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Department of Applied Science and Technology

Master of Science in Textile Engineering.

Master Thesis

The Role and Applications of Fabrics and Fibers in the Absorption of Noise

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Abstract

Sound is essential part of our daily life. On the contrary if it is out of control, it would be created different types of problem, so we have to control the noise of sound. Traditionally we can use wood, textiles and synthetics to control the noise. However, textile materials are used for noise reduction based on two factors like low production cost and low specific gravity. Textiles can play dual role like aesthetics quality and functional quality. So, these qualities added advantage to use textile as an acoustics. Textile fibers and fabrics are used for noise absorption. Textile fibers are materials which can be spun into a yarn or made into a fabric by interlacing and intermeshing. Noise is an unwanted sound which forms from irregular fluctuation of vibration. Sound is a mechanical wave which travel though a fluid medium like air, water etcetera and fluctuation of vibration. Vibration is the source of sound which is an energy transmitted through denser materials like wood, metal etcetera. Noise absorptions materials should have porosity more than 90% which is open cell foam or fibers. Noise absorption is a process by which energy is converted from kinetic energy to heat energy when the sound strikes the cell or fibers.

Acoustic insulation materials work by two processes: absorption of sound energy, which dissipates sound as heat energy, and reflection, which reflects noise away from a location where quieting is desired. A single composite insulation material will be effective as both an absorber and a reflector.

A textile is a flexible material consisting of a web of natural or artificial fibers. Yarn is delivered by turning raw filaments of wool, flax, cotton, hemp, or different materials to create long fibers. Textiles are formed by weaving, knitting, stitching, or felting.

The word fabrics are utilized as a part of textile gathering exchanges, as equivalent words for textile. A Textile is any material made of interweaving filaments. A fabric is a material made through weaving, knitting, spreading, stitching, or bonding that might be utilized as a part of creation of further products. Cloth may be used synonymously with fabric but is often a finished piece of fabric used for a specific purpose.

The thesis is divided into six parts. The first part is covered about origin of textile fiber, yarn and fabric and their classification. This chapter emphasize s about the fiber shape, cross-section and fabric types. The second chapter gives the overview of acoustic sound and noise. Exemplary, shown some sound level and phenomena. Third chapter is the focus of noise reduction mechanism and material strength to absorb sound. The fourth chapter is the review of some fibers applied for acoustic purposes. The fifth chapter is the study of some fabrics role in the noise absorption. The sixth chapter shows some application fields of acoustic textile.

Key words: Noise, Fiber, Fabric, Absorption, Non-woven,

Chapter 01: Overview of Fibers, Yarns and Fabrics

1.1 Introduction:

The word "Textile" come from Latin "Textilis" and French "Texere", means to weave. Originally' textile refers only woven fabrics. But modern textiles include lots of categories. Like: Woven, Knit, Non-woven, Thread, Rope and so on. [3] Fibers are the establishment for every textile product and can either be natural (normal filaments) or man-made (produced or man-made regenerated). Inside these two types or groups, there are two fundamental types of fibers,

• Fibers of uncertain (exceptionally incredible) length, called filaments

• Fibers of considerably shorter length, called staple fibers

Fibers are for the most part combined and twisted to form yarns, while staple fibers are spun to make yarns. Yarns are then normally woven or knitted into fabrics. A piece of a fabric contains a huge number of filaments. For instance, a little piece of light weight fabric may contain more than 100 million filaments. Individual types of filaments can be utilized alone or joined with different types of fibers to improve the nature of the finished result. The procedure for joining filaments is known as blending. There are some notable blended filaments available, for example Viyella, which is made of a blend of cotton and wool. A fiber is characterized as a little threadlike structure. It is described by having a length no less than 100 times its diameter across. The Textile Institute characterizes a fiber as a 'textile raw material, for the most part described by flexibility, fineness and high ratio of length to thickness. A comparative industry definition is a 'unit matter with a length no less than 100 times its diameter, a structure of long chain particles having a distinct favored introduction, a measurement of 10– 200 microns (micrometers), and flexibility. All fibers have a atomic structure that adds to their particular attributes and properties.

The common attributes of filaments from these definitions are:

• The measurement of a fiber is little in respect to its length

• Properties of 'flexibility' and 'fineness' (a method for describing the thickness of a fiber) [1]

1.2 Types of Fibers (According to Origin)

There are three fundamental types of fiber groups:

• Natural filaments • Regenerated filaments • Synthetic filaments [1]

1.2.1 Natural fiber can be classified into two primary types:

• Vegetable or cellulosic fibers • Animal or protein fibers. [1]

Animal (protein)- based fibers can be partitioned into the accompanying classifications:

• Wool (from sheep) • Hair (e.g. from goats, for example, mohair and cashmere; or from rabbits, for example, angora) • Silk (from silkworms)

In view of which part of the plant they originate from, vegetable filaments can be isolated into:

• Seed (e.g. cotton) • Bast (filaments got from the external, or bast, layers of plant stems, e.g. flax, hemp and jute) • Leaf (e.g. sisal) [1]

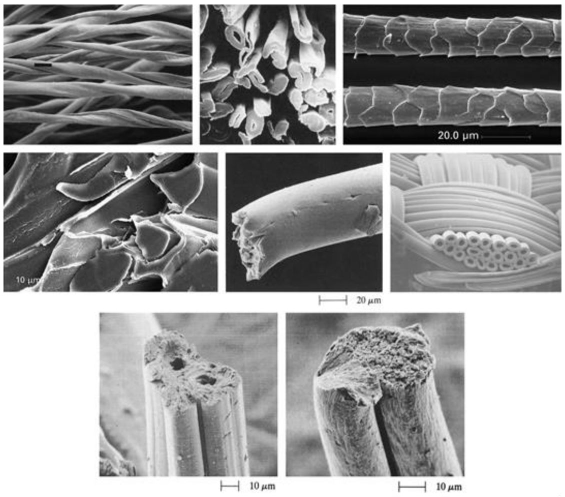


Figure 1.1[1]

Image generates of fibers view: (Count serially by row) (1) longitudinal view of cotton fibers showing their characteristic twist. (2) view of cross-sections of cotton fibers showing their characteristic dog-bone shape (3) wool fibers showing scales on the fiber surface (4) silk fibers showing a trilobal cross-section (5) nylon fiber with round cross-section (6) nylon fibers with hollow cross-sections in a woven fabric (7) viscose rayon fiber with a multilobal cross-section (8) acrylic fiber showing a dog-bone shaped cross-section.

1.3 Types of Man-made fibers:

• Synthetic polymers, e.g. polyester, nylon (polyamide), acrylic, lycra

• Regenerated, e.g. viscose, modal, acetate

• Inorganic, e.g. carbon, glass, ceramic and metallic filaments [1]

1.4 Some definitions of synthetic polymeric fiber

• **Polyesters:** Defined as any long-chain manufactured polymer made out of no less than 85% by weight of an ester of a substituted atomic carboxylic acid, including, however not confined to, substituted terephthalate units and parasubstituted hydroxybenzoate units (e.g. PET, PTT, PBT, PEN, PLA, high-modulus high-tirelessness (HM-HT) filaments). [1]

• **Polyamides:** Defined as polymers having in the chain repeating during groups, no less than 85% of which are joined to aliphatic or cyclo-aliphatic groups (e.g. nylon, PVA, PVC).

• **Aramid:** These are characterized as polyamide, where every amide assemble is shaped by the response of an amino gathering of one atom with a carboxyl gathering of another (e.g. Kevlar, Nomex).

• **Olefins:** Defined as made fibers in which the essential unit is any long-chain manufactured polymer made out of no less than 85% by weight of ethylene, propylene or other olefin units (e.g. polypropylene, polyethylene).

• **Elastomers:** Defined as materials that, at room temperature, can be extended over and again to at any rate twice their unique length, and upon quick discharge will come back to around the first length (e.g. polyurethane, Lycra, Spandex).

• **Acrylics:** Defined as produced filaments in which the fundamental contents is a long-chain synthetic polymer made out of no less than 85% by weight of acrylonitrile units. [1]

1.5 Types of Fibers and Yarns based on Formation

1.5.1 Fibers

Fibers are commonly ordered in the accompanying way:

• Staple fibers

• Filaments

• Tow

Staple fiber- A staple fiber is a fiber of generally short length, just like the case with most natural fibers, which go from a couple of millimeters (e.g. the briefest cotton filaments, known as linters) to around a meter (e.g. filaments from bast plants). Staple filaments are ordinarily between of 3 and 20 cm long. Given the distinctions in normal fiber length, cotton fibers (2– 3cm) and wool filaments (at least 5cm) are, for instance, here and there referred to as 'short staple' and 'long staple' filaments, separately.

A Filaments- A filament is a fiber of inconclusive length. The different silks are the main natural filaments fibers. Most regenerated and manufactured fibers are created as filaments. These can be utilized as a part of single or multifilament shape. Some of these are additionally gathered to create a 'tow' which is then cut or broken into required short lengths to create staple filaments reasonable for blending with different fibers, specifically with cotton or wool.

A tow can mean two distinct things:

• In the synthetic fiber industry, a tow is a substantial gathering of fibers that is bound to be cut into shorter (staple) fibers. [1]

• In the handling of natural fibers (flax), tow is the shorter fiber created when the stalks are handled to remove the filaments (the long fibers are called line flax). [1]

1.5.2 Yarns:

A yarn has been characterized as 'a result of significant length with a moderately little cross-area, consisting of fibers and additionally fibers with or without twist. Another meaning of yarn is 'groupings of filaments to form a constant fiber. Most staple fibers are made into yarn through a procedure of drawing, twisting and winding that enables a gathering of fibers to hold together in a constant fiber. There are distinctive strategies for twisting, contingent upon the fiber being spun; Filaments can also be gathered into bigger structures in different ways, e.g. felt and nonwoven fabrics.

Yarns can be arranged in different ways. Essential yarn types are:

• Monofilament

• Multifilament

• Staple or spun

These types are represented in Figure 1.2 As their name proposes, monofilament yarns contain a single fiber. Generally, numerous fibers are twisted together to form multifilament yarns. As noted before, staple or spun yarns comprise of staple filaments joined by twisting into a long, constant fiber of yarn. The key components of a staple yarn are contents, fineness and length, yarn utilize furthermore, wind. There are numerous methods for making a staple yarn from groups of filaments. Run of the lowest yarn developments include:

• Single (filaments combined into a single yarn)

• Ply/utilized (at least two yarns twisted together)

• Cabled/corded (a few utilized yarns twisted together)

• Blended/compound (distinctive fiber types combined in a yarn)

• Core spun (a yarn with one kind of fiber, often than not a fiber, in the middle (core) of the yarn, which is normally secured (wrapped) by staple fibers)

• Fancy or impact (yarns with embellishments or think inconsistencies, e.g. slabs (thicker parts) or loops happening consistently or arbitrarily along the length of the yarn).

The blend of various filaments and yarn structures can be utilized to design a specific arrangement of properties. Sewing thread are a case of a yarn that is particularly built for a particular reason. Extra completes are frequently added to yarns to guarantee they are fit for reason. [1]

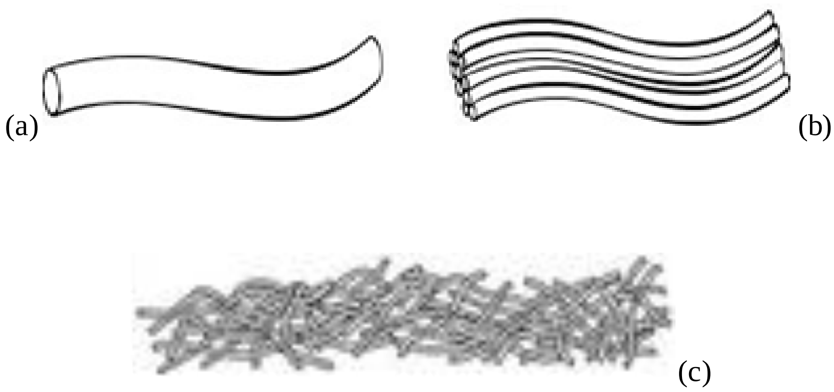


Figure 1.2 Types of yarn: (a) monofilament; (b) multifilament; (c) staple/spun. [1]

1.6 Fiber Length, Shape and Diameter

Fiber length influences a large number of the properties of a staple yarn, including strength, evenness and hairiness. Since they are persistent, fiber yarns can be made into yarn with almost no twist, delivering a smooth, splendid appearance, especially when no crease (see below) is available. Staple filaments should be twisted together to shape a length of yarn with fiber closes distending from the surface of the yarn. This delivers a blunter appearance and more uneven surface. This can be an advantage since it gives a few fabrics a milder 'hand' or feel. A trademark highlight of a few filaments is 'pleat', which refers to the waviness of a fiber along its length. The main common fibers that have huge pleat are creature filaments (wool and hairs).

Crimp is frequently conferred to manufactured fiber filaments, with a specific end goal to make them more cumbersome and agreeable, what's more, to man-made staple fibers for blending with wool or cotton. Crimp can be measured by tallying the quantity of pleats or waves per unit length or the rate increase in fiber length on removal of the crimp. Creased filaments have a tendency to be more cumbersome and stick (stick) together more successfully while being spun into staple fiber yarn. Fiber 'cohesiveness' is a critical factor in the effective twisting of staple filaments, and can deliver more grounded yarns. Pleated fibers, for example, wool, have more mass and better protecting properties, the last being because of something beyond captured air. Common filaments arrive in a scope of shapes, while synthetic fibers can be made in any shape required.

Fiber shape can basically be examined in two ways:

• By taking a look at the cross-section of a fiber (i.e. cross-sectional)

• By taking a look at the fiber lengthways (i.e. longitudinally) [1]

1.7 Types of fiber cross-sections:

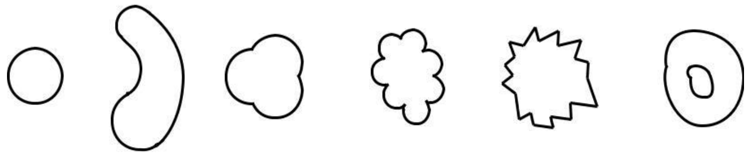


Figure 1.3–fiber shape [1]

i) Round

ii) Dog-bone molded

iii) Trilobal

iv) Multilobal

iv) Serrated

v) Hollow

Average textile fibers have a measurement of between of 10 and 20µm, however some can achieve 50µm. Natural fibers go in diameter across from silk (10– 13µm) to wool (up to 40µm). Synthetic filaments can be produced in diameters across from as little as 6µm (known as microfibers) up to substantial obligation cover fibers (over 40µm). Nano fibers, with a diameter below 100nm (nanometers), are also created. A little measurement produces 'finer' filaments with a greater malleability, flexibility and delicateness. This results in a fabric with better or gentler hand (i.e. feel) and wrap (the way a fabric hangs). [1]

1.8 Methods of Fabric Forming

The most usually utilized fabric shaping strategies are weaving, braiding, knitting, felting, tufting and nonwoven fabricating. However, real strategy for fabric development is weaving. [2]

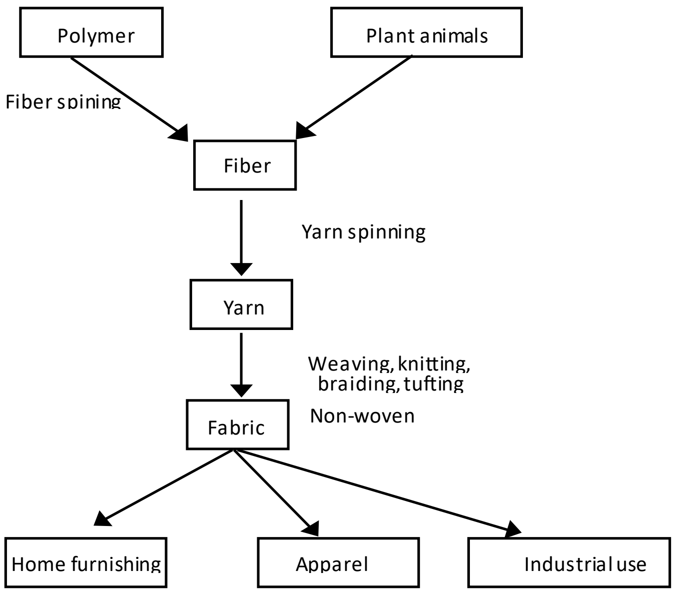


Figure 1.4 Material flow diagram for fiber to fabric process[2]

1.8.1 Weaving

Weaving is the interweaving of warp and weft yarns opposite to each other. There are basically an unending number of methods for joining warp and weft yarns. Each unique way comes about an alternate fabric structure. Roughly 70% of the fabrics made on the planet are woven fabrics. Figure 1.5 demonstrates the outline of woven fabrics. [2]

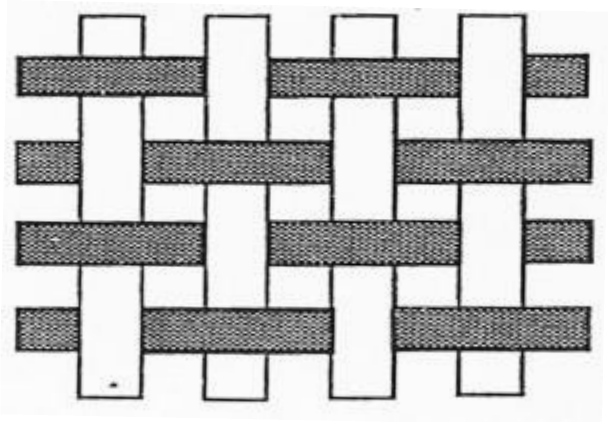


Figure 1.5 Woven fabrics [2]

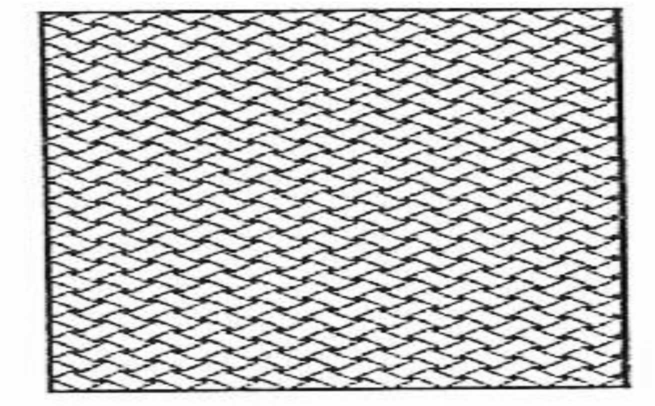


Figure 1.6 Braided fabrics [2]

1.8.2 Braiding

Braiding is most likely the least complex method for fabric arrangement. A braided fabric is shaped by inclining entwining of yarns. In spite of the fact that there are two arrangements of yarns associated with the procedure, these are not named as warps and wefts as on account of woven fabrics. Each arrangement of yarns moves in an inverse course. Meshing does not require shedding, weft addition, and beat up. Figure 1.6 demonstrates the outline of braded fabrics. [2]

1.8.3 Knitting

Knitting refers to interloping of one yarn system into vertical sections and flat columns of loops called wales and courses, separately. There are two principle types of knitting: weft knitting and warp knitting. [2]

1.8.4 Tufting

Tufting is the way toward assembling a few classifications of floor coverings and comparative structures. In this procedure surface yarn arrangement of loops is 'knit' or 'knitted' through an essential backing fabric, as a rule a woven or nonwoven fabric. The loops are arranged in vertical sections (lines) and flat lines (piles). Loops can be as cut or uncut loops (heaps) or a blend of thereof. The fabric is typically back-covered in a later procedure to secure tufted loops. Introduction of tuffed loops is appeared in Figure 1.7. [2]

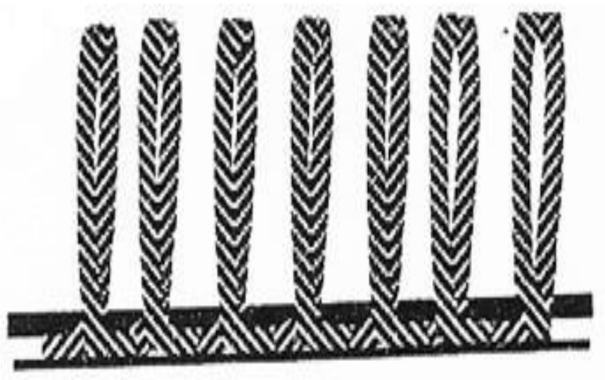


Figure 1.7 Tuffed loop [2]

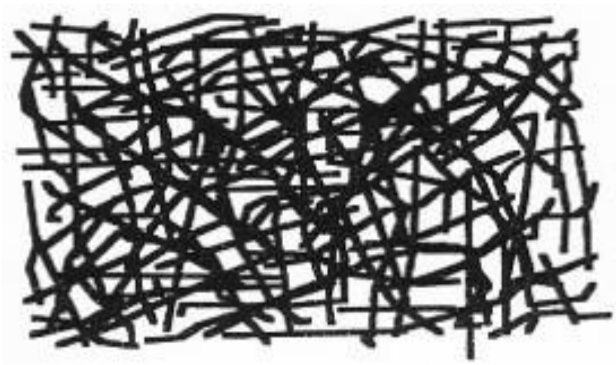


Figure 1.8 Bonding of nonwoven fabric [2]

1.8.5 Nonwoven

Non-woven is the strategy for assembling utilized textile, paper, expulsion, or blend of these advances, to form and bond polymers, fibers, filaments, yarns or blend sheets into an adaptable, porous structure. Truth be told, some nonwoven products are subjected to both textile and paper industry. Figure 1.8 demonstrates the bonding of nonwoven fabric. [2]

Chapter 2: Overview of Acoustic, Sound and Nosie:

2.1 Acoustic terms

Sound wave is a pressure wave movement noticeable all around that the ear distinguishes and sees as sound (ne.se). By definition, sound is a wave movement in a flexible media and the elastic media could be the air, water or a stone. The sound wave conveys energy to the media and the energy is diverted by the sound wave. A sound wave could also be described as a sound wave happen when a vibrating body sets the surrounding air in work stations and variety in pneumatic stress. These movements in pneumatic stress sees as sound and the sound can be influenced by various articles. How hard protests, for example, influence sound, relies upon how enormous the question is contrasted with the wavelength by the present sound. High frequencies with a short wavelength acts similarly as light does. The sound reflects by the surface of the hard object like a mirror. This phenomenon can also be compared with the little water waves from a little shake tossed in the water, when they hit an obstruction. Sound waves with long wavelength will pass a barrier unaffected, similarly as when waves from a speedboat surge hit the extension post. This is one reason that an activity noise assurance shield hoses high frequency much better that low frequencies.

With regards to sound there are two ascribes to mull over, tone and loudness. The physical sum for loudness is sound pressure, and for tone it is frequency. Frequency is the rehashed events in a given time interim and it's deliberate in Hertz (Hz). 1 Hz implies that one event rehashes once every second. The scope of frequency in a specialized viewpoint covers more than the area that is capable of being heard by the human ear, the hearing level. For the human ear the hearing extent begins around 16 Hz and goes up to around 20 000 Hz and the area in which the human hearing is most touchy is in 1000 – 3000 Hz. [3]

Sound	Frequency, Hertz (Hz)
Audible sound	16 Hz - 16 kHz
Ultrasound	> 16 kHz
Infrasound	< 16 Hz
Hypersound	> 1 GHz

Table 2.1 Categories of frequency. [3]

The human ear isn't similarly delicate to all frequencies, the view of sound relies upon sound pressure level, the target strength and furthermore on a confused way of the spectral composition of sound signal, span and different variables. Underneath the scope of discernable sound to the human ear, the frequency run is known as the infrasound. The infrasound is more pertinent when managing vibration control of machinery and structures for instance. Over the hearing extent is the ultrasound, which is utilized as a part of uses as therapeutic analysis. The human voice exists in 500-4000 Hz and the human hearing is most responsive to sounds in that area. Sounds can be isolated into classes as far as frequency. [3]

2.2 Decibel

Diverse sounds have distinctive force. To have the capacity to gauge the power generally the logical unit decibel (dB) is utilized, and the most effortless approach to portray it is the volume of sound, the sound pressure. The sound pressure is the contrast between the quick pressure and the static pressure. The idea of decibel is logarithmic, and the scale is planned by the limit of the human becoming aware of detecting sound pressure. The pressure of sound sinks with increasing distance from the source of the sound. How we see sound is extremely individual, a few people have a torment edge at 120-130 dB, however in the event that you are sensible to sound or have a debilitated hearing you have a breaking point at 40-50 dB. What additionally assumes a part is to what extent one is presented to the sound. On the off chance that presented to 100 dB for fifteen minutes it has an indistinguishable impact from on the off chance that one is presented to 85 dB for eight hours. [3]

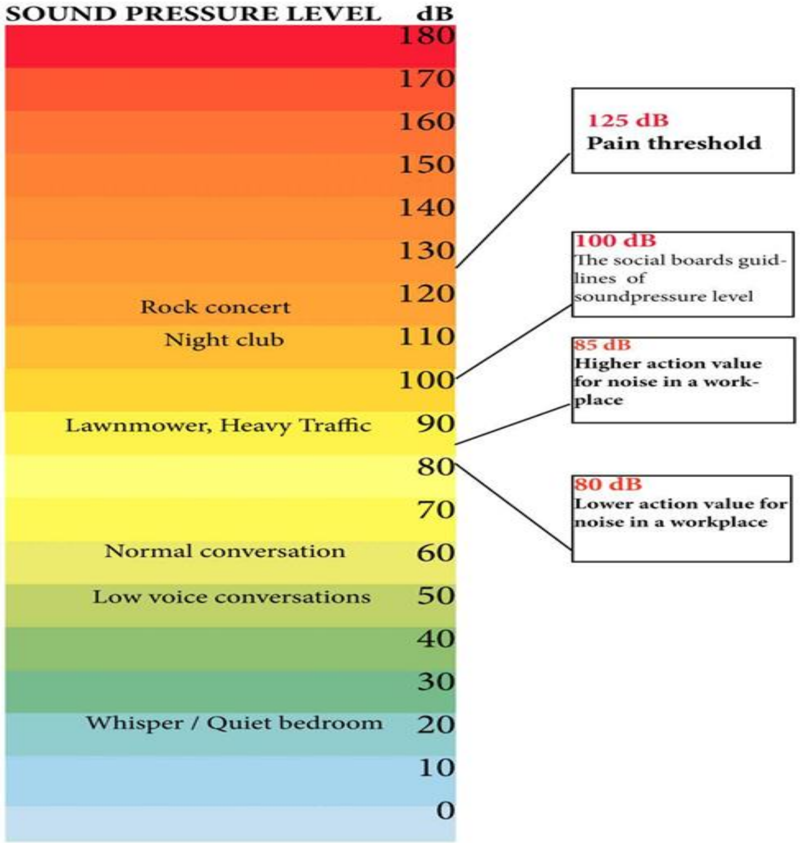


Figure 2.1 Examples of sound are shown and to what dB level they correspond. [3]

2.3 Sound and Noise

Noise can be characterized as "unsavory or undesired sound" or other aggravation. From the acoustics perspective, sound and noise constitute a similar wonder of air pressure variances about the mean environmental pressure; the separation is enormously subjective. What is sound to one individual can likely be noise to another person. The acknowledgment of noise as a genuine wellbeing danger is an improvement of current circumstances. With present day industry the huge number of sources has quickened noise incited hearing loss; opened up music also inflicts significant damage. While enhanced music might be considered as sound (not noise) and to offer delight to numerous, the over the top noise of quite a piece of current industry most likely offers joy to not very many, or none by any stretch of the imagination.

Sound (or noise) is the consequence of pressure varieties, or motions, in a elastic medium (e.g., air, water, solids), created by a vibrating surface, or turbulent liquid flow. Sound propagates as longitudinal (instead of transverse) waves, including a progression of compressions and rarefactions in the flexible medium. At the point when a sound wave propagates in air, the motions in pressure are above and underneath the surrounding atmospheric pressure. [5]

2.4 Sound generation:

Any source of vibration, which irritates air atoms, makes sound. It pushes and pulls air atoms that conversion over the vibrations into acoustic signs, known as sound. Sound relies upon three things: vibration source to shape a sound wave, wave transporter medium, (for example, air) and a receiver to recognize the sound (Fig.2.2). Sound source oscillates and brings the surrounding air into movement and within the sight of a receiver, sound can be perceived. Sound is a mechanical unsettling influence that goes through a elastic or thick medium at a speed contingent upon the normal for that medium. Sound is a wave movement in a elastic media, for example, air, water or a stone. While air tubulates, the mass and momentum sources of a material are eventually sound generators. [4]

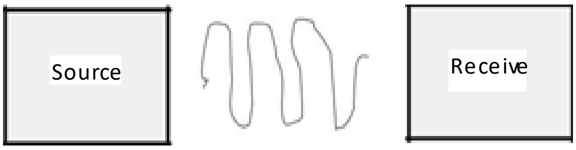


Figure 2.2 Sound generation [4]

2.5 When Sound hits in the Surface

Absorption

The sound wave interface with the material or object surface and might be absorbed, transmitted, reflected, refracted or diffracted shape the surface contingent upon kind of the surface. These phenomena are described in Fig. 2.3. At the point when all the discharged sound waves are consumed by the receiver, sound absorption happens. It is precisely similar to wipe absorbing water. Sound absorption is a vital phenomenon the extent that sound insulation is concerned. There are diverse materials accessible for sound absorption. The sound absorbers might be porous or resonant. Porous sponges are named fibrous materials and open-celled foams. Fibrous materials conversion over acoustic energy into heat energy when sound waves encroach the absorber. If there should arise an occurrence of foam, sound wave dislodging happens through a restricted section of foam and causes heat loss. Reverberation sponges are of mechanical type, where there is a strong plate with a tight air space behind. It is vital that some material, for example, foam absorbs sound waves through the glass blocks it. The determination of material to be utilized relies upon the end utilize application. For instance, the workplace room in a building can be planned as sound absorbing or sound sealing. Sound absorption measures the measure of energy consumed by the material and communicated as sound absorption coefficient (α). The coefficient goes between of 0 and 1 where 0 is no absorption and 1 is most elevated or total absorption. The higher coefficient yields bring down reverberation time. The reverberation time is diligence of sound in a space after a sound source has been stopped. It is the time slack, in seconds, for the sound to rot by 60 dB after a sound source has been stopped. Sound absorption is vital to make the acoustic condition reasonable for a particular reason; for example, in recording studios, address corridors, show rooms, address theaters, and so forth. The low frequency sound of 500 Hz is generally hard to absorb than high frequency sound. [4]

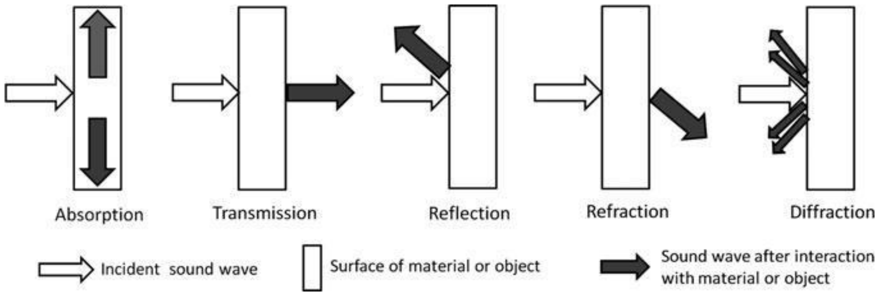


Figure 2.3 Sound wave interaction with material or object surface [4]

Transmission

Sound waves from the source propagate through the medium and collector without being consumed or reflected and go through the receiver with no frequency loss, which is known as sound transmission. [4]

Reflection

At the point when sound waves encroach on hard or smooth surface they may reflect back with their full energy without modifying their qualities. The reflection angle of sound wave from the reflecting surface is equivalent to the angle of occurrence. The angles are characterized between a typical to the reflecting plane and the incident and reflected waves. The reflected sound waves, accordingly, take after Huygen's geometry where both the frequency and reflection points are equivalent.

The reflection phenomenon of sound waves finds numerous applications. For instance, a reflected sound wave is utilized to quantify the depth of water from ocean level with the assistance of reverberate delivered from the reflective surface. The land arrangement at the base of the sea and in the earth hull is also distinguished utilizing the impression of sound wave. Resound is a straightforward case of sound reflection wonder. Reverberate can be heard when the sound wave, opposite to the sound source, hits a level and smooth surface. [4]

Refraction

Refraction happens when sound waves transmit through the surface and bend away from the straight line of travel. Sound refraction relies upon variables, for example, the speed of sound, angle between sound propagation direction and wind direction and atmospheric conditions, for example, temperature and relative humidity. [4]

Diffraction

Diffraction includes an adjustment toward sound waves as it strikes through a surface. Sound waves when affect on an incomplete barrier, some of them get mirrored, some engender with no unsettling influence and some twisted or diffract over the highest point of the obstruction [4]. As sound source draws nearer to the boundary, less solid diffraction is acquired. The sound at bring down frequencies has a tendency to diffract more effortlessly than sound at higher frequencies. [4]

Sound Insulation

Sound insulation is soundproofing of an encased space. It is obvious that when all the sound waves consumed by the receiver, the encased space is said to be sound protected. In acoustic science, sound insulation has turned out to be imperative especially in present days to counteract noise contamination. Sound insulation material is embedded in where sound insulation is required; for example, in private and business places. The protecting material, for example, fiber glass, foam, and so forth can be granted in roof, dividers and base of the floor. The adequacy of the distinctive sound absorbing materials can be assessed utilizing a review scale. This is referred as sound classification system. [4]

2.6 Amplitude, Frequency and Wavelength

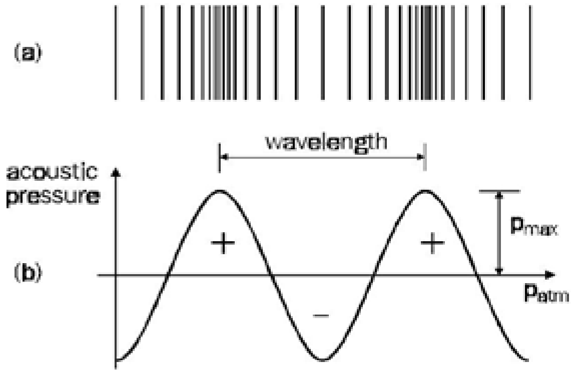


Figure 2.4 Representation of a sound wave (a) compressions and rarefactions caused in air by the sound wave.[5] (b) graphic representation of pressure variations above and below atmospheric pressure.

Sound waves which consist of a pure tone only are characterized by the amplitude of pressure changes, which can be described by the maximum pressure amplitude, Pm, or the root-mean-square (RMS) amplitude, Prms and is expressed in Pascal (Pa). Root-mean-square means that the instantaneous sound pressures (which can be positive or negative) are squared, average and the square root of the average is taken. The quantity, Prms = 0.707 Pm; the wavelength (λ), which is the diameter travelled by the pressure wave during one cycle; the frequency (f), which is the number of pressure variation cycles in the medium per unit time, or simply, the number of cycles per second, and is expressed in Hertz (Hz). Noise is usually composed of many frequencies combined together. The relation between wavelength and frequency can be seen in Figure 2.4 the period (T), which is the time taken for one cycle of a wave to pass a fixed point. It is related to frequency by: $T = \frac{1}{f}$

The speed of sound propagation, c, the frequency, f, and the wavelength λ are related by the following equation: $c = f\lambda$ the speed of propagation, c, of sound in air is 343 m/s, at 20 C and 1 atmosphere pressure. At other temperatures (not too different from 20 C), it may be calculated using: $c = 332 + 0.6Tc$ [5]

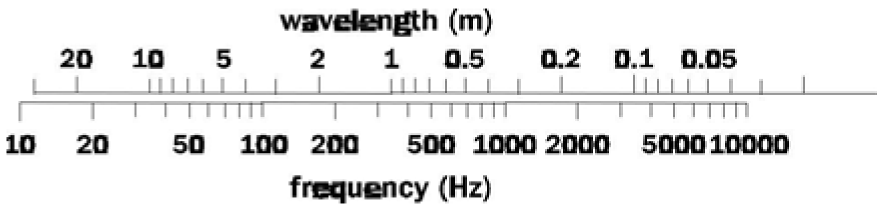


Figure 2.5 Wavelength in air versus frequency under normal conditions. [5]

2.7 Frequency Analysis

Frequency investigation might be thought of as a procedure by which a period differing signal in the time space is changed to its frequency sections in the frequency area. It can be utilized for measurement of a noise issue, as the two criteria and proposed controls are frequency subordinate. Specifically, tonal parts which are recognized by the investigation might be dealt with fairly uniquely in contrast to broadband noise. Once in a while frequency investigation is utilized for noise source and in all cases frequency examination will permit assurance of the viability controls. There are various instruments accessible for completing a frequency investigation of discretionarily time-changing signs as described.

Accordingly, the International Standards Organization has settled upon "preferred" frequency groups for sound measurement and investigation. [5]

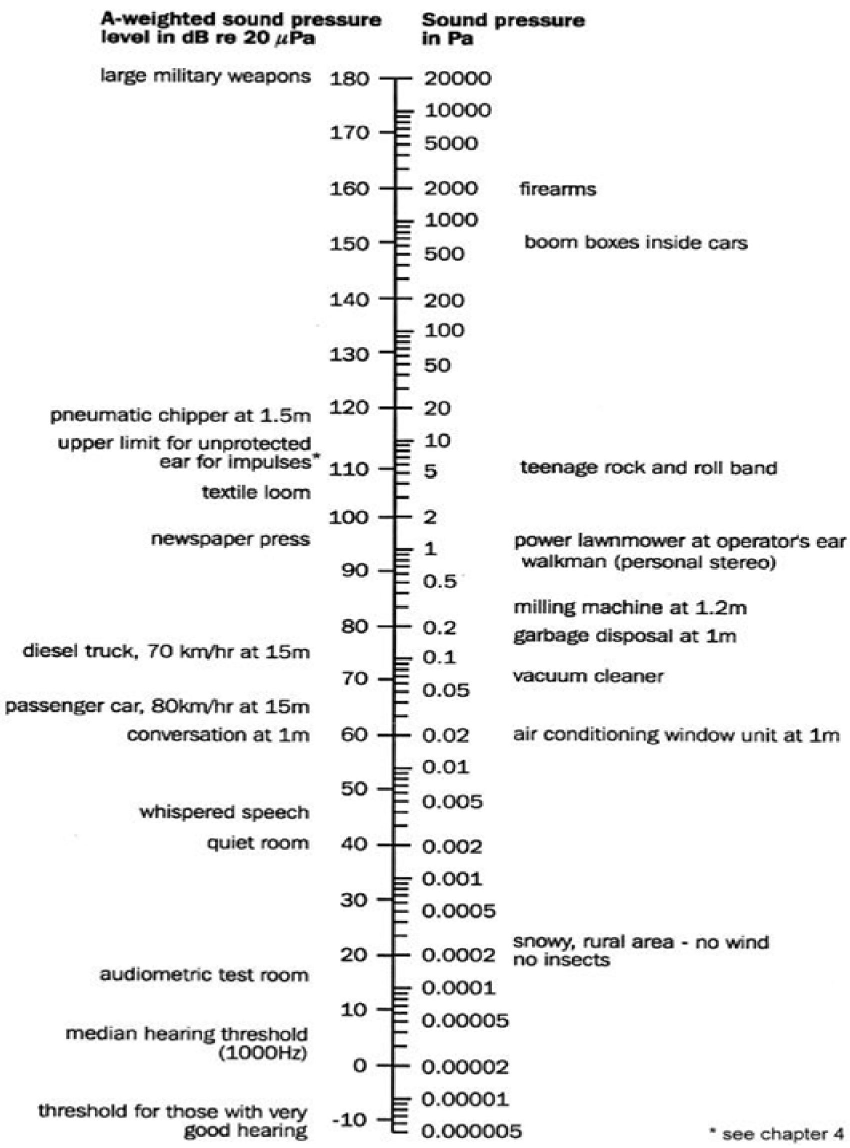


Figure 2.6 Sound levels produced by typical noise sources [5]

2.8 Propagation of Noise

A free field is a homogeneous medium, free from limits or reflecting surfaces. Considering the least difficult type of a sound source, which would transmit sound similarly every which way from an evident point, the energy discharged at a given time will diffuse every which way and, one moment later, will be disseminated over the surface of a circle of 340 m radius. This kind of spread is said to be circular and is produced in Figure 2.7.

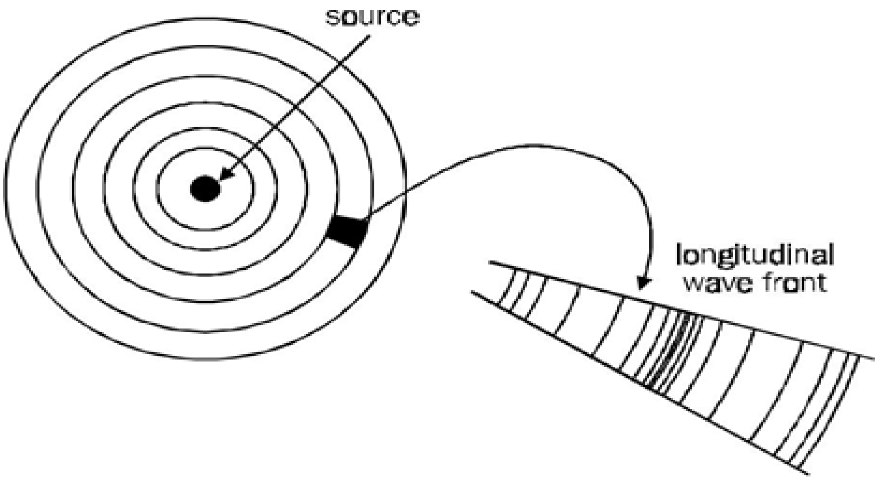


Figure 2.7 A representation of the radiation of sound from a simple source in free field. [5]

2.9 Types of Noise

Noise might be delegated steady, non-steady or impulsive, contingent on the fleeting varieties in sound pressure level. The different types of noise and instrumentation required for their measurement are outlined.

Steady noise is a noise with unimportantly little variances of sound pressure level interior the time of perception. In the event that a somewhat more exact single-number portrayal is required, evaluation by NR (Noise Rating) bends might be utilized.

A noise is called non-steady when its sound pressure levels move altogether during the time of perception. This kind of noise can be separated into discontinuous noise and fluctuating noise.

Fluctuating noise is a noise for which the level changes ceaselessly and, as it were, during the time of perception.

Tonal noise might be either ceaseless or fluctuating and is described by maybe a couple single frequencies. This kind of noise is substantially more irritating than broadband noise described by energy at a wide area of frequencies and of a similar sound pressure level as the tonal noise. [5]

Chapter 03: Overview of Acoustic textile materials, General mechanism of noise reduction and considering factors.

3.1 Textile material for sound reduction:

Textile materials are used to use in noise reduction possible in any form such as the fiber or fabric form. Natural, synthetic, protein fiber such as cotton, silk, hemp wool, and polyester usually used to use as noise reduction system. Fabrics made from the same type of fibers are also able to use in noise reduction processes which depend on the material needed type.

Cotton - Considering the light weight, biodegradability and minimal effort of the cotton raw material, the carbonized and enacted cotton nonwoven can possibly be utilized as superior and practical acoustical materials.

Silk for Curtain - Silk weavers, have created light weight, translucent blind materials, which are phenomenal at absorbing sound. This is a blend that has been missing as of not long ago in current interior plan.

Hemp - Hemp fiber is normally antimicrobial and impervious to bright light, shape, buildup, and creepy crawlies, which makes it of potential use in open air applications. [6]

Wool Carpet - wool cover is a standout amongst the most pragmatic and financially savvy products accessible for controlling noise in the manufactured condition. Wool cover decreases airborne sound, Wool cover reduces surface noise, Wool cover decreases noise transmission, Wool cover gives predominant acoustic insulation. [18]

3.2 Sound absorptive materials:

Materials that decrease the acoustic energy of a sound wave as the wave goes through it by the phenomenon of absorption are called sound absorptive materials. They are commonly used to soften the acoustic condition of a shut volume by reducing the amplitude of the reflected waves. Absorptive materials are by and large resistive in nature, either fibrous, porous or in rather exceptional cases receptive resonators. Exemplary cases of resistive material are nonwovens, fibrous glass, mineral woods, felt and foams. Resonators include hollow core workmanship pieces, sintered metal et cetera. A large portion of these products give some level of absorption at about all frequencies and execution at low frequencies commonly increases with increasing material thickness.

Porous materials utilized for noise control are by and large typed as fibrous medium or porous foam. Fibrous media as a rule comprises of glass, rock wood or polyester fibers and have high acoustic absorption. Now and then fireproof fibers are also utilized as a part of making acoustical products. Commonly sound walls are mistaken for sound absorbing materials. For the most part materials that give great absorption are poor obstructions. Not at all like, boundaries and damping materials, the mass of the material has no immediate impact on the execution of the absorptive materials. [7]

3.3 Mechanism of Sound Absorption in Fibrous Materials

A few materials enable sound to effortlessly enter it. These materials are called porous. Acoustic porous materials can have porosity more than 90%. Normal sound absorption materials are open cell foam and fiber. Sound absorption is a energy transformation process. The kinetic energy of the sound (air) is conversion over to heat energy when the sound strikes the cells or fibers. Thus, the sound vanishes after striking the material because of its conversion into heat.

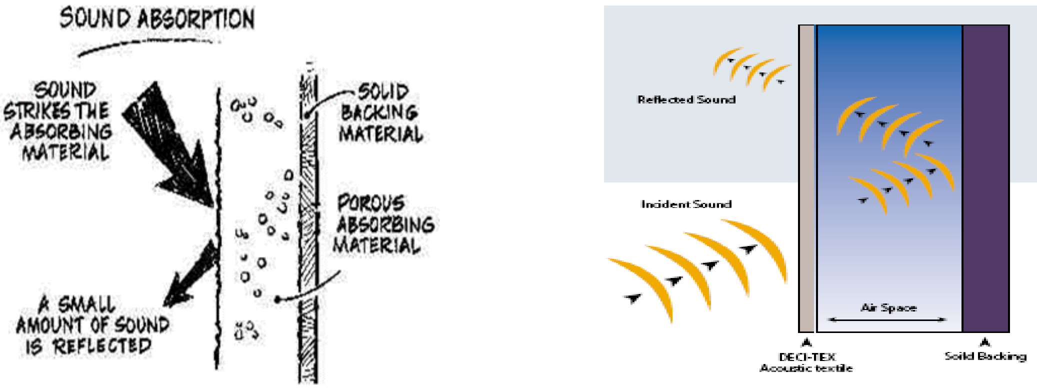


Figure 3.1: Sound absorptive materials [7]

The absorption of sound results from the scattering of acoustic energy to heat. At the point, when sound enters porous materials, attributable of sound pressure, air particles waver in the interstices of the porous material with the frequency of the energizing sound wave. This wavering outcome in friction losses. A conversion in the flow direction of sound waves, together with development and compression phenomenon through irregular pores, as a result, loss of momentum. Owing of energizing of sound, air atoms in the pores experience periodic compression and relaxation. This results in conversion of temperature. Because of, long time, large surface to volume ratios and high heat conductivity of fibers, heat exchange isothermally at low frequencies. In the mean time in the high frequency area compression happens adiabatically. In the frequency locale between these isothermal and adiabatic pressure, the heat exchange brings about loss of sound energy. This loss is high in fibrous materials if the sound spreads parallel to the plane of fiber and may account up to 40% sound constriction. Along these lines, the explanations behind the acoustic energy loss, when sound goes through sound absorbing materials are expected to:

- Frictional losses
- Momentum losses
- Temperature fluctuation

The more fibrous a material is the better the absorption; then again denser materials are less absorptive. The sound absorbing qualities of acoustical materials shift fundamentally with frequency. When all is said in done low frequency sounds are exceptionally hard to absorb in view of their long wavelength. On the other hand, we are less defenseless to low frequency sounds. [7]

3.4 Measurement of Sound Absorption

Sound is a variation of pressure that propagates through a elastic medium, for example, air which creates a sound-related. Logical investigation of sound including the impact of reflection, refraction, absorption, diffraction and obstruction is known as "Acoustics".

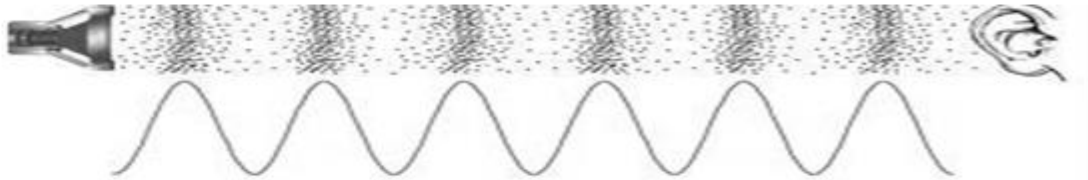


Figure 3.2: Alternative patterns of dense and sparse particles [8]

Sound absorption is an energy conversion process. The kinetic energy of the sound (air) is conversion over to heat energy when the sound strikes the cells or filaments. While diffused reflection splits the reflected sound wave in numerous ways. Diffusive surfaces are utilized to stay away from echoes and sound fixations particularly in rooms intended for music. Sound wave achieves a surface of acoustic material during its spread in air and gets separated into three sections: a reflected section, a transmitted part and absorbed part (Figure 3.3). A collector on an indistinguishable side from the sound source can get both the incident and reflected sound waves. The capacity of the acoustic material to absorb the occurrence sound wave can be assessed by contrasting the sound power levels between the reflected sound wave and the incident sound wave. The absorption coefficient α is communicated as: $\alpha = \frac{\text{transmitted + absorbed energy}}{\text{total incident energy}}$

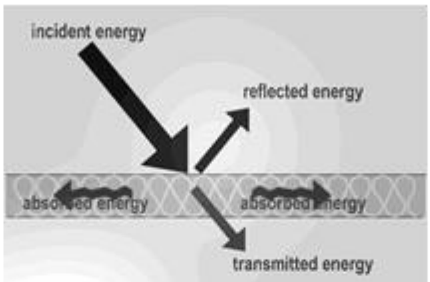


Figure 3.3: Sound wave propagation [8]

Estimation procedures used to describe the sound absorptive properties of a material are reverberant field strategy, impedance tube technique and consistent state technique. Reverberant field technique is utilized to quantify the execution of a material presented to a haphazardly incident sound wave, which actually happens when the material is in diffusive field. Impedance tube strategy utilizes plane sound waves that strike the material straight thus the sound absorption coefficient is called ordinary rate noise absorption coefficient (NAC). Relentless state strategy is utilized to quantify the transmission coefficient of the materials. A third receiver or even a moment combine of amplifier can be set behind the sample in a moment impedance tube.

Acoustical properties of fabrics are measured by impedance tube technique. The impedance tube strategy utilizes little sample samples. For substantial test samples, large reverberation rooms are utilized, and the strategy is known as acoustic chamber technique [8]. The estimation of sound absorption of the nonwoven based on ASTM E 1050 utilizing a tube, two microphones and a computerized frequency analyzer as appeared in Figure 3.4. A sound source is mounted toward one side of the impedance tube and the material example is put at the other side. The amplifier produces broadband, stationary random sound waves. These occurrence sound signs spread as plane waves in the tube and hit the example surface. The mirrored wave's signs are grabbed and contrasted with the occurrence sound waves. The frequency of waves is tried by the diameter of the tube. A large tube (100mm diameter) is utilized to quantify the sound absorption in the low frequency extend (50 to1600Hz), while a little container of 29 mm measurement is utilized for high-frequency sound waves.

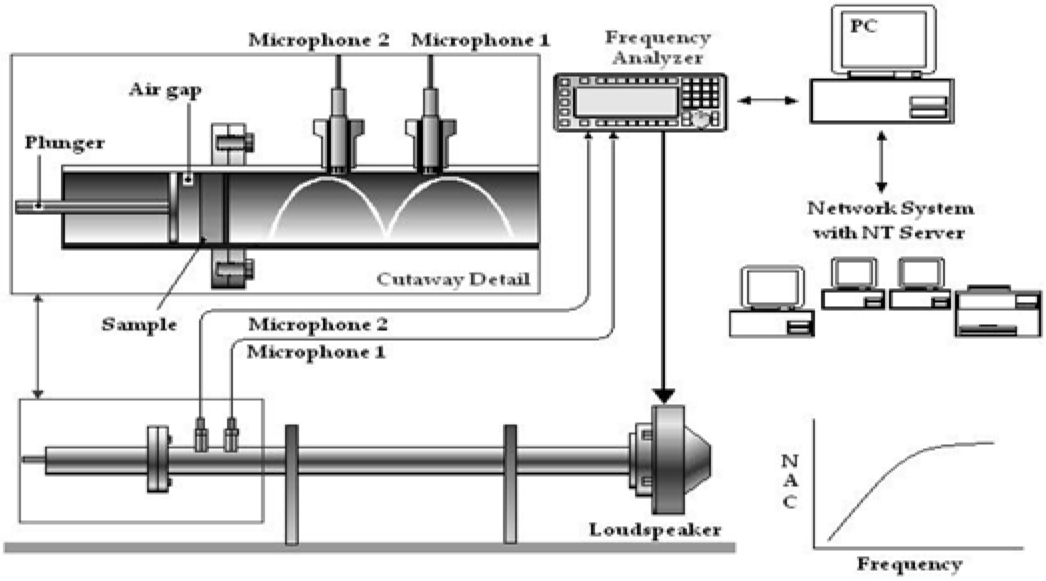


Figure 3.4: Impedance tube setup [8]

3.5 Absorbent Material:

3.5.1 Porous Absorber

Porous absorbers are the most ordinarily utilized absorbing materials, where thickness assumes a critical part in sound absorption. These materials enable air to flow into clear structure where sound energy is conversion over to heat energy. Regular porous absorbers include carpet, draperies, spray applied cellulose, aerated plaster and fibrous mineral wool/glass fiber (Figure 3.5)

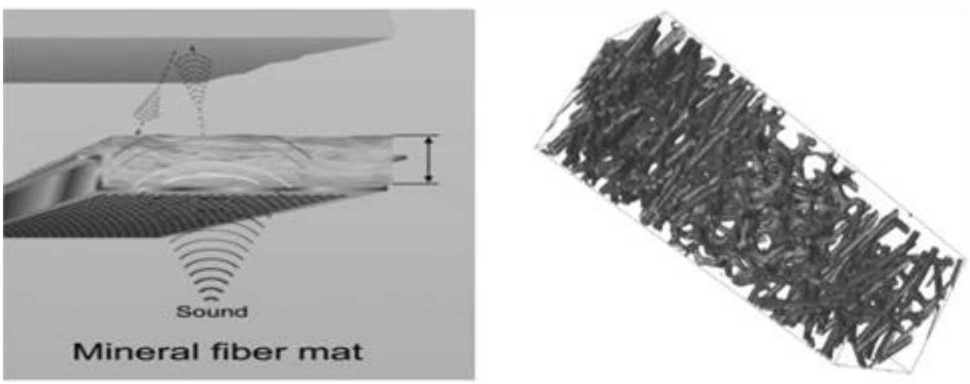


Figure 3.5: Porous absorbers [8]

3.5.2 Resonators

Resonant absorption does not rely upon the properties of the material similarly with respect to porous absorption. The absorption is acquired by energy losses in a wavering system. There are two fundamental types of resonators: Membrane and Cavity (Helmholtz) Resonators. Cavity resonators as appeared in Figure 3.6, commonly act to absorb sound in a limited frequency run. These resonators include some perforated materials; e.g. HELMHOLTZ resonator. It has the state of a jug and the resonant frequency is represented by the span of the opening, the length of neck and the volume of air caught in the chamber.

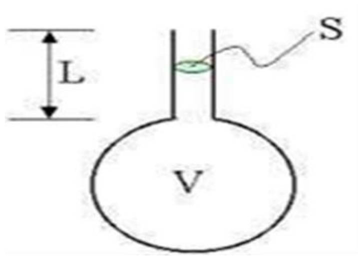


Figure 3.6: Cavity resonator [8]

Panel absorbers or membrane resonator is a thin, solid panel at a separation from an inflexible divider with an encased air volume in the middle. Panel absorbers are non-rigid, non-porous materials which are put over an airspace that vibrates in a flexural mode in response of sound pressure applied by contiguous air particles. Normal panel absorbers include thin wood panels over casing, light weight impenetrable roof and floors, coating and other extensive surfaces equipped for reverberating because of sound.

3.5.3 Smart Absorbing Materials

More recently, the utilization of active noise control has been joined with passive control to create hybrid sound absorbers. Active control advancements seem, by all accounts, to be the best way to lessen the low-frequency noise parts. In this way, a hybrid absorber can absorb the occurrence sound over a wide frequency run. Figure 3.7 demonstrates the guideline of a hybrid absorber, which joins passive absorbent properties of a porous layer and active control at its back face, where the controller can be actualized utilizing computerized procedures.

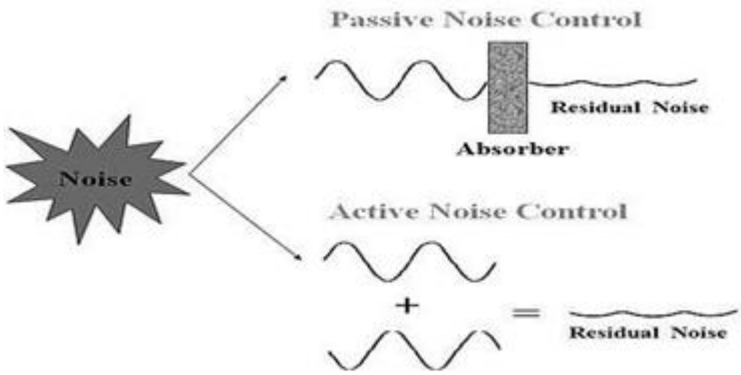


Figure 3.7: Hybrid sound absorber [8]

3.6 Factors affecting for the noise absorption system:

Concentrates on different parameters that impact the sound absorption properties of fibrous materials have been distributed generally in the writing. A summary of those work are given beneath.

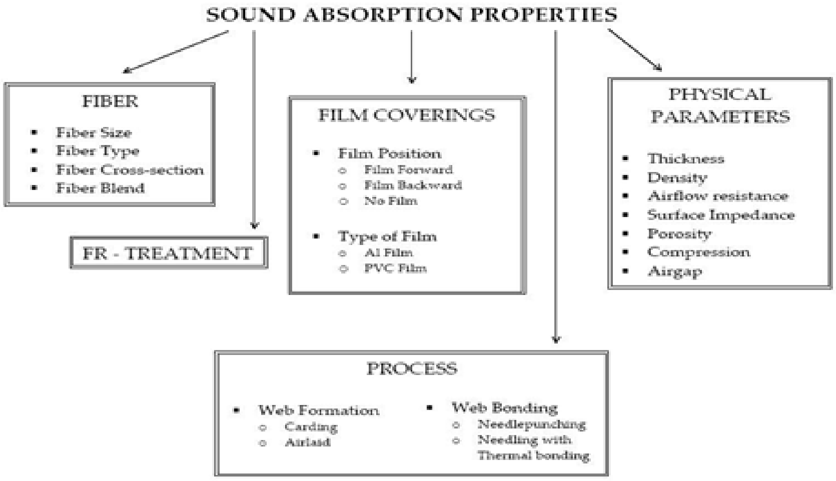


Figure 3.8: Sound Absorption Properties [7]

Fiber diameter:

An increase in sound absorption coefficient with a decrease in fiber diameter. This is because, thin filaments can move more effortlessly than thick fibers on sound waves. Additionally, with fine denier filaments more fiber are required to achieve for same volume thickness which brings about a more tortuous path and higher air flow resistance. An examination presumed that the fine fiber content increase NAC values. The increase was because of an increase in airflow insulation by methods for friction of viscosity through the vibration of the air. An examination demonstrated that fine denier fibers running from 1.5 - 6 denier/fiber (dpf) perform preferred acoustically over coarse denier filaments. Additionally, it has been accounted for that, small scale denier filaments (under 1 dpf) give an dramatic increase in acoustical performance. [7]

Fiber Surface Area:

There is an immediate connection between sound absorption and fiber surface area. The examination clarified that the friction between fiber and air increases with fiber surface area bringing a higher sound absorption. Additionally, it has been said that, in the frequency extend 1125 Hz – 5000 Hz, fibers with serrated cross section (e.g., Kenaf) absorb more sound contrasted with ones with round cross-sectional area. The sound absorption in porous material is because of the viscosity of air pressure in the pores or the friction of pore wall. Consequently, sound absorption increases with specific surface area of fiber with increase of relative density and friction of pore wall. Man-made filaments are accessible in different cross-sectional shapes for example: hollow, pentagonal and other novel shapes like 4DG fibers. These cross-sectional shapes can include acoustical incentive by giving more surface area than typical round normal round shape fiber. [7]

Airflow Resistance:

A most important qualities that impact the sound absorption attributes of a nonwoven material is the particular air flow insulation per unit thickness of the material. The trademark impedance and spread steady, which describes the acoustical properties of porous materials, are represented, by air flow insulation of the material. Filaments interlocking in nonwovens are the frictional components that give insulation from acoustic wave movement. As a rule, when sound enters these materials, its frequency is decreased by friction as the waves attempt to travel through the tortuous path. In this way the acoustic energy is conversion over into heat. [7]

Porosity:

Number, size and kind of pores are the major components that one ought to consider while examining sound absorption mechanism in porous materials. To permit sound dissemination by friction, the sound wave needs to enter the porous material. This implies, there ought to be sufficient pores on the surface of the material for the sound to go through and get dampened. The porosity of a porous material is defined as the ratio of the volume of the voids in the material to its total volume. In planning a nonwoven web to have a high solid absorption coefficient, porosity should increase along the engendering of the sound wave. [7]

Tortuosity:

Tortuosity is a measure of the extension of the section path through the pores, contrasted with the thickness of the example. Tortuosity describe the impact of the interior structure of a material on its acoustical properties. It is a measure of how far the pores deviate from the normal, or wander about the material. It was expressed that, tortuosity chiefly influences the area of the quarter wavelength peaks, though porosity and flow resistivity influence the height and diameter of the peaks. It has additionally been said by the estimation of tortuosity decides the high frequency behavior of sound absorption porous materials. [7]

Thickness:

Various examinations that managed sound absorption in porous materials have conclude that low frequency sound absorption has direct relation with thickness. The general guideline decide that has been taken after is the successful sound absorption of a porous absorber is accomplished when the material thickness is around one tenth of the wavelength of the occurrence sound. Peaks absorption happens at a resonant frequency of one-quarter wavelength of the incident sound (overlooking compliance impact) A study demonstrated the increase of sound absorption just at low frequencies, as the material gets thicker. However, at higher frequencies thickness has irrelevant impact on sound absorption. At the point when there is air space inside and behind the material, the most maximum estimation of the sound absorption coefficient moves from the high to the low frequency area. [7]

Density:

Density of a material is frequently thought to be the vital factor that oversees the sound absorption behavior of the material. In the meantime, cost of an acoustical material is specifically identified with its density. An investigation demonstrated that the increase of sound absorption value in the middle and higher frequency as the thickness of the example increased. The quantity of fiber increases per unit area when the obvious density is large. Energy losses increases as the surface friction increase; accordingly the sound absorption coefficient increases. Not so much thick but rather more open structure absorbs sound of low frequencies (500 Hz). Denser structure performs preferable for frequencies above over 2000 Hz. [7]

Compression:

Very little has been published on the impact of compression on sound absorption behavior. A paper demonstrated that, compression of fibrous mats decreases the sound absorption properties. Under compression the different filaments in the tangle are conveyed closer to each other with no twisting (with no adjustment in fiber size). This compression results in a decrease of thickness. Compression brought about an increase in tortuosity and air flow resistivity, and a decreasing of porosity and thermal characteristic length (shape factor). Regardless of these physical parameter varieties in the compacted material. The reason for a drop in sound absorption value is mainly due to a decrease a sample thickness. The impact of compression on sound absorption can assume an essential part in the field of car acoustics. The seat cushioning in the vehicle is subjected to pressure/extension cycles because of the traveler's pressure. This results in crushing down the porous materials (fibrous or cell) which thus brings about variety of the above physical parameters. [7]

Surface Treatments:

Acoustical materials are utilized interior structures and these materials need to satisfy standards, for example, material ought to have great light reflecting behavior, ought to have a decent appearance etcetera. Frequently when utilized interior structures, acoustical materials are covered with paints or some finishes. Accordingly, it is important to examine the impact of these surface coatings on sound absorptive behavior. It was discovered that, more open surface type materials experience the bad effects of the use of paint. In this way, it was proposed that a thin layer of paint covering ought to be connected over the material surface. This should be possible with the assistance of spray gum. Here and there, fibrous materials are covered with film in order to enhance the sound absorption properties at low frequencies by the phenomenon of surface vibration of film. [7]

Arrangement/Position of Sound Absorptive Materials:

Sound absorption of a material depends additionally on the position and arrangement of that material. It has been accounted for that if a few types of absorbers are utilized, it is desirable to put some of each type on end, sides and roofs so that every one of the 3 axial modes (longitudinal, transverse and vertical) will go under their impact. In rectangular rooms it has been shown that absorbing material put close corners and along edges of room surfaces is best. In speech studios, some absorbents that are viable at higher sound frequencies ought to be connected at head height on the wall. Truth be told, material applied to the lower parts of high walls can be as much a twice as effective as a similar material put somewhere else. Additionally, it is suggested that untreated surfaces ought to never face each other. [7]

Surface Impedance:

The higher the acoustic resistivity of a material, the higher is its dispersal, for a given layer of thickness. In the meantime the surface impedance of the layer also increases with resistivity, bringing about a greater amount of reflections at surface layer, giving a lower absorptivity capacity. In addition the entire procedure is frequency subordinate, so that for bring down frequency groups the vital layer thickness increases as resistivity decreases.

Performance generally increases with an increase in frequency. In this manner in true applications, sound absorptive materials are picked by the area of sound being emitted. For instance, in car noise control, more thin materials that are fit for absorbing high frequencies are utilized for main events. In the meantime, thicker materials fit for absorbing lower frequencies are utilized for entry way panels and cover backing. Along these lines, it is basic to know the area of frequencies that should be controlled in order to have powerful utilization of sound absorptive materials. [7]

3.7 Addition of a Woven Fabric Layer in Nonwoven Fiber Webs

The noise absorption by blends of a few layers of nonwoven fiber networks of high noise absorption coefficients and a layer of woven fabric of high noise reflection coefficient has been examined. The deliberate sound absorption coefficients, in the perceptible frequency extend, of such blends were fundamentally higher than those of the fiber-web layers independent from anyone else. To decide tentatively the ideal area of the woven fabric in respect to the fiber-web layers, the NAC of a blend of six layers of cotton fiber web and one layer of woven fabric made of Kevlar have been measured. The most greater sound absorption was acquired when the layer nearest to the source of noise was the woven fabric. For this situation, the commitment of the woven fabric to the noise absorption limit of the nonwoven fiber networks was most greater (20-40%) in the lower-frequency go ($f<500$ Hz). [8]

3.8 Plasma Treatment

The plasma treatment on nonwoven fabrics conversions their sound absorption, viscoelastic behavior, fabric weight and pore measurement by changing the fiber surface morphology. Plasma treatment has both compound and mechanical consequences for fibers, surface carving and ionic charging. Scratching happens when the particles with high active energy hit the surface, evacuate the frail part or debased locale of filaments. Hollow polyester fabric demonstrates the increased sound absorption and viscoelastic behavior after the treatment with increased pore sizes, while standard polyester fabric shows immaterial conversions. The cellulose fabrics are influenced more by plasma treatment when contrasted with polyester fabrics regarding fabric weight reduction and pore measure. Jute fabric exhibits the decreased sound absorption and viscoelastic behavior, while kenaf fabric demonstrates the increased sound absorption with the unaltered viscoelastic behavior after the treatment. [8]

3.9 Orientation of Web

The nonwovens absorber which has an unoriented web in the core layer has a higher NAC than nonwovens which have a completely situated web structure, however the distinction is peripheral. Web introduction impacts were investigated through the nonwoven made out of a similar fiber contents, however with various angles (0°, 35°, 45° and 90°), produced and controlled during the checking procedure. The NAC (Noise absorbing coefficient) of multi-angle layered web is appeared. The most elevated NAC, which implies the higher angle variety gives littler pore sizes. The pore measure as well as air insulation is connected with web layering properties, despite the fact that the distinction in the NAC is minimal in the low and high frequencies, and even at core frequency it didn't demonstrate any awesome contrast. Along these lines, the distinction of NAC between samples was inconsequential for the given example and frequency conditions (within an extremely wide area). [8]

3.10 Some processes of Sound reduction:

Noise control issues and the emergence of sound strength is becoming very important in an automotive product design, acoustic material and is increasingly relevant to engineers, designers and manufacturers from a broad image of industries. Sound absorptive materials are generally used to counteract the undesirable effects of sound reflection by hard, rigid and interior surfaces and thus help to reduce the reverberant noise levels

There are some renowned processes to make noise less i.e, Absorption, Mass Layers and Damping.

Absorption -The two common materials for acoustic absorbers are open-cell urethane foams and fiberglass. High-strength panels in urethane and fiberglass are of about the same acoustic effectiveness for the same thickness. [9]

Mass Layers - Mass layers must be non-porous and limp for maximum effectiveness. Plywood and other stiff lightweight materials do not block sound as well because their stiffness properties allow them to transmit noise through sympathetic vibrations.

Damping - Damping materials are typically in sheet and tile format, as well as spray able and bush able compounds whether for extension or constrained treatments. [9]

Chapter 04: Role of different Fibers in the noise absorption.

4.1 Polyester Fiber for Sound Absorption and Influencing Parameters:

4.1.1 Polyester fiber studies:

Polyester fiber products are for the most part known as non-woven or bonded fiber fabrics. This industry has developed significantly during this century due to the improvement of a few manufactured polymer fibers, of which polyester is one. Chemically, polyester is a polymeric ester shaped by the reaction of a acid (terephthalic acid) with alcohol (ethylene glycol). The fibers are at that point spun from liquid polymer and this produces polyester fibers with for all intents and purposes round cross-sections. Every single manufactured fiber, for example, nylon, polyester and acrylics now contend with natural fibers, for example, cotton and wool in the creation of textiles. The fibers are normally hacked into short lengths called staple fibers which are then used to form web structures. The webs are shaped by a progression of rollers secured with saw tooth wires. The outcome is basically parallelized webs, although recent improvements permit the generation of three-dimensional webs from carding machines. Since the mass/area of the web from a carding machine is constrained, utilize is made of cross-lappers which develop the important layers to accomplish the desired mass/area. Notwithstanding when the fibers have been organized in a web despite everything they must be bonded together as the unbonded web has insignificant strength and would pull separated effectively. This binding is accomplished with a binder which can be either a adhesive connected to the web or a thermoplastic fiber that constitutes some portion of the web. In the polyester fiber material concentrated here, thermoplastic binding fibers consisting of low melting point polyester are blended at the feeder area with different fibers. The bonding is accomplished by heating the fiber blend under controlled conditions to a reasonable temperature took after instantly by quick cooling. The binding fibers melt locally and wire or weld together with other normal polyester where they touch. The fitting blend ratio is dictated by the strength and bulkiness expected of the last product. One preferred standpoint of the polyester fiber product is that it is recyclable, i.e. the completed product can be broken down to the crude material again if necessary. [10]

4.1.2 Considered variables of Polyester Fiber for Acoustic Application:

Various parameters can be fluctuated in the polyester fiber web (held together by the binding filaments) to create a last result of required properties and appearance. [10] These include:

i. length of polyester fiber

ii. length of binding fiber

iii. mass/area of the last product

iv. thickness of the batt or blanket produced

v. diameter of the consistent polyester fibers

vi. kind of fibers - hollow or solid

vii. percentage of binding filaments in the total as a ratio

viii. kind of fiber crease - spiral or sawtooth

ix. web arrangement - parallel or randomized.

Due to the wide assortment of blends with the above parameters, it was chosen to examine deliberately the impact of some of these parameters on acoustic behavior, so products with known acoustic execution can be produced.

The two most vital properties for acoustic applications are (a) sound insulation, or all the more definitely the improvement by the product in sound insulation of lightweight cavity walls, and (b) sound absorption, which for fibrous textiles is known to be an element of the material flow resistivity. Thusly the sound transmission loss of plasterboard dividers containing polyester fiber carpets in the cavity was considered and relating flow resistivity of the polyester fibers were measured. [10]

4.1.3 Study of physical factors of polyester for acoustic purpose:

MASS:

Polyester fiber batts or blankets can be produced with a scope of mass/area, and the generation cost of the products is essentially straightforwardly relative to the mass/area. Talks with the manufacturer that products with mass/area of higher than 1000 g/m^2 are likely to be uneconomic and those with under 100 g/m^2 are unreasonable from a creation procedure perspective. [10]

FIBER DIAMETER:

The diameters of polyester fibers are administered by the denier of the product. The denier of a yarn or fiber is characterized as the mass in grams of a length of 9000 m of that yarn or fiber. A reasonable denier of the general polyester fiber for batts or blankets is 6 deniers. Binding fibers of just 4 deniers were utilized as the manufacturer needed to keep up the denier of binding fibers steady at 4 deniers. [10] Since just a narrow range of diameters is viewed as practical for batts and blankets, the capability of 4 denier general polyester was also examined notwithstanding the 6-denier fiber. The decrease in fiber denier (or diameter across) brings about greater thickness and strength, and prominent darkness of the completed product. [10]

TYPE OF FIBER:

Polyester fibers can be either hollow or solid. The blankets made with solid fibers have a tendency to be somewhat compliment and not as flexible as the ones made with hollow fibers. Hollow fibers can contain either a single opening or numerous gaps (normally four or seven). Since numerous gap fibers are much costlier than either solid or single-gap hollow fibers, they were most certainly not considered a possibility for this work. Moreover, binding polyester fibers were solid for all examples. The structure of the hollow fibers is with the end goal that the internal fiber cavity stays detached to the space between the fibers, along these lines keeping the hole from assuming a valuable part in acoustic energy absorption. [10]

FIBER CRIMP:

Crimp is a pointer of the waviness of the fibers. While sheep's wool has a characteristic and perpetual crimp, crimp is regularly presented in manufactured fibers to influence them to seem like wool. For polyester fibers, crimp is ordinarily set or balanced out by heat. Two types of crimps are normally utilized, in particular mechanical (sawtooth) and conjugate (spiral). At the point when crimped fibers are inspected under a magnifying instrument, it is seen that they have skin asymmetry which prompts crimpness. In this manner, while hollow fibers with mechanical crimp will have concentric holes, conjugate-hollow fibers will have eccentric holes. Exceedingly crimped fibers tend to shape a more uniform mate. For polyester, material with conjugate crimp yields a lofty product, i.e. more prominent thickness for a given mass/area. Both hollow and conjugate crimp were explored in this work, but since the product consisting of conjugate crimp fibers can be around 20% more costly, it is just of functional utilize if a ratio conversion in the execution is achieved. [10]

PERCENTAGE OF BINDING FIBERS:

The polyester batts or blankets feel harder or stiffer as the measure of binding fibers, communicated as level of the total fibers, is increased. For products requiring bulkiness, for example, blankets, a blend ratio of 15-25% is suggested by the producer of the binding fiber. For products requiring hardness and bond, a blend ratio of between of 30 and 50 is recommended. In this work, blend ratios of 20%, an ordinarily utilized ratio for yielding attractive product strength, and 35%. [10]

TYPE OF BINDING FIBERS:

Binding fibers of the hot-melt type consisting of 100% polyester (called Melty fibers) with a dissolving purpose of 110°C were utilized for the readiness of sample examples. The binding fibers with a nominal fiber diameter across of 22 µm consisted of a sheath and core with a weight ratio of 1: 1 and empowered bonding with customary polyester fibers by union under controlled heating. [10]

FIBER LENTH

Only material made using 64 mm long polyester fibers was available, so the fiber length was taken as a constant rather than a variable. [10]

WEB ARRANGEMENT:

Two types of web, i.e. a level course of action of fibers, are possible: (a) parallel webs, (b) random webs. Parallel webs are created by the traditional fabricating strategies and were utilized for the sample examples, yet this type of web creates a product that has great rigidity along the machine bearing and is feeble over the diameter or cross course. Arbitrary webs, then again, create a product whose cross-directional strength is practically as extraordinary as the machine-bearing strength. Irregular web material, in little amounts, just wound up plainly accessible towards the finish of the task and flow insulation estimations on one example were conveyed out to build up whether any huge contrast happened in flow resistivity by randomizing the web structure. [10]

4.2 Comparison Study Between Glass Fiber and Polyester Fiber:

As it is proposed to utilize polyester fiber as a substitute for fiberglass in the fabricate of batts and blankets, it is helpful to analyze their properties. Fiberglass is essentially arbitrary web in two measurements since fibers tend to remain level in layers, and is in this way more arbitrary than the parallel webs of polyester created from carding machines. While for fiberglass the recorded (l-10 µm) fiber diameter run speaks to the run of the lowest factual area within the material, for polyester fibers the area appeared (12-26 µm) speaks to the normal measurement go within which the product can be effectively produced as bla**n**kets appropriate for acoustic and heat applications. [10]

4.3 Development of Different Natural Fibers of Nonwoven for Interior Noise Control of Car:

As natural fibers are noise absorbing textiles, sustainable and biodegradable nonwovens have been produced utilizing normal fibers, for example, banana, bamboo, and jute fibers for the car interior to reduce noise, which at present contain customary textiles, for example, glass and other fabricated fibers and foams that are hard to reuse. Three types of nonwovens were produced utilizing needle-punching method by blending bamboo, banana, and jute fibers with polypropylene staple fibers in the ratio of 50 : 50. Sound absorption coefficient was tried by impedance tube strategy (ASTM E 1050). Comparison of physical properties, for example, areal density, thickness, solidness, elasticity, prolongation, basic properties, and comfort properties, for example, air permeability and thermal conductivity were performed for all specimens [11]. It is observed that the bamboo/polypropylene nonwoven with its smaller structure appeared, higher elasticity, higher solidness, bring down stretching, bring down heat conductivity, bring down air permeability, and great absorption coefficient than others and it is appropriate for the car interior noise control. At 800 Hz, the absorption coefficient of bamboo/polypropylene and jute/polypropylene is comparable to the objective level yet it is bring down by 22% in banana/polypropylene. However, at higher frequencies (1600 Hz), there is a decrease from the objective level in all the nonwovens, which could be enhanced by increasing the thickness of the nonwovens. [11]

4.3.1 Natural Fibers Ratio:

The natural fibers were blended with polypropylene fibers to improve the soundness and to confer thermoformability to the nonwovens. Bamboo filaments were acquired from M/s Cheran Spinners, Erode, banana fibers were secured as reeds and handled in M/s Senthil Kumar Industries to get fibers, jute fibers from M/s Sudha Jute Industries, Erode, and polypropylene fibers from M/s Zenith Fibers, New Delhi.

The blend ratios were:

Bamboo/Polypropylene in the ratio of 50 : 50

Banana/Polypropylene in the ratio of 50 : 50

Jute/Polypropylene in the ratio of 50 : 50 [11]

4.3.2 Sound Absorption co-efficient:

Floor carpeting gives about 40% of the total surface in a vehicle for sound sealing. Sound absorption by floor carpeting is critical and consequently three diverse nonwovens were tried for sound absorption. Sound absorption % values are appeared in Table 4.1 demonstrates the absorption coefficient of the bamboo/PP, banana/PP, and jute/PP nonwovens. From Table 4.1, it is showed that when all is said in done, the sound absorption % of bamboo/PP are greater than that of banana/PP and jute/ PP in all frequency levels. At 800 Hz, the sound absorption % accomplishes the objective level. The most extreme absorption % is seen at 1250 Hz for all the nonwovens. Over 800 Hz, the absorption % is lower than the objective level for all the nonwovens, which can be increased by increasing the thickness. [11]

Frequency (Hz)	Target (%)	50 : 50 Bamboo/PP	Banana/PP	50 : 50 Jute/PP
800	9	9	7	8
1000	16	9	6	7
1250	–	20	13	17
1600	35	13	7	8

Table 4.1. Sound absorption % of nonwovens. [11]

4.4 Natural Fibers of Nonwoven Floor Carpeting System for noise control in car

For a product to be a decent "carpet system" the system needs to be a sensible barrier (i.e. have great TL appropriate ties) to hold the noise under the vehicle from passing through the floor carpeting system and into the driving compartment. Also, it needs to viably absorb sound that figures out how to get into the driving compartment (regardless of how it got inside). So, notwithstanding a good TL, it also needs great absorption. The sheet metal that forms the floor of the vehicle goes about as a barrier, but there may also be a persistent impermeable liner under the carpet to additionally enhance the TL execution. Then, on best of the barriers a floor carpeting that is an excellent absorber to disseminate the sound energy in the passenger compartment is additionally required.

Car manufacturers stress the utilization of efficient sound-absorptive textiles in vehicles to reduce unwanted noise. The current sound-absorptive textiles are for the most part made of synthetic fibers, which are not biodegradable. Toward the finish of vehicle's life, the most of auto interior textiles for the most part wind up in satisfy. As the cost of satisfy is escalating, reusing endeavors have been increasing. We have developed nonwoven floor carpets from ease, biodegradable, ecologically benevolent regular fibers (kenaf, jute, cotton and flax) in blends with polypropylene (PP)and polyester (PET) as potential sound-absorbing textiles. They were sample assessed for their capacity to absorb sound energy, utilized either alone or in combination with (an) a delicate cotton under pad, or (b) a reinforced PU under pad, by the standard sample technique ASTM E-1050-98. A floor carpeting system was made by stacking an under-cushion and a floor carpeting together. Both the under pads were additionally separately assessed for their capacity to absorb sound energy. [12]

4.5 Acoustical Absorptive Properties of Cotton, Polylactic Acid Batts and Fabrics

4.5.1 Web Formation

Polylactic Acid fibers and Ultra-Clean Cotton fibers were changed over into three-dimensional fibrous structure batts and Nonwoven fabrics with the Truetzschler Tuft Feeder Scan feed Machine at the Short Staple Fiber Laboratory of the North Carolina State University, Raleigh United States. These real operation set-up parameters utilized are Opening, Roller Top Card, Cross lapper and pre-needling. [13]

4.5.2 Web Bonding

The mechanical technique of bonding; which is attaching and needle-punch were utilized to affect adequate frictional power to the web. [13]

50/50 COTTON/PLA

SAMPLE (1)	SAMPLE (2)	SAMPLE (3)	SAMPLE (4)	SAMPLE (5)
PLA	PLA	COTTON	PLA	COTTON
PLA	PLA	PLA	PLA	COTTON
PLA	COTTON	COTTON	COTTON	PLA
PLA	COTTON	PLA	COTTON	PLA
COTTON	PLA	COTTON	COTTON	PLA
COTTON	PLA	PLA	COTTON	PLA
COTTON	COTTON	COTTON	PLA	COTTON
COTTON	COTTON	PLA	PLA	COTTON

75/25 PLA/COTTON

SAMPLE (6)	SAMPLE (7)	SAMPLE (8)
PLA	COTTON	PLA
PLA	PLA	PLA
PLA	PLA	COTTON
COTTON	PLA	PLA
COTTON	PLA	PLA
PLA	PLA	COTTON
PLA	PLA	PLA
PLA	COTTON	PLA

75/25 COTTON/PLA

SAMPLE (9)	SAMPLE (10)	SAMPLE (11)
COTTON	PLA	COTTON
COTTON	COTTON	COTTON
COTTON	COTTON	PLA
PLA	COTTON	COTTON
PLA	COTTON	COTTON
COTTON	COTTON	PLA
COTTON	COTTON	COTTON
COTTON	PLA	COTTON

Table 4.2. Layering Arrangement of Samples [13]

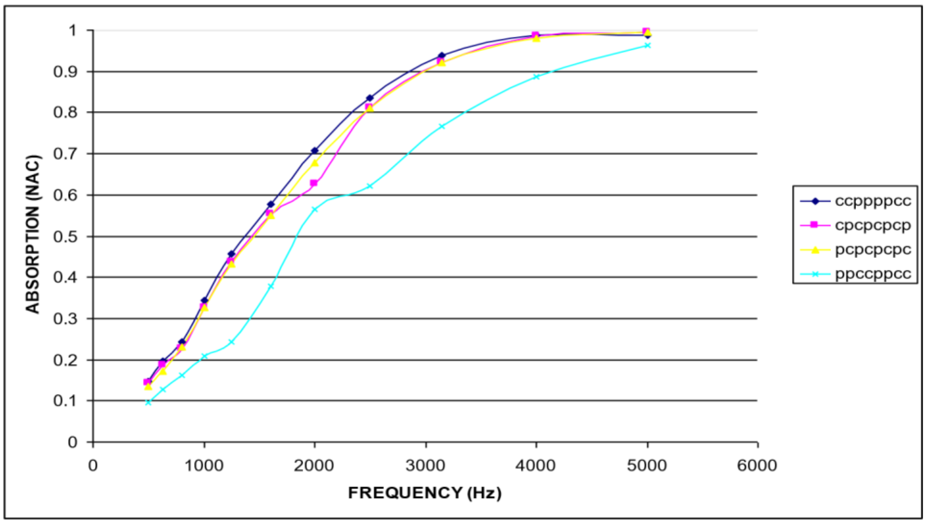


Figure 4.1 Comparing 50% Cotton and 50% PLA layering order: A flip of front and back of samples 2 and 3 batt. [13]

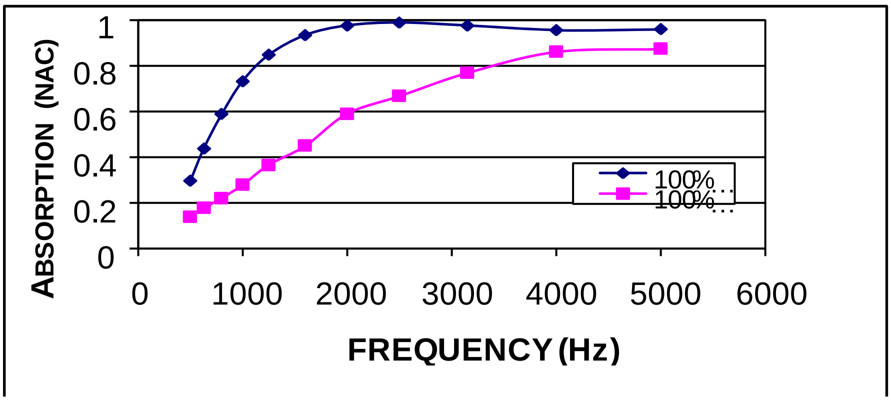


Figure 4.2: Comparing NAC curve of (8) layers 100% Cotton and (8) layers 100% PLA Batt. [13]

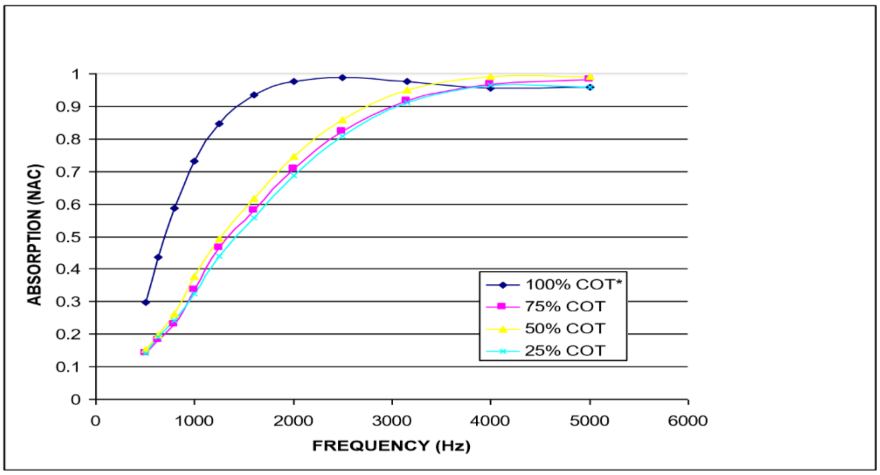


Figure 4.3: NAC curves Comparing the level of absorption of Cotton/PLA batt at 100%, 75%, 50% and 25% respectively. [13]

4.6 Nonwoven composed with different recycled polyester fiber contents

The contents of fine fiber increased to FIN1, FIN2, FIN3 and FIN4; every one of the FINs contained 40% LMP, the section of the fine fiber increased from 0 to 60% against the coarse PET. The relationship between sound absorption and fine fiber contents is shown in Figure 4.4. The NAC of the specimen is relative to the expansion in the fine fiber contents. The distinction of NAC amongst FIN1 and FIN4 achieved a most extreme in f=750 Hz, and the variety amongst FIN1 and FIN4 came to very nearly 0.2. Increasing with the frequency, the distinction of the NAC curves between samples decreased. In the instance of high frequency (f>1500 Hz), NAC bends demonstrated no reasonable inclination with fine fiber contents, in any case, every one of the specimens have a great sound absorption rate.

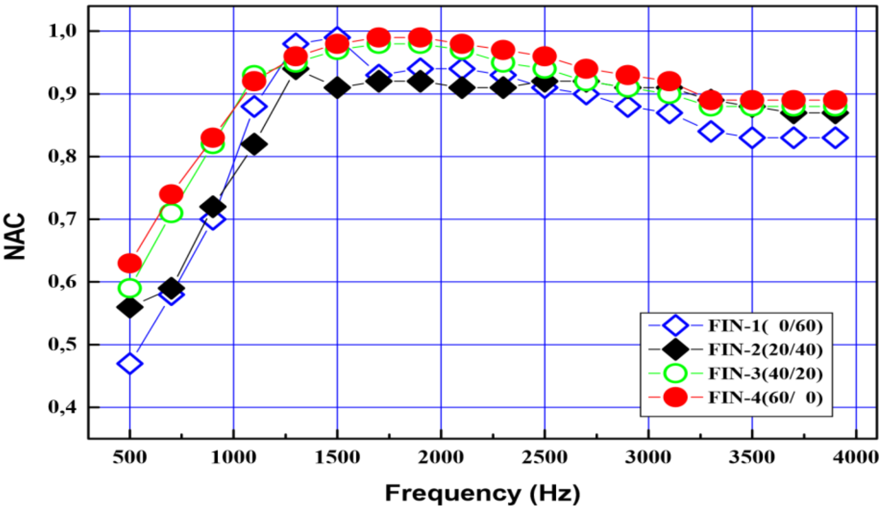


Figure 4.4. Effect of fine fiber contents on sound absorption properties [14]

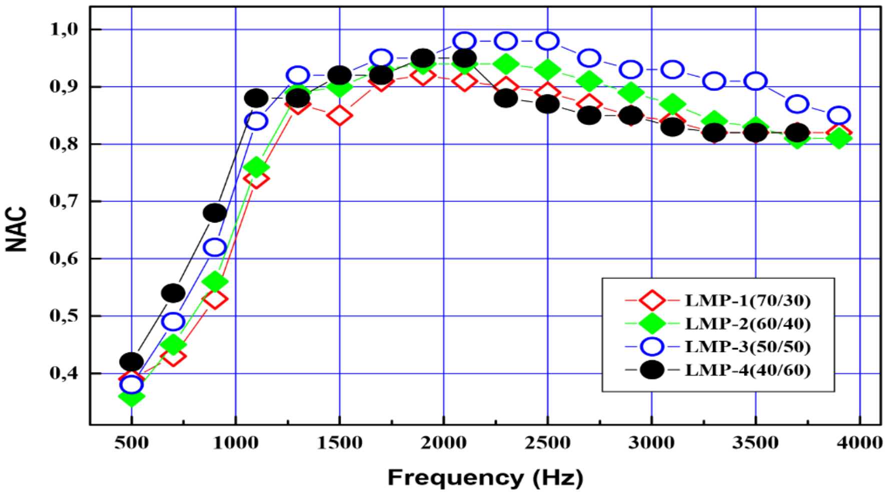


Figure 4.5. Effect of LMP on sound absorption properties [14]

We also tried the impact of low melting point (LMP) polyester contents on sound absorption properties; low melting point polyester was utilized for bonding and better strength. The schematic chart of this sample is given in Figure 4.5. Generally, the expansion of the low melting point polyester contents made the NAC reduce (visible especially within the range 2000-3500Hz) due to the decreasing in the nonwoven thickness and the impact of the correspondent impact [14]. The dissolved low melting point polyester fiber inside the nonwoven caused a reducing in nonwoven thickness and influenced the structure in the web to shrivel during the bonding process, which additionally brought about the demolition of the micro pore of the nonwoven structure. So, the dissolved low melting point polyester fiber can create a micro film structure in the within the absorber, which should make the incidental impact. [14]

4.6.1 Nonwoven composed with multi-angle layered web and different thickness

Web introduction impacts were broken down through the nonwoven composed of a similar fiber contents, in any case, with various orientation angles (0°, 35°, 45° and 90°), fabricated and controlled during the carding process. The NAC of multi-edge layered web was appeared in Figure 4.6. LAY-4 demonstrated the most elevated NAC, which implies the higher orientation angle variety gives littler pore sizes. The pore estimates as well as air insulation is connected with web layering properties, in spite of the fact that the distinction in the NAC is minimal in the low and high frequencies, and even at middle frequency it didn't demonstrate any incredible contrast. Along these lines, the distinction of NAC between samples was unimportant for the given example and frequency conditions in this sample. [14]

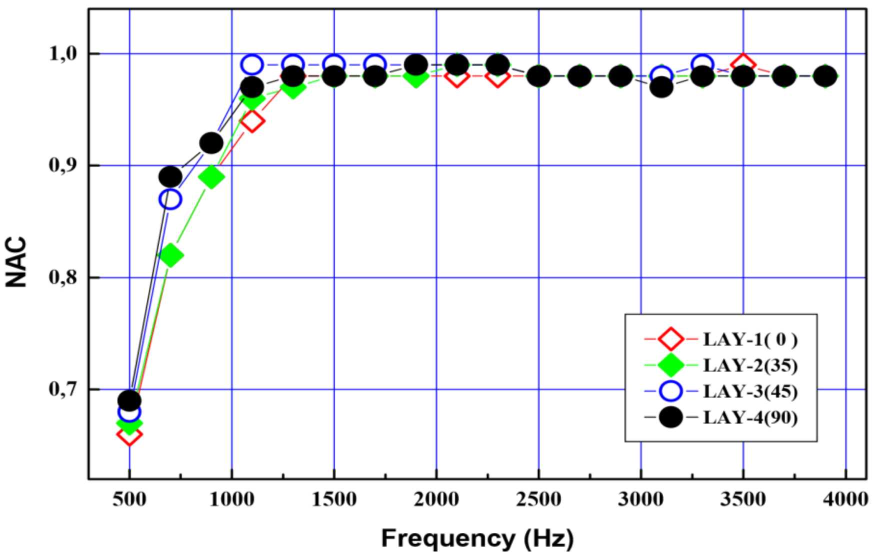


Figure 4.6. Effect of mid-web angle on sound absorption properties [14]

4.7 Sound Absorption Properties of Multilayer Structure of Discarded Polyester Fiber

4.7.1 Fabricating multilayer structural material

The thermoplastic polyurethane matrix was melted utilizing SK-160B two-role blender (Sinan Rubber Machinery Co., Ltd, Shanghai) heated at 165 °C, and afterward the discarded of polyester fiber with length of 10 mm was included and blended for 5 min. The blend was then united in a hot plate squeeze machine type QLB-50D/Q (Zhongkai Rubber Machinery Co., Ltd., Jiangsu) framing square plates, measuring 160 × 160 × 4 mm3. The square plates were cooled and got out discarded of polyester fiber reinforce thermoplastic polyurethane fiberboard composite. Finally, the fiberboard composite was penetrated and combined with discarded of polyester fabric. [15]

4.7.2 Sound absorption properties

Table 4.3 demonstrates the sound absorption coefficient of various examples.

A– Fiberboard, the thickness is 4 mm, B – Perforated fiberboard, the thickness is 4 mm; puncturing ratio is 7%; and openings diameter across is 6 mm, C– Polyester fabric, the thickness is 4 mm, D– Perforated fiberboard (thickness is 2 mm) combined with polyester fabric (thickness is 2 mm) and air cavity depth was 30 mm.

Frequency (Hz)	A	B	C	D
80	0.02	0.04	0.02	0.08
100	0.01	0.02	0.01	0.07
200	0.08	0.01	0.03	0.04
250	0.10	0.04	0.05	0.07
400	0.11	0.02	0.03	0.18
500	0.12	0.02	0.05	0.21
630	0.11	0.03	0.12	0.46
800	0.13	0.03	0.14	0.75
1000	0.13	0.02	0.2	0.90
1250	0.15	0.02	0.33	0.80
1600	0.12	0.04	0.57	0.61
2000	0.15	0.08	0.75	0.45
2500	0.16	0.12	0.89	0.34
3150	0.12	0.06	0.99	0.30
4000	0.14	0.03	0.99	0.20
5000	0.15	0.01	0.92	0.19
6300	0.17	0.04	0.85	0.11

Table 4.3 Sound absorption coefficient under different frequencies. [15]

As appeared in Table 4.3, absorption coefficient of A and B was under 0.2 in the frequency scope of 80– 6300 Hz, so the sound absorption properties were poor. C absorbed the greater part of the sound in the frequency scope of 1250– 6300 Hz and the absorption coefficient shut to one when the frequency go was 3150– 4000 Hz. D absorbed the majority of the sound in the frequency scope of 500– 4000 Hz and furthermore had a peaks of sound absorption when the frequency was 1000 Hz. Comparing D with C, the peak of sound absorption shifts to 1000 Hz from 4000 Hz and the absorption bandwidth of D becomes wider. When D was compared with A and B, it can be stated that the characteristics were much improved, both in the absorption frequency area and in the peak of sound absorption. So, it warrants further investigation on the multilayer structural sound absorption material. [15]

Chapter 05: Role of Fabrics in the noise absorption and considering factors.

5.1 Needle punched nonwoven fabric in sound absorption

Control of acoustical related fact in surroundings, for example, work area and private homes, utilizing different materials has increased principal significance. Nonwoven fabric in general is perfect acoustical protector because of their high volume-to-mass ratio. This exploration inspected acoustic attributes of organized needle punched floor covers in connection to fiber fineness, surface impact, punch density, areal thickness, and chemical bonding process. Sound absorption of the test samples was measured utilizing the impedance tube technique. Results demonstrate that fabric delivered from fine fibers absorb sound waves all the more proficiently. It was discovered that, specimens with no surface impact appreciate the greatest sound absorption. This is trailed by velour and cord surface impact samples. It was set up that, larger amounts of punch density and higher areal density caused the noise reduction coefficient (NRC) of the fabric to be increased. It was additionally discovered that chemical completing unfavorably influenced the sound absorption property of the samples. [16]

5.1.1 Influence of Fiber Fineness

Varieties of sound absorption coefficient of samples with plain, velour and cord surface impact delivered from various fiber fineness are produced in Figures 5.1, 5.2 and 5.3, separately (samples P1-P5, V1-V5 and (C1-C5). As can be observed, an absorption coefficient increases as the fiber diameter decreases.

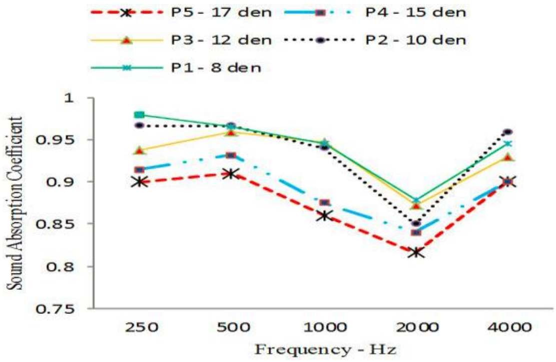


Figure 5.1: [16] Variation of absorption coefficient with frequency for plain surfaced nonwoven fabrics produced using various fiber fineness.

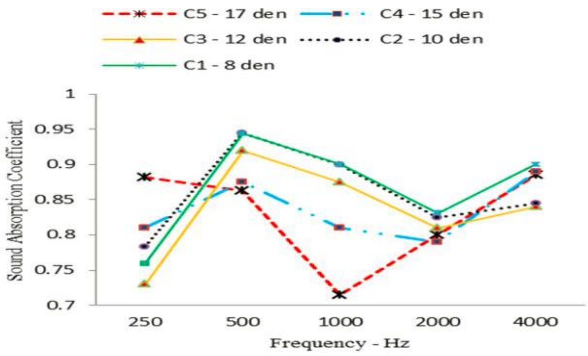


Figure 5.2. Variation of absorption coefficient with frequency for cord surfaced nonwoven fabrics produced using various fiber fineness [16]

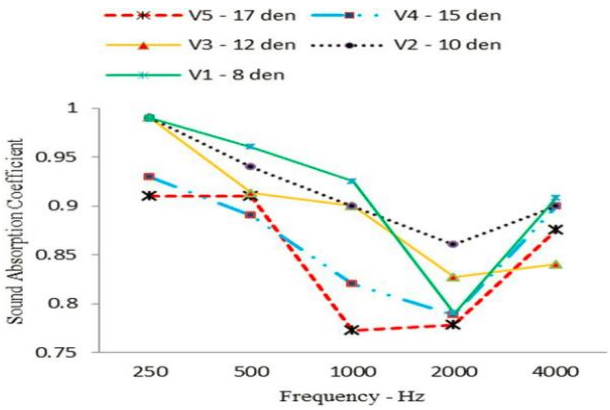


Figure 5.3. Variation of absorption coefficient with frequency for velour surfaced nonwoven fabrics produced using various fiber fineness. [16]

As fiber fineness increase, for a given volume thickness a higher number of fibers is required. These results in a more convoluted way and higher wind flow insulation in the fibrous get together. Fine fibers also have more opportunity to contact sound waves; this thus brings about increasing wind current insulation by methods for frictional consistency through the vibration of the air, subsequently the observed increase in absorption coefficient. Also, fine fibers can move promptly in comparison with coarse fibers. The simplicity of development related with finer fibers brings about quick transformation of acoustic energy to heat. Moreover, the presence of fine fibers decreases the probability of pore availability which improves the absorption behavior of nonwoven samples. [16]

5.1.2 Influence of Surface Effect

Examination of the results exhibited in Figures above, demonstrates that under given conditions plain and cord surfaced samples delivered the most greater and the least absorption coefficient, separately. Keeping in mind the end goal to upgrade the drawn results, NRC of the examples is exhibited in Figure 5.4 To the extent surface impact granted to the examples is concerned, plain surfaced fabric appreciates the highest NRC values, while cord surfaced samples experience the lowest effects of the most reduced ones. This can be attributed to the activity of the needles loom

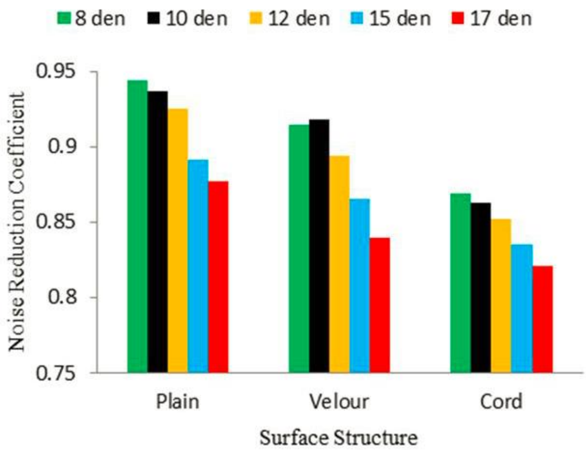


Figure 5.4: Variation of NRC for various surface effects (Areal density 560 g/m2). [16]

Felting needles are utilized on a needle punch machine to create compact webs. As the needle loom shaft climbs and down, the working cutting edge of needles penetrates the fibrous batt. Barbs situated on the blade get up fibers on the downwards cycle. The pickup fibers are conveyed a separation roughly equivalent to the set needle penetration depth. Consequently, the free batt is conversion over into a generally minimized nonwoven fabric. Velour and cord surface impacts are conferred to the pre-merged batt utilizing an organizing needle loom furnished with fork needles. Fork needles transfer fibers from pre-united batt to the surface as velour or cord pile. This activity of fork needles adequately delivers a double structure made out of a dense base and a free surface. NRC of these structured fabrics is lower than that of comparable plain surface examples because of the variety in the porosity of the base and pile section of the fibrous get together.

The reduction of absorption coefficient at frequency groups of 1000 and 2000 Hz can be because of the coincidence. This phenomenon is usually known as the basic frequency which can seriously confines sound absorption capacity of the specimen. The occurrence dip happens when the incident sound wave is in stage with the reflected wave from the sample. As can be seen in Figure 5.3, at frequency of 250 Hz, cord surfaced samples experience the lowest effects of low absorption coefficient. It can be attributed to the less compactness of fibers in the pile area of the cord surfaced fabric which brings about exchanging the correspondent frequency to bring down frequency bands. [16]

5.1.3 Influence of Punch Density and Areal Density

Figures 5.5 to 5.7 portray variety of absorption coefficient with frequency for plain, velour and cord surfaced fabric at four distinctive punch thickness levels.

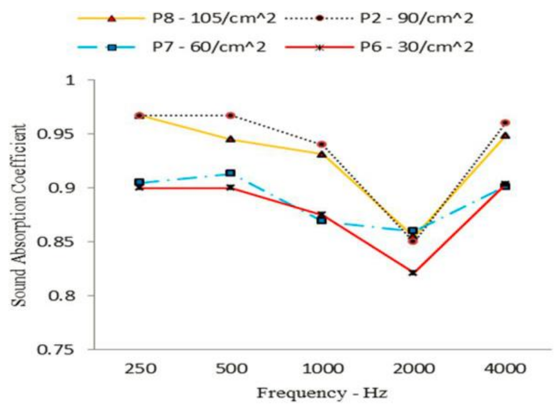


Figure 5.5. Variation of absorption coefficient with frequency for plain surfaced nonwoven fabrics produced at different punch density levels. [16]

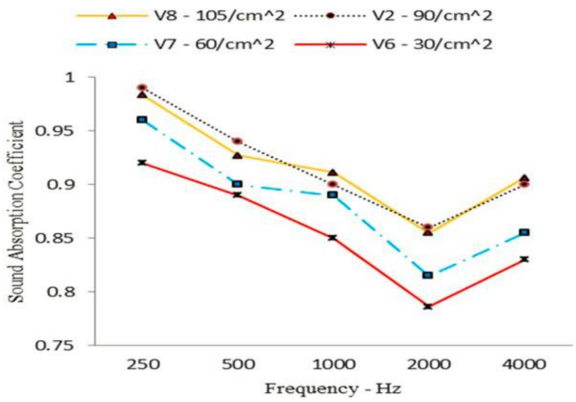


Figure 5.6. Variation of absorption coefficient with frequency for velour surfaced nonwoven fabrics produced at different punch density levels. [16]

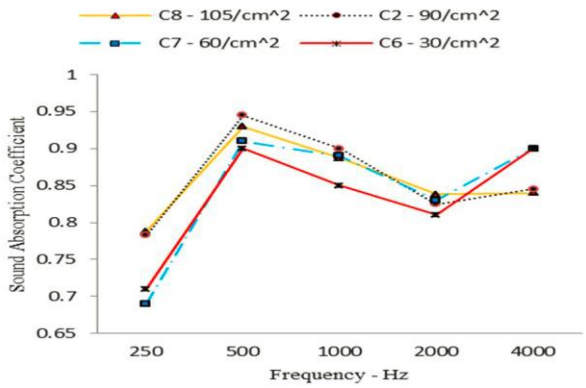


Figure 5.7. Variation of absorption coefficient with frequency for cord surfaced nonwoven fabrics produced at different punch density levels. [16]

As can be seen, for the given conditions, the sound absorption coefficient increases up to a punch thickness of 90/cm2 and afterward has a tendency to reduce. This pattern may be attributed to the higher flow resistivity of samples needled at more elevated amounts of punch thickness. At high punch density the fabric has high tortuosity, high number of little size pores and higher fiber to fiber contact areas. Besides, at high punch thickness, fiber entanglement within the fabric is increased which thus prompts creation of compact or high-density fabric. The slight decreased saw in sound absorption of samples beyond 90/cm2 punch density might be credited to increase in fiber breakage which conversions the inward adjusts of fabric tortuosity, pores and fiber to fiber contact area. Comparison of NRC of the three types of samples is introduced in Figure 5.8.

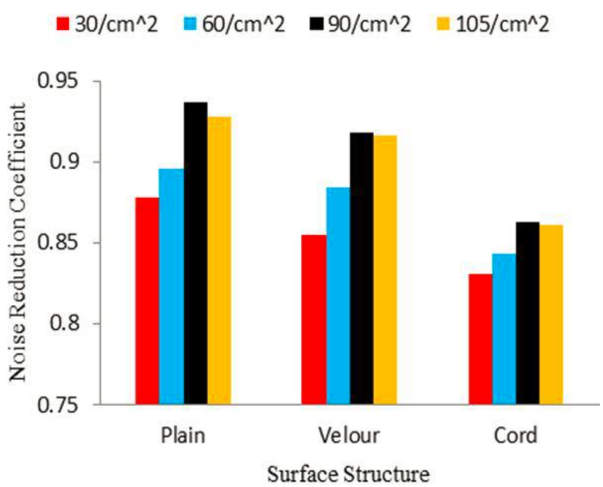
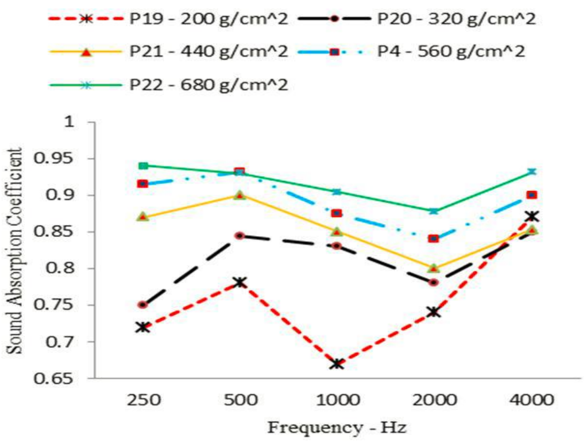


Figure 5.8. Variation of NRC for various surface effects at different punch density. [16]

Impact of fabric areal density on sound absorption coefficient of plain examples is produced in Figure 5.9. As can be seen, sound absorption coefficient increases with areal density. This is because of increase in fabric thickness as areal density increases. It is additionally observed that at low frequency, sound absorption has an immediate relation with thickness and at high frequency thickness modestly affects sound absorption [16].

This is in all out concurrence demonstrated that, as opposed to high frequencies where material thickness inconsequential influences sound absorption property of the porous material, at low frequencies sound absorption increases with increase in material thickness. Samples directed utilizing needle punched fabric of other surface impacts, for example, velour and cord yielded comparable results to the extent areal density was



concerned.

Figure 5.9. Variation of absorption coefficient with frequency for plain surfaced nonwoven fabrics having different areal densities. [16]

Figure 5.10 delineates the association between needle punch density and areal density and its impacts on NRC for plain surface impact samples. As can be seen, for the most part thick specimens appreciate higher NRC values. Besides, the results show that a slight decreasing in NRC measurements of samples with bring down areal densities happen as punch thickness increases from 90/cm2 to 105/cm2. This is because of the way that for a given needle penetration depth as areal density of the example reduce more fiber breakage happens, as well as fabric density is reduced. Notwithstanding, in the event of samples with higher areal dentity, increase in punch density correspondingly builds fabric compactness and thickness which brings about better sound absorption. Comparable results were acquired for samples with velour and cord surface impacts. [16]

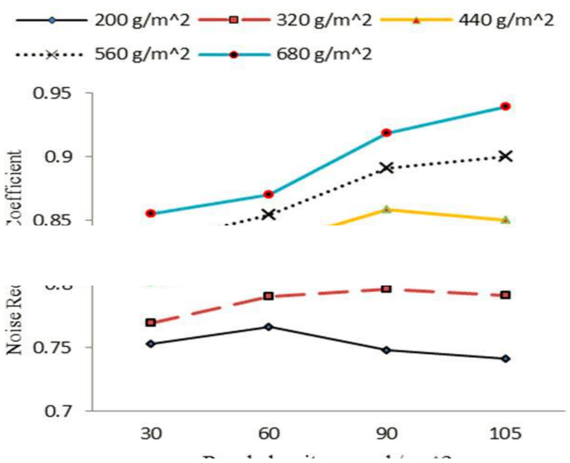


Figure 5.10 Variation of NRC with neddle punch density for plain nonwoven fabrics having different areal densities [16]

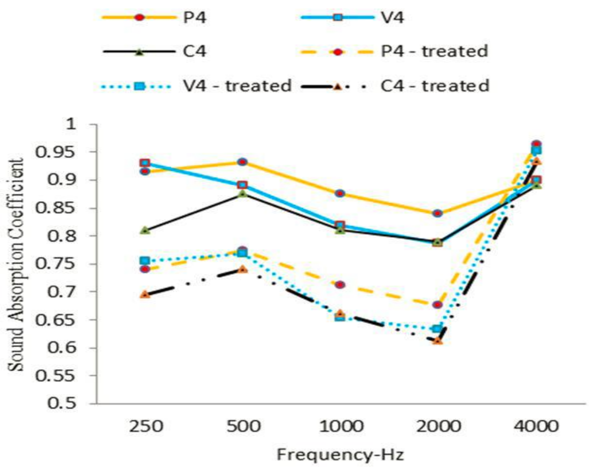


Figure 5.11. Effect of chemical bonding on absorption coefficient. [16]

5.1.4 Influence of Chemical Bonding

Sound absorption behavior of the specimens after chemical bonding utilizing SBR latex is produced in Figure 5.11. As can be seen, except for 4000 Hz, at different frequencies because of coincidence impact sound absorption coefficient of the bonded examples has detectably decreased. Besides, unbending nature of the examples increases because of expansion of SBR latex which adequately goes about as a sound reflecting obstruction. The stamped increase in sound absorption at frequency of 4000 Hz is identified with the way that the covered film of SBR latex viably goes about as an additional layer that anticipates event of happenstance impact at this frequency in this way they observed increase in absorption of sound by the examples.

5.2 Efficacy of nonwoven materials as sound insulator

Nonwoven materials of different origins have been considered as far as their viability in decrease of sound utilizing tube set-up. Different parameters, for example, frequency of sound produced, distance between sound generator and sample, and physical highlights of samples (air permeability, thickness and GSM), are contemplated with reference to adequacy of sound reduction of these fabric. The sound reduction is also measured utilizing another strategy looking like genuine circumstance. It is observed that with the expansion in frequency and GSM the degree of sound decreasing increases while with the expansion in air penetrability, the degree of sound reduction by the material declines. Even though the degree of sound decrease values marginally contrasts, the order of adequacy of different nonwoven fabric samples showed by both the strategies continues as before. This investigation empowers the clients to choose a proficient material to be utilized as a part of noise control. [17]

5.2.1. Efficacy of Nonwoven Fabrics for Sound Reduction in Tube setup.

The results regarding these nine nonwoven samples of polyester(P), cotton(C), viscose(V) and polypropylene(PP) are appeared in Fig. 5.12. The degree of normal reduction in sound (%), which is assumed control three separations, increases with the expansion in frequency, regardless of the separations between the speaker and the example for every one of the specimens considered. However, the rate decreasing in sound is observed to be most extreme at 4000 Hz frequency and furthermore at the greatest separation (150 cm). By and large, the lower decrease is seen in the frequency scope of 250-1000 Hz and at any rate separation of 50 cm. [17]

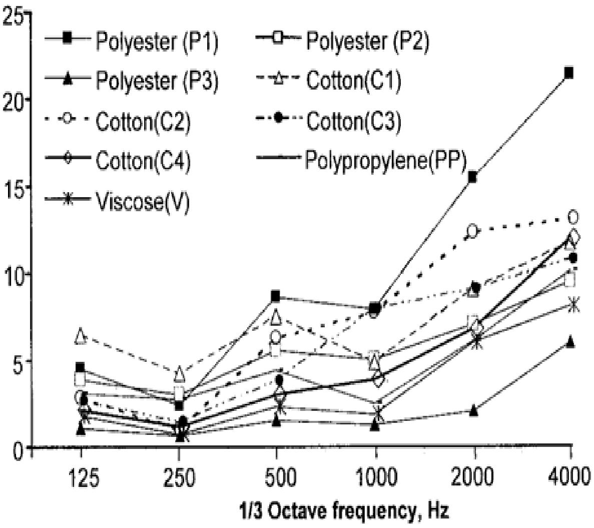


Figure 5.12: Relation between frequency and average sound reduction of different nonwoven fabrics. [17]

Results show that the normal sound reduction values are in the scope of 1-8% when the frequency fluctuates from 125 Hz to 4000 Hz. In any case, at 2000 Hz and 4000 Hz frequencies, the varieties in sound decreasing because of samples variety are very extraordinary and the normal sound reduction differs in the accompanying order of fabric samples:

P1>C2>C4>C1>C3>PP>P2>V>P3

Also, when the mean sound decreasing is figured averaging over the frequencies, comes about demonstrate the accompanying order:

P1>C1>C2>C3>P2>C4>PP>V>P3

Figure 5.13 plainly demonstrates that the mean sound decreasing (%) saw on account of P1 is most extreme, that of P3 is least. This might be attributed to the most greater GSM (999.5) of P1 which might be in charge of absorbing the sound energy during the greatest association of sound waves with the substrate more than 0.3 cm thickness.

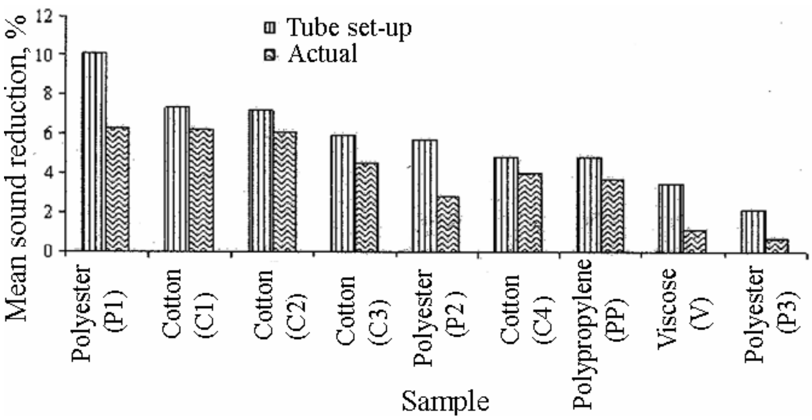


Figure 5.13–Comparison of sound reduction between tube set-up and actual behavior. [17]

The air porousness of the P1 sample is tremendously decreased and hence foam such a dissemination of energy is greatest, giving the most greater degree of decreasing in sound. The minimum of air porousness (68.28 cc/cm2/s) was shown by cotton sample C2 giving second order in mean sound reduction. In a normal sound reduction at 4000 Hz frequency, C1 displays such a second order adequacy. Both these examples C1 and C2 have low air porousness with rational thickness, although C1 has marginally higher GSM than that of C2. The specimens P1, C1, C2 give the GSM per unit cm of the thickness substantially higher than 3000 and in the meantime their air penetrability values are some place in the scope of 68-105 cc/cm2/s and thus P1, C1 and C2 samples demonstrate the most elevated mean sound decreasing and in addition most greater degree of normal sound reduction level. The mean sound decreasing level of C4 (cotton) is also observed to be higher fundamentally since its GSM per unit thickness value is generally high (2471.10) although its air penetrability is moderately low. The P3 sample demonstrates the slightest of degree of mean sound decreasing, fundamentally since the GSM per unit thickness is practically least and in the meantime air porousness is second generally greater. This is trailed by the viscose whose GSM per unit thickness is second last and the air penetrability is also beside P3. [17]

It is clear that the nonwoven fabric samples in view of their contrasting air porousness and GSM values give differed reaction with respect to mean sound decreasing. The specimen P2 gives middle order sound decrease despite the fact that it has most reduced GSM per unit thickness and most greater air porousness and is observed to be normally not the same as some other fabric samples. Its thickness is just about 3-10 times of alternate specimens. This specimen shows upgraded level of absorption of sound, might be attributed to its open structure and consequent dissemination of sound energy which is very direct. Polypropylene sample demonstrates a low order mean sound decreasing, which might be credited to its low order GSM per unit thickness and generally higher air porousness. At the end of the day, air porousness, GSM, thickness and fabric structure essentially influence the degree of sound decrease. [17]

5.2.2. Efficacy of Nonwoven Fabrics as Sound Insulator in Actual Condition

Nine nonwoven samples tried before in tube set-up were again tried for their adequacy in this set-up taking after genuine circumstance. The consequences of mean sound reduction (%), measured at 30 cm distance, are appeared in Fig. 5.12. The order in which the adequacy of these examples going about as a sound wall decreases from left to right (Fig. 5.13) is demonstrated as follows:

P1>C1>C2>C3>C4>PP>P2>V>P3

This order is observed to be great in contrast with prior discoveries utilizing tube set-up, as far as mean sound decrease (Fig. 5.13). It is fascinating to take note of that the measurements, done prior utilizing tube set-up on the fabric samples to assess their adequacy as sound walls, are found in congruity with the results got in the genuine circumstance and hence foam this strategy is effective in finding out the viability of different examples to go about as sound wall. However, the comparison of the fabric sample isn't fundamentally talked about, just on the grounds that the nonwoven samples utilized are arbitrarily chosen in light of the accessibility and our point was to sample the materialness of the measurement of sound decreasing technique versus the one in view of sampleing of arbitrary examples, all things considered, circumstance. [17]

5.3 The Contribution of wool carpet in the acoustical properties

5.3.1. Wool carpet reduces airborne sound

Sound is transmitted by the vibration of air atoms. The porosity of the surface of carpet implies that sound waves can enter into the pile, as opposed to being reflected once more into the room as they would from a smooth surface. Carpet are to a great degree compelling sound absorber since the individual fibers, pile tufts and underlay have diverse resounding frequencies at which they absorb sound. In this regard, wool carpet is especially compelling, as a great many wool fibers in an area of cover have a scope of lengths, diameters, crimps and spirality, which empowers them to absorb sounds over an extensive variety of frequencies. [18]

5.3.2. Wool carpet reduces surface noise

Surface noise in a room is the sound from footsteps, dropped products and furniture development. Uncovered tile floors create 7-12 times more surface noise than carpet which cushion the effect of the noise source, absorbing and stifling the sound. This is accomplished by changing over some of the high frequencies into less perceptible lower ones. For instance, footsteps on concrete make a high extent of high frequency sound which will be heard as a sharp snap or tap, though carpet will conversion this to a suppressed pound. Carpet reduces affect noise by more than 20 dB (decibels), and furthermore guarantees that the "life" of the noise is just half if that with hard floor materials. Once more, the thick the pile, the better the sound reduction.

This type of noise control is especially essential in occupied eateries and different areas where individuals should have the capacity to impart during a ton of action making a foundation of constant effect sounds. [18]

5.3.3. Wool carpet reduces noise transmission

While carpet reduce noise transmission through the floor in multi-storied structures, the degree of real noise decreasing, and individuals' view of it, is dependent on the frequency distribution of the sound. So once more, wool carpet, because the fiber's common capacity to absorb a more extensive scope of frequencies, additionally gives better solid insulation than those below.

A material's capacity to decrease noise transmission can be classified by its impact insulation class (IIC), the higher the rating the more proficient a material is in decreasing the sounds transferred to the room below. Wool carpet layed directly on a solid section floor-roof get together multiplied the IIC value, which was enhanced by a further 13-18% while changing weight of underlay were also utilized. Carpet can enhance the IIC of basic deck/roof systems by roughly 30 dB. [18]

5.3.4. Wool carpet provides superior acoustic insulation

The majority of the broadly utilized specific acoustic insulation materials are by and large just intended to handle one type of sound decrease, though wool cover can give equal execution with greater adaptability of utilization.

Soundproofing within the divider cavity will stop sound transmission to connecting rooms however will not reduce airborne sound in the room where the sound was produced. Essentially, while acoustic roof panels absorb airborne sound, they don't reduce surface effect noise. Thusly, in classrooms and other such areas, where great sound reflection from the roof will offer project the instructor's voice to the back of the class, wool carpet will absorb or confine other diverting effect noise.

Carpet's multi-entrusting capacities also imply that it can give even more all-round acoustic execution than different carpet. For instance, while a viscose foam supported vinyl may well stifle footsteps in the room below, those footsteps will in any case be perceptible in a similar room. Carpet, with its capacity to both absorb affect noise and decrease noise transmission will give noise decrease benefits for the both rooms. [18]

Trials under pragmatic conditions have demonstrated that the sound absorbing proficiency of even vigorously worn carpet was reduced by close to 16%, while after shampooing, which enhances tuft definition; the reduction was just 10%. Wool carpet, which react well to wet cleaning, would be relied upon to demonstrate a much more greater conversion.

Since carpet on dividers has an indistinguishable sound absorbing impact from that on the floor, hand tufted wool mats make appealing tapestries, as well as add to noise control. Research has demonstrated that the air gap between the floor covering and the divider really increases the noise absorption limit in the low and medium frequencies. [18]

5.4 Acoustical Behavior of Vertically Lapped Nonwoven Fabrics

Acoustical insulation and absorption properties of nonwoven fabric rely upon fiber geometry and fiber course of action within the fabric structure. The diverse structures of the fibers result in various total surface areas of nonwoven fabric. Nonwoven fabric, for example, vertically lapped fabric are perfect materials for use as acoustical insulation products, since they have high total surface. Vertically lapped nonwoven innovation comprises of carding, opposite layering of the carded webs, and through-air bonding utilizing synthetic binder fibers. The surface area of the fabric is specifically identified with the denier and cross-sectional state of the fibers in the fabric. Littler deniers yield more fibers per unit weight of the material, higher total fiber surface area, and greater possible results for a sound wave to interface with the fibers in the fabric structure.

The examination in the writing utilizes two strategies for measuring acoustical properties of fabric materials: the impedance tube and reverberation room technique. Little sample samples are in the impedance tube strategy and sound absorption coefficient is resolved at every frequency. Extensive reverberation rooms and vast sample samples are utilized for the reverberation room strategy. An immediate relative acoustical properties measurement gadget that was composed and manufactured at Clemson University School of Materials Science and Engineering was utilized to measure acoustical insulation in this exploration. This paper gives a description of the measurement gadgets and acoustical measurement information for vertically lapped nonwoven fabric produced using three distinctive polyester fiber shapes and two denier levels. [19]

5.4.1 Fiber Materials

Five diverse vertically lapped nonwoven fabric were utilized with three distinctive fiber shapes and two distinctive fiber deniers. They were packed at a temperature of 180°C out of a Carver mechanized pressure forming mechanical assembly. The compression molded samples were trimmed to suitable example measurement for the Sound Insulation Sampler, in particular 30.5cm by 30.5cm (12in by 12in). [19]

Fiber blends made of 65% matrix polyester fiber and 35% binder fiber were utilized for all vertically lapped nonwoven samples. The binder fiber was a 4 denier co-polyester low-melt fiber. Three diverse cross-sectional fibers (4DG, trilobal, and round) two distinctive fiber deniers were utilized as lattice to make vertically lapped nonwoven fabric. 4DG, trilobal, and round fiber photographs are appeared in Figure 5.14.

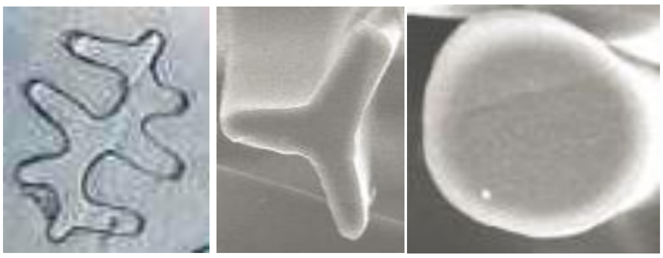


Figure 5.14. (a) 4DG, (b) trilobal, and (c) round fiber cross-sections.[19]

5.4.2 Fabric Air Permeability

Fabric air penetrability is vital parameter for heat and acoustical insulation of nonwoven fabric. Higher air porousness brings about higher sound transmission, along these lines less sound insulation.

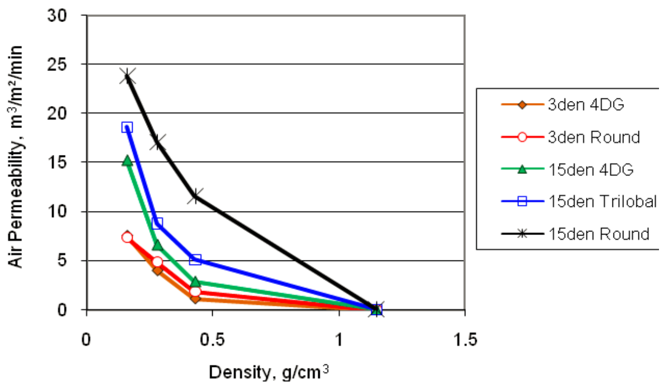


Figure 5.15. Air permeability results of vertical lapped sample fabrics at different fabric densities and fiber cross-sections. [19]

As appeared in Figure 5.15, vertical lapped fabric produced using 4DG fiber has less air permeability information at all fabric densities and deniers than vertical lapped fabric produced using round fibers. Air penetrability distinction of vertical fabric produced using diverse fiber cross-section relies upon the total surface area in fabric.

5.4.3 Effect of Fiber Denier

The acoustical insulation comparison among the nonwoven fabrics made from 3den round, 3den 4DG, 15den round, and 15den 4DG polyester fibers were used to study the effect of the fiber denier on fabric acoustical insulation.

As appeared in Figure 5.16, vertically lapped sample materials produced using 3den round fibers are preferred sound encasings over sample materials produced using 15den round polyester fibers. For all frequencies between of 73Hz and 20,000Hz, vertically lapped fabric produced using 3 denier round polyester fibers protect the sound around 5dB more than vertically lapped fabric produced using 15 denier round polyester fibers. [19]

The 5dB contrast shows that vertically lapped fabric produced using 3 deniers round polyester fiber protects the sound 3.16 times more than the vertically lapped fabric produced using 15 denier round polyester fiber. The purpose behind this outcome might be on account of littler deniers yield more fibers per unit weight of the material, higher total fiber surface territory, and greater potential results for a sound wave to collaborate with the fibers in the structure.

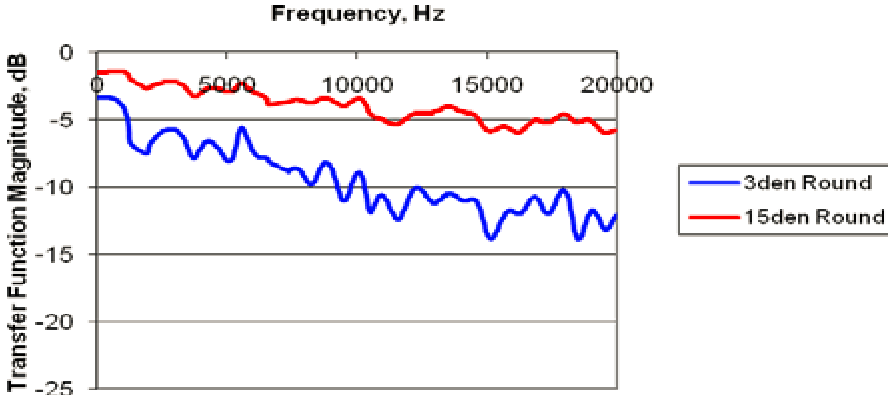


Figure 5.16. Transmitted sound results for vertically lapped nonwoven fabrics made from 3 and 15 denier fibers with 0.07g/cm3 fabric density. [19]

The distinction in transmitted sound between sample materials produced using 3den round polyester fibers and 15den round polyester fibers does not conversion with thickness of the fabric. Sound insulation of nonwoven sample material produced using 3 deniers round fibers is greatly improved than the sound insulation of nonwoven sample material produced using 15den round fibers. [19]

5.4.4 Effect of Fiber Shape

The acoustical insulation examination for the vertically lapped nonwoven sample materials produced using 15den round, trilobal, and 4DG formed fibers with similar thicknesses and densities was utilized to consider the impact of extended surface area. Extended surface territory comes about because of trilobal and 4DG fiber shapes.

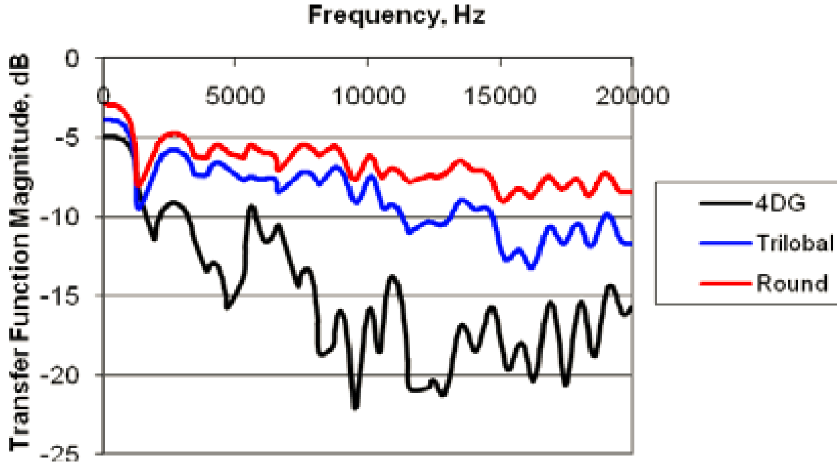


Figure 5.17. Transmitted sound results for vertically lapped fabrics made from 15 denier 4DG, trilobal, and round fibers with 0.43g/cm3 density. [19]

As appeared in Figure 5.17, the vertically lapped fabric produced using 4DG and trilobal fibers have preferable sound insulation qualities over nonwoven fabric produced using round fibers. For the frequencies between of 4500Hz and 5000Hz, the distinction in sound insulation information between the vertically lapped fabric produced using 15 denier 4DG fiber and fabric produced using 15 denier round fiber achieves 8dB, which demonstrates that vertically lapped fabric produced using 15 denier 4DG polyester fiber protects the sound 6.3 times more than the fabric produced using 15 denier round polyester fiber at those given frequencies. The explanation behind this outcome might be a direct result of the impact of surface area in the fabric. 4DG fibers have around three times more surface area than round fibers. Higher surface area in a nonwoven fabric builds the likelihood of the sound wave cooperation with the fibers and results in more compelling sound stifling in the nonwoven fabric. [19]

5.4.5 Effect of Fabric Density

To acquire a sign of the impact of fabric thickness on acoustical properties, nonwoven fabric with equivalent densities at similar thicknesses and weights were chosen.

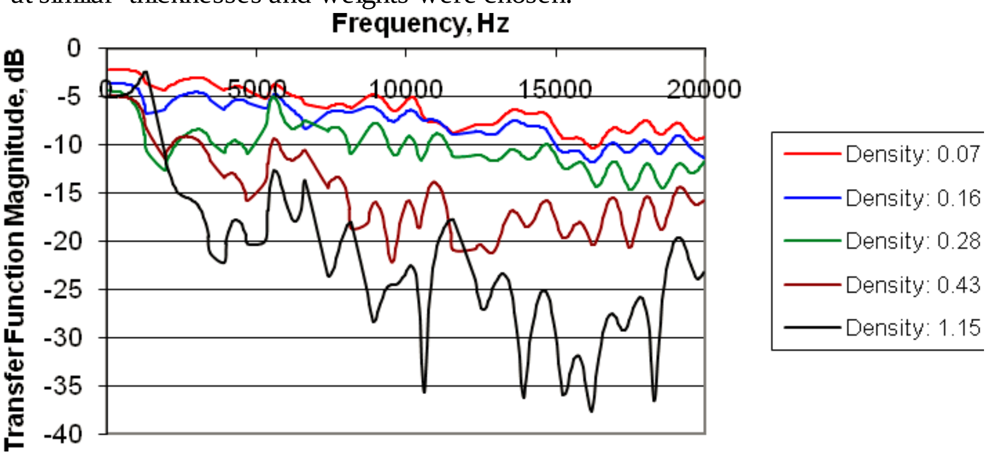


Figure 5.18. Transmitted sound results for vertically lapped fabrics made from 15 denier 4DG fibers with various volumetric densities. [19]

As shown in Figure 5.18, vertically lapped fabric at higher density insulated the sound more than the fabric at lower density. At the frequencies between 4000Hz and 5000Hz, the difference in insulation data between vertically lapped fabric at 0.43g/cm3 fabric density and the fabric at 0.07g/cm3 fabric density reaches 13dB, which shows that vertically lapped fabric at 0.43g/cm3 fabric density insulates the sound 20 times more than fabric at 0.07g/cm3 fabric density. [19]

5.5 Sound Absorption Behavior of Knitted Spacer Fabrics

An exploratory examination on the sound absorption behavior of knitted spacer fabrics. Both weft-knitted and warp-knitted fabrics were utilized as a part of the examination due to their distinctive structure highlights. The weft-knitted spacer fabric utilized was made out of two different plain knitted external layers and one textured polyester multifilament spacer layer, and it was considered as a porous sound absorber. The warp-knitted spacer fabric utilized was made with mesh structure on the external layers and monofilament yarn in the spacer layer, and it was considered as microperforated panel sound absorber. [20] The noise absorption coefficients (NACs) of these two sorts of fabrics under both single and multilayer shapes and their mixes were tried utilizing a two-receiver impedance estimation tube. The outcomes appear that the fabric surface structure and thickness, spacer yarn sort and their interfacing ways, fabrics combination and their arrangement strategies have significant consequences for the sound absorbability. [20]

5.5.1 Weft Knitted Spacer Fabrics

The weft-knitted spacer fabric utilized was indicated as sample A, and it was knitted on a Stoll CMS 822 E7.2 electronic level knitting machine of gage 14, utilizing the nylon/spandex 70D/20D yarn as the external layer yarns and 150Den/64F finished polyester multifilament as the spacer yarns. The yarn way documentation of the fabric structure is appeared in Figure 5.19. This was a weft-knitted spacer fabric exceptionally intended for sound absorption. In this fabric structure, both the best and base layers are delivered with varied plain weaved structure and they are interconnected together with six independent spacer yarns through tuck join. The warp-knitted spacer fabric used in this study was denoted as sample B, and it was produced on a KARL MAYER RD 6 N E24 double-needle bar Raschel machine of gauge 24, which is equipped with six yarn guide bars. [20]

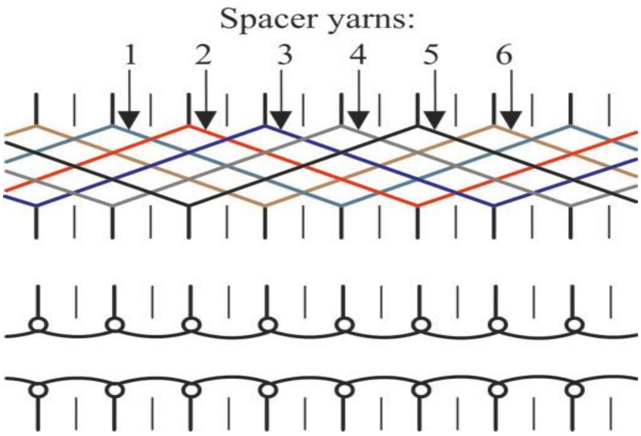


Figure 5.19 - Yarn path notation of weft-knitted spacer fabric.[20]

5.5.2 Noise absorption behavior of knitted spacer fabric

The noise absorption coefficients (NACs) of single layer spacer fabrics without an air-back layer are appeared in Figure 5.20. It is discovered that the NACs of the two specimens A and B increase with increase of the frequency. The NACs of sample A are 0.06, 0.14 and 0.35 at 500 Hz, 1000 Hz and 2000 Hz, individua lly, which exhibits a typical sound absorption behavior of porous material. Contrasted and sample A and sample B has brought down NACs for every one of the frequencies. The NACs of sample B is 0.035, 0.05 and 0.07 at 500 Hz, 1000 Hz and 2000 Hz, separately. Besides, the curve of sample B has two slight peaks. This is the normal behavior of MPP absorbers beginning from consolidating distinctive sizes of punctured gaps. Because of the presence of openings like punctured gaps, sample A can also be considered as a punctured panel absorber if the air-back cavity exists. The NACs of A and B with two distinct thicknesses (8 and 16 cm) of air-back cavity are appeared in Figure 5.21 [20]

It can be seen that all the sound absorption curves are as frequency spectra, on the grounds that the presence of the air-back cavity causes frequency chose sound retentions due to the reverberation of the system. In addition, the presence of the air-back pit brings about smaller absorption frequency areas, however with higher NACs at bring down frequencies if compared to the situation where no air-back cavity is utilized. The thickness of the air-back hole additionally has the effect on the NACs. The expansion of the air-back cavity influences the absorption frequency to advance toward the lower frequency side.

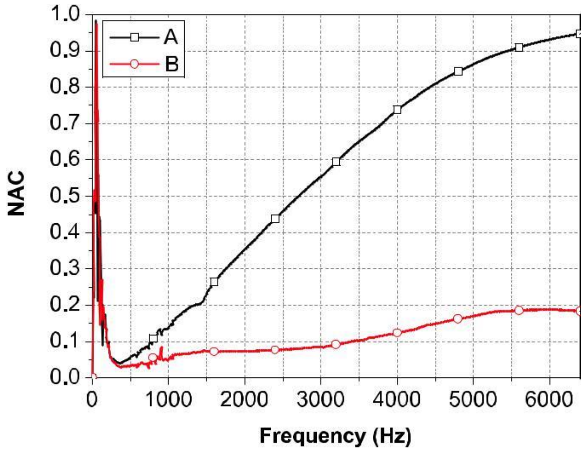


Figure 5.20: NACs) of single layer spacer fabrics without an air-back layer. [20]

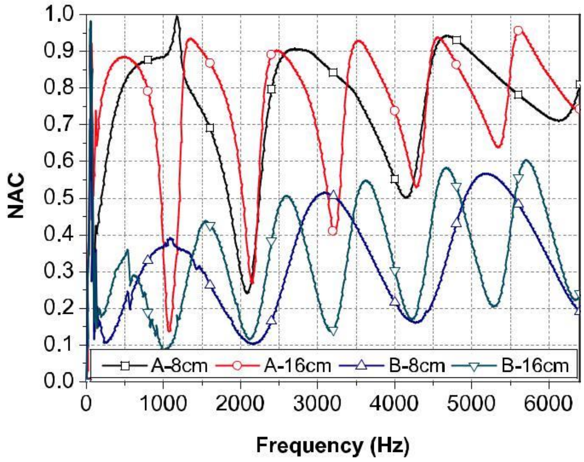


Figure 5.21: NACs) of single layer spacer fabrics with an air-back layer. [20]

From Figure 5.20 and 5.21, it can also be discovered that example A has preferred sound absorbability over specimen B for the two instances of utilizing and not utilizing the air-back cavity because of higher thickness. In any case, its sound sponginess at lower frequencies is still lowest without the utilization of air-back cavity. [20]

5.6 Acoustic Building Interior with Woven Fabric Combination

5.6.1 Woven and Nonwoven Fabric Combination

In the wall covering, the cover fabric has fundamental significance to give the enhancing and stylish appearance, so diverse variety of woven fabrics secured from market like Velvet, Denim, Jacquard, and so forth have been chosen in view of its qualities and strategy for assembling. The fabrics chose to have distinctive GSM and Thickness as given in Table 5.1

Sr. No.	Code	Specification	GSM	Thickness (mm)
1	T1	Brown Jacquard Woven	134	0.43
2	T2	Brown Jacquard Woven	188	0.39
3	T3	Plain Woven / Open Structure	192	0.51
4	T4	Printed Brown	204	0.46
5	T5	Grey Velvet with Knitted Back-up	228	1.20
6	T6	Maroon Jacquard Woven Two Side Fabric	260	1.05
7	T7	Brown Velvet (Woven Back-up)	291	1.12
8	T8	Denim	323	0.76
9	T9	One Side Laminated	483	1.35
10	T10	Maroon Jacquard Woven	744	2.57

Table 5.1: Specification and Coding of Cover Fabrics[21]

The needle punched nonwoven fabrics are produced using polyester having distinctive GSM and Thickness has been utilized as back up material. The nonwoven fabric has been provided by Ravi Industry, Jaipur. The subtle elements of the specimens are given in Table 5.2.

Sr. No.	Code	Material	GSM	Thickness(mm)
1	N1	Polyester	500	4.65
2	N2	Polyester	750	25
3	N3	Polyester	1000	35

Table 5.2: Specification and Coding of Back-up Fabrics [21]

5.6.2 Sound Reduction of Woven Fabric + Nonwoven Fabric

Sr. No.	Sample	Air Permeability	Sound Reduction in dB			
			5 cm	10 cm	15 cm	20 cm
N1						
1	T2 + N1	600	8.2	8.6	9.4	10.7
2	T7 + N1	400	9.6	11.4	12	14
3	T8 + N1	575	8.4	8.8	9.2	10.5
4	T9 + N1	225	10.9	12.4	13	14.7
5	T10 + N1	750	7.8	8.5	9.4	10.8
N2						
1	T2 + N2	1200	6.9	8.3	10.2	10.5
2	T9 + N2	1000	9.8	11.2	12.8	13.3
3	T10 + N2	1300	7.2	8.2	9.5	9.8
N3						
1	T7 + N3	1400	9.8	11.2	12.5	12.7
2	T8 + N3	1500	7.2	7.9	9.6	10.1
3	T9 + N3	1300	10.5	11.2	13.4	12.7
4	T10 + N3	1500	7.6	8.5	9.8	9.9

Table 5.3: Sound Reduction of Woven Fabric + Nonwoven Fabric [21]

The cover fabric alone does not indicate huge conversion in sound decrease properties. Henceforth, combination of woven fabric as cover material and nonwoven fabric as back up material was done and after that the testing was completed. The results for conversion in sound reduction properties are given in Table 5.3.

The sound proof walls are made by utilizing the three to four layers of various materials. The verities of the materials are utilized for making the sound verification divider. For the most part to make the sound evidence divider the primary layer is cover fabrics which are the chosen in light of its look, feel and application. The second layers utilized the fibrous materials as reinforcement materials. In this layer diverse types of fibers (Rock wool, fiber glass) or nonwoven fabrics are utilized and these layers are primarily in charge of the absorbing sound. A cover fabric having lower air penetrability, the combined air porousness of the cover and back up fabric is lower compared with different specimens and henceforth more sound reduction is gotten. This can be found in the specimen blend of T9 and N1 whose air porousness are separately 65 and 3200, giving a joined penetrability of 225, most reduced contrasted with different examples and thus gives most greater sound decrease. Consequently, Combination of woven and nonwoven fabric gives conversion in sound decrease properties. [21]

Chapter 06: Applications of textiles in the noise absorption:

6.1 Acoustic Applications of Textile in Different Fields:

Textile materials are utilized for numerous applications of acoustics:

i. Acoustic boards for workstations;

ii. Car insulation

iii. Upholstery in concert hall

iv. Public Buildings

v. Industrial Plants

vi. Inplant Offices

vii. Loud, stationary Noise Sources

viii. Enclosable Noise Sources

ix. Outdoor Noise Sources

x. Compressors [22]

xi. Machine Enclosure Curtains

xii. Inplant Noise Baffles

xiii. HVAC Applications

xiv. Stamping Presses

xv. Conveyors

xvi. Pipe and Duct Jackets

xvii. Inplant Noise Curtains

xviii. OEM Applications

xix. Auditoriums.

An acoustic material, must have acoustic properties in its own. It must be particularly engineered to absorb sound. In general terms, acoustic materials fall in 2 classes of porous sound absorbers:

i. Bulky, high-loft materials, which basically carry on as an inflexible, porous sound absorber.

ii. Light weight, compact woven and nonwoven materials that act as porous screen.

Mass porous absorber, for example, fiberglass or mineral wool batts or blancket, and needle punched, resin or thermally bonded porous materials, are outstanding and all qualify as rigid porous absorber. flow resistive screens can give comparative execution to the high-loft materials, without the mass. Thin lightweight acoustic materials, for example, INC Synthetic Materials Deci-Tex area, about as adaptable porous screens.[22]

6.2 Applications for Sound Absorption

Sound absorptive materials are largely used to neutralize the unwanted impacts of sound reflection by hard, inflexible and interior surfaces and in this manner help to reduce the reverberant noise levels. They are utilized as interior coating for flats, automotive, airplanes, and conduits, enclosure in areas for noise equipment and protections for apparatuses. Sound absorptive materials may also be utilized to control the response of creative execution spaces to consistent and transient sound sources, along these lines influencing the character of the aural condition, the understandability of unreinforced discourse and the nature of unreinforced melodic sound. [22]

6.3 Automotive Acoustic textile

6.3.1 Automotive Textiles and Vehicle Noise

Despite the fact that this section is basically centered around autos, the exchange is also pertinent to trucks, buses, motor homes and caravans. The car business is undoubtedly the biggest customer of acoustic materials. The measure of textiles utilized for a standard traveler auto can be as much as 42 m^2. Acoustic materials made of polyethylene terephthalate (PET) and nylon filaments are the most utilized as a part of vehicles to give sound absorption, in spite of the fact that glass fiber is also utilized for reinforcing hard composite boards to give sound segregation.

Discourse clarity estimations are once in a while utilized for evaluating the capacity of the clients interior the vehicle to hold a discussion or tune in to music during vehicle operation.

As a rule, acoustic materials are utilized as a part of vehicles to decrease interior noise and vibration and enhance the vibe of ride comfort for the vehicle's inhabitants. Interior noise is presently an aggressive strength normal for autos.

Control of the interior frequency reaction might be accomplished by altering the cabin geometry with the goal that high acoustic reverberation peaks are decreased and the interior frequency reaction has a tendency to be direct. In any case, the new plan of car cabin shapes is generally restricted, and the acoustic resonances are regularly damped using sound absorption. Expansion of acoustic damping as a sound-absorbing material on the surfaces incredibly influences the acoustic character of the traveler space. Figure 6.1 demonstrates the frequency reaction of a cabin enclosure in area prior and then afterward including a sound absorption material. In this case, the expansion of a thick nonwoven material coating fundamentally reduces the resounding reaction peaks of the acoustic modes at mid and high frequencies. [23]

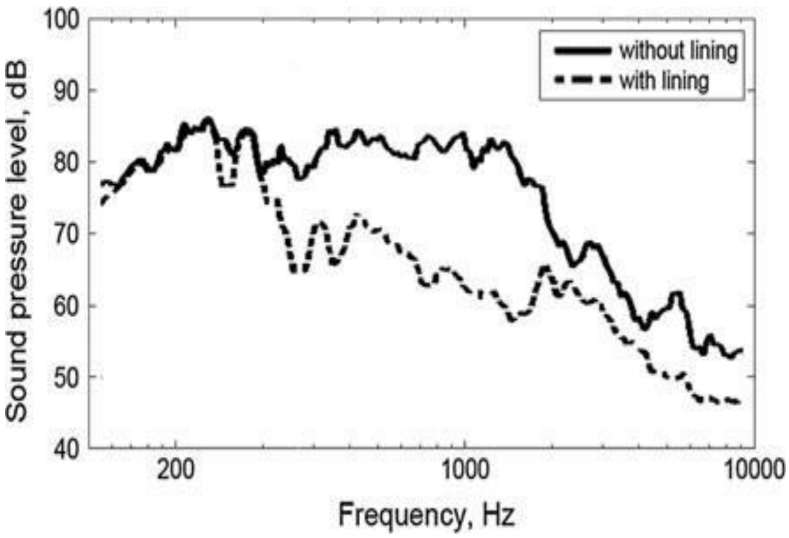


Figure 6.1 Frequency response of a cabin enclosure with and without an absorbing lining.[23]

6.3.2 Sources of noise within vehicles

An assortment of sources adds to the interior noise of a vehicle which can be structure-borne or airborne sound. The principle sources of noise and vibration in vehicles include those identified with the power system (kinetic, cooling fans, gearboxes and transmissions, brakes and bay and fumes systems) and those non-control system sources created by the vehicle movement (tire/street association noise and aerodynamic noise caused by flow over the vehicles). In general, structure-borne sound is the predominant source of interior total vehicle noise beneath 400 Hz, and airborne noise is dominant over 400 Hz. Acoustical binding between the power train part excitation and the vehicle cabin cavity is also a predominant source of up to 50 Hz of vehicle interior low frequency blast noise.

The noise generation systems of the tire/street noise of a vehicle are vibration related (tread effect and grip) and aerodynamic (air dislodging because of the communication between the tire and the street surface). The level of this noise is also dependent upon vehicle working conditions and street characteristics that could fluctuate from solid asphalt to various porous blends. Power train noise is the prevailing noise source during the speeding up of generally vehicles. Despite the fact that power system noise in inward burning kinetic autos has been decreased throughout the years, interior noise of most new autos is ruled by the sources created by the vehicle movement. This reality is especially critical at speeds more than 50 km/h, where tire/street association noise and aerodynamic noise are the dominating sources. Studies have demonstrated that tire/street noise has a tendency to dominate during cruise conditions on a smooth street at around 80 km/h. This noise increases around 10 dB for each multiplying of speed, which speaks to an inexact multiplying of subjective loudness. For hybrid and electric vehicles that utilization calm electric engines, the power system noise can practically be dismissed in contrast with moving noise. In this manner, the nonpower system noise has gotten much consideration from makers and specialists as of late.

Since sound power is corresponding to the area of a vibrating structure, the auto rooftop also speaks to an imperative source of noise to the vehicle interior. Both structure-borne and aerodynamic noises incite vibration of the metal rooftop bringing about a huge transmitting panel like sound source. This source is vital at frequencies that are near the frequencies of the main basic methods of the rooftop.

Every one of the sources described above deliver low frequency noise, shrieking tones that can be transmitted structure-borne into the vehicle interior, and aggravating sound that brings down the comfort feeling interior the vehicle, actuates weariness, and may lessen driving security. Figure 6.2 demonstrates the area of significant sources of noise on a car. [23]

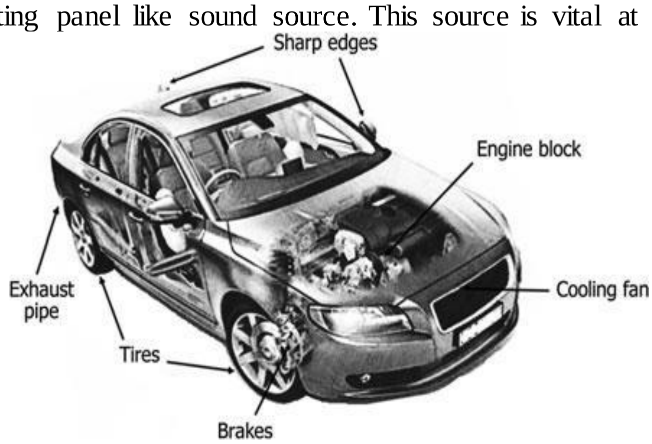


Figure 6.2 Location of some of the sources of power system, tire, and aerodynamic noise on an automobile [23]

Different sources that add to the interior noise in vehicles are the sections of the heating, ventilating and air conditioning (HVAC) equipment, for example, the air channels and vents, the blower, and the complex. These sections should be analyzed in detail to lessen their sound commitments. Car HVAC noise can be exceptionally irritating to the travelers, especially when it is worked under most extreme wind current conditions. Figure 6.3 demonstrates the in-cabin noise levels of two unique autos under sit out of gear conditions when the HVAC system is off and on.

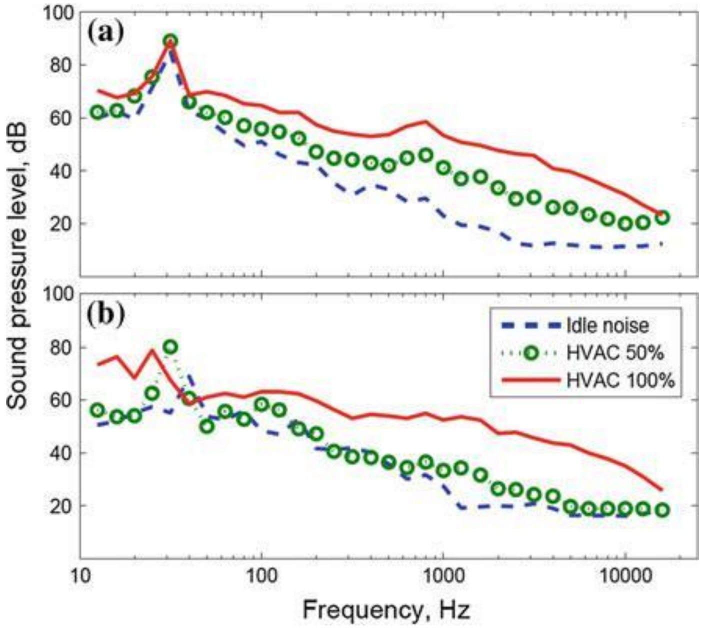


Figure 6.3 Sound pressure level interior an automobile produced by the HVAC system at driver's ear location: (a) American sport utility vehicle (SUV) and (b) Japanese compact car [23]

6.3.3 Interior Vehicle Noise Control

Vehicle interior sound pressure levels can be controlled by reducing the noise created by the sources, by decreasing the noise during transmission through air-borne, and structure-borne ways, and by decreasing the noise transmitted interior the vehicle.

Materials used to enclose noise sources are named barrier materials in the car business. The noise detachment execution of these materials is for the most part dominated by their mass/unit territory. This is a plan challenge since auto weight decrease is also a prerequisite of the transportation business for fuel decreasing. In general, obstruction materials are described by transmission loss (TL), that is, 10 logs of the division of occurrence energy that is transmitted. For single layers, TL increases hypothetically by 6 dB for each multiplying of frequency or by 6 dB at a given frequency if their mass/unit area is multiplied. Much better execution can be accomplished utilizing multilayer boards, and the TL for such boards can be more similar to 12 dB/octave as opposed to 6 dB/octave of a single layer. Noise disengagement of the vehicle additionally relies on the TL of the vehicle windows. Consequently, the utilization of overlaid glass is normally utilized to give impedance mismatch and vibration damping. [23]

Noise decreasing is additionally accomplished by giving mechanical damping to the basic vibrating boards of the auto body, especially at reverberation frequencies. Obliged and unconstrained viscoelastic layers are normally utilized for this purpose. Damping layer materials include mass, which can also lessen airborne sound transmission through areas, for example, floor boards.

Sound absorption can also help in reducing interior noise once airborne and structure-borne sound has entered the traveler cabin. TL is joined with the vehicle interior normal sound absorption to get the total noise decreasing. The expansion of noise isolation is scientifically assessed by 10 logs of the sound absorption, that is, noise decrease increases by 3 dB for each multiplying of total sound absorption.

Sound absorption can be given on the interior surfaces of the vehicle (sidewalls, housetop and floor) or interior the volume by the seats. In transports, the surface underneath overhead compartments can be utilized to include additional sound absorption. Even though the materials are normally chosen for factors other than sound absorption, for example, insulation from mechanical harm, simplicity of cleaning, appearance and acoustic execution, there are a few surface areas that can be planned considering sound absorption. These include main events, entryway housings, carpets, and other interior trims. Figure 6.4 indicates areas where obstruction and sound-absorbing materials are frequently connected in a vehicle. [23]

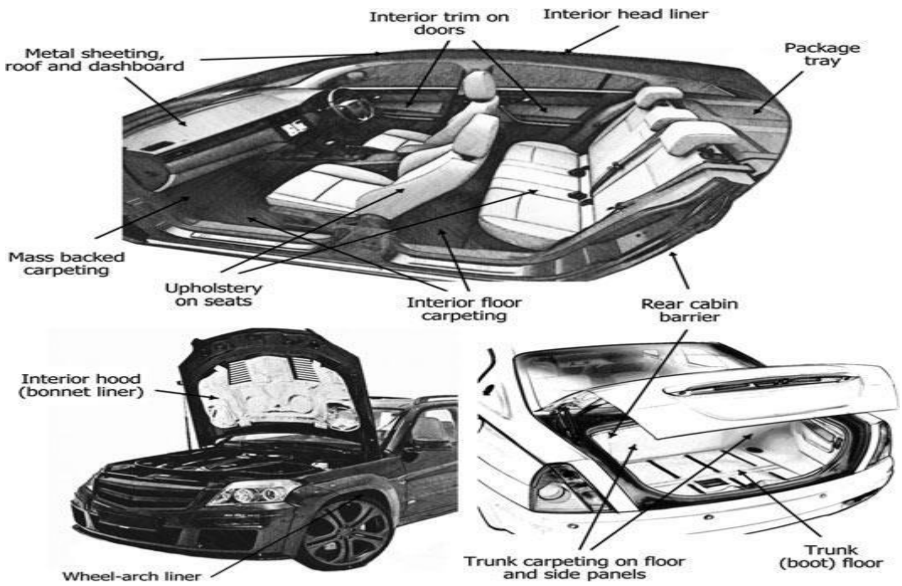


Figure 6.4 Typical locations in an automobile where barrier and sound-absorbing materials are utilized [23]

6.3.4 Use of Acoustic Textiles in Vehicles

Acoustic materials used to control noise in vehicles must give airborne transmission decreasing, damping and sound absorption. [23]

Seating Area

A lot of vehicle interior sound absorption is given by the seating area in present day vehicles. The total sound absorption relies upon the blend of materials used to make the seat. Nylon, polyester, polypropylene and some common fibers have been utilized as crude materials for situate covers. The utilization of woven and knitted materials, (for example, tricot, twofold needle bar Raschel and round weave) is regular in American, European, and Asian seat upholstery makers Figure 6.5 demonstrates the average sections of an auto situate. [23]

Figure 6.5 Simplified diagram of the typical components of a car seat [23]

In general, the material seat cover goes about as a porous looking to mass foam, and relying upon its flow insulation, it has the impact of increasing the sound absorption at low frequencies and decreasing the sound absorption at higher frequencies as saw in Figure 6.6. It has been noticed that unless the level of the open territory of the covering is 20 % or more, the reduction of sound absorption at high frequencies might be greater. [23]

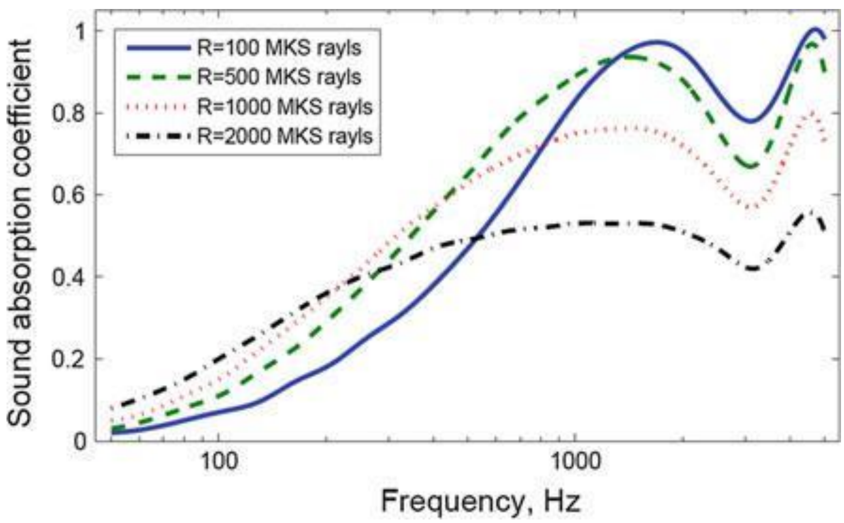


Figure 6.6 Effect on the normal incidence sound absorption of the airflow resistance (R) of a nonwoven textile used as facing of 50 mm thick porous foam [23]

Headliners

Fundamentally, present day main events are made of a blend of materials that include no less than an inflexible base structure to be appended to the metal panel (semi-unbending polyurethane foam, fiber-fortified porous polymer, fiberglass, resin trashy fibers, card-panel), a moderate delicate layer (polyurethane foam, polyester nonwoven, poly-olefin foam, polypropylene foam), and an interior embellishing rooftop trim cover confront (polyester nonwoven, weaved nylon/polyester, PVC foil). The layers are limited utilizing hot liquefy glues, and after that the structure is press formed to the required shape. These structures give airborne noise disconnection, basic inflexibility and damping of the auxiliary methods of the rooftop metal panel.

PET overlays utilized as ornamental rooftop trim have been proposed for enhancing main event sound absorption [23]

Carpets

Floor covering through carpeting, including tufted mats (made of nylon, PET, or polypropylene), speaks to a higher measure of material acoustic surface utilized as a part of a normal current auto.

Usually, vehicle carpet is upheld utilizing viscoelastic polyurethane foam, resinated trashy fiber/polyurethane foam, cotton fiber cushions and an acoustic boundary made of ethylene, propylene and diene monomer elastic (EPDM) for noise decreasing.

Needle-punched nonwoven (nylon, polypropylene, pigmented reused PET fiber) is regularly utilized as surface material for interior carpet. Natural fiber nonwoven floor covering systems for decreasing car interior noises have also been used. Figure 6.7 schematically demonstrates the principle types of surface examples for needle-punched cover: plain, circle like, and velour-like. [23]

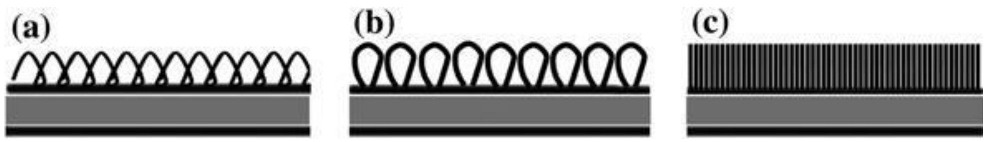


Figure 6.7 Typical carpet surface patterns used for automotive interior lining: a) plain, b) loop-like, and c) velour-like [23]

The last two examples can be made by the blend of particular needles and needling designs.

Low frequency sound delivered by vehicle underbody fluctuating pressure is because of its huge arrangement form area essential for interior noise. Reduction of this noise is a genuine sample for producers since this type of noise is hard to protect with floor covering since high surface mass is required to give enough TL. Subsequently, hard composite parts are getting to be plainly standard in the car business. A great case of a car composite panel is a fiber-reinforced plastic (FRP) made of glass/carbon fiber and thermoplastic/thermoset gums, although some propelled composites have been as of late tried [23]

Trunks

Textile formed parts utilized as a part of trunks ought to give a boundary of high TL to keep airborne noise from the fumes system interior the auto interior. What's more, some vehicle sound systems include amplifiers flush mounted into the bundle plate (and to different sidewalls additionally), where the storage compartment is utilized as an amplifier acoustic enclosure in area to show signs of improvement low frequency reaction. For this situation, sound absorption of the storage compartment decreases unwanted resonances, enhancing sound system quality. [23]

Hood (Bonnet Liner)

A typical multilayer elective utilized for decreasing kinetic noise is made of a fibrous felt sandwiched between two layers of warmth safe sap impregnated nonwoven. Figure 6.8 indicates two cases of the inclusion loss of a hood liner. The addition loss is the distinction, in dB, between two sound weight levels that are measured at a similar point in space prior and then afterward the hood liner is set up utilization have prompted the improvement of composite multilayer structures for this reason.

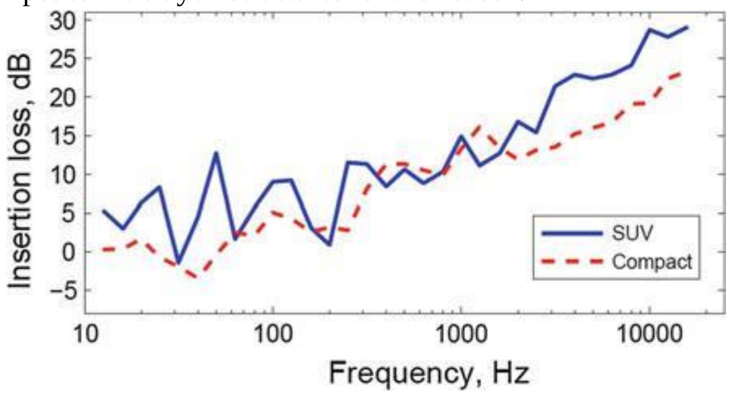


Figure 6.8 Measured insertion loss provided by a hood liner of an American SUV and a Japanese compact car [23]

Hood liner (hat liner) is critical for decreasing kinetic noise and structure-borne vibration. Before, hood liners were made of a mass fiberglass tangle secured with a defensive PVC film. Higher gauges in noise decrease and fuel. [23]

6.4 Other Applications

Package trays are also generally secured with needle-punched nonwoven material for the most part in polypropylene or polyester. Unique nonwoven wheel well embeds have additionally been created to lessen tire/street noise. This moderately new utilization of textiless has been discovered suitable to supplant PVC and EPDM in autos. Latex-covered needle-punched polyester and polypropylene are utilized as a part of shaped wheel curve liners to keep the transmission of tire/street noise and stone-affect noise to the traveler's cabin. Better noise disconnection and weight decrease have been observed when contrasted and old plastic liners, specifically on wet streets. Go by noise may also be reduced with fiber wheel liners since they additionally give sound absorption at the source of tire/street noise. [23]

In addition, fiber arrangement in respect to the occurrence sound aims the acoustic materials to be anisotropic since wind current resistivity clearly changes for various edges. Therefore, sound absorption coefficient and TL often vary for the instance of brushing and typical rate in coating applications. Fiber introduction also impacts the rigidity of a nonwoven material. Figure 6.9a demonstrates the fiber introduction of a cross section opposite to the contents of a polyester nonwoven and Figure 6.9b demonstrates the pentalobe cross-sectional state of a man-made fiber.

It appears that the contact amongst air and fibers can be increased for bigger fiber surface territory with the goal that mind-boggling fiber cross areas may give preferred sound absorption over round cross-section filaments. Figure 6.9b demonstrates a case of such a man-made fiber of a monofilament with longitudina lly arranged grooves shaping a pentalobe cross area. In Japan, an altered cross-area (trilobal) polyester fiber material was connected to the dash silencer, which delivered conversion in sound absorption execution in a frequency scope of 300– 1000 Hz. The dash silencer was appended to the dash panel separating the kinetic compartment from the auto interior to keep the transmission of the kinetic noise to the traveler cabin.

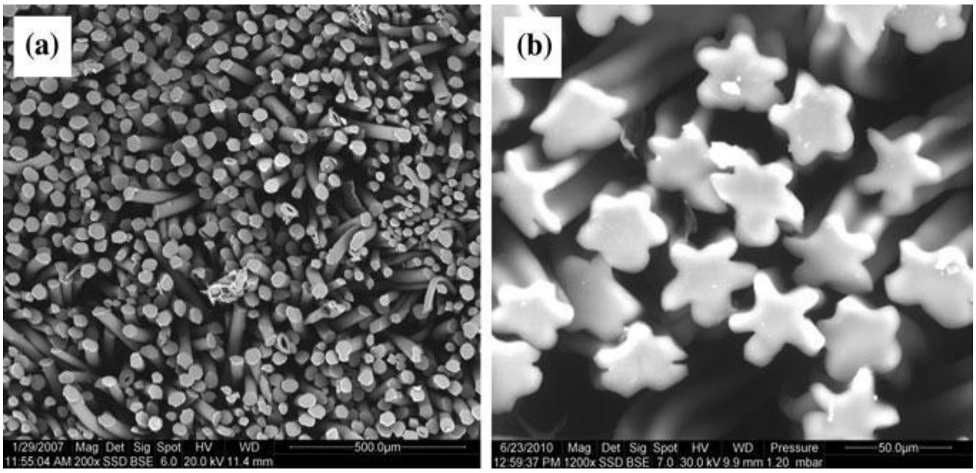


Figure 6.9 Scanning electron microscope images of samples of fibrous sound absorbers: (a) fiber orientation of a cross section perpendicular to the face of a polyester nonwoven textile, (b) pentalobe cross-sectional shape of a man-made fiber [23]

The sound-absorbing properties of carbonized and initiated nonwovens have been as of late concentrated by a few specialists. Textiles can be changed over into dynamic carbon products utilizing pyrolysis, and they could be utilized as superior sound absorbers. Actuated carbon fiber (ACF) fabrics have two levels of porous structures: macro pores among fibers and yarns and micropores on the sur-face of ACF. Fiber forerunners for creating business ACF include rayon, acrylic, polyacrylonitrile (PAN). Up until this point, investigates composites made of surface layers of ACF and fibers of cotton, ramie, and PP as base layers have demonstrated high sound absorption coefficients in an extensive variety of frequencies. These materials can possibly be utilized as elite sound-absorbing and noise isolators in car and different methods for transport applications. [23]

An exceptionally regular outline of a sound-detaching panel is a boundary normally made up of a punctured cover plate encasing a core of a porous absorbing material and air holes. Reused materials can be utilized as core components of these obstructions. Reused fibers have been utilized for a long time as a source of crude material to deliver acoustic materials. Mechanically pulled squander attire, known as disgraceful, has been utilized to create porous nonwoven fabrics. Nonwovens made of reused fibers that are utilized as a part of covered sections consolidate thermoplastic filaments to enable trim to accommodate sporadic car shapes. Figure 6.10 demonstrates the estimations of sound absorption for reused materials made from textile waste.

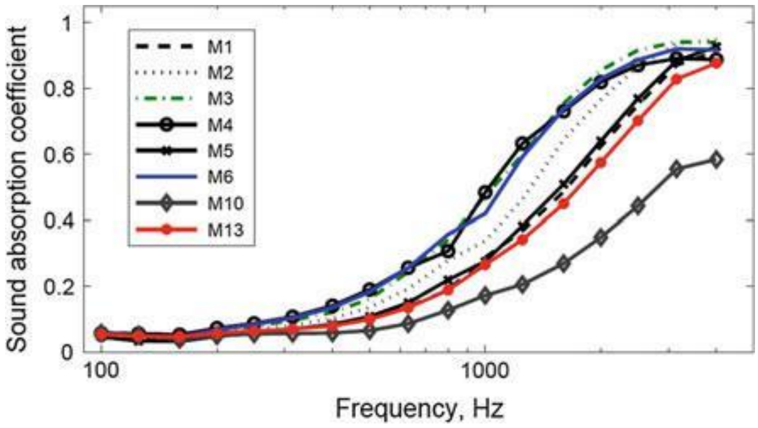


Figure 6.10 Sound absorption coefficient at normal incidence of some recycled materials manufactured from textile waste [23]

Either hot liquefy fibers of reused polyester or phenolic resin were utilized as binder. The properties of each of the fabricated materials are compressed in Table 6.1

Sample	Multi-fibers	Binder	Density (kg/m^3)	Thickness (cm)	Airflow resistivity (kNs/m^4)
M1	80 % (75 % CO–25 % PES)	20 % PES	71	1.5	26.9
M2	80 % (75 % CO–25 % PES)	20 % PES	102	1.5	26.7
M3	80 % (75 % CO–25 % PES)	20 % PES	116	1.7	23.2
M4	74 % (75 % CO–25 % PES)	26 % PES	127	1.6	25.1
M5	74 % (75 % CO–25 % PES)	26 % PH	71	1.4	28.8
M6	74 % (75 % CO–25 % PES)	26 % PH	136	1.5	26.8
M10	80 % (75 % CO–25 % BP)	20 % PES	57	1.5	26.8
M13	80 % (75 % CO–25 % BP)	20 % PES	67	1.0	40.2

Table 6.1 Properties of the recycled materials manufactured from textile waste [23]

6.5 Applications in Other Means of Transport

Although the largest amount of acoustic textile is employed in the automotive industry, other forms of transportation also use textiles to reduce noise and vibration. Some of these applications are discussed in this section. [23]

6.5.1 Use in Aircraft

Interior noise levels in an air ship cabin are regularly over 80 dB. This noise is created by outside sources (motors, propeller and turbulent boundary layer) and interior sources (aerating and cooling and water powered system, gearbox, landing gear, and so forth.). One of the principle sources of interior noise in an air ship is delivered by motors. The idea of the noise relies on the kinetic power and the mounting position of the motors (wing-and fuselage-mounting). Kinetic noise is transmitted into the cabin both airborne and structure-borne, where flying machine windows are typically an imperative noise transmission way.

Propeller noise is described by the nearness of low frequency discrete tones at the essential sharp edge entry frequency of the motors and their sounds. For flow controlled flying machines, the kinetic noise is prevalently broadband and the excitation relies upon the mounting position of the motors. Interior noise in turbo propeller driven flying machine is typically 5– 10 dB higher than in a tantamount turbofan-fueled flying machine. Pivoting lopsidedness powers interior the motors can also cause noise in the interior cabin.

There is an imperative interest for reducing the interior noise in planes to improve cabin comfort of both the crew and the travelers, specifically for whole deal flights. However, control of air ship interior noise is hard to accomplish utilizing detached strategies because of the limited mass and volume requirements interior an air ship. This is especially clear in turbo propeller-driven flying machines, where the noise is typically predominant in the low frequency district (underneath 400 Hz) causing traveler inconvenience.

The most widely recognized latent noise control method in a flying machine is to enhance the TL of the fuselage structure utilizing multi element sidewalls. Essentially, fiberglass sound-absorbing covers are put between the fuselage and the trim boards framing a twofold divider. Increasing the separation between the sidewall boards permits extra space for an air hole which builds the total noise decreasing of the system. Fiberglass covers with a thickness of around 7 kg/m3 contained in impenetrable sacks are typically utilized between the fuselage structure and interior trim boards as noise insulation.

Honeycomb boards are broadly utilized as a part of assembling parts of present day planes. A honeycomb panel is a lightweight sandwich panel with a honeycomb core. This core can be made with an assortment of cell shapes, yet the most generally utilized shape is the hexagonal shape. Although expensive, honeycombs are utilized because they have high firmness opposite to the plane and the most elevated shear solidness and strength to-weight ratios of all accessible core materials. [23]

Unitapes and woven fabrics have been utilized as composite face sheet materials of honeycomb boards. Regular weaves include unidirectional fabrics, plain weave fabrics and glossy silk weave fabrics. Plain weave seems to have the soundest construction, and its strength is uniform in both face headings.

To add damping to the panel, a compelled viscose elastic layer is normally stuck to a face of the panel. This treatment is generally used to scatter vibration, thus reducing sound radiation from the structure. Figure 6.11 shows a diagram of a typical honeycomb panel. [23]

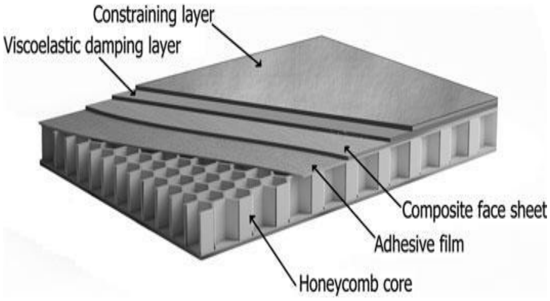


Figure 6.11 Diagram of a typical lightweight honeycomb structural panel. [23]

6.5.2 Use in Trains

For most train insides, the predominant airborne noise source originates from the wheel/rail interface, or moving noise. Different sources of noise and vibration are from subordinate gear, vibration of boards, splowests in body structure, a turbulent boundary layer that energizes body boards and HVAC equipment.

Harshness of rails and wheels, particularly groove in rails and out-of-round wheels, has been distinguished as a greater reason for rail noise. The utilization of composite brake pieces instead of cast press brake squares will fundamentally enhance the wheel running contact surface and decrease noise levels.

The train business has possessed the capacity to bring down the sound pressure level in trains to a mean of under 70 dB(A) (A-weighted decibel). A quantitative and subjective investigation on the impacts of noise sources on the interior noise attributes in different types of trains has been as of late detailed. The investigation demonstrated that moving, effect and bend screech noises were caused by wheel– rail cooperation. Effect noises have bigger parts at bring down frequencies (beneath 1000 Hz) and bend screech noises contain bigger components at frequencies between of 125 and 500 Hz in both underground and surface trains.

Pantographs in present day high speed trains can deliver critical aerodynamic noise achieving a noise level like moving noise. In spite of the fact that noise from container tographs can be decreased by protecting and legitimate shape plan, porous coatings can also give huge noise decrease.

Honeycomb boards are exceptionally regular in railroad auto body structures, for example, door boards, and in supplanting ordinary wooden interior floors, because of their low mass, insulation from dampness, and furthermore to take into consideration electrical floor heating systems. Sound absorption to decrease noise in train insides is given principally via situate upholstery, lose covering carpets, covers, drapes and bedding in sleeper compartments. [23]

6.5.3 Use in Ships

Comparative noise issues happen in traveler ships as in surface transportation vehicles and flying machines. Significant sources of noise in ships are the drive equipment and propellers. Because of the low damping of run of the still send development, airborne and structure-borne sound transmitted through the body is hard to decrease.

There is a developing interest for acoustic comfort in ships. Subjective investigations have shown that acoustics is the hugest comfort paradigm pronounced by passengers during a journey. Acoustics was also said as the foundation to be improved, a longways in front of different variables. The impact of acoustic inconvenience on individuals is to create rest unsettling influence and disturbance. The examination demonstrated that the most bothering noises for journey travelers fall into three classes: (a) Squeaking, banging, splitting, squeaking clamors, (b) Noise of motors, and (c) Ventilation and shrieks.

A method for noise and vibration decrease in transport lodges is the utilization of a drifting floor. Now and again where lodges are situated above greatly uproarious rooms, for example, kinetic or assistant equipment rooms, drifting floor might be the main option for reducing the noise levels in the cabin. Ordinarily, the skimming floor comprises of upper panel and mineral wool, which is thus laid on the steel deck plate. Mineral wool can be swapped for reused cover squander. [23]

6.5.4 Use in Spacecraft

A substantial number of materials utilized as a part of rocket applications have been created fundamentally to decrease noise and vibration introduction of people, equipment and pay-loads.

Serious acoustic noise and vibration are both unavoidable and unwanted results created by the starting of a shuttle. The noise produced during the terminating of rocket motors shows itself to the dispatch vehicle, delicate space-make and the platform, as airborne acoustics and structure-borne vibration.

The principle sources of noise and vibration in shuttle are from rocket motors, supersonic flow deplete, pyro shocks, acoustic burdens at dispatch, on-circle jitter, and some of the time, planetary landing loads. Because of the high-power levels, rocket is subjected to the most unfriendly and outrageous noise and vibration condition of any transportation system.

Composite materials made of at least two fabrics fortified together utilizing gums and glues have been produced for the rocket business. Composites are intended to form a general material whose properties are superior to the entirety of the properties of their individual sections. For instance, contrasts in the way the material fibers are arranged may give diverse qualities to a composite material. Carbon, glass and Aramid fiber strengthened materials are a portion of the composites that have been utilized for requesting rocket applications. [23]

Rocket and payload structures are not by any means the only things subjected to noise and vibration that could make a mission fall flat; different conditions are additionally very essential to consider, for example, a hard vacuum, outrageous temperatures, electromagnetic radiations and direct entrance by micrometeoroids and flotsam and jetsam. [23]

6.6 Innovative Textile Acoustic System and Its Application

A critical parameter in the working environments is the comfort, so it was essential to extend a system that could decrease the room reverberation time, considering the size and the crowding of the room. This creative textile system is formed by an aluminum structure, called "sail", within shaped rock wool panel; everything is included by an extended EPS "acoustically transparent" fabric (Figure 6.12). These "sails" are suspended from the roof and held by metallic sidelong backings. These structures have an alternate shape, keeping in mind the end goal to make a dynamic impact in the room and enhance the room acoustic quality.

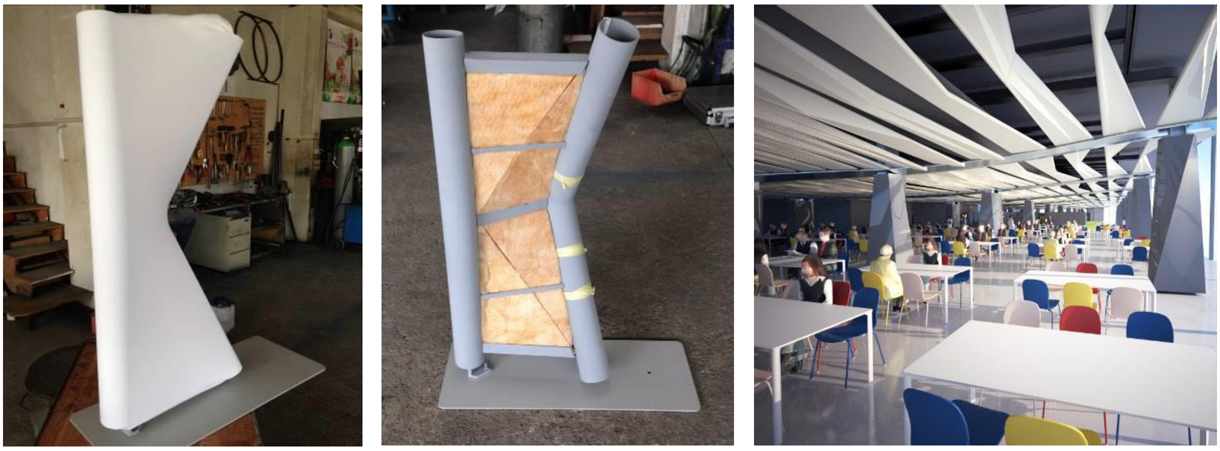


Figure 6.12: Sail prototype covered with fabric (left); Sail prototype without fabric (centre); photorealistic view of the restaurant (right). [24]

To fit the whole roof surface the "Sails" were outlined with various lengths. The aluminum structure shape has a practically roundabout hollow section, to which are welded "T" profiles, important to hold shake wool boards. In the roundabout section there are two metallic stiffening, which hold two PVC grips, called "Sollto Grip". These grips can induce tension in the fabric, giving the panel a uniform finishing. Rock wool soundproofing shaped panel (Figure 6.13) are fitted in the aluminum frame [24]. The "Sails" have a twofold exposed absorption surface giving a high acoustic execution (Figure 6.13). "Sails" are secured by an acoustically transparent fabric, extensible and can demonstrate itself on the shaped panel. [24]

Figure 6.13: Views of the shaped rock wool panels (left and centre); sail covered with EPS fabric (right).

[24]

Conclusion

Sound is the intimate part of our daily life. When sound goes out of control it becomes a threat for our health and environment and turns to noise. So, we should reduce the noise level to make a healthy and comfortable life. We can control noise a significant percentage by using textile materials in transportation, building etc.

Nowadays, people are very concern about environmental impact of materials. Which materials are degradable and recyclable those are environment friendly. So, we can take these benefits by using acoustic textile materials. Transportation sector is currently the largest consumer of acoustic textiles. New developments expected to increase the advance acoustic textile in the future. Construction sector also is going to be a very popular consumer of acoustic textile.

Although several researchers have established a number of theoretical and semi empirical approaches in order to predict the acoustic characteristics of fibrous materials, further research on this topic is still lowest required. More precise and reliable prediction models will allow us to provide the engineering of advanced textiles, consequently increasing their use to design better acoustic textiles.

Therefore, the challenges that engineers will face is to create an acoustic material that supplies all of the aesthetic, technical, economical, ecological and security features that are required for use in modern application.

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