CHAPTER 3
EXPERIMENTAL

This chapter describes the raw materials used for the study, the experimental design used for sample preparation, the machines used for preparing the samples along with process conditions, the methods used for testing the yarns and fabrics; and the methods used for analyzing the results.

3.1 Raw materials
3.1.1 Filament yarns

Polyester filament yarns were procured from Indorama Synthetics Ltd., and viscose filament yarns were procured from Indian Rayon. The filament yarns came with the specifications listed in Table 3.1.

<table>
<thead>
<tr>
<th>Fibre</th>
<th>Yarn denier (dtex)</th>
<th>No. of filaments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyester</td>
<td>72 (80)</td>
<td>75</td>
</tr>
<tr>
<td>Viscose</td>
<td>72 (80)</td>
<td>24</td>
</tr>
</tbody>
</table>

The values in the table represent the numbers as supplied by the manufacturer. However the yarns were tested for their mean denier, number of filaments, tensile properties and frictional properties. The denier was measured by simple cut and weigh method with 20 readings each. Number of filaments was counted by observing the yarn under optical microscope with 20x magnification. An average of 20 readings was taken. The tensile properties were measured using Instron 4411 with following process parameters:
- Gauge length: 500 mm
- Crosshead speed: 300 mm/min
- Yarn linear density: 72 denier (80 dtex)
- No of readings: 15 each
The yarn-to-yarn coefficient of friction was measured using CTT (Constant Tension Transport) testing instrument from Lawson-Hemphill Inc. at an operating speed of 20 m/min.

3.1.2 Staple fibres

Polyester and viscose staple fibres were used for warp yarns as well as for weft yarns with different blend proportions. Polyester staple fibres were procured from Bhiwani Textile Mills, and viscose staple fibres were procured from Grasim Industries. The staple fibres came with the specifications shown in Table 3.2.

<table>
<thead>
<tr>
<th>Fibre</th>
<th>Denier (dtex)</th>
<th>Cut length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PET</td>
<td>1.20 (1.33)</td>
<td>44</td>
</tr>
<tr>
<td>Viscose</td>
<td>1.50 (1.67)</td>
<td>44</td>
</tr>
</tbody>
</table>

3.2 Preparation of textured yarn samples

Some initial trials were taken to select the range of values for the process parameters (overfeed, air pressure and machine speed) according to the scheme shown in the next chapter. After the samples were produced on the machine, they were tested for physical bulk and instability by the processes mentioned in the next section. On the basis of the trials taken the selected range of process parameters were found to be

- Machine speed (m/min) : 300 to 500
- Overfeed (%) : 14.7 to 33.3
- Air pressure (bar) : 7 to 10

Within this range three different values for each parameters at equal intervals were taken as high, medium and low (coded as +1, 0, -1) values as shown in Table 3.3 and these values were used in different combinations according to Box Behenken 3 level design (Table 3.4) to prepare the yarn samples for the study. The combinations were used
randomly according to random number table as 1, 4, 7, 12, 10, 18, 2, 16, 19, 3, 9, 15, 1, 11, 4, 6, 17, 5, 8, 13 for sample preparation to avoid any biasness of sampling.

Table 3.3 Actual and coded values of process parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Low (coded -1)</th>
<th>Medium (coded 0)</th>
<th>High (coded +1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine speed (m/min)</td>
<td>300</td>
<td>400</td>
<td>500</td>
</tr>
<tr>
<td>Overfeed (%)</td>
<td>14.7</td>
<td>24</td>
<td>33.3</td>
</tr>
<tr>
<td>Air Pressure (bar)</td>
<td>7</td>
<td>8.5</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 3.4 Box Behnken design for the process parameters used for the study

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Overfeed(%)</th>
<th>AirPressure(Bar)</th>
<th>Tex.Speed(m/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-1(14.7)</td>
<td>-1(7)</td>
<td>0(400)</td>
</tr>
<tr>
<td>2</td>
<td>+1(33.3)</td>
<td>-1(7)</td>
<td>0(400)</td>
</tr>
<tr>
<td>3</td>
<td>-1(14.7)</td>
<td>+1(10)</td>
<td>0(400)</td>
</tr>
<tr>
<td>4</td>
<td>+1(33.3)</td>
<td>+1(10)</td>
<td>0(400)</td>
</tr>
<tr>
<td>5</td>
<td>-1(14.7)</td>
<td>0(8.5)</td>
<td>-1(300)</td>
</tr>
<tr>
<td>6</td>
<td>+1(33.3)</td>
<td>0(8.5)</td>
<td>-1(300)</td>
</tr>
<tr>
<td>7</td>
<td>-1(14.7)</td>
<td>0(8.5)</td>
<td>+1(500)</td>
</tr>
<tr>
<td>8</td>
<td>+1(33.3)</td>
<td>0(8.5)</td>
<td>+1(500)</td>
</tr>
<tr>
<td>9</td>
<td>0(24)</td>
<td>-1(7)</td>
<td>-1(300)</td>
</tr>
<tr>
<td>10</td>
<td>0(24)</td>
<td>+1(10)</td>
<td>-1(300)</td>
</tr>
<tr>
<td>11</td>
<td>0(24)</td>
<td>-1(7)</td>
<td>+1(500)</td>
</tr>
<tr>
<td>12</td>
<td>0(24)</td>
<td>+1(10)</td>
<td>+1(500)</td>
</tr>
<tr>
<td>13-19</td>
<td>0(24)</td>
<td>0(8.5)</td>
<td>0(400)</td>
</tr>
</tbody>
</table>

Five different blends along with 100 % polyester and 100 % viscose filament yams were taken for the study. Blending was carried out by feeding the required number of yarn combinations to the jet according to Table 3.5.

The following machine parameters were kept constant for all the runs:

- Machine used : Eltex AT/HS
- Nozzle used : Hemajet S325
- Winding underfeed : 0.7%
Mechanical stretch : 4.7%
Stabilizing temperature : 200°C
Water application : 1 lt./hr at 1 bar water pressure

Table 3.5 Blends of filament yarns used for preparation of textured yarn samples

<table>
<thead>
<tr>
<th>Sr No.</th>
<th>Blend (P/V) (Theoretical blend ratio)</th>
<th>Polyester (no. of yarns)</th>
<th>Viscose (no. of yarns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0/6 (0/100)</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>1/5 (16.67/83.33)</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>2/4 (33.33/66.67)</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>3/3 (50/50)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>4/2 (66.67/33.33)</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>5/1 (83.33/16.67)</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>6/0 (100/0)</td>
<td>6</td>
<td>0</td>
</tr>
</tbody>
</table>

The polyester yarns were fed through a wetting head before entry to the jet whereas the viscose yarns were fed dry to the jet because during the initial trials it was observed that the wet viscose filaments have a tendency to stick to each other inside the jet inhibiting proper separation of filaments resulting in lesser loop formation (poor texturing effect). The moistened viscose filaments also gave rise to breakage in the nozzle.

The yarns produced were tested for their physical bulk, instability, tenacity and denier according to the methods discussed in Section 3.3 below.

3.3 Yarn testing

The air-jet textured yarns were tested for their physical bulk, instability and tensile properties by the following methods.

3.3.1 Physical Bulk

Physical bulk of air-jet textured yarns was measured using the package density method. Packages of equal diameter were wound using parent and air-jet textured yarns under constant tension of 3cN at a speed of 300m/min for 30 mins in a spindle driven winder. The physical bulk is measured using the equations 3.1 and 3.2.
Physical bulk (%) = \dfrac{\text{Density of parent yarn package (g/cm}^3\text{)}}{\text{Density of textured yarn package (g/cm}^3\text{)}} \times 100 \quad (3.1)

\text{package density (g/cm}^3\text{)} = \dfrac{M_{c+y} - M_c}{\pi L (R_{c+y}^2 - R_c^2)} \quad (3.2)

where,

- \(M_{c+y}\) = total weight of full package in g
- \(M_c\) = weight of empty package in g
- \(L\) = traverse length of the package in cm
- \(R_{c+y}\) = overall radius of full package in cm
- \(R_c\) = radius of empty package in cm

3.3.2 Instability

The instability of the air-jet textured yarns were measured using Du Pont’s weight hanging method. A basic load of 0.01gf/den (0.0088 cN/dtex) was applied to the yarn and a mark was made at 100 cm distance from the clamp. Yarn was then subjected to an additional load of 0.5 gf/den (0.44 cN/dtex) for 30 s. The permanent extension in the length of the yarn, measured 30 s after the removal of heavy load was taken as a measure of instability. Ten readings were taken from a sample package to estimate instability and between each successive reading nearly 5 m yarn was unwound from the package and discarded.

3.3.3 Tensile properties

Tensile properties of all textured yarns were measured according to ASTM Test method D2256-95a using Instron tester(model 4411) with 500 mm gauge length, 300 mm/min cross head speed and a pretension level of 0.055 gf/den (0.048 cN/dtex). Forty samples from each package were tested to obtain average tensile properties.
3.3.4 Yarn denier

Skeins were prepared on a wrap reel of 1m girth. Five skeins of 100m each were prepared from each package and weighed on an electronic balance capable of measuring to an accuracy of 1 mg. The denier was calculated as follows:

\[
\text{Yarn denier} = \frac{\text{Weight of 100m skein in grams}}{100} \times 9000
\]

(3.3)

\[
\text{Yarn dtex} = \frac{10}{9} \times \text{YarnDenier}
\]

(3.4)

3.4 Optimization of texturing process parameters

3.4.1 Determination of regression equations for prediction of yarn properties

To obtain the optimum process parameters initially regression equations for prediction of physical bulk, instability, tenacity and denier for all the blends were generated using backward elimination method. Prediction in real life textile applications is becoming essential and common. Prediction of the expected behaviour/performance of a process or product, before it is made, is required to minimize or reduce the set-up cost and set-up time. Alternatively, there could be situations where a decision is required to be taken based on the past data where a normal human brain has limitations of drawing out inferences. Ability to predict properties of yams accurately has become a challenge due to the highly non-linear interactive behaviour of fibres and yams, especially under dynamic conditions [100].

3.4.2 Optimization of process parameters

The optimum process parameters for different blends were determined with the help of the regression equations and assigning seven different weightage ratios to instability (low), bulk (high) and tenacity (high) of the yams viz. 3:2:1, 2:2:1, 2:1:1, 1:1:1, 3:2:0, 2:1:0, 1:1:0. This is done with the help of a TURBO C program. The flowchart to explain the logic used in the program is given in Appendix 2 and the program listing and the output of the program is given in the Appendix 3. The optimization process also
involved selection of parameters on the basis of lower air pressure keeping in mind the process cost.

3.5 **Final yarn preparation for fabric production**

Finally, the textured yams of each blend were produced using the optimum process parameters. The actual values of the yarn properties viz. physical bulk, instability, tenacity and denier were also measured.

3.6 **Preparation of ring spun yams and their testing**

3.6.1 **Preparation of yarns used as weft**

Ring spun yams of corresponding blends were produced with similar linear densities as the textured yams using the staple fibres shown in Table 3.2. The process flow chart of the same is shown below:

```
BLENDING
  ↓
BLOWROOM (Lakshmi Rieter)
  ↓
CARDING (MMC)
  ↓
DRAWFRAME (LR DO/2S)
  ↓
SPEEDFRAME (Texmaco Howa)
  ↓
RINGFRAME (Lakshmi Rieter G5/1)
  (Spindle speed – 14000rpm, TM – 3.4)
```

Fig. 3.1 Sequence of machines used for preparation of ring-spun yams from fibres.

3.6.2 **Hairiness testing**

The yarn hairiness was measured with the help of Zweigle Hairiness tester (Model G565) using photo electric principle. 200 m of yarn was taken for one test. Yarn draw-off speed was kept at 50 m/min and five observations were taken for each sample.
3.6.3 Preparation of yarns used for warp

Ring spun yam of 30s Ne (197 dtex) with 65/35 P/V blend was produced using the same fibres as shown in Table 3.2. The process used for yarn preparation was also similar as shown in Fig. 3.1. The yarns were then doubled in a Texmaco (Textool) doubling frame (DY200) at a speed of 8000 rpm to get 2/30s Ne (394 dtex) doubled yarn. Warp beam was prepared from these yarns.

3.6.4 Yarn diameter testing

All the yarns were tested for their diameter in a Lieca projection microscope. 10 readings were taken for each sample.

3.7 Fabric preparation

Plain woven fabric samples were prepared with the above mentioned warp in a Lakshmi sample loom at 140 picks/min and a reed space of 20 inches (0.508 m). Seven blended air-jet textured yams and the corresponding spun yams were used as weft to prepare 14 samples. The ends/cm and picks/cm on loom was kept as 21.5 and 17.5 respectively. The fabrics were heat-set on Primatex stenter at 20 m/min speed with 3% overfeed allowing 5% widthwise shrinkage at 180°C. The fabrics were then relaxed in a jet dyeing machine at boil with 1% non-ionic detergent for 30 mins.

3.7.1 Yarn diameter measurement from fabric

The actual diameter of the yarns in the fabric were measured using a Leica projection microscope. 5 readings were taken for each sample each in warp and weft directions.

3.8 Fabric tests

Before testing all the fabric samples were pre-conditioned in standard atmosphere for 8 hours according to ASTM D 1776 – 98 standards.
3.8.1 Fabric thickness

Fabric thickness was measured on Instron tester (Model 4411) in compression mode using a platen of 49 mm diameter and compression rate of 1.2 mm/min. Thickness values at pressure levels of 2 gf/cm² and 5 gf/cm² were obtained.

3.8.2 Air Permeability

The air permeability of a fabric is defined as the volume of air passed in unit time through unit area of the fabric at a pressure difference of 10mm head of water. Five specimens were tested each with a test area of 508 mm² (25.4 mm diameter) according to IS 11056 – 1984 and DIN 53887 standards.

3.8.3 Thermal Insulation

The instruments generally used for the measurement of thermal conductivity λ and thermal resistance R of thin layers are not sufficiently precise, because the changes in heat flow caused by the low thermal resistance of fabrics are nearly undetectable for classical instruments of the skin model type. ALAMBETA, does not exhibit this problem and it measures transient thermal characteristics of textile fabrics, where one of these characteristics can be used for objective evaluation of warm or cool feeling. This is important during short contact with the fabric, or when wearing some fabrics (like trousers) which come into intermittent thermal contact with our skin. The simplified scheme of the instrument is shown on Fig 3.2. The principle of this instrument depends on mathematical processing of time course of heat flow passing through the tested fabric due to different temperatures of a bottom measuring plate and the measuring head. The instrument consist of a heat flow sensor 4, which is attached to a metal block 2 with constant temperature (at 32°C with the help of heater 3 and thermometer 8), which differs from the sample temperature (22°C). When the measurement starts, the measuring head 1 containing the mentioned heat flow sensor drops down and touches the sample 5, which is located on the instrument base 6 under the measuring head. At this moment, the surface temperature of the sample suddenly changes and the instrument computer registers the heat flow course.
Simultaneously, a photoelectric sensor measures the sample thickness. All the data are then processed in the computer according to an original programme, which involves the mathematical model characterizing the transient temperature field in thin slab subjected to different boundary conditions [101]. To simulate the real life conditions of warm-cool feeling evaluation, the instrument measuring head is heated to 32°C, which correspond to the average human skin temperature, while the fabric is kept at the room temperature 22°C. Similarly, the time constant of the heat flow sensor, which directly measures the heat flow between the automatically moved measuring head and the fabrics, exhibit small value (0.07 sec). The full signal response is achieved within 0.2 sec. The whole measurement procedure, including the measurement of thermal conductivity, $\lambda$, thermal resistance $R$, peak heat flow rate $q_{\text{max}}$, sample thickness takes less than 5 mins. Five readings were taken for each sample.

3.8.4 Water vapor permeability

Fabric water vapour permeability was measured in PERMETEST (SENSORA). It presents a small ‘skin model’ and under standard laboratory conditions (at 22 °C and relative humidity 65%) it offers reasonable precision of measurement, according to both BS 7209 and ISO 9920 standard. Results of measurement are expressed in units defined
in the ISO Standard 11092. Five readings were taken for each sample. The instrument offers fast and non-destructive testing of water vapour permeability of textile fabrics. A curved porous surface is moistened (either continuously or on demand) and exposed in a wind channel to parallel air flow of adjustable velocity of 3-5 m/s shown in Figure 3.3. A tested sample is located at a small distance from the wetted area of diameter about 80 mm and characterized by high thermal conductivity. The amount of evaporation heat of liquid water taken away from the active porous surface is measured by a special integrated system. Thus, very low time constant of the whole system was achieved, resulting in short measurement time – full signal is registered within several minutes. Besides basic elements described in the figure the device consists of water dosing syringe, an industrial digital temperature controller, a consumer ambient digital thermometer joined with relative humidity meter, a chart recorder and a supply unit. The core system can be heated to temperature exceeding the room temperature or can be kept at the room temperature to maintain the isothermal working conditions. At the beginning of the measurement, heat flow value $q'_{h0}$ without a sample is saved. If water was regularly distributed and the head temperature was properly controlled the signal becomes quite stable but will include some small turbulent variations which cannot be avoided. In the next step, the measuring head pulls down and a sample is inserted between the head and the cut out in the wind channel. Then the measuring head moves back to the channel and squeezes the sample.

![Permetest apparatus](image)

Fig. 3.3 Permetest apparatus

After short period when the signal reflects the effect of different temperature on the sample, the signal becomes steady and new value $q'_{hs}$ which quantifies heat loses of
moist measuring head covered by a sample is read. Relative water vapour permeability of the textile sample $r_{wv}$ is calculated from the formula

$$r_{wv} = \frac{q'_{hs}}{q'_{ho}} \times 100\%$$  \hspace{1cm} (3.5)

When water vapour resistance is to be measured according to the ISO 11092 standard then a cellophane foil permeable to water-vapour but not permeable to liquid water is put to cover the head surface. Application of the same procedure as above gives two values $q''_{ho}$ and $q''_{hs}$. The demanded water vapour resistance of the sample $R_{wf}$ then follows from the equation 3.6.

$$R_{wf} = (p''_{wv} - p_{wv}) \left( \frac{1}{q''_{hs}} - \frac{1}{q''_{ho}} \right) \text{ m}^2\text{PaW}^{-1}$$  \hspace{1cm} (3.6)

The values $p''_{wv}$ and $p_{wv}$ in this equation represent the water vapour saturated partial pressure valid for ambient temperature and actual partial water vapour pressure in the laboratory. Five tests were carried out for each sample and the average of five readings has been reported.

**3.8.5 Wicking**

Horizontal wicking is the transmission of a liquid through the thickness of the fabric, that is, perpendicular to the plane of the fabric. The thickness of the material governs this type of wicking. “Demand wetting” or “spontaneous transplanar liquid uptake” [102] is a term used to define the transport of a liquid in a fabric upon demand. Several techniques have been developed to measure the rate of transport and fluid holding capacity employing the demand wettability principle. An instrument developed by IIT Delhi has been used to measure in-plane wicking of fabrics. The schematic view of the instrument is shown in Fig. 3.4. A fabric sample (160 mm×160 mm) is placed on a horizontal base plate which is connected to a liquid reservoir by means of a siphon tube. The fabric sample is covered by a cover plate so as to ensure intimate contact between the base plate and the fabric. The spatial relationship between the bottom surface of the test specimen in contact with the liquid in the siphon tube and the liquid level in the reservoir is adjustable. Water level in the reservoir and fabric level is kept same.
The liquid reservoir is placed on a suitable electronic balance which is interfaced with a PC. The balance indicates the weight of water that left the reservoir and the difference between the two consecutive readings shows the weight of water taken by the fabric with time. Five observations were taken for each sample for different wicking times (30s and 90s).

### 3.8.6 Pilling

After rubbing of a fabric it is possible to assess the amount of pilling quantitatively either by counting the number of pills or by removing and weighing them. However, pills observed in worn garments vary in size. A large numbers of factors contribute to the formation of pills which are not taken into consideration during counting the pills quantitatively. Also the process is time consuming and there is also difficulty in deciding which surface disturbances constitute pills. The more usual way is to assess the pilling subjectively by comparing it with either standard samples or with photographs of them or by the use of a written scale of severity. The method used for measuring the tendency of a fabric to pilling is BS5811-1986 (ICI Pilling Tester) with four specimens each of 125mm x 125mm. After 18,000 turns for the ICI Pilling-Box, the pilling properties of the samples were evaluated by comparing their visual appearance with standard photographs. Samples were rated on a scale of 1 to 5 (1 for the worst, 5 for the best).
3.8.7 Strength and elongation

Ravelled strip method was used for measuring the breaking force and elongation of the fabrics according to ASTM D5035 – 95 using Instron 4411. The specimen size was 25 mm x 120 mm (gauge length + 20 mm + 2 x jaw face width in direction of load in mm). Gauge length of 75 mm and a cross head speed of 300 ± 10 mm/min were used for testing 5 warp and 5 weft wise specimens from each sample. A pretension of 0.5% of the breaking load was used at the bottom end of the specimen before gripping it in the lower clamp.

3.8.8 Fabric weight

The fabric weight was measured by ASTM – D3776-96 (Option C) method using an area of 20 in² (130 cm²). Ten observations were taken for each sample.

3.8.9 Abrasion resistance

Abrasion resistance tests on the fabric samples were conducted on the Martindale pilling and abrasion tester in accordance with standards BS EN ISO 12947-2 and 3. Four samples from each fabric type were used to determine the mass loss and thickness loss at the end of 25,000 cycles. The pill rating was checked for each sample after 15000 cycles. After 10,000 cycles, the sample surfaces were checked at intervals of 1,000 cycles.

3.8.10 Crease recovery

Crease recovery of fabrics were measured by AATCC 66-1998 method with a 500 gf load and creasing and recovery time of 5 min each. 12 samples of 40 x15 mm, six from warp and six from weft directions were tested from each fabric. Out of six warp or weft direction samples three were folded face-to-face and the remaining three back-to-back and the average of the six readings were calculated.
3.8.11 Handle related mechanical, physical and surface properties

Aesthetic properties are the most highly subjective and complex features of fabrics. FAST (Fabric Assurance by Simple Testing) measures the mechanical and dimensional properties of fabric that can be used to predict performance in garment manufacture and the appearance of the garments in wear. FAST consists of three instruments and a test method:

FAST-1 is a compression meter that measures fabric thickness.
FAST-2 is a bending meter that measures the fabric bending length.
FAST-3 is an extension meter that measures fabric extensibility.
FAST-4 is a test procedure for measuring dimensional properties of fabric. In our study we only used the three instruments and not the test method.

FAST-1,2,3 test samples are 150 mm X 50 mm. The tests are performed in the order FAST-1, FAST-2, FAST-3. This avoids deformations that would affect later results.

The number of samples used was:

FAST-1 Compression - 5 samples
FAST-2 Bending-3 warp and 3 weft samples
FAST-3 Extension - 3 warp, 3 weft, and 6 bias samples (3 left-bias and 3 right-bias)

The samples were then steam released and the SiroFAST-1 tests repeated. The values of following parameters were obtained:

**Fabric thickness** is measured on a 10 cm² area at two different pressures of 2gf/cm² and 100gf/cm². The difference between the two values gives the surface layer thickness. The thickness measurements are repeated after steaming on an open Hoffman press for 30s in order to determine the stability of the surface layer (**Released surface thickness**).

The bending meter measures the bending length according to BS 3356-1961 and the readings are converted to **bending rigidity** (9.8 x 10⁻⁶ x mass per unit area x bending length).
The extensibility is measured in warp and weft directions at three fixed forces (5, 20 and 100 gf/cm). Bias extension is also measured in both directions at 5 gf/cm. Bias extension is converted to shear rigidity.

Formability is calculated from longitudinal compressibility and bending rigidity. It is a measure of degree of compression in the fabric plane sustainable by it before buckling occurs.

3.8.12 Porosity and Fabric cover

The porosity of the fabrics (defined as the pore volume per unit fabric volume) was determined theoretically using the following formula:

\[
\text{Porosity} = \left(1 - \frac{\text{Fibre volume in the fabric}}{\text{Fabric volume}}\right) \times 100
\]

\[
= \left(1 - \frac{\text{Fabric gsm/avg. fibre density in g/m}^2}{\text{Volume of one m}^2 \text{ fabric}}\right) \times 100
\]

considering density of polyester 1.38 g/cm³

density of viscose 1.52 g/cm³

The fabric cover is the fraction of the total fabric area that is ‘covered’ by the component yarns. It is calculated from the yarn width (measured in the fabric) and the threads per inch as follows:

Fractional warp cover, \( K_e = \frac{d_e}{1/e} = ed_e \)  

Fractional weft cover, \( K_p = \frac{d_p}{1/p} = pd_p \)  

Total fractional cover, \( K = K_e + K_p - K_e K_p \)

Where, \( e = \) ends per cm in fabric  
\( p = \) picks per cm in fabric  
\( d_e = \) width of warp yarn in fabric, cm  
\( d_p = \) width of weft yarn in fabric, cm