CHAPTER- 5

RESULTS AND DISCUSSIONS

5.1 COMPARATIVE PROPERTIES OF PET MOTHER YARN 240/12

After modifying the PET FDY spinning line, 240/12 mother yarn is taken in production. All chemical and physicals testings are made in respective laboratories. Physical testings of new spinning line mother yarn and imported TOPLON mother yarn are also carried out. Test results are summarized in table no. 5.1 and following observations are made.

i) The coefficient of variation in denier results of modified line mother yarn is on the higher side as compared to the new spinning line and imported TOPLON mother yarn which may be due to combining of 6 ends from two spin packs and then winding the yarn bundle of 240/12 on one package at take-up. Whereas in the case of a new spinning line and imported TOPLON mother yarn all 12 filaments are taken from single spin pack.

However, results are within the control limit of ±3 s.d. (standard deviation)

In the case of modified mother yarn -- ±2.30 s.d.
In the case of new spinning line mother yarn -- ±2.0 s.d.
In the case of imported TOPLON mother yarn -- ±1.64 s.d.

Industrial practice is to accept ±1.5% from target value i.e. acceptance limit for 240/12 denier is ±3.6 denier.

ii) Tenacity (g/d) and % elongation results at break are comparable with new spinning line mother yarn and imported TOPLON mother yarn as such no significant difference is observed.
iii) In table no. 5.1 Sr.no.3, T-10 (tenacity at 10% extension) values are given which has its significance in downstream operations. It indicates the strength of the mother yarn in further operation where 5-10% extension takes place.

iv) Results of % Uster of imported TOPLON mother yarn is on better side as compared to indigenous mother yarn. However, results are comparable but the difference in the results observed may be due to following reasons:-

a. In modified line mother yarn 12 filaments are taken from two spin packs whereas in the case of new spinning line mother yarn and imported TOPLON mother yarn all the 12 filaments are taken from a single pack.

b. Present modified line is running on old modified winders and also quench air velocity is high i.e. 0.8 m/s in place of 0.5 m/s which is creating more turbulence in quench zone causing higher % Uster.

v) There is hardly any difference in boiling water shrinkage values of modified yarn, new spinning line yarn and imported TOPLON mother yarn which is as expected. Boiling water shrinkage is a manifestation of the thermal history of polymer and drawing.

vi) Oil pickup % (OPU) and uniformity of spin finish application on the surface of the filaments is very important for downstream operations of mother yarn i.e. performance at splitting stage and other further operations.

The spin finish application system is modified from jet spray system to kiss roll application system which is best suited for uniform application throughout the surface of the filaments. It helps greatly in the splitting of the mother yarn to produce monofilament 20/1. Shore hardness of all three sources of mother yarn bobbins is around 55° which is sufficient for transportation and smooth unwinding, however,
there is further scope to produce packages up to 60° shore hardness which further helps to avoid transit damage.

Table 5.1 Comparative properties of modified, new spinning line and imported TOPLON mother yarn

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Properties</th>
<th>Unit</th>
<th>Modified FDY line</th>
<th>New spinning line mother yarn</th>
<th>Imported TOPLON yarn</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Denier</td>
<td>Number</td>
<td>Average</td>
<td>241.17</td>
<td>241.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SD</td>
<td>0.766</td>
<td>0.665</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CV</td>
<td>0.317</td>
<td>0.276</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Target</td>
<td>240.5</td>
<td>240.5</td>
</tr>
<tr>
<td>2</td>
<td>Tenacity</td>
<td>Grams/denier</td>
<td>-</td>
<td>4.57</td>
<td>4.70</td>
</tr>
<tr>
<td>3</td>
<td>T-10</td>
<td>Grams/denier</td>
<td>-</td>
<td>3.51</td>
<td>3.65</td>
</tr>
<tr>
<td>4</td>
<td>Elongation</td>
<td>%</td>
<td>Average</td>
<td>26.58</td>
<td>26.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SD</td>
<td>1.37</td>
<td>1.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CV</td>
<td>5.17</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Target</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>5</td>
<td>Uster</td>
<td>%</td>
<td>Average</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>6</td>
<td>Shrinkage (boiling water) SH</td>
<td>%</td>
<td>Average</td>
<td>6.57</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Target</td>
<td>6.5</td>
<td>6.0</td>
</tr>
<tr>
<td>7</td>
<td>OPU</td>
<td>%</td>
<td>Average</td>
<td>0.89</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Target</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>8</td>
<td>Shore Hardness</td>
<td>Degree</td>
<td>Average</td>
<td>53</td>
<td>53</td>
</tr>
</tbody>
</table>
5.2 SPINNING PERFORMANCE

Data of spinning performance of mother yarn of modified line and new spinning line are summarized in table no. 5.2

Table 5.2: Spinning performance of modified and new spinning line mother yarn

<table>
<thead>
<tr>
<th>Item</th>
<th>Modified machine</th>
<th>Original machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breaks/Ton</td>
<td>1.2</td>
<td>0.8</td>
</tr>
<tr>
<td>Waste %</td>
<td>2.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Full bobbin %</td>
<td>90</td>
<td>93</td>
</tr>
<tr>
<td>% Efficiency</td>
<td>97.5</td>
<td>98</td>
</tr>
<tr>
<td>% First grade</td>
<td>94</td>
<td>98</td>
</tr>
</tbody>
</table>

The performance of modified line is slightly inferior as compared to new spinning line mother yarn which can be due to following reasons:-

Being a new product, operators are not trained enough
In modified quench chambers with higher quench air velocity creating more flickering of filaments ultimately causing more breaks.
In modified line % waste is higher by 1% which can be further reduced by further optimizing quench conditions and thus controlling the spinning line tension. In due course of time operators will become used to operate modified line on this denier and thus further reduction in % waste at spinning is possible.
5.3 COMPARATIVE PROPERTIES OF MONOFILAMENT OF DIFFERENT SPINNERS

Looking the results of monofilaments of different spinners it is observed that results are quite comparable and performance of weavers in downstream operations was found to be quite comparable except performance at the splitting stage.

**Table 5.3: Properties of monofilaments of other spinners**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Supplier</th>
<th>Product</th>
<th>MONO YARN PROPERTIES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Den.</td>
</tr>
<tr>
<td>1</td>
<td>GARDEN (modified)</td>
<td>240/12 FB PET</td>
<td>20.07</td>
</tr>
<tr>
<td>2</td>
<td>TOPLON (imported yarn)</td>
<td>300/10 SD PET</td>
<td>29.87</td>
</tr>
<tr>
<td>3</td>
<td>TOPLON</td>
<td>300/15SD PET</td>
<td>20.03</td>
</tr>
<tr>
<td>4</td>
<td>TOPLON</td>
<td>300/10 SD</td>
<td>30.03</td>
</tr>
<tr>
<td>5</td>
<td>TOPLON</td>
<td>200/10 SD PET</td>
<td>20.03</td>
</tr>
<tr>
<td>6</td>
<td>J.KORIAN (new spinning line)</td>
<td>240/12 SD PET</td>
<td>19.93</td>
</tr>
<tr>
<td>7</td>
<td>SHUBHLAXMI (new spinning line)</td>
<td>240/12 SD PET</td>
<td>19.89</td>
</tr>
</tbody>
</table>
5.4 SPLITTING PERFORMANCE:

The most crucial aspect in the production of monofilaments through mother yarn is its performance at the splitting stage. Therefore utmost care is to be taken at spinning on following points:

(a) Quenching should be slow, proper and sufficient.
(b) The spin finish should be applied properly throughout the surface of the individual filaments.
(c) Special spin finish oil (low friction and low cohesive type) is required which helps in the splitting of filaments from yarn bundle.
(d) All the filaments in the yarn bundle should maintain parallelism without any twist and turns to avoid any problem in splitting of mother yarn into monofilaments.

In the following table comparative performance of imported, original and modified line mother yarn at the splitting stage is given. From the study, it is very much clear that the performance of imported mother yarn at splitting stage is quite superior as compared to original and modified line mother yarn. However, the performance of modified line mother yarn is quite comparable with original line mother yarn.
### Table 5.4: Comparative performance of 240/12 PET mother yarn of different spinners at splitting stage

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Product</th>
<th>Length / Per kg</th>
<th>Breaks / Creel</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toplon</td>
<td>240/12 SD</td>
<td>450000 meter</td>
<td>2 ~ 4</td>
<td>Toplon imported mother yarn</td>
</tr>
<tr>
<td></td>
<td>240/12 Brt.</td>
<td>450000 meter</td>
<td>4 ~ 10</td>
<td></td>
</tr>
<tr>
<td>J Korian</td>
<td>240/12 SD</td>
<td>450000 meter</td>
<td>10 ~ 12</td>
<td>Original line mother yarn</td>
</tr>
<tr>
<td>Subh Laxmi</td>
<td>240/12 SD</td>
<td>450000 meter</td>
<td>10 ~ 12</td>
<td>Original line mother yarn</td>
</tr>
<tr>
<td>Welspun</td>
<td>240/12 SD</td>
<td>450000 meter</td>
<td>10 ~ 12</td>
<td>Original line mother yarn</td>
</tr>
<tr>
<td>Geelon</td>
<td>240/12 SD</td>
<td>450000 meter</td>
<td>12 ~ 16</td>
<td>Modified FDY line mother yarn</td>
</tr>
<tr>
<td>Garden</td>
<td>240/12 SD</td>
<td>450000 meter</td>
<td>12 ~ 30</td>
<td>Modified FDY line mother yarn</td>
</tr>
</tbody>
</table>

It is clear from the table 5.4 that splitting performance of semi-dull and bright 240/12 of the same spinner (imported TOPLON) is not same and there are more breaks in case of bright 240/12 mother yarn which may be due to its special cross section.

Modified 240/12 mother yarn of Garden, performance is comparatively poor as compared to original line mother yarn of J. Korian, Subhlaxmi, and Welspun company. It may be due to our limitation of quench chamber length and old modified winders at take-up. However, the quality of monofilament 20/1 form modified line yarn is comparable from monofilaments of original line mother yarn.

Items like groove guides, traverse guides, tension bar guides, oil rollers, spinnerets and quench chambers for modification are imported from CERATEC (South Korea). Old winders are modified at garden itself by incorporating 4 end traverse cam arrangement of winding instead of 8 end bi rotor winding system.
5.5 COSTING OF MATERIALS REQUIRED FOR MODIFICATION OF PET FDY LINE

Cost of different items required for modification both imported and indigenous are summarized below in table 5.5

Table 5.5 Costing of materials required for modification (1 USD = Rs.68)

<table>
<thead>
<tr>
<th>QTY</th>
<th>Imported Items</th>
<th>DESCRIPTION</th>
<th>USD/Per Unit</th>
<th>USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td></td>
<td>Winder modification</td>
<td>8000</td>
<td>208000</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>Groove Guide for Mother Yar</td>
<td>165</td>
<td>8250</td>
</tr>
<tr>
<td>1000</td>
<td></td>
<td>Traverse guide for Mother Yar</td>
<td>2</td>
<td>2000</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>Tension Bar guide for Mother Yar</td>
<td>70</td>
<td>3500</td>
</tr>
<tr>
<td>75</td>
<td></td>
<td>Bar guide fixing unit for Mother</td>
<td>40</td>
<td>3000</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>Groove guide fixing unit for Mother</td>
<td>40</td>
<td>2000</td>
</tr>
<tr>
<td>24</td>
<td></td>
<td>Oil Roller (Dia.180xL260mm) for Mother</td>
<td>1050</td>
<td>25200</td>
</tr>
<tr>
<td>300</td>
<td></td>
<td>Spinneret</td>
<td>45</td>
<td>13500</td>
</tr>
<tr>
<td>24</td>
<td></td>
<td>Quench chamber for mother yar</td>
<td>2580</td>
<td>61920</td>
</tr>
</tbody>
</table>

**Total= USD 327370**

= Rs 22261160

Indigenous items
Miscellaneous, tension meters, guides and brackets =Rs2000000

Grand total = 24261160
5.6 INDUSTRIAL APPLICATIONS OF PET MONOFILAMENT

Following are the industrial applications of PET monofilaments:

- Filter cloths, Zippers, Brushes, Sport-industry, Automobile industry, Agriculture-industry, Geo textiles, Medical Textiles, Air bags, Heavy duty tires, Intimate apparels, Swim wears, Dress materials, Sarees and other technical textiles.

Following is the list of Technical textiles where PET monofilaments are used:

- Electrical cables, 3D printer filament, Eye wear retainers, Industrial fastening systems, Threads, woven or knitted narrow fabrics, Double wall tank inter layers, Braid reinforce medical tubing, Circular knitting needle cables, Waste water filtrations treatment systems, Braided ropes and cords, Mist eliminators/ stack scrubbers, Auto mobile air filter structure, Woven flexible conduit, Fish hatchery pond protective netting, Dental applicators, Automobile fabrics, Non-roll waste-bands, fishing nets, mosquito nets, Weather seals, Various medical devices, Ultra-violet stabilized, Infusion flow reinforcement textiles, Hook and loops fastening systems, Whisker disk.

5.7 FABRIC TESTING AND RESULTS

240/12 PET mother yarn, produced on modified FDY Spinning line, is supplied to different consumers near Surat. Weavers are using 20/1 PET mono filaments after splitting 240/12 mother/parent yarn.

These mono filaments after splitting at high-speed splitters are used to prepare different quality of fabrics by using various yarns as WEFT on power looms. Normally simple plain weave is taken for such fabrics.

A very famous quality of 20/1mono x 20/1mono, known as bolting cloth is used as filter cloth in the industry.
20 fabric samples are collected from the market where 20/1 mono PET is used as WARP or WEFT on the different type of looms to produce various type of qualities.

Six fabric samples are tested for bursting, tensile and permeability test at the textile lab of Textile Engineering Department of MS University Vadodara.

Results are summarized in the following table.

**Table No 5.6 Results of Bursting Strength in Kg/cm sq.**

<table>
<thead>
<tr>
<th>Sample No</th>
<th>Readings</th>
<th>Average Kg/cm sq</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8.91, 8.04, 9.03</td>
<td>8.66</td>
</tr>
<tr>
<td>6</td>
<td>9.28, 9.56, 8.96</td>
<td>9.26</td>
</tr>
<tr>
<td>17</td>
<td>9.33, 9.69, 9.00</td>
<td>9.34</td>
</tr>
<tr>
<td>18</td>
<td>10.08, 9.59, 9.99</td>
<td>9.88</td>
</tr>
<tr>
<td>19</td>
<td>10.65, 10.63, 10.86</td>
<td>10.71</td>
</tr>
<tr>
<td>Knitted Sample</td>
<td>6.08, 5.93, 5.86</td>
<td>5.95</td>
</tr>
</tbody>
</table>
Table No 5.7 Air permeability values in m³/m²/hours at 100 Pascal’s.

<table>
<thead>
<tr>
<th>Sample no</th>
<th>Observations</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1@100 Pascal’s</td>
<td>4900,5000,5200,5200,5100</td>
<td>5080</td>
</tr>
<tr>
<td>18@100 Pascal’s</td>
<td>3700,4000,3800,4200,3700</td>
<td>3880</td>
</tr>
<tr>
<td>19@50 Pascal’s</td>
<td>4800,4400,4800,4200,4200</td>
<td>4480</td>
</tr>
</tbody>
</table>

Table no 5.8 Tensile Strength (Strip width 2cm.)

<table>
<thead>
<tr>
<th>Date</th>
<th>Batch Reference</th>
<th>Sample Reference</th>
<th>Speed m/min</th>
<th>Maximum Load in kgf</th>
<th>Deflection of max. load in mm.</th>
<th>Gauge Length in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/20/2017</td>
<td>Sample 1</td>
<td>WARP</td>
<td>100.00</td>
<td>5.7877</td>
<td>18.079</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 1</td>
<td>WARP</td>
<td>100.00</td>
<td>6.1457</td>
<td>22.497</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 1</td>
<td>WARP</td>
<td>100.00</td>
<td>5.3658</td>
<td>19.645</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 1</td>
<td>WEFT</td>
<td>100.00</td>
<td>21.709</td>
<td>20.162</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 1</td>
<td>WEFT</td>
<td>100.00</td>
<td>21.786</td>
<td>24.499</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 17</td>
<td>WEFT</td>
<td>100.00</td>
<td>22.353</td>
<td>26.773</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 17</td>
<td>WARP</td>
<td>100.00</td>
<td>9.2380</td>
<td>33.300</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 17</td>
<td>WARP</td>
<td>100.00</td>
<td>9.1920</td>
<td>37.884</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 17</td>
<td>WARP</td>
<td>100.00</td>
<td>9.3652</td>
<td>34.218</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 17</td>
<td>WEFT</td>
<td>100.00</td>
<td>18.199</td>
<td>9.0294</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 17</td>
<td>WEFT</td>
<td>100.00</td>
<td>17.459</td>
<td>9.4052</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 6</td>
<td>WEFT</td>
<td>100.00</td>
<td>19.373</td>
<td>9.8053</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 6</td>
<td>WARP</td>
<td>100.00</td>
<td>14.384</td>
<td>48.624</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 6</td>
<td>WARP</td>
<td>100.00</td>
<td>13.531</td>
<td>46.624</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 6</td>
<td>WARP</td>
<td>100.00</td>
<td>17.383</td>
<td>47.606</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 6</td>
<td>WEFT</td>
<td>100.00</td>
<td>16.524</td>
<td>19.170</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 6</td>
<td>WEFT</td>
<td>100.00</td>
<td>16.859</td>
<td>19.296</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 19</td>
<td>WARP</td>
<td>100.00</td>
<td>7.2194</td>
<td>18.505</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 19</td>
<td>WARP</td>
<td>100.00</td>
<td>6.4141</td>
<td>25.161</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 19</td>
<td>WARP</td>
<td>100.00</td>
<td>5.7078</td>
<td>25.204</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 19</td>
<td>WEFT</td>
<td>100.00</td>
<td>25.095</td>
<td>20.769</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 19</td>
<td>WEFT</td>
<td>100.00</td>
<td>26.289</td>
<td>29.162</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 19</td>
<td>WEFT</td>
<td>100.00</td>
<td>26.455</td>
<td>26.037</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 18</td>
<td>WEFT</td>
<td>100.00</td>
<td>28.762</td>
<td>29.060</td>
<td>10</td>
</tr>
<tr>
<td>3/20/2017</td>
<td>Sample 18</td>
<td>WEFT</td>
<td>100.00</td>
<td>26.925</td>
<td>26.045</td>
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