PERFORMANCE OF MECHANICAL CRIMP TEXTURED YARN IN WOVEN STRUCTURE

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ABSTRACT

Fabrics were produced using the Mechanical crimp textured polyester filament yarns, having different pre-twist and their corresponding feeder flat polyester filament yarns as wefts. Weaving as well as finishing of all the fabric samples was carried out under the identical conditions. Changes in the structural properties, mechanical properties and comfort associated properties before and after finishing of the fabrics were analysed. Marginal improvement in fabric characteristics was noticed on finishing. However, extent of improvement observed was higher for textured filler yarn fabric comparatively. Higher pre-twist textured filler yarn finished fabric had executed best results in terms of constructional properties, tensile strength, tear-strength, abrasion resistance and bulk realization due to its compact structure. However, better extension and low air permeability were gone in the account of looser but voluminous, low pre-twist textured weft yarn finished fabric.

KEYWORDS: Mechanical Crimp Texturising, Weft Yarn, Pre-Twist, Mechanical Properties, Fabric Sett

INTRODUCTION

Mechanical crimp texturising concept was launched by Shaikh et al.(2010). It was based on high level false twisting of pre-twisted and underfed flat configured continuous multifilament yarn. This had imparted crimpy configuration to flat filaments by undergoing torsional and bending distortion. Shaikh et al. (2011) had also empirically derived the formula for the evaluation of optimum false twist to get preferable crimpy configuration for polyester yarn. The structural integrity of the newly engineered yarn must be remained unimpaired during the fabric formation as well as after being subjected to finishing operations like washing, dyeing, and stentering etc. This is a useful requirement for ascertaining acceptability of innovative yarn by the end-users. The present paper represents the work done in this direction. Fabrics were woven under identical conditions by using parent as well as textured yarn as weft. The fabrics were evaluated for their functional and comfort properties before and after undergoing finishing operations.

EXPERIMENTAL

Material

Fully drawn white 100 denier (111.11 dtex) /48 filaments polyester yarn was used as parent yarn for the experiment. Fully drawn polyester yarn of 50 denier (55.55 dtex)/24filaments with high twist of 3000 tpm and post heat-set at 90-95°C for 50 minutes was used as warp. The warp was kept finer to bring weft prominently on the surface and execute its influence on the fabric performance.

Methodology

The selected parent yarn was textured on the mechanical crimp texturising apparatus. Texturising was carried out in each division with optimum processing conditions, viz; 25 mm bulking zone length, 25 % under feed, 250 m/min speed.
and the bulked yarn winding tension of 0.075 gf/den (0.675 gf/tex) (based on parent yarn linear density) [Shaikh et al.(2010) and (2011)]. Sen et al.(1970) have suggested this winding tension for building suitable package for mechanical bulked yarn. The value of underfeed used was mainly influenced by the ductility and mechanical properties of the parent yarn. It was selected to give 25–28 per cent residual parent yarn extension [Wilson et al. (1991)]. Whereas optimum false twist was calculated by using empirical formula (equation 1) derived by Shaikh et al. (2011).

\[ K \text{ (tpm)} = 7151.7 - 53.9D + 0.2D^2 - 0.000255D^3 \] (1)

Two pre-twist levels (twist factor in tex\(^{1/2}\).tpcm) were used, viz; 0.6 and 24. Owing to the greater effect on fabric characteristics [Booth (1996), Tretoar (1965), Hearle et al. (2001) and Goswami et al. (1976)], pre twist, a real twist in yarn structure was varied to two extremes. The selection of twist values was influenced by the previous work done on mechanical crimping of polyester [Shaikh et al. (2011)]. Parent, feeder (drawn flat polyester multifilament yarn after underfeed) as well as textured yarns was checked for their quality parameter, viz; fineness [Shaikh et al. (2010-2011)], strength & extension [D 2256-02(2002)], bulk factor [Burnip et al. (1961)], boiling water shrinkage [Shaikh et al. (2010-2011)] and percent instability [X154, (1961)].

Woven fabrics were produced by using the textured yarns and the corresponding feeder yarns as wefts on the loom. Weaving conditions, viz; type of weave (plain), warp yarn and fabric sett (40 per cm x 32 per cm; on the loom), loom speed (130 picks/min) were retained constant on plain power loom. This had avoided undue overlapping of variables and given prominence to the weft yarn on fabric performance.

The fabrics were dyed by HTHP (high temperature high pressure) method in mill. Disperse Dye along with acetic acid and dispersing agent was used for dyeing of fabric samples. Starting temperature was kept 40°C, increased steadily and reached to highest temperature of 132°C in 10 minutes. Diffuse dyeing was carried out for next 145 minutes at higher pressure of 4-5 kg/cm\(^2\). It was followed by cooling at 80°C for next 30 minutes. Washing, drum drying and setting were the processes followed in the sequence. All the woven fabric samples were checked for their structural properties, mechanical properties and comfort property, as per the standard test methods [Booth (1996), Tretoar (1965), Berkeley (1966), Usenko (1975), Saville (1999) and Kothari et al (1999)], in grey as well as finished state.

**RESULTS AND DISCUSSIONS**

Test results for the quality measures of parent, feeder and textured yarns were reported in table 1. Grey and finished fabrics characteristics were studied in three selected groups, viz; constructional properties, mechanical properties and comfort associated properties. The selection was based on their expected end use in apparel sector.

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>Sample Description</th>
<th>Fineness (dtex)</th>
<th>Tenacity (CN/dtex)</th>
<th>Extension (%)</th>
<th>Boiling Water Shrinkage (%)</th>
<th>Instability (%)</th>
<th>Bulk Factor (θ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>Parent yarn 100 d/48 fils. White.</td>
<td>111.11</td>
<td>4.01</td>
<td>45</td>
<td>4.60</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>F&lt;sub&gt;L&lt;/sub&gt;</td>
<td>Feeder yarn, Low pre twist; 0.6 tex(^{1/2}).tpcm.</td>
<td>87.78</td>
<td>4.21</td>
<td>25.60</td>
<td>2.54</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>F&lt;sub&gt;H&lt;/sub&gt;</td>
<td>Feeder yarn, High pre twist; 24 tex(^{1/2}).tpcm.</td>
<td>88.88</td>
<td>4.56</td>
<td>24.81</td>
<td>2.89</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>T&lt;sub&gt;L&lt;/sub&gt;</td>
<td>Textured yarn with Low pre twist; 0.6 tex(^{1/2}).tpcm.</td>
<td>108.06</td>
<td>3.03</td>
<td>36.48</td>
<td>4.80</td>
<td>4.21</td>
<td>19.82</td>
</tr>
<tr>
<td>T&lt;sub&gt;H&lt;/sub&gt;</td>
<td>Textured yarn with High pre twist; 0.6 tex(^{1/2}).tpcm.</td>
<td>110.19</td>
<td>3.26</td>
<td>29.13</td>
<td>5.64</td>
<td>1.37</td>
<td>10.59</td>
</tr>
</tbody>
</table>
Performance of Mechanical Crimp Textured Yarn in Woven Structure

Constructional Properties

Constructional properties values before and after finishing for all the four fabrics under consideration were given in table 2.

Linear Density of Constituent Yarns

Constituent yarn linear density was increased in finished fabric as compared to grey fabric and bobbin [tables (1-2)]. Increase was higher in textured weft-yarns fabrics, as compared to flat feeder weft-yarns. Highest rise in linear density was observed for high pre-twisted textured weft yarn.

This was in good agreement with earlier findings, [Hearle (1967), Saville (1999), Hearle et al. (1969) and Salem et al. (1995)]. According to them, constituent yarn denier gets increased in direct relation to their crimping power and twist contraction apart from their shrinkage during wet processing.

Fabric Sett

Fabric sett values did not show higher change in grey state fabrics and finished feeder yarn fabrics from loom sett values. However, considerable difference was found for finished fabrics having textured weft yarn. This was mainly due to change in fabric geometry on constituent yarn fineness and spacing [Hearle et al. (1969)]. Coarse but compact weft yarn, with higher boiling water shrinkage had allowed the constituents in fabric T_H to pack tightly on wet treatment. Although, having identical end density, higher pick density was observed for sample T_H as compared to sample T_L on finishing. This had substantiated the argument.

Table 2: Constructional Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Grey State</th>
<th></th>
<th>Finished State</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear density (dtex)</td>
<td>F_L</td>
<td>F_H</td>
<td>T_L</td>
<td>T_H</td>
</tr>
<tr>
<td>Warp</td>
<td>57.32</td>
<td>57.76</td>
<td>57.77</td>
<td>59.58</td>
</tr>
<tr>
<td>Weft</td>
<td>87.92</td>
<td>89.67</td>
<td>108.02</td>
<td>112.64</td>
</tr>
<tr>
<td>Fabric sett</td>
<td>40</td>
<td>41</td>
<td>40</td>
<td>42</td>
</tr>
<tr>
<td>Ends/cm</td>
<td>32</td>
<td>31</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>Pcs/cm</td>
<td>4.06</td>
<td>4.04</td>
<td>4.24</td>
<td>4.52</td>
</tr>
<tr>
<td>Crimp (%)</td>
<td>6.98</td>
<td>8.21</td>
<td>7.98</td>
<td>8.24</td>
</tr>
<tr>
<td>Warp</td>
<td>0.86</td>
<td>1.28</td>
<td>1.09</td>
<td>1.24</td>
</tr>
<tr>
<td>Weft</td>
<td>0.1523</td>
<td>0.1542</td>
<td>0.2016</td>
<td>0.2238</td>
</tr>
<tr>
<td>Thickness (mm)</td>
<td>0.1579</td>
<td>0.1908</td>
<td>0.2491</td>
<td>0.2793</td>
</tr>
<tr>
<td>Fabric weight per unit area (GSM)</td>
<td>51</td>
<td>52</td>
<td>58</td>
<td>62</td>
</tr>
<tr>
<td>Physical Bulk (%)</td>
<td>116.39</td>
<td>121.72</td>
<td>118.90</td>
<td>130.85</td>
</tr>
</tbody>
</table>

Fabric Weight per Unit Area and Fabric Thickness

Finished fabrics had shown higher thickness and weight per unit area as compared to grey fabrics in all categories as per expectation. The highest rise in higher pre-twist textured weft-yarn finished fabric was mainly attributed to closer thread setting and higher increase in constituent yarn linear density on finishing [table 2].

Physical Bulk

Wray (1969) had defined improvement in the air jet textured yarn fabric cover or bulk, as an outcome of increase in the density of textured yarn fabric as compared to flat parent yarn fabric [Equations (2-3)].

\[
\text{Physical Bulk} \ (%) = \left( \frac{\text{Parent yarn fabric density}}{\text{Textured yarn fabric density}} \right) \times 100
\]
Physical Bulk (\%) = \frac{W_p}{T_p} \times \frac{T_t \times 100}{W_t}

Where \( W_p \) = weight/unit area of parent yarn, \( W_t \) = weight/unit area of textured yarn, \( T_p \) = Parent yarn fabric thickness and \( T_t \) = Textured yarn fabric thickness

Fabric bulk get increased with twist and diminishes with stretch (under feed) induced to the constituent yarn [Hearle et al. (2001) and Wilson et al. (1991)]. Mechanical crimp textured weft yarn undergoes both the mechanical changes before bulking [Shaikh et al. (2010) and Shaikh et al. (2011)]. Physical bulk of the unfinished and finished fabrics was calculated by considering respective feeder yarn fabrics density instead of parent yarn fabric, to avoid influence of both the factors. However, weaving would also become difficult with flat parent yarn, due to fraying.

Higher bulk had gone in the account of high pre-twisted weft yarn fabrics in both the categories (grey and finished). Compact and coarser higher pre-twist weft yarn had enforced constituent warp to follow longer bend length. This had added to the warp crimp [table 2]. Fabric with higher warp crimp and fabric sett had shown higher fabric thickness as well as weight per unit area. Both of them together had contributed positively in physical bulk of grey and finished samples \( T_H \).

Mechanical Properties

Mechanical properties are considered for utility, performance and durability of fabric. Type of warp yarn, type of weft yarn, type of weave, fabric sett and weaving conditions are the factors affects fabric durability [Mukhopadhyay et al. (2004), Grosberg (1969) and Kothari (1999)]. Except weft yarn rest of the parameters were kept constant during fabric formation in present experiment. Therefore tensile properties of the weft-yarn and Cloth Assistance Factor (CAF) together had defined fabric’s mechanical properties. The forthcoming discussion was thereby restricted for weft way tensile strength evaluation only.

Cloth Assistance Factor (CAF) represents cohesive/ frictional forces amongst the yarns in the fabric. These in addition to constituent yarn strength resist against applied force to break [Vernekar et al. (1996)]. It can be calculated as follows;

\[
\text{Cloth Assistance Factor (CAF)} = \frac{\text{Fabric strength per thread}}{\text{Yarn strength in bobbin}}
\]

Table 3: Tensile Properties of Fabrics

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>Tensile Strength (N)</th>
<th>Single Weft-Thread Tenacity (CN/dtex)</th>
<th>CAF</th>
<th>Single Weft-Thread Extension (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( F_L )</td>
<td>11.87</td>
<td>17.32</td>
<td>14.78</td>
<td>20.33</td>
</tr>
<tr>
<td>( F_W )</td>
<td>7.12</td>
<td>10.96</td>
<td>8.82</td>
<td>12.97</td>
</tr>
<tr>
<td>( T_L )</td>
<td>8.65</td>
<td>12.33</td>
<td>10.2</td>
<td>15.13</td>
</tr>
<tr>
<td>( T_W )</td>
<td>15.43</td>
<td>17.98</td>
<td>17.19</td>
<td>20.84</td>
</tr>
</tbody>
</table>

Cloth Assistance Factor (CAF) value was found higher than one for all the fabrics, irrespective of grey or finished. This was mainly due to preferable increase in yarn to yarn friction for the selected plain weave. This positive fabric assistance had unanimously allowed the rise in weft yarn tenacity value drawn from the fabric, compared to that measured from the bobbin [table 3].
Finished fabrics had shown higher CAF values than respective grey fabrics as per expectation. This was mainly due to increased density and linear density of constituent yarn on finishing [table 2]. Higher bending path followed by coarser warp yarn for comparatively coarser weft had not only increased warp-crimp but also inter yarn friction [table 2]. Tightness of weave attained on finishing, had further added to static friction amongst the yarns [Butterworth (1968) and Offermann Peter et al (1993)]. Increased yarn to yarn friction had enhanced CAF value accordingly.

During tensile testing crimp decreases in the direction investigated, but increases in the perpendicular direction. More the crimp more delayed the rupture [Booth (1996)]. Supporting basic theories for fabrics tensile strength, finished fabric (sample T_H), with highest warp crimp and higher CAF [tables (2-3)] had executed highest weft-way strength amongst all. However, its weft yarn strength was low. Thus, fabric strength was mainly affected by filler yarn fineness, fabric sett and warp-crimp (%), but least by weft yarn strength.

Higher extension was observed for the weft yarn, unraveled from the fabric compared to bobbin form, for all the categories. This behaviour was going in close resemblance to the findings of Grosberg (1969), on tensile properties of woven fabrics. Accordingly, any extension that takes place in warp and weft direction is usually of higher order of magnitude than the extension of constituent yarns. By and large, the first part of extension is due mainly to crimp redistribution while the latter part of the extension is due to fiber or filament extension and to a certain extent, to thread compression.

**Tearing Strength**

Warp way tear strength behaviour was not considered for discussion, as identical warp was used for all the fabrics. Although weaker from feeder yarn, sample T_H had executed highest tearing strength in the group [table 2 and table 4]. The yarn resistance against the tearing agency had gone in accordance to the finding of Harrison (1955). He identified tearing strength as a fabric characteristic that allows the threads to group closer together under the force of the tearing agency. Thus tearing strength, instead of the successive breakage of individual threads; becomes more of strength on group of yarns. Thus, sample T_H, although composed off a weaker yarn (in the direction of test), but with better grouping efficiency (highest pick/cm), was able to acquire highest tearing strength.

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>Tear-Strength (Grams)</th>
<th>Abrasion Resistance (Cycles)</th>
<th>Air Permeability (M3/M²/Hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grey Fabric</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F_L</td>
<td>1053</td>
<td>94</td>
<td>8500</td>
</tr>
<tr>
<td>F_H</td>
<td>1024</td>
<td>63</td>
<td>8812</td>
</tr>
<tr>
<td>T_L</td>
<td>1863</td>
<td>72</td>
<td>5315</td>
</tr>
<tr>
<td>T_H</td>
<td>2809</td>
<td>38</td>
<td>6538</td>
</tr>
<tr>
<td>Finished Fabric</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F_L</td>
<td>1826</td>
<td>79</td>
<td>7862</td>
</tr>
<tr>
<td>F_H</td>
<td>1997</td>
<td>48</td>
<td>8193</td>
</tr>
<tr>
<td>T_L</td>
<td>2948</td>
<td>40</td>
<td>3250</td>
</tr>
<tr>
<td>T_H</td>
<td>3152</td>
<td>32</td>
<td>4156</td>
</tr>
</tbody>
</table>

**Abrasion Resistance**

Reduction in abrasion cycles was observed for grey as well as finished fabric having high pre-twist textured weft yarn [table 4]. Yarn becomes more compact and held more tightly against abrader, with the increase in pre-twist [Saville (1999)]. It became further compact on wet finishing treatment and held more tightly together against abrader. This was resulted in reduced number of abrasion cycles for the identical load for sample T_H in both grey as well finished states.
**Air-Permeability**

Air-permeability is mainly attributed to the porosity of the fabric. Porosity of the fabric is purely dependent on the porosity of the constituent yarns and air gaps between the constituent yarns after interlacement [Kothari et al. (1989), Skinkle (1954) and Clayton (1935)]. They depend on compactness of yarn and weave respectively. Since weave was kept constant, porosity of the fabrics was affected by weft yarn porosity mainly.

Reduction in the air permeability was found fabrics, woven with textured yarn weft in comparison with respective feeder weft yarn fabrics [table 4]. This was mainly due to the better fabric cover obtained with bulky textured filler yarns. Increased air resistance of such fabrics had reduced air permeability [Booth (1996) and Skinkle (1954)]

It can also be noticed that fabric woven with higher pre-twist textured weft-yarn (sample F_H and sample T_H) had exhibited higher air permeability than the fabric woven with respective low pre-twist textured weft-yarn [sample F_L and sample T_L]. This was mainly attributed to higher packing coefficient of yarn attained at higher twist level [Goswami (1976)]. This had reduced air trapped in the yarn structure but increased air gaps between constituent yarns.

This was also gone in agreement to Clayton’s (1935) work. He has shown that the twist factor in the yarns has a great influence on air permeability. He found that for constant cover factor of warp and weft, only by changing twist factor of weft, air permeability increases linearly.

Wet treatment locked constituent yarns tightly [table 2]. Thereby air gaps available for air passage were further reduced. This had dropped air permeability for both the categories of textured weft yarn fabrics accordingly.

**CONCLUSIONS**

Fabrics were woven on plain power loom by using textured yarns and their feeder yarns as weft. The constructional parameters; type of weave, warp, reed count, fabric sett etc., for all the fabric samples were kept identical. Thus fabric properties were greatly influenced by type of weft used and its characteristics.

Fabric having textured weft yarn had shown preferable shuffle in its structural, mechanical and comfort associated properties over their feeder weft yarn fabrics. The best results were found for higher pre-twist textured yarn weft fabric. Various stresses undergone during finishing operation had not shown any adverse impact on the performance of the fabric. Rather than that remarkable improvement in fabric qualities were found on wet treatment. This has proven the proficiency of newly engineered weft structure to sustain the forthcoming stresses.

**REFERENCES**


