# ACOUSTIC PERFORMANCE OF MULTILAYER NONWOVEN

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**ABSTRACT:**

Multilayer or multicomponent composite nonwoven structures give extraordinary favorable circumstances to numerous specialized applications. Spunbond-meltblown-spunbond (SMS) type multilayer nonwovens have noteworthy business accomplishment regarding end-use adaptability. SMS type composite nonwovens, which can be delivered with both consistent and broken creation innovations, are developing step by step. Massive, stringy, permeable nonwoven structures are broadly utilized as sound safeguards for an assortment of utilizations for moment building and car protections, machine protections, and so on. The strands interlocking in nonwovens are the frictional components and give protection from acoustic wave movement. The same number of specialists detailed, the best factors on sound assimilation properties of stringy materials are fiber distance across, wind stream opposition, material thickness, tortuosity, porosity, and fiber surface territory. In this examination section, the sound retention execution of SMS type composite nonwovens according to air porousness and pore sizes has been resolved. The outcomes show that SMS type nonwovens perform sound protection at high frequencies.

## INTRODUCTION

Noise is the unwanted and undesirable sound that affects the human ear and cause disturbances. Noise adversely affects the human health and cause permanent hearing loss, mental illness, cardiovascular diseases, sleeping disturbance, etc. The audible frequency range of humans is about 20Hz to 20000Hz. Sound waves above this frequency range affects the human ear and also the environment. High noise levels can be controlled by the use of suitable sound control materials such as acoustic materials. It dampens the sound because of its porous nature.

Nonwovens are engineered fabrics i.e) they are created with the targeted structure and properties by applying set of scientific principles for variety of applications. A multilayer or multicomponent nonwoven is also called as composite nonwovens. It consists of the structure with various combinations of materials with a greater advantage. There are number of combinations of spunbond and meltblown nonwovens such as SM, SMS, SSMMMMSS, etc. Meltblown fabrics are weaker and they are sandwitched between stronger spun bond fabrics.

When sound enters into fibrous materials, its amplitude is decreased by friction as the waves try to move through the tortuous passages. Thus, the acoustic energy is converted into heat resulted with sound absorption. In multilayer nonwovens, in accordance with the layers' structural parameters, different fiber intersections and fiber orientations occur. Additionally as the number of layers increases or with different layer combinations in multilayer nonwovens, tortuosity and pore geometry will vary and different sound absorptions will be provided.

## LITERATURE REVIEW

### 2.1 SOUND ABSORTION MATERIALS

Materials that absorb the sound waves are called sound absorption materials. These materials reduce the energy of sound waves when it passes through it. These material should be resistant to sound and it can be fibrous or porous material. Some of the examples are nonwoven, fibrous glass, mineral wools, etc. Due to its porous structure, it can absorb high frequency sound waves.

Porous materials used for noise control applications are categorized into fibrous medium or porous foam. Glass, rock wool or polyester fibres have high sound absorption. Sometimes fire resistant fibres are also used for making acoustical products.

### 2.2 SOUND ABSORPTION MECHANISM IN FIBROUS MATERIAL

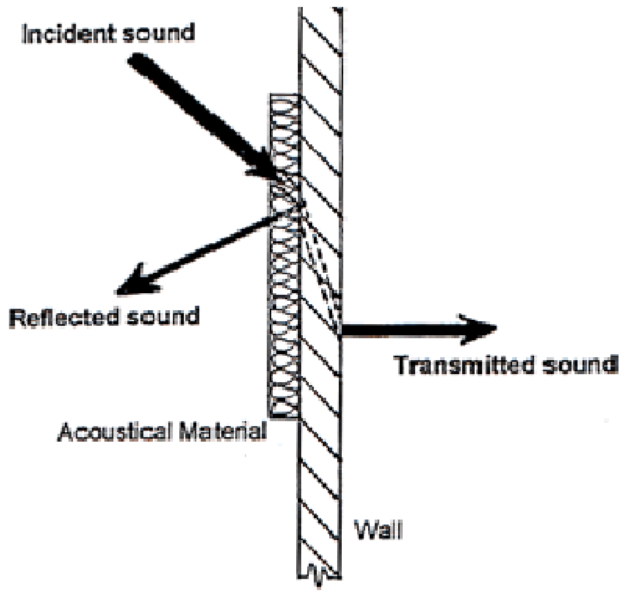


Figure 1 Mechanism of sound absorption

Porous materials allow the sound waves to pass through it. Hence sound absorbing materials have high porosity. Acoustic materials have about 90% porosity. Sound absorption is an energy conversion process. When the sound waves strikes the fibrous material, it is converted into heat energy. When sound absorbing materials absorb sound, it will lead to three loses. They are,

- Frictional loss
- Momentum loss and
- Temperature fluctuations

Frictional loss is caused by the oscillation of air molecules in the interstitial space of porous material. This oscillation is caused by the sound pressure when sound waves strikes the porous material.
Sound waves are accompanied with compressions and rarefactions. When there is change in the direction of the sound waves, it causes momentum loss.

Due to the excitation of sound waves, it causes periodical compression and rarefactions. Because of long time, surface to volume ratio becomes large, fibre conductivity becomes high and heat exchange takes place at low frequency. In the high frequency region, compression takes place. In between, the low and high frequency region, heat exchange takes place and it results in the loss of sound energy. Temperature fluctuation is high in fibrous material and it accounts for about 40% reduction in the amplitude of the sound signal.

If the amount of fibre content in the material is high then the sound absorption is also high. On the other hand, if the density of the material is increased then the sound absorption becomes less. The characteristic of sound absorption in a material varies for different frequencies level. High frequency sounds are absorbed more than the low frequency. This is because low frequency sound waves have larger wavelength.

### 2.3 FACTORS AFFECTING THE ACOUSTIC PROPERTIES OF NONWOVENS

There are various factors that affect the acoustic performance of nonwovens. Some of them are,

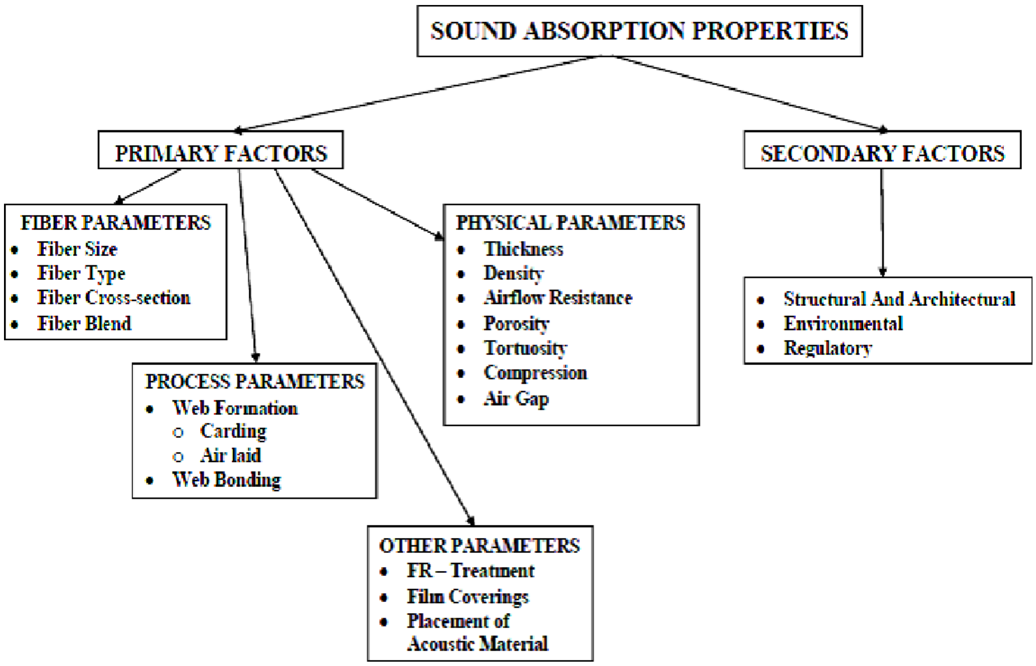


Figure 2 Factors of sound absorption

## 2.4 FIBRE PARAMETERS

### 2.4.1 Fibre Size

The coefficient of sound absorption decreases with increase in the fibre diameter. The reason is that the thin fibres move easily than the thick fibres. This means that the noise absorption coefficient increases with increase in thin fibres. The increase in NRC is mainly due to the increase in air flow resistance. Fibres ranging from 1.5 - 6 denier/filament (dpf) have better acoustic performance than the coarser fibres. Micro denier fibres ranging less than 1 denier/filament have a dramatic increase in the acoustic performance.

### 2.4.2 Fibre Type

Nonwovens made up of cotton and acrylic fibres have better acoustic performance. In comparison with polyester, they absorb sound waves in the frequency range of above 1000Hz. Surface properties of fibres plays a major role in the sound absorption. Kenaf fibres without any treatment cause negative effect in the noise reduction than the polyester fibres. On the other hand, at a high frequency level this effect is less pronounced.

### 2.4.3 Fibre Cross-Section

Surface area of the fibre and sound absorption is directly related. Increase in the surface area of the fibres causes increase in the friction between fibres and air. In comparison with the fibres with round and oval cross sections, fibres with serrated cross section absorbs more sound waves e.g) kenaf fibres.

### 2.4.4 Fibre Blend

The sound absorption properties of various fibre blends of cotton-polyester, flax-polyester and hemp polyester are found and it shows that the cotton-polyester blend exhibits high sound absorption than the other blends. The reason is that fineness of cotton fibre is more than that of the flax and hemp.

## 2.5 PROCESS PARAMETERS

### 2.5.1 Web Formation

In the web, the fibres are randomly oriented and it causes the higher airflow resistance than the carded web which has good orientation. The reason is that random fibre orientation gives high fibre to fibre friction and also it has small pores. This leads to the better sound absorption.

### 2.5.2 Web Bonding

It was found that the needled and needled with thermally bonded samples did not show much variation in sound absorption properties.

## 2.6 PHYSICAL PARAMETERS

### 2.6.1 Thickness

Sound absorption at low frequency and thickness of the material are directly related. Porous sound absorber achieves the effective sound absorption when the material thickness is about 1/10 of the wavelength of the incident sound. Peak absorption occurs at a resonant frequency of one ¼ wavelength of the incident sound. If the material is thick it shows increase in sound absorption at low frequency.

### 2.6.2 Density

Density of a material is an important factor in determining the sound absorption behavior of the material and at the same time, cost of an acoustical material is directly related to its density. When the density of the sample is increased, it causes increase in the sound absorption in the middle and high frequency. When the density increases, the number of fibres in cross section also gets increased. Materials with more open structure and less density absorb sound waves at low frequency (500Hz) and high denser structure absorbs frequency more than 2000Hz.

### 2.6.3 Airflow Resistance

One of the important parameter that influences the sound absorption is the airflow resistance offered by the material. The interlocking in the fibre provides friction and also it provides resistance to sound. When the sound waves enter into the material, the interlocking in the material causes decrease in the amplitude as the sound waves moves through the passages. Thus the sound energy gets converted into heat energy.

### 2.6.4 Porosity

When the sound waves enter the porous material, the waves get dissipated by friction. This implies, there ought to be sufficient pores on the outside of the material for the sound to go through and get dampened. The porosity of a permeable material is characterized as the proportion of the volume of the voids in the material to its all out volume. The porosity must be increased along the propagation of sound waves to get high coefficient of sound absorption.

### 2.6.5 Tortuosity

Tortuosity is a proportion of the extension of the entry path through the pores, contrasted with the thickness of the sample. Tortuosity depicts the impact of the inside structure of a material on its acoustical properties. Tortuosity is proportion of how far the pores veer off from the ordinary. It was mainly affects the location of the quarter wavelength peaks, whereas porosity and flow resistivity affect the height and width of the peaks. This value helps in determining the sound absorbency of porous material at high frequency.

### 2.6.6 Compression

Compression results in decrease in sound absorption in the fibrous material. During compression, the fibres in the fibrous mat are bought closer to each other with no twisting. This pressure causes reduced thickness, expansion in tortuosity and airflow resistivity and decline of porosity. The reason behind the fall of sound absorption is primarily due to the reduced thickness of the material.

### 2.6.7 Air Gap

One of the examination expressed that, for a similar measure of material, it is vastly improved to have an air hole behind the layer. The production of air hole expands sound assimilation in mid and higher frequencies. In addition, maxima top for various air hole is unique. This shows there is an ideal incentive for an air hole past which there isn't a lot of impact found in sound ingestion properties.

## 2.7 OTHER PARAMETERS

### 2.7.1 Flame Retardant Treatment

In one of the examinations, nonwovens arranged from fire resistant treated Kenaf strands and untreated Kenaf filaments were thought about for sound retention for properties. It was discovered that the fire resistant Kenaf nonwoven demonstrated a positive effect on sound ingestion. This might be on the grounds that the treatment of Kenaf strands with fire resistant may change its fiber structure so that it assimilates sound superior to untreated Kenaf filaments. Additionally the treatment may expand the surface voids on the fiber which may entangle the sound.

### 2.7.2 Film Coverings

Permeable screens, woven fabrics and films are used for covering the permeable and sound absorption material so as to keep it away from the negative environments and also for aesthetic look. Now these coverings are used to keep the fall of strands from the material. Film connected materials are profoundly intelligent to the sound waves and therefore impact absorptive properties of permeable or stringy materials. The samples which are covered by the film has better sound absorption than that of the samples that are not film attached.This is due to the reflective phenomenon of sound waves by the film which makes the sound waves to pass through the material twice, resulting in better absorbency.

When comparing two films: PVC and Aluminium for sound absorption properties, samples attached with Al film shows better results which might be due to the effect of physical properties of film like thickness, stiffness and bonding of film to the material.

## 2.8 SECONDARY FACTORS

Notwithstanding the above properties a sound absorbing material can meet the requirements. It should also satisfy the following properties

a) Structural and architectural
Appearance, beautiful impact, light reflectivity, viability, strength, and so forth.
b) Environmental
solvents, vibration, soil, oil and oil, destructive materials, erosive conditions, and so forth.
c) Regulatory
Limitations on lead bearing materials in food and medication territories, limitation on materials reaching food and medication items, necessities for cleansing/cleaning, firebreak prerequisites, pipes, shafts and so forth., limitation on shedding strands, prerequisites for tying down gear and guarding hardware.

## 2.9 ACOUSTIC INSULATION BY MULTILAYER NONWOVEN

Multilayer or composite nonwovens are produced by a modern and innovative industry that have numerous applications including, but not limiting to, hygiene, medical, filtration, insulation, automotive, agriculture, home furnishing, and packaging. Hygiene is the basic usage of multilayer nonwovens used in numerous products including baby care, feminine care, and adult products. The automotive industry also represents a significant market for application. Also breathable composite nonwovens are available for agriculture market. These materials offer engineering solutions by creating multifunctional products as well as economic solutions.

In this chapter, it has been examined that the sound absorption characteristics of SMS (Spunbond + Meltblown + Spunbond) type composite nonwovens. SMS structure is a spunmelt structure where the center layer is the meltblown, sandwiched between the two top and base spunbonded layers.

Spunbonded and meltblown methods are both melt spinning method basically, with the shortest textile production line from polymer chips to a web. In the spunbonded method, continuous filaments are extruded directly from thermoplastic polymer chips. The formation of a web of continuous filaments deposited on the conveyor belt is assisted by air suction.

Meltblown method is similar to spunbond. The low viscosity polymer is melted and gets forced through nozzles to form a stream of polymer. The filaments that are coming out through the nozzle is taken by high velocity steam so that the filaments are stretched by dragging forces to get extremely fine diameter.

Spunbonded structures have a number of advantages as fabric's durability and lower cost in comparison to other nonwovens and woven and knitted fabrics. Meltblown nonwovens are made from microfibers that are much finer than in the spunbonded process. The fibre's fineness makes fabrics that are softer but much weaker than spunbonded materials.

Due to the larger volume of fibre per unit weight, meltblown materials have improved fibre distribution and are important to a broad range of functional applications. For example, meltblown fabrics have good barrier properties and high insulating values and thus are used in filtration, barrier materials for medical and disposable apparel and apparel insulation. So together, the combination of spunbonded and meltblown structures can create a strong product which can also offer functional applications. Spunbonded layers act as protective layers for meltblown layers.

For binding the spunmelt nonwovens, thermal bonding method is used. In this method, the web is heated by means of hot rollers i.e) calendar rollers. In these methods, fusing fibers act as thermal binders. Important process parameters affecting the web properties are roller temperature, roller speed or contact time and pressure applied to web. In addition, the fabric strength, stiffness, drape, etc, can be controlled by the pattern in the roller. Heating temperature of rollers should be suitable for melting point of the polymer consisting of web.

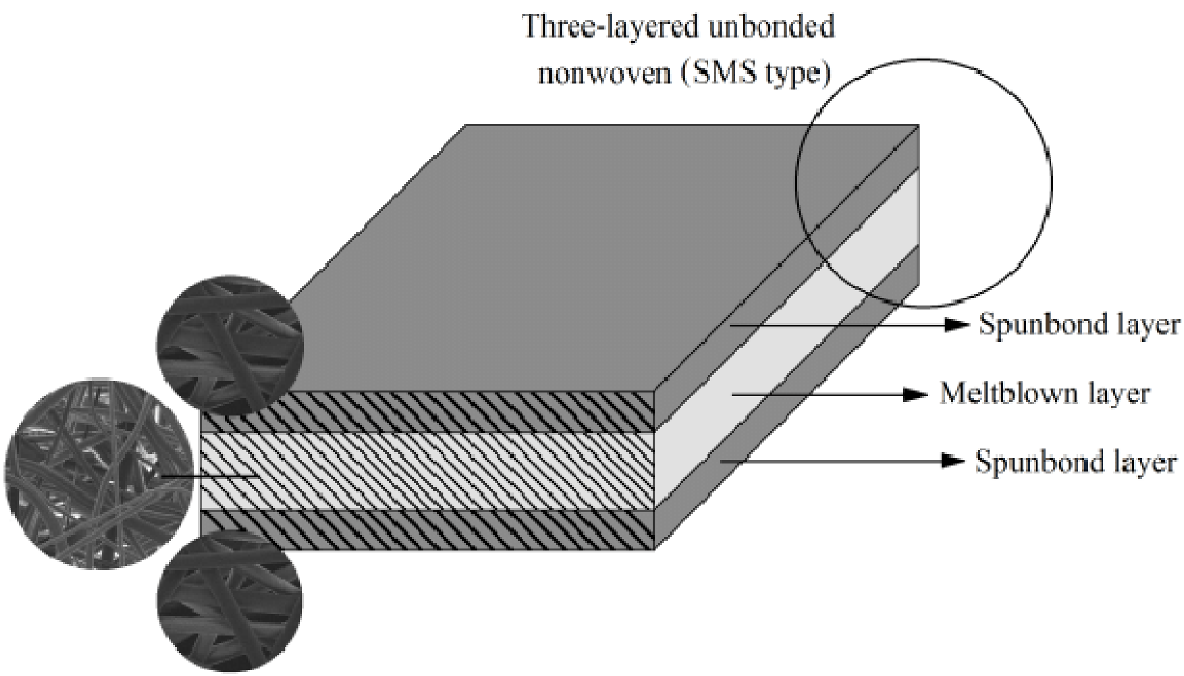


Figure 2 schematic diagram of multilayer nonwoven

**MATERIALS AND METHODS**

**3.1 MATERIALS**

Raw material of all layers was polyester with the upsides of accessibility, adaptability, and economically achievement. Spunbonded layers, level fortified thermally, having a premise weight of 40 gsm, were created from homocomponent and bicomponent strands in the diameter of 20–24 μm. Seven distinctive meltblown layers had a premise weight of 50–200 gsm with homocomponent round strands at the width of 5–8 μm.

Meltblown nonwovens were bonded thermally at same conditions to form nonstiffer middle layer of multilayer structures. SMS compositions of two different spunbonded layers and seven different meltblown layers were prepared manually, resulting in 14 multilayer nonwoven structures.

The thickness of the samples ranged from 1.28 to 1.79 mm. The samples were coded as HC and BC according to the change of fiber type in the spunbond layers, sample codes of 1, 2, 3, 4, 5, 6, and 7 defined the changes in basis weight of the meltblown layers. For instance, HC1 designates an SMS type three-layered nonwoven in which the outer spunbonded layers with homocomponent round fibers and a meltblown layer have a basis weight of 50 gsm. BC7 means spunbonded layers with bicomponent fibers and meltblown layer having a basis weight of 200 gsm. In this research, bicomponent fibers, round core/sheath type, in the spunbonded layers have a polyester core with an outer sheath of copolyester. The composition of polymers in core/ sheath type is 90% polyester (PET) core with 230–250°C melting point and 10% copolyester (Co-PET) sheath with 110–140°C melting point.

| Sample ID | Type of layer | Fibre type | Fibre content | Fibre cross section | Basic weight (gsm) | Thickness (mm) |
|---|---|---|---|---|---|---|
| HC | Spunbonded layers | Homocomponent | PET | Round | 40 | 0.37 ± 0.07 |
| BC | Spunbonded layers | Bicomponent | PET / Co-PET | Bico-round/ sheath-core type | 40 | 0.35 ± 0.05 |
| 1 | Meltblown layer | Homocomponent | PET | Round | 50 | 0.59 ± 0.09 |
| 2 | | | | | 75 | 0.60 ± 0.08 |
| 3 | | | | | 100 | 0.62 ± 0.06 |
| 4 | | | | | 125 | 0.67 ± 0.07 |
| 5 | | | | | 150 | 0.84 ± 0.05 |
| 6 | | | | | 175 | 0.93 ± 0.06 |
| 7 | | | | | 200 | 1.1 ± 0.04 |

Table1 Sample description and specifications

### 3.2 METHODS

All measurements were carried out at standard temperature (20 ± 2°C) and relative humidity (65 ± 2%). The thickness of the 10 different samples from each material was measured using a standard measuring device according to NWSP 120.6.R0. Air permeability of multilayer nonwovens was obtained by using an SDL Atlas digital air permeability tester (SDL-Atlas Inc., USA). The measurements were done on five different samples from each material by 200 Pa pressure through a 20 cm2 test area. The reported results are the averages of the five samples.

Sound absorption coefficients of multilayer nonwovens were measured according to ISO 10534-2. Nonwoven samples were cut into 100 and 29 mm diameters for the measurement of large and small tubes. Sound absorption coefficients of three samples (two replications from each material) were obtained by using a Brüel and Kjær impedance tube kit.

The capillary flow porometer (Porous Materials Inc., USA) has been effectively used to access the pore structures of multilayer nonwovens. Determination of porosity of samples according to ISO 15901-1 standard, 5 samples were prepared at 0.03 cm and determined by taking the average of the measurement values

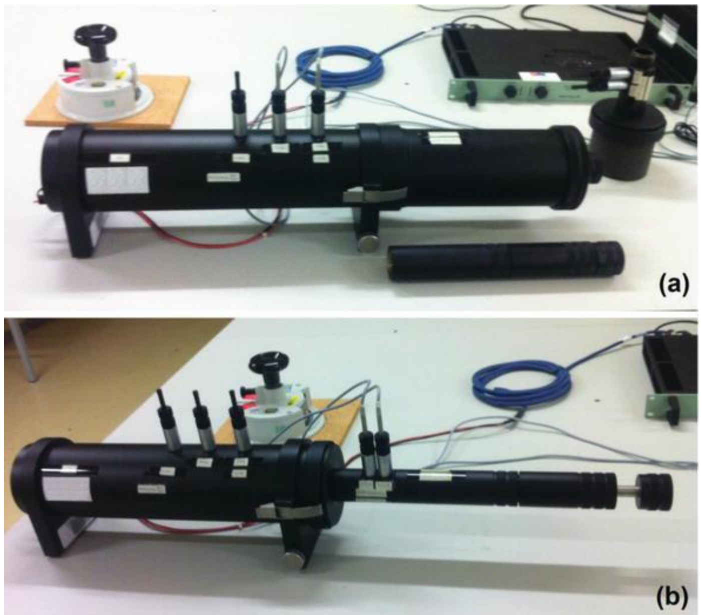

Figure 4 Impedence tube a) large tube (0.5 – 6.4 kHz) b) small tube(0.5 – 1.6 kHz)

**RESULTS AND DISCUSSION**

**4.1AIRPERMEABILITY**

In figure 3, the air permeabilities of the nonwoven samples with bicomponent fibers are lower than the air permeabilities of the nonwoven samples with homocomponent fibers. For each range of premise weight, BC samples are more impervious to air flow than the HC samples. Air permeability is expressed as the ratio of air flow between the two surfaces of the fabric. The speed of the air flow passing vertically from a given area is measured by the pressure difference within the measuring area of the fabric. The degree of air permeability is one of the major affecting parameters of thermal and acoustic insulation capabilities of nonwoven fabrics. Higher air permeability results in higher sound absorption.

The bicomponent fibres containing the nonwoven samples, thermal bonding causes the melting of Co-PET and gets binded around the web by spreading of fibres. This attribute limits the cross sectional and connection between fibres, and when considering that it affects the fibre roughness, the decrease in pore diameters is determined by the pore size measurements. When the relationship between air permeability and pore structure is evaluated, it is thought that this will increase air flow resistance and create a decrease in air permeability values. This indicates that bicomponent structures restricted the size of air passages, so that air permeability decreased. At higher basis weights of the fabrics, the increase in the number of fibres creates more spaces and a longer tortuous path through which the air must flow. Thus the structure gets changed with low air permeability and it becomes airflow resistant.

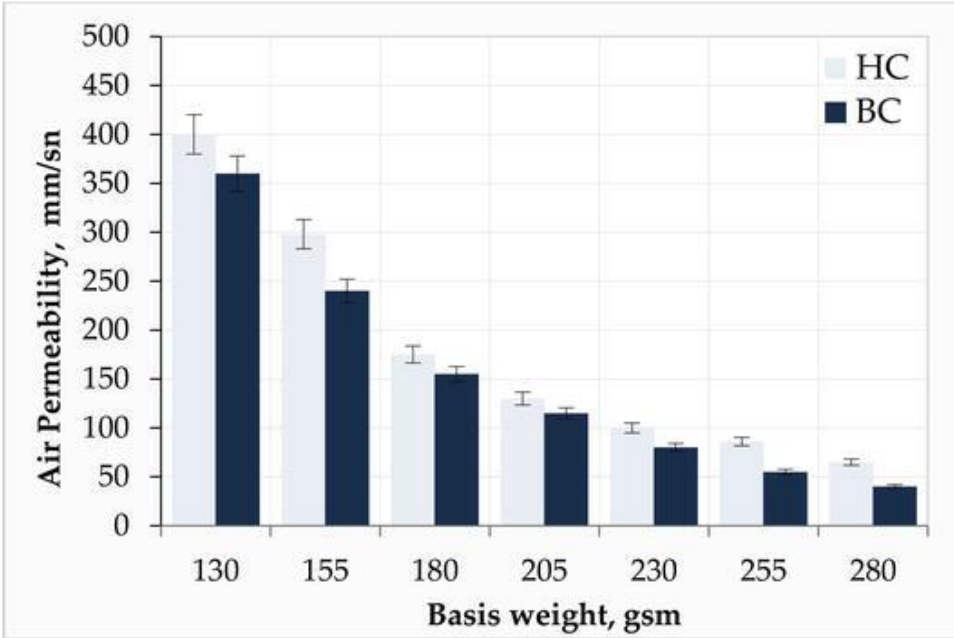


Figure 3 Air permeability of the sample

**4.2 BASIS WEIGHT AND FIBRE TYPE**

In the statistical data analysis, the effect of independent parameters, basis weight (A) and fiber type (B), on the dependent parameter, air permeability, has been examined with the analysis of variance at significance level of p value less than 0.05. The model summary statistics and ANOVA results for the data obtained in the study are shown in Table 2.

As presented in Table 2, R-Squared (R2) equals 0.9938, and predicted R-Squared equals 0.9865 for the model. It means that dependent parameters have been affected by independent parameters 99.38%, and this model predicts air permeability successfully at very high proportion of 98.65%. In the ANOVA results of BC and HC samples, both A and B are significant model terms.

Contribution to model of significant terms according to F values, it has been determined that A-basis weight is more significant factor with higher F value for air permeability than B-fiber type. It very well may be indicated that fiber type (bicomponent and homocomponent), is less powerful parameter than premise weight to control air porousness of multilayer nonwovens measurably.

Regression equation for air permeability of BC and HC samples obtained from the model is presented below according to codded factors. The high levels of the factors are coded as +1, and the low levels of the factors are coded as −1.

$$\text{Air permeability} = +121.00 - 124.34 * A - 14.93 * B + 97.23 * A^2 - 40.50 * A^3$$

| Source | Sum of squares | Degree of freedom | Mean square | F | significance |
|---|---|---|---|---|---|
| Model | 1.748E + 005 | 4 | 43703.18 | 362.97 | <0.0001 |
| A-Basis weight | 13084.75 | 1 | 13084.75 | 108.67 | <0.0001 |
| B-Fiber type | 3120.07 | 1 | 3120.07 | 25.91 | 0.0007 |
| Factors within group | 20580.48 | 2 | | | |
| Residual | 1083.64 | 9 | 120.40 | | |

| | | | | | |
|---|---|---|---|---|---|
| Cor total | 1.759E + 005 | 13 | | | |
| Model | Std. deviation | 10.97 | R-Squared | | 0.9938 |
| | C.V.% | 6.68 | Adjusted R-Squared | | 0.9911 |
| | PRESS | 2380.21 | Predicted R-Squared | | 0.9865 |

Table 2 ANOVA table for air permeability

**4.3 MEAN PORE DIAMETER**

The porosity of the fabrics is a complex feature characterized by parameters such as pore diameter, pore distribution, pore volume, while the porosity of the fabrics is associated with the total fabric volume area of the empty volume. Fabric porosity directly affects permeability properties, and the shape, layout, and size distribution of the media spaces are important considering the flow from porous structure.

Porosity, thickness, and fiber diameter are the factors that affect tortuosity of the structure. Co-PET polymer with low melting point in the bicomponent nonwoven samples melted earlier and smeared the adjacent fibers during the bonding. The reason may be the variation of intersection of fibers, roughness, and tortuosity resulted with the change of the pore structure as smaller pore diameters for bicomponent nonwovens.

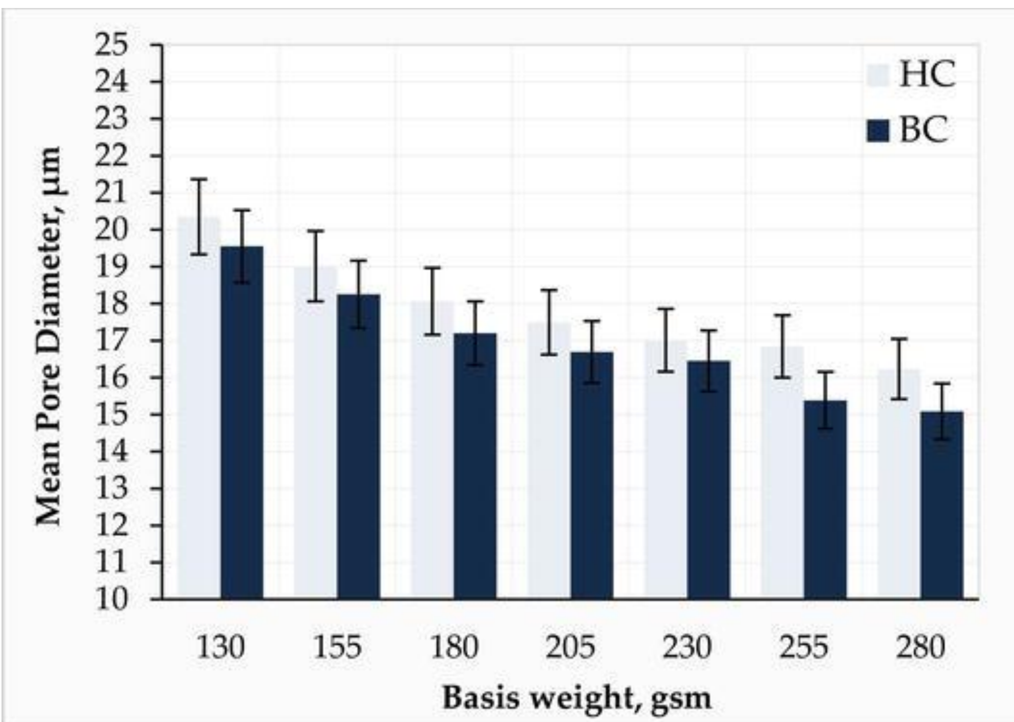


Figure 4 Mean pore diameter of the sample

The statistical analysis of mean pore diameter of BC and HC samples exhibited in Table 3 indicates the significant effect of fiber type with higher F values. Mean pore diameters have been affected by basis weight and fiber type 98.97%, and the model predicts the actual values of air permeability 97.60%. It tends to be indicated that fiber type (bicomponent and homocomponent), is more compelling parameter than premise weight to control mean pore distance across of multilayer nonwovens measurably.

Regression equation for air permeability of BC and HC samples obtained from the model is presented below according to codded factors. The high levels of the factors are coded as +1, and the low levels of the factors are coded as −1.

$$\text{Mean pore diameter} = +17.09 - 1.51 * A + 0.46 * B + 0.70 * A^2 - 0.65 * A$$

| **Source** | **Sum of squares** | **Degree of freedom** | **Mean square** | **F** | **significance** |
|---|---|---|---|---|---|
| Model | 29.47 | 4 | 7.37 | 216.22 | <0.0001 |
| A-Basis weight | 1.92 | 1 | 1.92 | 56.46 | <0.0001 |
| B-Fiber type | 2.91 | 1 | 2.91 | 85.34 | <0.0001 |
| Factors within group | 1.28 | 2 | | | |
| Residual | 0.31 | 9 | 0.034 | | |
| Cor total | 29.78 | 13 | | | |
| Model | Std. deviation | 0.18 | R-Squared | | 0.9897 |
| | C.V.% | 1.06 | Adjusted R-Squared | | 0.9851 |
| | PRESS | 0.71 | Predicted R-Squared | | 0.9760 |

Table 3 ANOVA table for mean pore diameter

### 4.4 SOUND ABSORPTION

The performance of sound absorbing materials is generally explained by the sound absorption coefficient (α). It is defined as the ratio of acoustic energy that is trapped in the material by the material and ranges between 0 and 1. "α = 0" signifies 0% sound retention so the impression of all the sound waves, and "α = 1" signifies 100% sound assimilation of all the sound waves. The sound absorption results of nonwoven sample. It is certain that as many researchers reported, the increase in basis weight influences the sound absorption positively. So also in this research, the higher sound absorption coefficients were proved for the higher weights. In any case, it ought to be noticed that BC tests have better solid protection for each scope of texture weight. Increasingly viable sound retention with bicomponent filaments is self-evident.

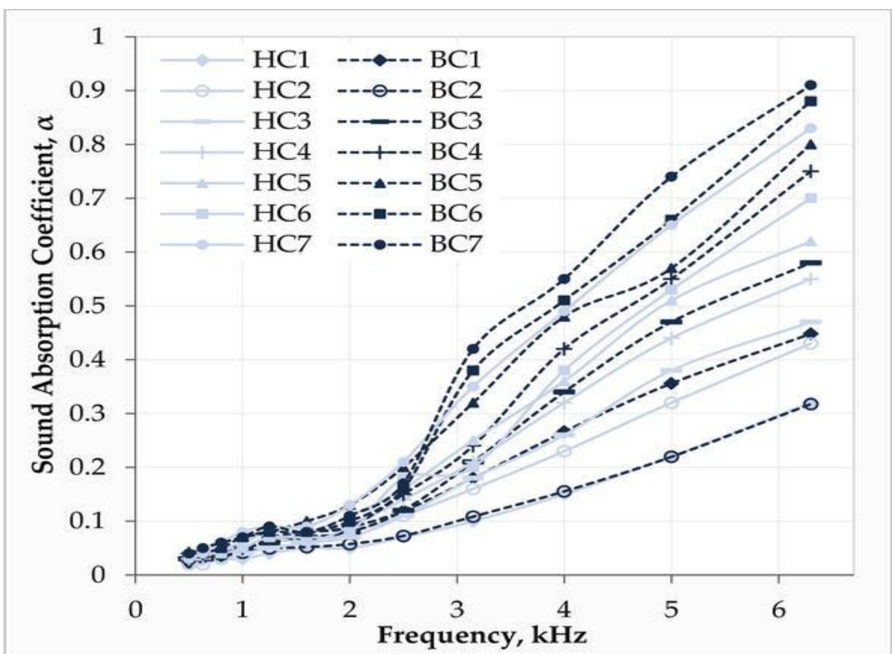


Figure 5 sound absorption coefficient of the samples

The effectiveness of a material in sound absorption depends mainly on the frequency of the sound wave subjected to the material, basis weight, air permeability, fibre geometry, and fiber arrangement. Sound ingestion happens because of the effect of sound waves on material, frictional losses while moving in the pores and channels of the structure, and the decline in sound vitality. As a result of increasing basis weight, fiber density, and porosity of random fibers, the sound wave will contact more fibers, and friction losses will increase. As a result, the sound energy will be reduced, and higher sound absorption coefficients will be obtained. The results obtained from this research are evidence of this situation. In bicomponent fibers with core/sheath type round cross section, melting Co-PET smeared to adjacent fibers to bind the nonwoven structure. It can be concluded that melting part of bicomponent fibers affects the cross-section area and fiber surface roughness, resulted with the variation of tortuous passages performed as higher sound absorption. As the aftereffect of confined progression of sound waves, the sound ingestion coefficients got higher.

The statistical analysis of sound absorption of BC and HC samples presented in Table 4 indicates the significant effect of fiber type with higher F values. Sound absorption has been affected by basis weight and fiber type 98.98%. It tends to be indicated that fiber type (bicomponent and homocomponent) is more viable parameter than premise weight to control sound assimilation of multilayer nonwovens factually.

Regression equation obtained is,

$$\text{Sound absorption} = +0.65 + 0.25 * A + 0.10 * B + 0.012 * AB - 0.25 * A^2 - 0.30 * A^2 B + 0.24 * A^3 + 0.4 * A^3 B + 0.23 * A^4 + 0.25 * A^4 B - 0.25 * A^5 - 0.44 * A^5 B$$

| Source | Sum of squares | Degree of freedom | Mean square | F | significance |
|---|---|---|---|---|---|
| Model | 0.53 | 11 | 0.048 | 900.08 | 0.0011 |
| A-Basis weight | 0.012 | 1 | 0.012 | 230.51 | 0.0043 |
| B-Fiber type | 0.036 | 1 | 0.036 | 685.34 | 0.0015 |
| Factors within group | 0.005 | 9 | | | |
| Residual | 1.061E-004 | 2 | 5.303E-005 | | |
| Cor total | 0.53 | 13 | | | |
| Model | Std. deviation | 7.282E-003 | R-Squared | | 0.9998 |
| | C.V.% | 1.18 | Adjusted R-Squared | | 0.9987 |
| | PRESS | 0.20 | Predicted R-Squared | | 0.6143 |

Table 4 ANOVA table for sound absorption coefficient

**CONCLUSIONS**

From the above contents, following ends can be drawn,

The relationship between the independent parameters such as basis weight (A) and fibre type (B), and the dependent parameters such as air permeability (C), mean pore diameter (D), and sound absorption (E) has been examined and the results are obtained. It is obvious that the air permeability, mean pore diameter and sound absorption has correlation between them. It is also proved that the pore size and air permeability has an inverse relationship with each other.

In this examination, acoustic protection conduct of SMS type composite nonwovens has been researched. The outcomes show that sound ingestion has been influenced by fiber kind of homocomponent or bicomponent, and progressively high sound absorption with bicomponent filaments is self-evident. Higher sound retention coefficients were given multilayer nonwoven tests containing bicomponent strands. The explanation behind these outcomes might be on the grounds that the distinctive porosity, tortuosity, and harshness of bicomponent and homocomponent structures. Higher value of tortuosity would therefore indicate longer, more complicated, and sinuous path, thus resulting in greater resistance to sound wave flow. Tortuosity also directly influences propagation of acoustic waves and absorbance efficiency in fibrous porous media. It has also been said that the degree of tortuosity determines the high frequency behavior of sound absorbing porous materials.

At the high frequencies, as the wavelength becomes smaller, the thinner fabrics control the sound absorption efficiently. In this manner, the more slender spunmelt nonwovens contrasted with needle-punched ones are acceptable sound safeguards at high frequencies.

The outcomes show that sound protection at high frequencies can be improved by utilizing spunmelt multilayer nonwovens. Spunmelt multilayer nonwovens offer chances to tailor textures to wanted applications through varieties in fiber type and premise weight.

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