CHAPTER 4

DEVELOPMENT OF ACOUSTIC COATED WOVEN PLAIN AND TWILL FABRICS OF COTTON, VISCOSE AND POLYESTER

4.1 INTRODUCTION

Acoustic absorbing material plays a number of roles that are important in acoustic engineering such as the control of building acoustics, industrial noise control, studio acoustics and automotive acoustics. Sound absorptive materials like screens, wall hangings and coating materials are generally used to counteract the undesirable effects of sound by rigid interior surfaces and thus help to reduce the reverberant noise level. They were used as interior covering materials for auditoriums, halls, shopping malls, apartments, automotives, aircrafts, ducts and enclosures for noise equipments and insulations for machineries.

The porous textile materials like woven and knitted fabrics are used as wall hangings and screens in building furnishing. The acoustic absorption of the open structured fabrics shows very low frictional resistance to flow. The incident sound wave while enters the air passages of the material, the frictional resistance to flow is very less by the fiber inside the fabric and the conversion of kinetic energy of the flow in to heat energy will be very less. Higher porosity, low thickness and low frictional resistance to flow are the main reason for less acoustic absorption of the woven and knitted fabrics. The acoustic performance of the woven and knitted fabrics can be enhanced by finishing the surface of the fabrics by coating materials which will increase
thickness and thereby increasing frictional resistance to flow, care may be taken to minimize the reduction of pores.

The influence of woven plain and twill fabrics of cotton, viscose and polyester uncoated, pad dry coated and spray coated materials on acoustic absorption and sound resistance has been studied in this chapter. Based on the study the material selection, optimization of fabric structure and coating method has been identified to obtain maximum acoustic absorption and resistance level.

4.2 MATERIALS AND METHODS

In order to study the influence of raw material, linear density, fabric structure thickness, aerial density, porosity, air permeability and coating method on acoustic absorption of cotton, viscose and polyester woven plain and twill fabrics (2x2) of different yarn linear densities are produced from Sri Ganapathy impex, Karur, Tamil Nadu. The produced fabrics are coated by pad - dry cure method (M1) and spray coating method (M2) with PVAc (Specific Gravity 1.30) as shown in the Figure 4.1. The care has been taken to coat the adhesive with 20% add on.

4.2.1 Method of pad- dry cure coating

The plain and twill woven fabrics are hot washed and bleached. All the samples are treated with a wetting agent for half an hour at 60\(^\circ\)C - 70\(^\circ\)C temperature and dried in a stentering machine at 140\(^\circ\)C. These fabrics are immersed in PVAc with viscosity of 5.0 - 6.0 mpa.s and PH value of 5-7 at 60\(^\circ\)C - 70\(^\circ\)C temperature. The samples are padded with padding mangle, dried and cured in a stenter at 120\(^\circ\)C -140\(^\circ\)C and subjected to relaxation for 48 hours.
Figure 4.1 Process flowchart for Development of Coated woven plain and twill Fabrics
4.2.2 Method of spray coating

The hot washed and bleached plain and twill woven (2x2) fabric samples are treated with a wetting agent for half an hour at 60° - 70°C temperature and dried in a stentering machine at 140°C. These fabrics are sprayed with PVAc with Viscosity of 5.0 - 6.0 mpa.s and PH value of 5-7 at 60° - 70°C temperature by a spray gun. The coated samples are dried and cured in a stenter at 120° -140°C and subjected to relaxation for 48 hours.

The acoustic absorption coefficients are measured by Two-fixed microphone impedance method (ASTM E 1050). The standard test procedure BS 2471- (2005) is followed to find the Areal density (g/m²) and Shirley thickness gauge is used for the measurement of thickness as per ASTM D1777-96(2011). The sound resistance of all samples are tested by the novel sound resistance testing method.

4.3 RESULTS AND DISCUSSIONS

The physical properties of the cotton, viscose and polyester woven plain and twill fabrics with different linear densities of uncoated, pad coated and spray coated were measured and average values of ten samples are given in tables 4.1, 4.2, 4.3, 4.4, 4.5 and 4.6.

4.3.1 Physical properties of uncoated and coated cotton plain fabrics

From the Table 4.1, the uncoated samples reveal that when the linear density increases the thickness, areal density and the porosity of the fabric reduces.

When the fabric is coated with PVAc the packing factor also increases. That may be due to the increase in thickness and areal density of the fabrics. While comparing the porosity of two types of coated fabrics, M2 coated
fabrics are in higher level. That may be due to higher thickness and higher aerial density by M2 coating method.

**Table 4.1 Physical properties of uncoated and coated cotton plain woven fabrics**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Sample</th>
<th>Thickness (mm)</th>
<th>Areal density (g/m²)</th>
<th>Bulk density (g/cm³)</th>
<th>Fabric packing factor</th>
<th>Fabric porosity</th>
<th>Air permeability (cc/s/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CP1UC</td>
<td>0.35</td>
<td>139.33</td>
<td>0.398</td>
<td>0.258</td>
<td>0.742</td>
<td>79.82</td>
</tr>
<tr>
<td>2</td>
<td>CP1M1</td>
<td>0.37</td>
<td>168.01</td>
<td>0.454</td>
<td>0.305</td>
<td>0.695</td>
<td>25.28</td>
</tr>
<tr>
<td>3</td>
<td>CP1M2</td>
<td>0.38</td>
<td>170.1</td>
<td>0.448</td>
<td>0.300</td>
<td>0.700</td>
<td>37.6</td>
</tr>
<tr>
<td>4</td>
<td>CP2UC</td>
<td>0.25</td>
<td>110.33</td>
<td>0.441</td>
<td>0.286</td>
<td>0.714</td>
<td>77.02</td>
</tr>
<tr>
<td>5</td>
<td>CP2M1</td>
<td>0.27</td>
<td>133.2</td>
<td>0.493</td>
<td>0.331</td>
<td>0.669</td>
<td>30.1</td>
</tr>
<tr>
<td>6</td>
<td>CP2M2</td>
<td>0.28</td>
<td>134.1</td>
<td>0.479</td>
<td>0.321</td>
<td>0.679</td>
<td>44.02</td>
</tr>
<tr>
<td>7</td>
<td>CP3UC</td>
<td>0.23</td>
<td>103.8</td>
<td>0.451</td>
<td>0.293</td>
<td>0.707</td>
<td>69.81</td>
</tr>
<tr>
<td>8</td>
<td>CP3M1</td>
<td>0.25</td>
<td>124.11</td>
<td>0.496</td>
<td>0.333</td>
<td>0.667</td>
<td>33.7</td>
</tr>
<tr>
<td>9</td>
<td>CP3M2</td>
<td>0.27</td>
<td>125.6</td>
<td>0.465</td>
<td>0.312</td>
<td>0.688</td>
<td>46.4</td>
</tr>
</tbody>
</table>

The uncoated samples reveal that when the linear Density of the warp and weft increases air permeability decreases. After coating the 6.3%, 5.6%, 6.3%, 4.9%, 4.9% and 5.7% reduction in porosity of CP1M1, CP1M2, CP2M1, CP2M2, CP3M1 and CP3M2 decreases the air permeability up to 68%, 53%, 61%, 43%, 52% and 34%. These comparison reveal that even with small reduction of porosity, higher reduction of air permeability can be achieved.
4.3.2 SEM analysis of uncoated and coated cotton woven plain fabrics

SEM photomicrographs of cotton fabrics uncoated and coated are shown in the following figures. It is observed that the uncoated fabric in the Figure 4.2(a) with X 2000 10µm show the space between the fibers and Figure 4.2(b) with X 50 500 µm show the voids between interlaced yarns. The Figure 4.3(a) with X 2000 10µm show the M1 fabric with more even surface due to impregnation of fabric with PVAc. The Figure 4.3(b) with X 50 500 µm show compact binding structure of the interlaced warp and weft. The Figure 4.4(a) show the irregular surface of sprayed PVA coating, because most of the coating materials will settle in the top surface only. When comparing with the M1 coated fabric, the Figure 4.4(b) show less compactness of the fabric, due to less penetration of coating materials in to the fabric.

Figure 4.2 SEM photomicrograph of uncoated cotton woven plain fabric  a)X 2000 10µm and (b) X 50 500 µm
Figure 4.3  SEM photomicrograph of M1 coated cotton woven plain fabric. a)X 2000 10µm and (b) X 50 500 µm

Figure 4.4  SEM photomicrograph of M2 coated cotton woven plain fabric. a)X 2000 10µm and (b) X 50 500 µm
4.3.3 Physical properties of uncoated and coated cotton woven twill fabrics

From the Table 4.2, it can be observed that the linear density increases the thickness and areal density reduces. Accordingly the porosity of the uncoated fabrics also showed the same trend.

Table 4.2 Physical properties of uncoated and coated cotton twill woven fabrics

<table>
<thead>
<tr>
<th>S.No</th>
<th>Samples</th>
<th>Thickness (mm)</th>
<th>Areal density (g/m²)</th>
<th>Bulk density (g/cm³)</th>
<th>Fabric packing factor</th>
<th>Fabric porosity</th>
<th>Air permeability (cc/s/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CT1UC</td>
<td>0.43</td>
<td>151.3</td>
<td>0.351</td>
<td>0.228</td>
<td>0.772</td>
<td>38.1</td>
</tr>
<tr>
<td>2</td>
<td>CT1M1</td>
<td>0.45</td>
<td>178.4</td>
<td>0.396</td>
<td>0.263</td>
<td>0.734</td>
<td>14.3</td>
</tr>
<tr>
<td>3</td>
<td>CT1M2</td>
<td>0.46</td>
<td>180.1</td>
<td>0.391</td>
<td>0.262</td>
<td>0.738</td>
<td>16.7</td>
</tr>
<tr>
<td>4</td>
<td>CT2UC</td>
<td>0.33</td>
<td>131.8</td>
<td>0.399</td>
<td>0.259</td>
<td>0.741</td>
<td>26.09</td>
</tr>
<tr>
<td>5</td>
<td>CT2M1</td>
<td>0.36</td>
<td>156.8</td>
<td>0.436</td>
<td>0.292</td>
<td>0.707</td>
<td>11.8</td>
</tr>
<tr>
<td>6</td>
<td>CT2M2</td>
<td>0.37</td>
<td>158.2</td>
<td>0.428</td>
<td>0.286</td>
<td>0.713</td>
<td>13.3</td>
</tr>
<tr>
<td>7</td>
<td>CT3UC</td>
<td>0.30</td>
<td>119.6</td>
<td>0.397</td>
<td>0.258</td>
<td>0.741</td>
<td>24.34</td>
</tr>
<tr>
<td>8</td>
<td>CT3M1</td>
<td>0.34</td>
<td>143.0</td>
<td>0.420</td>
<td>0.282</td>
<td>0.718</td>
<td>10.38</td>
</tr>
<tr>
<td>9</td>
<td>CT3M2</td>
<td>0.35</td>
<td>142.6</td>
<td>0.407</td>
<td>0.273</td>
<td>0.727</td>
<td>13.9</td>
</tr>
</tbody>
</table>

When the fabrics are coated with PVAc the packing factor also increases. This may be due to the increase in thickness and areal density of the fabrics. While comparing the porosity of two types of coated fabrics, M2 coated fabrics showed higher value.

The uncoated samples reveal that when the linear Density of the warp and weft increases air permeability decreases. After coating the 4.9%, 4.4%, 4.5%, 3.7%, 3.1% and 1.9% of reduction in porosity of CT1M1, CT1M2, CT2M1, CT2M2, CT3M1 and CT3M2 decreases the air permeability up to 62%, 56%, 55%, 48%, 57% and 44% respectively.
4.3.4 Sound absorption performance of 20Ne cotton woven plain and twill uncoated and coated fabrics

From Figure 4.5 it can be observed that while the frequency increases the sound absorption coefficient (SAC) of all the samples CP1UC, CP1M1 and CP1M2 also increases. Similarly while thickness increases the sound absorbing performance also increases. At the highest frequency of 6400 Hz the SAC value of CP1UC, CP1M1 and CP1M2 are 0.17, 0.25 and 0.34. The calculated average SAC values of CP1UC, CP1M1 and CP1M2 which are 0.07, 0.10 and 0.13 also reveal the same. The performance of samples CP1UC and CP1M1 shows more or less equal values from 0 to 3000 Hz, this may be due to at lower frequency the small increase in thickness of this coated and uncoated woven fabric does not influence the sound absorption.

Figure 4.5 Sound absorption coefficients of 20 Ne cotton woven plain and twill uncoated and coated fabrics
At the highest frequency of 6400 Hz the SAC value of CT1UC, CT1M1 and CT1M2 are 0.25, 0.09 and 0.14. The calculated average SAC values of CT1UC, CT1M1 and CT1M2 are 0.09, 0.06 and 0.05. The performance of samples CT1M1 and CT1M2 shows same structural elements. The surface pores of the both coated samples may be totally reduced, resulting in low SAC.

The linear equation of CP1UC is $Y = 2E - 05X + 0.003$ with $R^2$ value of 0.9504, CP1M1 is $Y = 3E – 05X – 0.0013$ with $R^2$ value of 0.9084 and CP1M2 is $Y = 4E – 05X – 0.0088$ with $R^2$ value of 0.9221. The sound absorbing performance of CP1UC, CP1M1 and CP1M2 shows good correlation with the R values from 0.9084 to 0.9504.

The linear equation of CT1UC is $Y = 3E - 05X - 0.0094$ with $R^2$ value of 0.9139, CT1M1 is $Y = 3E – 05X + 0.0116$ with $R^2$ value of 0.9 and CT1M2 is $Y = 2E – 05X + 0.002$ with $R^2$ value of 0.9. The sound absorbing performance of CT1UC, CT1M1 and CT1M2 shows good correlation with the R values from 0.9 to 0.9139.

4.3.5 Sound absorption performance of 30Ne cotton woven plain and twill uncoated and coated fabrics

From Figure 4.6 it can be observed that while the frequency increases the sound absorption coefficient (SAC) of all the samples CP2UC, CP2M1 and CP2M2 also increases. Similarly while thickness increases the sound absorbing performance also increases. At the highest frequency of 6400 Hz the SAC value of CP2UC, CP2M1 and CP2M2 are 0.15, 0.29 and 0.40. The calculated average SAC values of CP2UC, CP2M1 and CP2M2 which are 0.09, 0.13 and 0.18 also reveal the same.

The linear equation of CP2UC is $Y = 2E - 05X + 0.0156$ with $R^2$ value of 0.9794, CP2M1 is $Y = 4E – 05X – 0.0075$ with $R^2$ value of 0.9557 and
CP2M2 is $Y = 6E - 05X - 0.0124$ with $R^2$ value of 0.978. The sound absorbing performance of CP2UC, CP2M1 and CP2M2 shows good correlation with the R values from 0.9557 to 0.9794.

Figure 4.6  Sound absorption coefficients of 30 Ne cotton woven plain and twill uncoated and coated fabrics

At the highest frequency of 6400 Hz the SAC value of CT2UC, CT2M1 and CT2M2 are 0.21, 0.07 and 0.08. The calculated average SAC values of CT2UC, CT2M1 and CT2M2 are 0.09, 0.05 and 0.04. This results are very similar to samples CT1UC, CT1M1 and CT1M2.

The linear equation of CT2UC is $Y = 3E - 05X - 0.0094$ with $R^2$ value of 0.9604, CT2M1 is $Y = 1E - 05X + 0.0135$ with $R^2$ value of 0.9 and CT2M2 is $Y = 1E - 05X + 0.0071$ with $R^2$ value of 0.9442. The sound absorbing performance of CT2UC, CT2M1 and CT2M2 shows good correlation with the R values from 0.9 to 0.9604.
4.3.6  Sound absorption performance of 40Ne cotton woven plain and twill uncoated and coated fabrics

From Figure 4.7 it can be observed that while the frequency increases the sound absorption coefficient (SAC) of all the samples CP3UC, CP3M1 and CP3M2 also increases. Similarly while thickness increases the sound absorbing performance also increases. At the highest frequency of 6400 Hz the SAC value of CP3UC, CP3M1 and CP3M2 are 0.20, 0.28 and 0.39. The calculated average SAC values of CP3UC, CP3M1 and CP3M2 which are 0.10, 0.14 and 0.22 also reveal the same.

![Figure 4.7: Sound absorption coefficients of 40 Ne cotton woven plain and twill uncoated and coated fabrics](image)

The linear equation of CP3UC is $Y = 3E - 05X + 0.0048$ with $R^2$ value of 0.9806, CP3M1 is $Y = 4E - 05X - 0.0075$ with $R^2$ value of 0.9759 and CP3M2 is $Y = 7E - 05X - 0.003$ with $R^2$ value of 0.984. The sound
absorbing performance of CP1UC, CP1M1 and CP1M2 show good correlation with the R values from 0.984 to 0.9759.

At the highest frequency of 6400 Hz the SAC value of CT3UC, CT3M1 and CT3M2 are 0.17, 0.04 and 0.06. The calculated average SAC values of CT3UC, CT3M1 and CT3M2 which are 0.11, 0.4 and 0.5.

The linear equation of CT3UC is \( Y = 2E - 05X + 0.0386 \) with \( R^2 \) value of 0.8825, CT3M1 is \( Y = 8E - 06X - 0.0161 \) with \( R^2 \) value of 0.5026 and CT3M2 is \( Y = 1E - 05X + 0.021 \) with \( R^2 \) value of 0.6334. The sound absorbing performance of CT1UC, CT1M1 and CT1M2 shows correlation with the R values from 0.5026 to 0.8825.

4.3.7 Influence of porosity on sound absorption of cotton plain coated and uncoated fabrics

The Figure 4.8 reveals that, when the porosity of the fabrics reduces the SAC values increases. When comparing with uncoated fabric, the 6.3%, 5.6%, 6.3%, 4.9%, 5.9% and 2.6% of reduction in porosity of CP1M1, CP1M2, CP2M1, CP2M2, CP3M1 and CP3M2 shows 30%, 46%, 31%, 50%, 28.6% and 54% increase in SAC.

While comparing the uncoated fabrics the CP2UC with 3.8% of reduction in porosity performs with 22% higher SAC than CP1UC and CP3UC with 4.7% of reduction in porosity performs with 30% higher SAC than CPIUC. This reveals that when the linear density of the warp and weft becomes finer the porosity reduces and thus increases the SAC.

The Twill structure being heavy and higher thickness coated fabrics of these samples performs lower SAC than uncoated fabrics. When comparing with uncoated the 4.9%, 4.4%, 4.5%, 3.8%, 3.1% and 1.8% reduction in porosity of CT1M1, CT1M2, CT2M1, CT2M2, CT3M1 and CT3M2 shows 33%, 44%, 44%, 55%, 63.6% and 54% reduction in SAC.
Figure 4.8  Influence of porosity on Sound absorption of cotton woven plain and twill coated and uncoated fabrics

Figure 4.9  Influence of air permeability on Sound absorption of cotton woven plain and twill coated and uncoated fabrics
While comparing the uncoated fabrics the CT2UC with 4.01% of reduction in porosity performs equal SAC to that of CT1UC and CT3UC with 4.01% of reduction in porosity performs with 18% higher SAC than CT1UC. This reveals that the uncoated twill fabric with its heavy structure performs with higher SAC than both M1 and M2 coated fabrics.

4.3.8 Influence of air permeability on sound absorption of cotton plain coated and uncoated fabrics

From the Figure 4.9, it is seen that the reduction in air permeability of the coated and uncoated fabrics increases the sound absorbing performance. When comparing with CPIUC, the fabric CP1M1 with 68% of reduction air permeability it shows 30% increase in SAC and the fabric CP1M2 with 61% of reduction in air permeability shows 46% increase in SAC. The fabric CP2M1 with 61% lower air permeability than CP2UC shows 31% increase in SAC and the fabric CP2M2 with 43% lower air permeability than CP2UC shows 50% increase in SAC. Whereas the fabric CP3M1 with 52% less air permeability than CP3UC shows 28.6% increase in SAC and the fabric CP3M2 with 36% less air permeability than CP3UC shows 54% increase in SAC.

While comparing the uncoated fabrics the CP2UC with 3.5% of reduction in air permeability performs with 22% higher SAC than CP1UC and CP3UC with 12.5% of reduction in air permeability performs with 30% higher SAC than CPIUC. This reveals that when the linear density of the warp and weft becomes finer the air permeability reduces and thus increases the SAC. When comparing with CT1UC, the fabric CT1M1 with 62% of reduction in air permeability shows 33% reduction in SAC and the fabric CT1M2 with 56% of reduction in air permeability shows 44% reduction in SAC. The fabric CT2M1 with 57% lower air permeability than CT2UC shows 44% reduction in SAC and the fabric CT2M2 with 50% lower air
permeability than CT2UC shows 55% reduction in SAC. Whereas the fabric CT3M1 with 58% less air permeability than CT3UC shows 64% reduction in SAC and the fabric CT3M2 with 46% less air permeability than CT3UC shows 54% reduction in SAC.

While comparing the uncoated fabrics the CT2UC with 31% of reduction in air permeability performs equally to CT1UC and CT3UC with 37% of reduction in air permeability performs with 18% higher SAC than CT1UC. This reveals that when the linear density of the warp and weft becomes finer the air permeability reduces and thus increases the SAC.

4.3.9 Multi variable ANOVA analysis for cotton plain and twill fabrics

The sound absorption values of pad dry cure coated, spray coated and uncoated woven cotton plain fabrics was analyzed using statistical tool of multivariable ANOVA. From the results it is observed that there is significant differences found between the samples of cotton at 95% confidence level shows $F_{\text{actual}} > F_{\text{critical}}$ (23.6 > 6.944272 for coated and uncoated samples and 8.3 > 6.944272 for different linear density samples). It is due to the different structural properties fibers and fabrics. Likewise the other fabric properties like aerial density, bulk density, air permeability and porosity were analyzed and found significant differences between the samples.

From the results of twill fabrics it is observed that there is significant differences found between the coated and uncoated samples at 95% confidence level resulting in $F_{\text{actual}} (21.1) > F_{\text{critical}} (6.944272)$ and for the different linear density samples there is no significant difference i.e. $F_{\text{actual}} (0.4) < F_{\text{critical}} (6.944272)$. It is due to the heavy structural properties of twill fabrics. Similarly the other fabric properties like aerial density, bulk density, air permeability and porosity were analyzed and found significant differences between the samples.
4.3.10 Physical properties of uncoated and coated viscose plain woven fabrics

From the Table 4.3, it is seen that the while the linear density increases the thickness and areal density reduces. Accordingly the porosity of the uncoated fabrics also shows the same trend.

**Table 4.3 Physical properties of uncoated and coated viscose plain woven fabrics**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Samples</th>
<th>Thickness (mm)</th>
<th>Areal density (g/m²)</th>
<th>Bulk density (g/cm³)</th>
<th>Fabric packing factor</th>
<th>Fabric porosity</th>
<th>Air permeability (cc/s/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VP1UC</td>
<td>0.39</td>
<td>131.02</td>
<td>0.336</td>
<td>0.221</td>
<td>0.779</td>
<td>85.01</td>
</tr>
<tr>
<td>2</td>
<td>VP1M1</td>
<td>0.41</td>
<td>156.21</td>
<td>0.381</td>
<td>0.258</td>
<td>0.742</td>
<td>31.31</td>
</tr>
<tr>
<td>3</td>
<td>VP1M2</td>
<td>0.42</td>
<td>157.3</td>
<td>0.374</td>
<td>0.243</td>
<td>0.747</td>
<td>36.18</td>
</tr>
<tr>
<td>4</td>
<td>VP2UC</td>
<td>0.34</td>
<td>114.12</td>
<td>0.335</td>
<td>0.220</td>
<td>0.780</td>
<td>82.61</td>
</tr>
<tr>
<td>5</td>
<td>VP2M1</td>
<td>0.37</td>
<td>135.08</td>
<td>0.369</td>
<td>0.243</td>
<td>0.757</td>
<td>27.03</td>
</tr>
<tr>
<td>6</td>
<td>VP2M2</td>
<td>0.38</td>
<td>137.97</td>
<td>0.363</td>
<td>0.246</td>
<td>0.754</td>
<td>34.09</td>
</tr>
<tr>
<td>7</td>
<td>VP3UC</td>
<td>0.30</td>
<td>107.21</td>
<td>0.357</td>
<td>0.234</td>
<td>0.766</td>
<td>80.3</td>
</tr>
<tr>
<td>8</td>
<td>VP3M1</td>
<td>0.32</td>
<td>126.89</td>
<td>0.396</td>
<td>0.268</td>
<td>0.732</td>
<td>35.9</td>
</tr>
<tr>
<td>9</td>
<td>VP3M2</td>
<td>0.33</td>
<td>131.01</td>
<td>0.397</td>
<td>0.269</td>
<td>0.731</td>
<td>48.2</td>
</tr>
</tbody>
</table>

Air permeability values of the three uncoated samples of viscose also reveal that when the linear density of the warp and weft increases air permeability decreases. The air permeability of VP1M1 with 5% of reduction in porosity performs with 63% reduction in air permeability and 4% reduction of porosity of VP1M2 decreases the air permeability up to 57%.

Where as 2.9% reduction in porosity of VP2M1 decreases the air permeability up to 67% and 3.3% reduction of porosity of VP2M2 decreases the air permeability up to 59%. Also, the 4.4% reduction in porosity of VP3M1 decreases the air permeability up to 55% and 4.6% reduction of
porosity of VP3M2 decreases the air permeability up to 40%. From this comparison we can know that similar to cotton even with small reduction of porosity, higher reduction of air permeability can be achieved.

4.3.11 Physical properties of uncoated and coated viscose twill fabrics

From the Table 4.4, when the fabric is coated with PVA porosity reduces. While comparing the porosity of two types of coated fabrics M2 coated fabrics are in higher.

Table 4.4 Physical properties of uncoated and coated viscose twill woven fabrics

<table>
<thead>
<tr>
<th>S.No</th>
<th>Samples</th>
<th>Thickness (mm)</th>
<th>Areal density (g/m²)</th>
<th>Bulk density (g/cm³)</th>
<th>Fabric packing factor</th>
<th>Fabric porosity</th>
<th>Air permeability (cc/s/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VT1UC</td>
<td>0.43</td>
<td>161.6</td>
<td>0.376</td>
<td>0.247</td>
<td>0.753</td>
<td>33.61</td>
</tr>
<tr>
<td>2</td>
<td>VT1M1</td>
<td>0.44</td>
<td>191.8</td>
<td>0.435</td>
<td>0.295</td>
<td>0.705</td>
<td>13.91</td>
</tr>
<tr>
<td>3</td>
<td>VT1M2</td>
<td>0.45</td>
<td>192.3</td>
<td>0.427</td>
<td>0.289</td>
<td>0.711</td>
<td>15.13</td>
</tr>
<tr>
<td>4</td>
<td>VT2UC</td>
<td>0.37</td>
<td>143.8</td>
<td>0.388</td>
<td>0.255</td>
<td>0.745</td>
<td>24.81</td>
</tr>
<tr>
<td>5</td>
<td>VT2M1</td>
<td>0.38</td>
<td>170.9</td>
<td>0.449</td>
<td>0.304</td>
<td>0.696</td>
<td>10.6</td>
</tr>
<tr>
<td>6</td>
<td>VT2M2</td>
<td>0.39</td>
<td>172.5</td>
<td>0.442</td>
<td>0.300</td>
<td>0.700</td>
<td>12.88</td>
</tr>
<tr>
<td>7</td>
<td>VT3UC</td>
<td>0.33</td>
<td>132.9</td>
<td>0.402</td>
<td>0.264</td>
<td>0.736</td>
<td>23.07</td>
</tr>
<tr>
<td>8</td>
<td>VT3M1</td>
<td>0.35</td>
<td>156.2</td>
<td>0.446</td>
<td>0.302</td>
<td>0.698</td>
<td>11.3</td>
</tr>
<tr>
<td>9</td>
<td>VT3M2</td>
<td>0.36</td>
<td>157.9</td>
<td>0.438</td>
<td>0.297</td>
<td>0.703</td>
<td>12.1</td>
</tr>
</tbody>
</table>

Air permeability values of the three uncoated samples of viscose reveal that when the linear density of the warp and weft increases air permeability decreases. The air permeability of VT1M1 with 6% of reduction in porosity performs with 58% reduction in air permeability and 5.5 % reduction of porosity of VT1M2 decreases the air permeability up to 55 %. Where as 6.5 % reduction in porosity of VT2M1 decreases the air
permeability up to 57% and 6% reduction of porosity of VT2M2 decreases the air permeability up to 47%. Also, the 5% reduction in porosity of VT3M1 decreases the air permeability up to 51% and 4.4% reduction of porosity of VT3M2 decreases the air permeability up to 47%. From this comparison we can know that similar to cotton even with small reduction of porosity, higher reduction of air permeability can be achieved.

4.3.12 Sound absorption performance of viscose 20 Ne woven plain and twill uncoated and coated fabrics

From Figure 4.10 it can be observed that while the frequency increases the sound absorption coefficient (SAC) of all the samples VP1UC, VP1M1 and VP1M2 also increases. Similarly while thickness increases the sound absorbing performance also increases. At the highest frequency of 6400 Hz the SAC value of VP1UC, VP1M1 and VP1M2 are 0.15, 0.23 and 0.31. The calculated average SAC values of VP1UC, VP1M1 and VP1M2 which are 0.08, 0.10 and 0.13 also reveal the same. The performance of samples VP1UC and VP1M1 shows more or less equal values of absorption from 0 to 3000 Hz, this may be due to at lower frequency the small increase in thickness of this coated and uncoated woven fabric doesn’t influence the absorption.

At the highest frequency of 6400 Hz the SAC value of VT1UC, VT1M1 and VT1M2 are 0.22, 0.09 and 0.13. From 0 Hz to 2000 Hz all the three samples shows the same trend in SAC, this may be due to at lower frequencies the structural variations of samples does not influence the sound absorbance and from 2400 Hz to 4800 Hz the samples VT1M1 and VT1M2 perform with same values due no influence of coated structures. The calculated average SAC values of VT1UC, VT1M1 and VT1M2 which are 0.09, 0.05 and 0.06 reveal that the twill coated fabrics are not permitting the
sound waves to penetrate into them, resulting in lower SAC than uncoated samples.

![Figure 4.10 Sound absorption coefficients of viscose 20 Ne woven plain and twill uncoated and coated fabrics](image)

**Figure 4.10 Sound absorption coefficients of of viscose 20 Ne woven plain and twill uncoated and coated fabrics**

The linear equation of VP1UC is $Y = 4E-05X-0.0023$ with $R^2$ value of 0.9613, VP1M1 is $Y = 3E - 05X - 0.0059$ with $R^2$ value of 0.922 and VP1M2 is $Y = 2E - 05X + 0.0046$ with $R^2$ value of 0.9644. The sound absorbing performance of VP1UC, VP1M1 and VP1M2 shows good correlation with the $R$ values from 0.922 to 0.9644.

The linear equation of VT1UC is $Y = 4E-05X-0.00271$ with $R^2$ value of 0.8868, VT1M1 is $Y = 1E - 05X + 0.0059$ with $R^2$ value of 0.8995 and VT1M2 is $Y = 2E - 05X + 0.00046$ with $R^2$ value of 0.9375. The sound
absorbing performance of VT1UC, VT1M1 and VT1M2 shows good correlation with the R values from 0.8868 to 0.9375.

4.3.13 Sound absorption performance of 30Ne viscose woven plain and twill uncoated and coated fabrics

From Figure 4.11 it can be observed that while the frequency increases the sound absorption coefficient (SAC) of all the samples VP2UC, VP2M1 and VP2M2 also increases. Similarly while thickness increases the sound absorbing performance also increases. At the highest frequency of 6400 Hz the SAC value of VP2UC, VP2M1 and VP2M2 are 0.17, 0.27 and 0.39. The calculated average SAC values of VP2UC, VP2M1 and VP2M2 which are 0.09, 0.12 and 0.15 also reveal the same.

![Sound absorption coefficients of the fabrics 30 Ne viscose woven plain and twill uncoated and coated fabrics](image)

Figure 4.11 Sound absorption coefficients of the fabrics 30 Ne viscose woven plain and twill uncoated and coated fabrics
The linear equation of VP2UC is $Y = 2E - 05X + 0.0187$ with $R^2$ value of 0.9793, VP2M1 is $Y = 4E - 05X - 0.002$ with $R^2$ value of 0.9616 and VP2M2 is $Y = 6E - 05X - 0.0305$ with $R^2$ value of 0.9196. The sound absorbing performance of VP2UC, VP2M1 and VP2M2 shows good correlation with the R values from 0.9196 to 0.9793.

At the highest frequency of 6400 Hz the SAC value of VT2UC, VT2M1 and VT2M2 are 0.18, 0.08 and 0.1. The calculated average SAC values of VT2UC, VT2M1 and VT2M2 which are 0.11, 0.04 and 0.05 reveal that the uncoated fabrics are performing better than coated fabrics. Both the coated fabrics are having similar influence with the sound frequencies.

The linear equation of VT2UC is $Y = 3E - 05X + 0.0324$ with $R^2$ value of 0.9256, VT2M1 is $Y = 1E - 05X - 0.008$ with $R^2$ value of 0.97 and VT2M2 is $Y = 9E - 06X + 0.0127$ with $R^2$ value of 0.8334. The sound absorbing performance of VT2UC and VT2M1 shows good correlation with the R values from 0.9256 and 0.97.

4.3.14 Sound absorption performance of 40Ne viscose woven plain and twill uncoated and coated fabrics

From Figure 4.12 it can be observed that while the frequency increases the sound absorption coefficient (SAC) of all the samples VP3UC, VP3M1 and VP3M2 also increases. Similarly while thickness increases the sound absorbing performance also increases. At the highest frequency of 6400 Hz the SAC value of VP3UC, VP3M1 and VP3M2 are 0.17, 0.30 and 0.38. The calculated average SAC values of VP3UC, VP3M1 and VP3M2 which are 0.11, 0.13 and 0.20 also reveal the same.

The linear equation of VP3UC is $Y = 3E - 05X + 0.00185$ with $R^2$ value of 0.9743, VP3M1 is $Y = 5E - 05X - 0.0234$ with $R^2$ value of 0.9725.
and VP3M2 is $Y = 7E - 05X - 0.0147$ with $R^2$ value of 0.9884. The sound absorbing performance of VP3UC, VP3M1 and VP3M2 shows good correlation with the R values from 0.9725 to 0.9884.

At the highest frequency of 6400 Hz the SAC value of VT3UC drops to 0.15 from 0.19 at 6000 Hz. This may be due to at highest frequency the sound waves experiences less friction with the fibers.

![Figure 4.12 Sound absorption coefficients of 40Ne viscose woven plain and twill uncoated and coated fabrics](image)

The samples VT3M1 and V3M2 are also show the same trend. The sample VT3M1 shows the SAC value of 0.04 at 6400 Hz from 0.05 at 6000 Hz, the sample VT3M2 shows the SAC value of 0.07 at 6400 Hz from 0.06 at 6000 Hz. The calculated average SAC values of VT3UC, VT3M1 and VT3M2 are 0.10, 0.04 and 0.05.
The linear equation of VT3UC is \( Y = 3E - 05X + 0.0011 \) with \( R^2 \) value of 0.9503, VT3M1 is \( Y = 7E - 06X - 0.084 \) with \( R^2 \) value of 0.6177 and VT3M2 is \( Y = 1E - 05X + 0.0131 \) with \( R^2 \) value of 0.9224. The sound absorbing performance of VT3UC and VT3M2 shows good correlation values of 0.9224 and 0.9224. The sample VT3M1 performs with \( R \) value of 0.6177.

### 4.3.15 Influence of porosity on sound absorption of Viscose plain coated and uncoated fabrics

When the porosity is low, higher level the sound absorption, the Figure 4.13 shows the influence of porosity on sound absorption. Less porosity and less air permeability of the samples permits the sound frequency lesser amount at low frequency level, but at higher frequency the sound enters into the fine pores and experiences friction between the fibers and adhesives. Thus performs with higher absorption of sound energy.

### 4.3.16 Influence of air permeability on sound absorption of viscose woven plain and twill coated and uncoated fabrics

From the Figure 4.14, it is seen that the reduction in air permeability of the coated and uncoated fabrics increases the sound absorbing performance. When comparing with VPIUC, the fabric VP1M1 with 63% of reduction air permeability shows 25% increase in SAC and the fabric VP1M2 with 57% of reduction in air permeability shows 38% increase in SAC. The fabric VP2M1 with 67% lower air permeability than VP2UC shows 25% increase in SAC and the fabric VP2M2 with 58% lower air permeability than VP2UC shows 40% increase in SAC. The fabric VP3M1 with 55% less air permeability than VP3UC shows 15% increase in SAC and the fabric VP3M2 with 40% less air permeability than VP3UC shows 45% increase in SAC.
**Figure 4.13** Influence of porosity on Sound absorption of viscose woven plain and twill coated and uncoated fabrics

**Figure 4.14** Influence of air permeability on Sound absorption of viscose woven plain and twill coated and uncoated fabrics
While comparing the uncoated fabrics of viscose samples the VP2UC with 2.8% of reduction in air permeability performs with 15% higher SAC than VP1UC and VP3UC with 5.5% of reduction in air permeability performs with 45% higher SAC than VPIUC. This reveal that when the linear density of the warp and weft becomes finer the air permeability reduces and thus increases the SAC.

The Twill structure being heavy and higher thickness coated fabrics of these samples performs lower SAC than uncoated fabrics. When comparing with CT1UC the fabric CT1M1 with 4.9% of reduction in porosity shows 33% reduction in SAC and the fabric CT1M2 with 4.4% of reduction in porosity shows 44% reduction in SAC. The fabric CT2M1 with 4.5% lower porosity than CT2UC shows 44% reduction in SAC and the fabric CT2M2 with 3.8% lower porosity than CT2UC shows 55% reduction in SAC. Whereas the fabric CT3M1 with 3.1% less porosity than CT3UC shows 63.6% reduction in SAC and the fabric CT3M2 with 1.8% less porosity CT3UC shows 54% reduction in SAC.

While comparing the uncoated fabrics the CT2UC with 4.01% of reduction in porosity performs equal SAC to that of CT1UC and CT3UC with 4.01% of reduction in porosity performs with 18% higher SAC than CT1UC. This reveals that the uncoated twill fabric with its heavy structure performs with higher SAC than both M1 and M2 coated fabrics.

4.3.17 Multi variable ANOVA analysis on viscose plain and twill fabrics

The sound absorption values of pad dry cure coated, spray coated and uncoated woven viscose plain fabrics was analyzed using statistical tool
of multivariable ANOVA. From the results it is observed that there is significant differences found between the samples of viscose at 95% confidence level shows $F_{\text{actual}} > F_{\text{critical}}$ (20.6 > 6.944272 for coated and uncoated and 8 > 6.944272 for different linear densities). It is due to the different structural properties fibers and fabrics. Likewise the other fabric properties like aerial density, bulk density, air permeability and porosity were analyzed and found significant differences between the samples.

From the results of twill fabrics it is observed that there is significant differences found between the coated and uncoated samples at 95% confidence level resulting in $F_{\text{actual}} (35.2) > F_{\text{critical}} (6.944272)$ and for the different linear density samples there is no significant difference i.e. $F_{\text{actual}} (0.14) < F_{\text{critical}} (6.944272)$. It is due to the heavy structural properties of twill fabrics. Similarly the other fabric properties like aerial density, bulk density, air permeability and porosity were analyzed and found significant differences between the samples.

### 4.3.18 Physical properties of uncoated and coated Polyester plain fabrics

From the Table 4.5, it is seen that the thickness of the fabric PPIUC > PP2UC > PP3UC, similarly in aerial density and porosity the same trend is performed. When the fabric is coated with PVA the packing factor also increases. This may due to the increase in thickness and areal density of the fabrics. While comparing the porosity of two types of coated fabrics M2 coated fabrics are in higher porosity. This may be due to less reduction of voids by spray coating method.
Table 4.5  Physical properties of uncoated and coated polyester plain woven fabrics

<table>
<thead>
<tr>
<th>S.No</th>
<th>Samples</th>
<th>Thickness (mm)</th>
<th>Areal density (g/m²)</th>
<th>Bulk density (g/cm³)</th>
<th>Fabric packing factor</th>
<th>Fabric porosity</th>
<th>Air permeability (cc/s/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PP1UC</td>
<td>0.35</td>
<td>121.52</td>
<td>0.347</td>
<td>0.250</td>
<td>0.750</td>
<td>88.9</td>
</tr>
<tr>
<td>2</td>
<td>PP1M1</td>
<td>0.37</td>
<td>143.21</td>
<td>0.387</td>
<td>0.282</td>
<td>0.718</td>
<td>35.8</td>
</tr>
<tr>
<td>3</td>
<td>PP1M2</td>
<td>0.37</td>
<td>146.72</td>
<td>0.396</td>
<td>0.289</td>
<td>0.711</td>
<td>37.18</td>
</tr>
<tr>
<td>4</td>
<td>PP2UC</td>
<td>0.26</td>
<td>111.4</td>
<td>0.428</td>
<td>0.308</td>
<td>0.692</td>
<td>86.3</td>
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<tr>
<td>5</td>
<td>PP2M1</td>
<td>0.30</td>
<td>134.4</td>
<td>0.448</td>
<td>0.326</td>
<td>0.674</td>
<td>38.02</td>
</tr>
<tr>
<td>6</td>
<td>PP2M2</td>
<td>0.31</td>
<td>135.1</td>
<td>0.435</td>
<td>0.318</td>
<td>0.682</td>
<td>41.2</td>
</tr>
<tr>
<td>7</td>
<td>PP3UC</td>
<td>0.22</td>
<td>103.13</td>
<td>0.468</td>
<td>0.337</td>
<td>0.663</td>
<td>83.09</td>
</tr>
<tr>
<td>8</td>
<td>PP3M1</td>
<td>0.25</td>
<td>123.7</td>
<td>0.495</td>
<td>0.360</td>
<td>0.640</td>
<td>43.4</td>
</tr>
<tr>
<td>9</td>
<td>PP3M2</td>
<td>0.26</td>
<td>124.1</td>
<td>0.477</td>
<td>0.348</td>
<td>0.652</td>
<td>46.8</td>
</tr>
</tbody>
</table>

4.3.19 Physical properties of uncoated and coated Polyester twill fabrics

Air permeability values of the three uncoated samples reveal that when the linear density of the warp and weft increases air permeability also increases. After coating the 5% of reduction in porosity of PT1M1 decreases the air permeability up to 59% and 5% reduction of porosity of PT1M2 decreases the air permeability up to 52%.

Where as 6% reduction in porosity of PT2M1 decreases the air permeability up to 38% and 5% reduction of porosity of PT2M2 decreases the air permeability up to 27%. Also , the 8% reduction in porosity of PT3M1 decreases the air permeability up to 37% and 4% reduction of porosity of PT3M2 decreases the air permeability up to 33%. These comparisons reveal that even with small reduction of porosity, higher reduction of air permeability is attained.
Table 4.6  Physical properties of uncoated and coated polyester twill fabrics

<table>
<thead>
<tr>
<th>S.No</th>
<th>Samples</th>
<th>Thickness (mm)</th>
<th>Areal density (g/m²)</th>
<th>Bulk density (g/cm³)</th>
<th>Fabric packing factor</th>
<th>Fabric porosity</th>
<th>Air permeability (cc/s/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PT1UC</td>
<td>0.44</td>
<td>149.6</td>
<td>0.340</td>
<td>0.244</td>
<td>0.756</td>
<td>32.1</td>
</tr>
<tr>
<td>2</td>
<td>PT1M1</td>
<td>0.45</td>
<td>177.1</td>
<td>0.394</td>
<td>0.287</td>
<td>0.713</td>
<td>13.01</td>
</tr>
<tr>
<td>3</td>
<td>PT1M2</td>
<td>0.46</td>
<td>179.00</td>
<td>0.389</td>
<td>0.284</td>
<td>0.716</td>
<td>15.3</td>
</tr>
<tr>
<td>4</td>
<td>PT2UC</td>
<td>0.38</td>
<td>135.7</td>
<td>0.357</td>
<td>0.257</td>
<td>0.743</td>
<td>26.34</td>
</tr>
<tr>
<td>5</td>
<td>PT2M1</td>
<td>0.39</td>
<td>160.8</td>
<td>0.412</td>
<td>0.301</td>
<td>0.699</td>
<td>16.1</td>
</tr>
<tr>
<td>6</td>
<td>PT2M2</td>
<td>0.40</td>
<td>161.2</td>
<td>0.403</td>
<td>0.294</td>
<td>0.706</td>
<td>19.3</td>
</tr>
<tr>
<td>7</td>
<td>PT3UC</td>
<td>0.31</td>
<td>128.1</td>
<td>0.413</td>
<td>0.297</td>
<td>0.703</td>
<td>33.84</td>
</tr>
<tr>
<td>8</td>
<td>PT3M1</td>
<td>0.32</td>
<td>154.6</td>
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<td>0.352</td>
<td>0.648</td>
<td>21.3</td>
</tr>
<tr>
<td>9</td>
<td>PT3M2</td>
<td>0.34</td>
<td>152.9</td>
<td>0.449</td>
<td>0.327</td>
<td>0.673</td>
<td>26.08</td>
</tr>
</tbody>
</table>

4.3.20 Sound absorption performance of 20Ne polyester woven plain and twill uncoated and coated fabrics

From Figure 4.15 it can be observed that while the frequency increases the sound absorption coefficient (SAC) of all the samples PP1UC, PP1M1 and PP1M2 also increases. Similarly while thickness increases the sound absorbing performance also increase.

At the highest frequency of 6400 Hz the SAC value of PP1UC, PP1M1 and PP1M2 are 0.17, 0.25 and 0.34. The calculated average SAC values of PP1UC, PP1M1 and PP1M2 which are 0.11, 0.12 and 0.15 also reveal the same. The performance of sample PP1UC shows higher SAC than the coated samples up to 1600 Hz, this may be due to the structural and fiber property of PP1UC.
The linear equation of PP1UC is $Y = 2E - 05X + 0.03$ with $R^2$ value of 0.937, PP1M1 is $Y = 4E - 05X - 0.007$ with $R^2$ value of 0.9877 and PP1M2 is $Y = 5E - 05X - 0.001$ with $R^2$ value of 0.9612. The sound absorbing performance of PP1UC, PP1M1 and PP1M2 shows good correlation with the $R$ values from 0.937 to 0.9877.

![Figure 4.15](image)

**Figure 4.15** Sound absorption coefficients of 20Ne polyester woven plain and twill uncoated and coated fabrics

At the highest frequency of 6400 Hz the SAC value of PT1UC, PT1M1 and PT1M2 are 0.27, 0.13 and 0.16. The calculated average SAC value of PT1UC is 0.12 and PT1M1 and PT1M2 is 0.07. This reveals that similar to viscose and cotton twill fabrics the polyester coated fabrics also shows lower SAC.

The linear equation of PT1UC is $Y = 4E - 05X + 0.0168$ with $R^2$ value of 0.9753, PT1M1 is $Y = 2E - 05X - 0.0018$ with $R^2$ value of 0.9143 and PT1M2 is $Y = 2E - 05X - 0.0002$ with $R^2$ value of 0.9433. The sound absorbing performance of PT1UC, PT1M1 and PT1M2 shows good correlation with the $R$ values from 0.9143 to 0.9743.
4.3.21  Sound absorption performance of 30Ne polyester woven plain and twill uncoated and coated fabrics

From Figure 4.16 it can be observed that while the frequency increases the sound absorption coefficient (SAC) of all the samples PP2UC, PP2M1 and PP2M2 also increases. Similarly while thickness increases the sound absorbing performance also increases. At the highest frequency of 6400 Hz the SAC value of PP2UC, PP2M1 and PP2M2 are 0.25, 0.36 and 0.40. The calculated average SAC values of PP2UC, PP2M1 and PP2M2 which are 0.16, 0.17 and 0.21 also reveal the same. The linear equation of PP2UC is $Y = 4E - 05X + 0.0429$ with $R^2$ value of 0.9794, PP2M1 is $Y = 7E - 05X - 0.0403$ with $R^2$ value of 0.956 and PP2M2 is $Y = 7E - 05X - 0.0015$ with $R^2$ value of 0.978. The sound absorbing performance of PP2UC, PP2M1 and PP2M2 shows good correlation with the R values from 0.956 to 0.989.

Figure 4.16  Sound absorption coefficients of 30Ne polyester woven plain and twill uncoated and coated fabrics
4.3.22 Sound absorption performance of 40Ne polyester woven plain and twill uncoated and coated fabrics

From Figure 4.17 it can be observed that while the frequency increases the sound absorption coefficient (SAC) of all the samples PP3UC, PP3M1 and PP3M2 also increases. Similarly while thickness increases the sound absorbing performance also increases. At the highest frequency of 6400 Hz the SAC value of PP3UC, PP3M1 and PP3M2 are 0.27, 0.39 and 0.39. The calculated average SAC values of PP3UC, PP3M1 and PP3M2 which are 0.16, 0.17 and 0.24 also reveal the same. The linear equation of PP3UC is \( Y = 4E - 05X + 0.0325 \) with \( R^2 \) value of 0.9742, PP3M1 is \( Y = 7E - 05X - 0.436 \) with \( R^2 \) value of 0.9759 and PP3M2 is \( Y = 7E - 05X - 0.0144 \) with \( R^2 \) value of 0.984. The sound absorbing performance of PP3UC, PP3M1 and PP3M2 shows good correlation with the \( R \) values from 0.963 to 0.9806.

![Sound absorption coefficients of 40Ne polyester woven plain and twill uncoated and coated fabrics](image)
At the highest frequency of 6400 Hz the SAC value of PT3UC, PT3M1 and PT3M2 are 0.20, 0.07 and 0.09. The calculated average SAC values of PT3UC, PT3M1 and PT3M2 are 0.12, 0.06 and 0.06.

The linear equation of PT3UC is \( Y = 3E - 05X + 0.0218 \) with \( R^2 \) value of 0.9321, PT3M1 is \( Y = 9E - 06X - 0.0253 \) with \( R^2 \) value of 0.07151 and PT3M2 is \( Y = 1E - 05X - 0.0212 \) with \( R^2 \) value of 0.8718. The sound absorbing performance of PT3UC shows good correlation with the \( R \) value of 0.9321. The PT3M1 and PT3M2 shows the correlation values of 0.07151 and 0.8718.

4.3.23 Influence of porosity on sound absorption of polyester plain coated uncoated fabrics

Lower level the porosity higher level the sound absorption, the Figure 4.18 shows the influence of porosity on sound absorption. Less porosity and less air permeability of the samples permits the sound frequency lesser amount at low frequency level, but at higher frequency the sound enters into the fine pores and experiences friction between the fibers and adhesives. Thus performs with higher absorption of sound energy.

4.3.24 Influence of air permeability on sound absorption of polyester plain coated and uncoated fabrics

From the Figure 4.19, it is seen that the reduction in air permeability of the coated and uncoated fabrics increases the sound absorbing performance. When comparing with PPIUC, The fabric PP1M1 with 60% of reduction air permeability shows 8% increase in SAC and the fabric PP1M2 with 58% of reduction in air permeability shows 26% increase in SAC. The
fabric PP2M1 with 56% lower air permeability than PP2UC shows 5.8% increase in SAC and the fabric PP2M2 with 52% lower air permeability than PP2UC shows 24% increase in SAC. Whereas the fabric PP3M1 with 48% less air permeability than PP3UC shows 5.9% increase in SAC and the fabric PP3M2 with 44% less air permeability than PP3UC shows 33% increase in SAC.

While comparing the uncoated fabrics of polyester samples the PP2UC with 2.9% of reduction in air permeability performs with 31% higher SAC than PP1UC and PP3UC with 6.5% of reduction in air permeability performs with 54% higher SAC than PPIUC. This reveals that when the linear density of the warp and weft becomes finer the air permeability reduces and thus increases the SAC.

From the figure, it is seen that the reduction in air permeability of the coated and uncoated fabrics does not increases the sound absorbing performance. When comparing with PTIUC, the fabric PT1M1 with 59% of reduction air permeability shows 50% reduction in SAC and the fabric PT1M2 with 53% of reduction in air permeability shows 50% reduction in SAC. The fabric PT2M1 with 38% lower air permeability than PT2UC shows 58% reduction in SAC and the fabric PT2M2 with 27% lower air permeability than PT2UC shows 50% reduction in SAC. Whereas the fabric PT3M1 with 36% less air permeability than PT3UC shows 58% reduction in SAC and the fabric PT3M2 with 21% less air permeability than PT3UC shows 50% increase in SAC.
Figure 4.18 Influence of porosity on Sound absorption of polyester woven plain and twill coated and uncoated fabrics

Figure 4.19 Influence of porosity on Sound absorption of polyester woven plain and twill coated and uncoated fabrics
While comparing the uncoated fabrics of polyester samples the PT2UC with 19% of reduction in air permeability performs with same SAC of PT1UC and PT3UC with 3% of increase in air permeability performs with same amount of SAC like PT1UC. This reveals that with variations in linear density of warp and weft from 20s to 40s in polyester twill structure there are very minimum deviations in air permeability and the SAC values.

4.3.25 Multi variable ANOVA analysis for polyester plain and twill fabrics

The sound absorption values of pad dry cure coated, spray coated and uncoated woven polyester plain fabrics was analyzed using statistical tool of multivariable ANOVA. From the results plain fabrics it was observed that there were significant differences found between the samples of polyester at 95% confidence level shows $F_{\text{actual}} > F_{\text{critical}}$ (19 > 6.944272 for for coated and uncoated and 24 >6.944272 different linear density samples). It is due to the different structural properties fibers and fabrics. Likewise the other fabric properties like aerial density, bulk density, air permeability and porosity were analyzed and found significant differences between the samples.

From the results of twill fabrics it is observed that there is significant differences found between coated and uncoated samples of polyester at 95% confidence level shows $F_{\text{actual}}(254) > F_{\text{critical}}$ (6.944272) and with different linear density $F_{\text{actual}}(2) > F_{\text{critical}}$ (6.944272) there is no significant difference. It is due to the polyester fiber properties and fabric structure. While analyzing the other fabric properties like aerial density, bulk density, air permeability and porosity, they showed significant differences between the samples.
4.3.26  Sound resisting performance of plain and twill fabrics

The Figure 4.20, 4.21 and 4.22 shows the sound resistance characteristics of cotton, viscose and polyester fabrics. The sound resistance of polyester fabric is higher than cotton fabrics. The viscose fabrics showed lowest value. While comparing twill and plain fabrics, the twill fabrics showed higher values of sound resistance up to 14%, because of its close structure. The influence of linear density of the fabrics on sound resistance reveals that courser the yarn higher the sound resistance. The sound resistance of CPIM1 showed the higher value of 6.6% and the CT1M1 showed the higher value of 14%.

The pad- dry cure coated fabrics of all samples shows higher sound resistance, because of higher closing of pores than uncoated and spray coated fabrics. The sound resistance of all the fabrics increases with the increase in distance of fabric to sound source.

4.4  CONCLUSIONS

For the building interiors like screens and hangings acoustic absorption is a important property required for textile materials. The woven plain fabrics which were made up of cotton, viscose and polyester with different linear density were coated with PVAc by pad – dry cure method and spray method were tested for sound absorption (SAC) by ASTM E 1050. While analyzing the SAC with Multi variable ANOVA there were significant differences found between the samples of uncoated cotton, viscose and polyester at 95% confidence level resulting with $F_{\text{actual}} > F_{\text{critical}}$ (25 > 6.944272 for different fibers and 9.7 > 6.944272 different linear density samples).
Figure 4.20 Sound resistance characteristics of cotton woven fabrics

Figure 4.21 Sound resistance characteristics of viscose woven fabrics

Figure 4.22 Sound resistance characteristics of polyester woven fabrics
When comparing the influence of types of fibers and linear density of the fibers on SAC, it was observed that the fiber type is having more influence. Coated and uncoated polyester fabric has the highest average absorption coefficient. The uncoated and coated cotton and viscose samples perform with similar values. Among the method of coating, the fabrics which were coated with spray coating method perform with higher SAC due to less closing of voids. Hence it is concluded that the woven plain fabric coated with spray type made of polyester with its higher fabric density performs with highest average sound absorbing coefficient (0.24). The cotton and viscose fabrics are also having highest average sound absorption value of 0.22 and 0.20. The major applications of these developed products may be for furnishing in hospitals, auditoriums, industries, houses and shopping malls.

The woven twill fabrics which were made up of cotton, viscose and polyester with different linear density were coated with PVAc by pad – dry cure method and spray method were tested for sound absorption (SAC) by ASTM E 1050. While analyzing the SAC with Multi variable ANOVA there is no significant differences found between the samples of uncoated cotton, viscose and polyester at 95 % confidence level resulting with $F_{\text{actual}} (6.142857) < F_{\text{critical}}$ for different fibers and $F_{\text{actual}} (1) < F_{\text{critical}} (6.944272)$ for different linear density samples.

When comparing the influence of types of fibers and linear density of the fibers in twill structure on SAC, it was observed that the fiber type is having no influence. All the uncoated and coated twill fabrics were having the similar values of SAC.

From this chapter the following conclusions were derived;

- The woven plain fabrics produced from polyester fiber exhibited higher average SAC of 0.24, due to the factors like fiber, yarn and fabric structural behavior.
The SAC Values of all the woven fabrics increases with the increase in linear density.

Coated fabrics, due to the reduction of voids perform with higher SAC than uncoated fabrics.

The reduction of surface pores by the Spray coating method is less when comparing with pad dry cure method of coating, resulting in higher SAC.

For all the fabrics when there is an increase in areal density SAC also increase.

The fabric density is having direct influence on SAC.

There is a significant negative correlation between sound absorption and air permeability.

Similar to air permeability lower level the porosity higher level the sound absorption.

The woven twill fabrics produced from cotton, viscose and polyester fibers shows similar values of sound absorption due to the factors like fiber, yarn and fabric structural behavior.

The Viscose fabrics show lowest sound resistance values.

Finer the linear densities lower the sound resistance.

The twill fabrics performed highest sound resistance of 14%.

The pad-dry-cure coated fabric shows higher values of sound resistance.