CHAPTER 6

INFLUENCE OF LAUNDERING ON COMFORT CHARACTERISTICS OF MOISTURE MANAGEMENT FINISHED MICRODENIER POLYESTER KNITTED FABRICS

6.1 INTRODUCTION

In the previous chapter it is seen that moisture management finished (MMF) single jersey fabric with 2.9 mm stitch length had given the optimum level of performance with respect to comfort characteristics. An interesting observation noticed was that the wicking length of MMF fabrics improved significantly after they were laundered. Further analysis is required related to the changes that may occur for other comfort characteristics. The comfort characteristics have to be analyzed for the single jersey fabrics when subjected to several laundry cycles.

For chemically treated fabrics, the durability of the moisture management finish is an important aspect. For use in clothing, fabric should have both appropriate mechanical properties and the durability to withstand the physical and chemical stresses of laundering. The treated fabrics used for sportswear and leisure wear should retain its ability to absorb water in subsequent uses after laundering. Thus, it is important to investigate any change in comfort characteristics that may occur as a result of laundering.

Clothing intended for repeated use must be able to be laundered. It is well known that weft knitted fabrics tend to undergo large changes in
dimensions and are often prone to distortion upon repeated laundering. A large number of factors are responsible for causing these undesirable effects in knitted structures. These are all associated with the yarn, knitting, finishing and making-up of the fabrics. It is also a fact that consumers are becoming increasingly concerned of fabric quality and expect higher standards of performance than ever before, even after a number of wash and dry cycles.

6.2 METHODOLOGY

The influence of laundering on comfort characteristics of moisture management finished microdenier polyester knitted fabrics has been studied, in order to investigate the durability of MMF on the fabrics when subjected to washing. The comfort characteristics such as wetting, vertical wicking, transverse wicking, moisture vapor transfer, air permeability and drying rate were analyzed after one, five, ten and twenty laundry cycles and compared with the results obtained prior to washing. All the test results have been analyzed using statistical tool at 95% confidence level and standard error has also been evaluated and represented in each figure.

Microdenier polyester filament yarn of 150 denier containing 108 filaments was taken as the raw material. The yarn was knitted on circular knitting machine of 28 gauge to produce knitted fabric of single jersey plain structure with 2.9 mm stitch length. Then the fabric was treated for moisture management finish as mentioned in chapter 4.3.
Figure 6.1 Process Flow Chart for Application of Moisture Management Finish on Knitted Fabric and Laundry Process

Micro Denier Polyester Filament Yarn (150 Denier - 108 filaments)

Development of knitted fabric
Single jersey with 2.9mm stitch length

Preparatory wet processing for the above fabric (Hot wash / Bleaching)
Application of wetting agent (Ethoxylated alcohol) to the fabrics

Application of Moisture Management Finish
Amino Silicon Polyether Copolymer : Hydrophilic polymer = 1:2, pH = 5.5, Temp = 60-70°C

MMF Fabrics subjected to laundry process

1 wash  5 wash  10 wash  20 wash

Fabrics subjected to testing for:
▶ Geometrical characteristics ▶ Wetting ▶ Vertical Wicking ▶ Transverse wicking
▶ Moisture vapour transfer ▶ Air permeability ▶ Drying rate
6.3 RESULTS AND DISCUSSION

The influence of laundering on comfort characteristics such as wetting, vertical wicking, transverse wicking, moisture vapour transfer, air permeability and drying rate were tested.

6.3.1 Geometrical Characteristics

The geometrical characteristics of Microdenier polyester fabrics were measured and the average value of ten samples was given in Table 6.1.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Wales per cm</th>
<th>Courses per cm</th>
<th>Stitch density (Loops/cm²)</th>
<th>Areal density (grams/m²)</th>
<th>Stitch length (mm)</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>16.53</td>
<td>17.32</td>
<td>286.3</td>
<td>122</td>
<td>2.9</td>
<td>0.52</td>
</tr>
<tr>
<td>Treated</td>
<td>17.53</td>
<td>18.11</td>
<td>299.35</td>
<td>133</td>
<td>2.8</td>
<td>0.55</td>
</tr>
<tr>
<td>1 wash</td>
<td>17.12</td>
<td>18.18</td>
<td>311.28</td>
<td>128</td>
<td>2.8</td>
<td>0.53</td>
</tr>
<tr>
<td>5 wash</td>
<td>17.26</td>
<td>18.22</td>
<td>314.42</td>
<td>127</td>
<td>2.8</td>
<td>0.53</td>
</tr>
<tr>
<td>10 wash</td>
<td>17.33</td>
<td>18.25</td>
<td>316.20</td>
<td>125</td>
<td>2.7</td>
<td>0.50</td>
</tr>
<tr>
<td>20 wash</td>
<td>17.32</td>
<td>18.26</td>
<td>316.12</td>
<td>125</td>
<td>2.7</td>
<td>0.50</td>
</tr>
</tbody>
</table>

The stitch density of the fabrics increased by 5% after moisture management finish was applied. The treated fabrics exhibited 5% higher areal density and 7% higher thickness than untreated fabrics. After the first wash the fabric shrinkage resulted in 4% decrease in areal density coupled with 4% increase in stitch density. The stitch length reduced to 2.8mm and thickness also reduced by 5%. There was no significant difference in values after 5 washes when compared to one wash samples. When comparing with 5 wash samples, in 10 and 20 wash samples there was a further reduction in stitch
length to 2.7mm and thickness by 7%. The effect of geometrical characteristics of the fabrics was significant.

6.3.2 Water Transmission Characteristics

The water transmission characteristics of MMF fabrics were analyzed at various levels of washing cycles. The washing cycles are one wash, 5 wash, 10 wash and 20 wash. The average values were given in Table 6.2.

<table>
<thead>
<tr>
<th>Samples</th>
<th>Sinking time (s)</th>
<th>Transverse wicking</th>
<th>Moisture vapor transmission (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Water spreading area for 1ml of water (cm²)</td>
<td>Area covered to reach saturation (cm²)</td>
</tr>
<tr>
<td>Untreated</td>
<td>7.3</td>
<td>4.8</td>
<td>116.23</td>
</tr>
<tr>
<td>Treated</td>
<td>6.3</td>
<td>5.3</td>
<td>122.34</td>
</tr>
<tr>
<td>1 wash</td>
<td>6.5</td>
<td>5.2</td>
<td>130.56</td>
</tr>
<tr>
<td>5 wash</td>
<td>6.8</td>
<td>5.3</td>
<td>141.32</td>
</tr>
<tr>
<td>10 wash</td>
<td>5.3</td>
<td>6.2</td>
<td>149.66</td>
</tr>
<tr>
<td>20 wash</td>
<td>5.1</td>
<td>6.25</td>
<td>151.34</td>
</tr>
</tbody>
</table>

From Table 6.2 it is seen that sinking time reduced with increase in laundry cycles. In transverse wicking the water spreading area increased with the number of laundry cycles. The moisture vapor transfer rate was higher for 5 wash to 20 wash fabrics.
6.3.3 Analysis of Wetting Characteristics

The ability of the fabric to sink completely in water were tested and included in Table 6.2.

![Figure 6.2 Wetting Characteristics of the Fabrics](image)

From Figure 6.1 it is seen that MMF treated fabric takes 13% lesser time to sink in water than the untreated fabric. The absorption of water by the treated fabric increases because the resistance to water is less. This is due to the MMF deposited on the surface of the fabric. It is interesting to note that the sinking time after one wash and 5 wash increases marginally by 3%. But for 10 wash samples the sinking time reduces by a significant 16% and a further 3% after 20 washes. This may be due to the lower fabric thickness and lower aerial density values due to shrinkage of the fabrics after 10 and 20 washes. For fabrics that undergo washing through repeated laundry cycles the sinking time also identifies the hydrophily degree of the fabric. i.e. the smaller the value of sinking time higher the hydrophily degree of the fabric will be. The sinking time reached after 10 and 20 washes was lesser which means that the washing process caused a higher hydrophilicity degree for these samples. A similar trend was observed by Belkis Zervent et al (2006).
6.3.4 Analysis of Wicking Characteristics

The wicking height of all six fabrics were analyzed with respect to wicking time from 5 seconds to 5 minutes.

![Figure 6.3 Longitudinal Wicking Rate of the Fabrics](image)

From Figure 6.3 it is seen that the wicking height increases significantly by 30% after the first wash. A similar trend was observed by Parthiban et al (2006). The MMF treatment first ensures that the finish is deposited on the external surface of the fabric. During the washing process the moisture management finish consisting of amino silicone polyether copolymer and hydrophilic polymer is able to penetrate into the yarn and between the individual filaments. They penetrate easily into the filament bundle and deposit themselves almost completely between the filaments. This is due to the positively charged amino silicone surfactant ions being drawn towards the negatively charged polyester filaments in the yarn and stick to them quiet strongly. Also amino silicones have strong affinity to polyester fabrics which promotes optimum orientation of silicone on the substrate. The
application of MMF also ensures a reduction in contact angles and an increase in surface tension which in turn enhances the wickability of the laundered fabrics. There is only a marginal 4% increase in wicking height between one wash and 5 wash samples. Between 5 and 10 washes the increase in not significant (only 2%). 10 wash and 20 wash samples show similar readings. The wicking rate increases with time for all samples. At 5 seconds interval the wicking height obtained is 25% of total height for all samples. From 1 minute interval onwards the rate of wicking by all four washed samples was faster than untreated and treated samples. The effect of laundering on fabric wicking rate is significant.

6.3.5 Analysis of Transverse Wicking Characteristics

The area covered by the spreading action of water for one drop and saturation method are given below.

6.3.5.1 Area of Water Spread for One Drop of Water

The area covered by the spreading acting of one drop (1ml) of water were tested and shown in Table 6.2.

![Graph of Area covered vs Washing Cycles](image)

**Figure 6.4 Area of Water Spread on the Fabrics**
From Table 6.2 and Figure 6.4 it is noticed that the drop of water spreads under the influence of capillary force and the spreading increases when the resistance to water flow is less. The treated sample exhibits a 9% increase in water spreading area. One wash and 5 wash samples exhibit similar values when compared to treated samples. The 10 wash samples show a significant 15% increase in spreading area than 5 wash sample. A similar increase was seen for 20 wash samples. This may due to the lower fabric thickness values obtained by the fabrics after 10 and 20 washes. This similar trend was observed already in the wetting test. Transverse wicking is a unique phenomenon with respect to water transfer behaviour of the fabrics, since it has no directional effect. When the area spread was more the evaporation of the fabric was also more. 10 and 20 wash samples exhibit a larger area spread and hence quicker is the moisture evaporation from these fabrics. The area of water spread is significant for 10 and 20 wash samples.

6.3.5.2 Area of Water Spread and Time Taken to Reach Saturation

The area covered and time taken to reach saturation point were tested and included in Table 6.2.

Figure 6.5 Area of Water Spread to Reach Saturation
From Table 6.2 and Figure 6.5 it is seen that the water spreading area (to reach saturation) has increased from untreated fabrics to 20 wash fabrics. The increase has been gradual. The treated fabrics show an increase in area spread by 5% when compared with untreated fabrics. After one wash the increase has been to the extent of 6%. Laundered fabrics have higher surface tension which helps to hold the water droplet and transfer it in the lateral direction against gravitational force. When the number of laundry cycles increased it exhibited higher water absorbency. This is due to more inter-fibre space due to which water spreads well in parallel. Here inter-fibre space increases due to the fabric shrinkage after washing. Fabric shrinkage increases the packing density of fibres thereby altering the inter fiber capillaries. The more the number of washes, higher was the water holding capacity of the fabrics. 5 wash fabrics shows 8% increase in area spread than one wash fabrics while for 10 wash fabrics it was 13% increase in total area spread. The difference in area spread between 10 wash and 20 wash fabrics was insignificant. The absorption of water by fibre molecules as well as the moisture fill up in the inter fibre and inter yarn pores of the fabric decides the area spread. Spreading of the water reduces troughs of low thermal resistance areas in the fabric. This is decided by the number of hydrophilic groups in the fabric after laundry cycles. Hydrophilicity is obtained when MMF penetrates into the yarn and deposits itself between the filaments during the washing process. The advantage of these assessments is that since transverse wicking being multidirectional it eliminates the directional effect.

When the time taken to reach saturation point is more correspondingly the area spread is also more for all the four washed samples. Interestingly the time taken for one wash fabric is 5% lesser than that of treated fabric even though the area spread was 6% more. The effect of laundry on area of water spread on the fabrics is significant.
6.3.6 Analysis of Moisture Vapor Transfer Behaviour

The rate at which moisture vapor moves through a fabric were tested and shown in Table 6.2.

![Figure 6.6 MVT for Height and Weight Reduction of Water](image)

From Table 6.2 and Figure 6.6 it is seen that the treated fabric shows 20% higher moisture vapour transfer (MVT) than untreated fabric with respect to height loss and weight loss. The moisture vapour transfer through one wash fabric gives the same values as treated fabrics. After 5 wash moisture vapor transfer increased by 9%. This is due to the fact that moisture management finish deposited on the fabric surface penetrates into the yarn and inbetween the filaments thereby clearing the pores of the fabric ensuring higher MVT. Fabrics after 10 and 20 washes show similar moisture vapour transfer rates. They also exhibited 9% increase in MVT than one wash and treated fabrics.
6.3.7 Air Permeability Characteristics

The rate of airflow through the fabric under a differential pressure between the two faces of a fabric were tested and shown in Figure 6.7.

![Air Permeability of the Fabrics](image)

**Figure 6.7 Air Permeability of the Fabrics**

From Figure 6.7 it is seen that air permeability values of fabrics were more or less the same for untreated, treated and all four laundered samples. It was clearly seen that laundry cycles do not have any effect on air permeability values.

6.3.8 Drying Characteristics

The drying capability of the fabrics were evaluated by its drying rate. Drying rate indicates the ability of the fabrics to evaporate the moisture presents. Drying rates were expressed as average weight loss over initial water content per unit area.
Figure 6.8 Drying Rate of the Fabrics

From Figure 6.8, it is seen that the treated sample and all the four laundered samples had equal drying rates of 8 minutes each while untreated fabrics took 10 minutes to return to original weight. Drying times of these fabrics, however, showed that one wash and 5 wash fabrics had quick and rapid drying rates upto six minutes level after which the drying rate was gradual upto 8 minutes. The drying rates of 10 wash and 20 wash fabrics were similar to that of treated fabrics. It appears that the length of time for the fabrics to dry depends mainly upon the amount of initial liquid water retained by the fabric per unit area for evaporation. A similar trend was observed by Cimilli et al (2010). The effect of laundering is significant with respect to drying rate of the fabrics.

6.4 CONCLUSION

One of the objectives of this research work is to study the influence of laundering on comfort characteristics of MMF microdenier polyester
knitted fabrics by investigating the durability of moisture management finish on the fabrics when subjected to washing. Comfort characteristics such as wetting, wicking, MVT, air permeability and drying rate were analyzed at different laundry cycles such as one, five, ten and twenty.

In geometrical characteristics, the stitch density and areal density of the fabrics increased by 5% after moisture management finish was applied. The treated fabrics exhibited 7% higher thickness than untreated fabrics. After the first wash the fabric shrinkage resulted in 4% decrease in areal density coupled with 4% increase in stitch density. The stitch length reduced to 2.8mm and thickness also reduced by 5%.

In the wetting test, it was seen that MMF treated fabric takes 13% lesser time to sink in water than the untreated fabric. The sinking time after one and 5 wash increases marginally by 3%. But for 10 wash samples the sinking time reduces by a significant 16% and a further 3% after 20 washes.

In the longitudinal wicking rate test, it was observed that the wicking height increases significantly by 30% after the first wash. There is only a marginal 4% increase in wicking height between one wash and 5 wash samples. Between 5 and 10 washes the increase was only 2%. At 5 seconds interval the wicking height obtained is 25% of total height for all samples. From 1 minute interval onwards the rate of wicking by all four washed samples was faster than untreated and treated samples.

In the transverse wicking test for one drop of water, the treated sample exhibited a 9% increase in water spreading area. The 10 wash and 20 wash samples show a significant 15% increase in water spreading area than 5 wash sample.
In the saturation test, the treated fabrics show an increase in area spread by 5% when compared with untreated fabrics. After one wash the increase had been to the extent of 6%. 5 wash and 10 wash fabrics showed 8% increase in area spread than one wash fabrics. The time taken for one wash fabric to reach saturation is 5% lesser than that of treated fabric even though the area spread was 6% more.

In the MVT test, the treated fabric showed 20% higher moisture vapour transfer than untreated fabric. After 5 wash moisture vapor transfer increased by 9%.

In the air permeability test the difference in values obtained for untreated, treated and all four laundered samples were insignificant.

In the drying rate test, the treated sample and all the four laundered samples exhibited equal drying rates. All five fabrics took 20% lesser time to dry and return to original weight than untreated fabrics.

Comparing all selected fabrics, it was concluded that 10 wash and 20 wash fabrics exhibited a superior performance in the various comfort characteristics. The durability of the moisture management finish applied on microdenier polyester fabrics was found to be good after 20 laundry cycles. Laundered fabrics transported moisture efficiently and dried quickly showing permanent wash proofness.