1].

2.1 Fibre dimensions

The squared fibre diameter has an inverse relationship with flow resistivity. If all other characteristics of the construction stay constant, finer fibres will result in higher flow resistance.

2.2 Density

The bulk density of a porous structure has a major influence in acoustic insulation. A material's mass concentration is expressed as mass per unit volume, and its density reveals its mass concentration

2.3 Thickness of fabric

Among several factors, fabric thickness plays an important role in acoustic insulation If the acoustic impedance of the textile structures' surface equals that of the medium, no sound is reflected back to it. Sound absorption increases as the structure becomes thicker. To have adequate acoustic insulation in this scenario, the materials thickness must be at least one-tenth of the input sound wave's wavelength. Low-frequency sound requires bigger structures for absorption due to its long wavelength.

Table 1. Factors influencing acoustic insulation [1]

Type	Factor
Material and fibre	• Resistivity towards air flow • Resistance towards air flow • Surface Impedance • Material thickness • Density of the material • Material Porosity • Fibre form • Fibre dimension • Fibre profile
Manufacturing and finishing parameters	• Web preparation method • Type of bonding • Finishing treatment • Physical treatment
Medium and Sound	• Density of the medium • Shear viscosity of the medium • Heat conduction coefficient

2.4 Tortuosity

The sinuosity and interconnection of empty places in a permeable material is referred to as tortuosity. In acoustic absorption, tortuosity refers to the lengthening of path through the pores.

2.5 Porosity

Porosity of a substance refers to the quantity of void it contains. Factors including pore size, pore type, and percentage of pores in acoustic materials have an impact on sound absorption. Large porosity or a large percentage pores in a material typically translates to a low bulk density porous material. Because flow resistivity is related to the bulk density of porous materials, a huge porosity will end up in a low flow resistivity assuming remaining structural factors remain constant.

2.6 Resistance to airflow

The airflow resistance has a big impact on a porous material's acoustic absorption. The barrier to the flow of air is provided by the interlacements of yarns in woven fabric or by the intermeshing of fibrous substrates in nonwoven fabrics. The resistance given by the fabric per unit thickness is used to calculate airflow resistance.

3. TEXTILE FIBRES

The following section discusses the sound absorption behavior of various textile fibres. Table 2 shows the characteristic features of textile structures for acoustic applications [1].

3.1 Coconut coir fibre

Coir is a lignocellulosic natural fibre that is widely employed in a variety of applications today. The coconut fibre has an average mean diameter of 250 mm, which is higher than other natural fibres. It has been reported that at low and medium frequencies, the sound absorption co-efficient of raw coconut fibre was good, also thicker fibrous layers, the sound insulation was much better. Binders are commonly used on coconut fibres mainly to enhance other properties including flammability, antifungal and stiffness and subsequent use in acoustic panels. Coconut coir fibre may be used as an alternative to synthetic based acoustics product. Coir based acoustic panels has a clear prospect as they are cost effective, low weight and ecofriendly as compared to synthetic acoustic panels [2,3].

Table 2. Characteristic features of textile materials for acoustic applications [1].

Technology	Properties	Advantages	Disadvantages
Weaving	Produces thin structures at a slow rate of manufacture.	The simplest of all approaches, and the most cost-effective.	Limitation on cloth thickness and a smaller window to maximize the parameters impacting sound insulation.
Nonwoven	Porous textile constructions are created in a short amount of time.	The degree and amount of porosity can be simply regulated, and many fibres can be prepared at the same time, making this the most commonly investigated approach.	Due to fabric thickness restrictions, only flat constructions may be created.
Polymeric composites	Most sound waves are repelled by rigid structures.	Textile waste may be used, a large range of combinations can be created, and the desired shape can be constructed, making this the second most researched approach.	Product flexibility is lost as the porosity of the product is reduced.
Knitting	Open structures are created by warp knitting and weft knitting process, but spacer knitting is not as much of common.	Simple non-planar structures are achievable thanks to the flexibility of the process parameters	Spacer fabric structures are dimensionally stable; therefore knitting with spacers lowers flexibility.

Hybrid structures	. A structure or technique that combines two or more other structures or approaches	High and low frequency ranges are both effective, and the final application is highly adaptable	The order in which components are installed affects sound insulation.

3.2 Kapok

Kapok is a natural fibre that can be used to make acoustical materials. Kapok is a hollow fibre with a hollow degree ranging from 80 to 90 percent. Researchers investigated the sound absorption of kapok fibre at low frequencies in relation to the amount of kapok fibre, bulk density, and thickness of nonwoven textiles. The impedance tube method was used to evaluate the acoustic insulation of kapok fibre structures in 100–2500 Hz frequency. Increases in kapok fibre content or nonwoven fabric thickness result in increased sound absorption. The bulk density of the nonwoven fabric was ideal for sound absorption. Nonwoven fabrics sound absorption rose with fibre density, but go down when density go beyond the acceptable levels. When compared to polypropylene fibre, kapok fibre-based fabrics had superior property at low-frequency sound absorption. Kapok fibre is naturally available eco-friendly substrate that outperforms several regularly used fibres in terms of low-frequency sound absorption [4].

3.3 Kenaf

Kenaf is a member of the Malvaceae family, which is similar to cotton. Stem of kenaf plant is composed of inner core fibre 65 percent and outer bast fibre 35 percent, resulting in pulp of poor and high quality. The ability of kenaf fibres to absorb sound has been established in both normal and random incidence sound absorption tests. The bulk density can be increased to boost the sound absorption coefficient even more. In the random incidence test, kenaf fibres can achieve an absorption coefficient above 0.5, with an average value of 0.8, starting at 400 Hz. Kenaf fibres was found to have good acoustic insulation capabilities and comparable to synthetic rock wool [5].

3.4 Flax

Superior quality flax fibres make up only around 20% of the flax plant mass and rest of the materials are used to manufacture price effective textile products. To make a revolutionary sound-absorbing cloth, the shortest fibres, also known as flax-tow, were used. Due to the removal of outer layer during processing, this substance became self-linked. Additional synthetic binder is not required for binding. The acoustic insulation of two fabric of different thickness 2 mm and 10mm flax-tows was tested. Despite the 2 mm fibre sample's slightly lower absorption properties, both fabrics can considered for acoustic panels [6, 7].

3.5 Typha

Typha is a natural organic fibre that is resultant from the leaves of Typha Australis plant. The fraction of constitutive fibres individually had a significant impact on the acoustic performance of nonwoven Typha/polypropylene samples. The acoustic insulation capabilities of fabrics would dramatically improve as the proportion of Typha fibres increased. The existence of Typha fibres with polygonal cross-sections raise the fibrous structure's frictional behaviour, resulting in increased sound energy losses. At frequencies of 250–2 kHz, the sound coefficients of Typha and polypropylene are 0.6–0.8 and 0.6–0.7, respectively. At frequencies between 250 and 2 kHz, the absorption coefficient of the Typha/polypropylene (50:50) composite was around 0.8–0.9 [8, 9].

4. Conclusions

Noise pollution is described as unwanted sound that disrupts the activity level of human as well as animal living. Problem associated with noise pollution is rising gradually around the globe. In this review, the parameters influencing the sound absorption behavior of textile structures and use of textile structure in acoustic insulation applications are discussed. From this brief review, it can be stated that textile materials are very effective in controlling the sound absorption due to its porous nature.

5. References

1. Padhye, R. and Nayak, R. " Acoustic textiles" Springer, 2016
2. U. A. Malawade, K.J. Mahamuni , G.J. Madhavrao and K.B.Virendra , "Investigation of Sound Loss Potential of Natural Fibers and their Compositions", Journal of Engineering and Technology, vol. 6 No. 1, April 2017, pp. 36–43
3. M. Hosseini Fouladi, M. Ayub and M. Jailani Mohd Nor, "Analysis of coir fiber acoustical characteristics", Applied Acoustics, vol. 72 No. 1, January 2011, pp. 35–42.
4. X. Liu, X. Yan, L. Li and H. Zhang, "Sound-Absorption Properties of Kapok Fiber Nonwoven Fabrics at Low Frequency", Journal of Natural Fibres, vol. 12 No. 4, July 2015, pp. 311–322.
5. Z. Y. Lim, A. Putra, M. J. M. Nor and M. Y. Yaakob, "Sound absorption performance of natural kenaf fibres", Applied Acoustics, vol. 130, January 2018, pp. 107–114.
6. M. Hosseini Fouladi, M. Ayub and M. Jailani Mohd Nor, "Analysis of coir fiber acoustical characteristics", Applied Acoustics, vol. 72 No. 1, January 2011, pp. 35–42.
7. Asdrubali F, Schiavoni S, Horoshenkov KV. A Review of Sustainable Materials for Acoustic Applications. *Building Acoustics*. 2012; 19(4):283-311. doi:10.1260/1351-010X.19.4.283
8. M. K. Moghaddam, S. Safi, S. Hassanzadeh and S. M. Mortazavi, "Sound absorption characteristics of needle-punched sustainable Typha /polypropylene non-woven", Journal of the Textile Institute, vol.107 No.2, March 2015, pp. 1–9.
9. U. A. Malawade, K.J. Mahamuni , G.J. Madhavrao and K.B.Virendra , "Investigation of Sound Loss Potential of Natural Fibers and their Compositions", Journal of Engineering and Technology, vol. 6 No. 1, April 2017, pp. 36–43.