Influence of Tenacity of Polyester Component on the Characteristics of Identically Processed Polyester-Viscose Blend Suitings

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The effect of tenacity of the polyester component in 67/33 polyester/viscose blend on the fabric characteristics and consumer comfort of suiting fabrics has been studied. The results obtained indicate that the use of high tenacity polyester could enable saving in cost through reduced requirement for the polyester component in the blend without any adverse effect on the desirable qualities of polyester/viscose blend suiting fabrics. However, the use of high tenacity polyester fibre demands judicious selection of type of fibre, blend composition, type of weave, loom sett for fabric and appropriate heat-set and resin finish treatments.

There are hundreds of man-made and natural fibres and their blend compositions. Among the man-made fibres and their blends available, the 67/33 blend of polyester and viscose fibres has occupied significant place in the Indian textile market. This is for the reason that polyester/viscose blend fabrics have the advantages of being durable, easy to care and maintain and elegant in appearance. The credit for this goes to the polyester component which imparts greater resilience, shape retention, dimensional stability and durability. Looking towards the popularity of 67/33 polyester/viscose blend and the role of polyester fibre in the blend towards improving the qualities of fabric, in the present study, an attempt has been made to observe the effect of polyester fibre tenacity on suiting fabric characteristics. Two samples of polyester fibre with tenacity 5.1 and 6.4 g/d were used. All other parameters, viz., the other component (viscose), blend composition, yarn structure, construction of fabric and fabric processing conditions were kept constant.

The fibre characteristics dominate the yarn and fabric characteristics and on heat setting and resin finishing polyester/viscose fabrics undergo significant changes in dimensions and characteristics. Therefore, in the present investigation, prior to studying the influence of tenacity of the polyester component, dimensional changes caused by finishing treatment in two types of blended fabrics in terms of fabric weight and increase in cover were examined. The use of fibres of different tenacities and changed dimensions influences the mechanical and functional characteristics like breaking and tearing strengths (determining durability and life), fabric flexural rigidity (determining drape and feel); crease recovery and dye uptake (determining aesthetic value); and air permeability (determining wear comfort).

Further, the polyester blend fabric when subjected to thermal treatment tends to shrink. It may further shrink when it is exposed to a temperature higher than that normally encountered and/or on consumer washing. This is objectionable and has been examined in terms of residual shrinkage. As with each blend two weaves and three weft sets have been employed, the effect of weft sett on fabric characteristics has also been examined.

Materials and Methods

The two samples of polyester of different tenacities (5.1 and 6.4 g/d) and the viscose fibres used were all of 51 mm staple length and 2.0 denier. The viscose fibre was of 2.125 g/d tenacity. The percentage extension at break of low and high tenacity polyester samples and the viscose fibre was 48, 30 and 20% respectively. All these were crimped and semidull fibres.

Two different blend yarns, each of 2/34 nominal count, with 67% polyester fibre (low tenacity sample in one case and high tenacity one in the other) and 33% viscose were spun under identical machine conditions adopting normal mill procedures. Blending was done at finisher drawing stage and the doubling of single yarns of both blend yarns was done on the same
doubling frame. The yarn characteristics are given in Table 1.

From each blended yarn, six different fabric samples, using the same kind of yarn for warp and weft, employing two weaves, viz., gaberdine 2-2 twill and matt 1-1-2-1-1 mat, and keeping three different weft setts, one below and one above the normal running weft sett were prepared. The three gaberdine fabrics were of 78 x 54, 78 x 60 and 78 x 66 construction and the three matty fabrics were of 64 x 54, 64 x 60 and 64 x 66 construction. Thus, altogether 12 suiting fabric samples were prepared. The details of the experimental fabrics used in the study are given in Table 2.

All the fabric samples were prepared on the same loom under identical machine conditions and care was taken to have a uniform level of tension on warp sheet throughout the preparation of fabric samples. The grey fabric samples were processed, heat-set, dyed, singed and resin finished in an identical manner by a continuous process under actual mill conditions.

Prior to testing, the fibre, yarn and fabric samples were conditioned in standard atmosphere (27 ± 2°C temperature and 65 ± 5% RH) for 12, 24 and 48 hr respectively.

Fabric weight was determined using Quadrant balance.

The loom set and finished fabric percentage covers were calculated as follows:

\[ \text{Cover, } \% = \frac{(n_1 d_1 + n_2 d_2 - n_1 n_2 d_1 d_2) \times 100}{n_1 n_2 d_1 d_2} \]

where \( n_1 \) and \( n_2 \) are warp-wise and weft-wise threads per inch respectively; and \( d_1 \) and \( d_2 \) are warp and weft thread diameters respectively in inches.

The percentage increase in cover caused by the finishing treatment was determined as follows:

\[ \text{Increase in cover, } \% = \frac{FC - LC}{LC} \times 100 \]

where \( FC \) is the percentage finished fabric cover; and \( LC \), the percentage loom fabric sett cover.

Warp and weft crimps of the fabric samples were determined on Eureka crimp tester, Shirley type, and the percentage total crimp was calculated as follows:

\[ \text{Total crimp, } \% = (C_1) \times (C_2) \]

where \( C_1 \) and \( C_2 \) are warp and weft crimps respectively in percentage.

The warp and weft direction breaking strength and breaking extension of each fabric sample were determined using Instron tensile strength tester and standard method for revelled strip. Each specimen, in both warp and weft directions, was cut 5 cm wide and 25 cm in length.

For the determination of warp and weft tear strength, German tensile strength tester, type FW 500, was used.

The bending length of warp and weft directions of each fabric sample was determined on Shirley stiffness tester and the flexural rigidity was calculated as follows:

\[ \text{Flexural rigidity, } mg \text{ cm} = 0.1 \frac{W}{L^3} \]

(Warp-wise or weft-wise)

where \( W \) is the weight of the fabric in g/m²; and \( L \), the bending length in cm.

To observe the general effect of fibre tenacity on the fabric characteristics, the overall value of each of the aforesaid characteristics of each fabric sample was determined by taking geometrical mean of warp and weft values.

Crease recovery of each fabric for both warp and weft directions was estimated on Shirley crease...
recovery tester. The total crease recovery was found by adding warp and weft direction values.

The air permeability of each fabric sample was determined on Matrimpex air permeability tester, ATL-2FF-12 type.

Residual shrinkage, which is defined as the potential shrinkage remaining in a fabric after treatment (like heat-set in synthetic blend fabric) designed to reduce or eliminate inherent shrinkage, in both warp and weft directions of each fabric sample, was determined as per the method laid down in BS 4923:1973.

For comparison purpose, the value of area residual shrinkage was calculated for each fabric sample as follows:

\[
\text{Area residual shrinkage, } \% = \frac{(100)^2 - (100 - RS_1)(100 - RS_2)}{100}
\]

where \(RS_1\) is the percentage warp-way residual shrinkage; and \(RS_2\), the percentage weft-way residual shrinkage.

The dye uptake by various sets of fabric samples was determined through visual assessment employing five judges.

Results and Discussion

Data on fabric weight and increase in cover are given in Table 3. From the values of fabric weight of polyester fabrics of different tenacities having the same construction and weave, and from the plot between fabric weight and weft sett (Fig. 1), it is seen that under identical conditions of processing and heat-set, the high tenacity polyester fabric exhibits lower weight compared to the low tenacity polyester fabric. This is on account of the different shrinkages suffered by the two fibres, when heat-set at the same temperature. This also, in turn, causes lesser increase in fabric cover in the high tenacity polyester fabric compared to the low tenacity one (Fig. 2), the trend being independent of weave and fabric sett. It may be concluded that high tenacity polyester fabric would shrink less area-wise than the low tenacity polyester fabric.

As expected, increase in weft sett results in an increase in fabric weight (Fig. 1). It is obvious from Fig. 2 that the initial increase in weft sett causes a reduction in the percentage increase in cover for both gaberdine and matty fabrics and further increase in weft sett decreases the percentage increase in cover in gaberdine; in matty, the reverse trend is observed. The reduction in percentage increase in cover due to increase in weft sett may be due to less exposition of intra-fibre and yarn surface to heat during heat setting, causing lower shrinkage in higher weft sett fabric. This also shows that with a particular construction, beyond a certain limit, increase in weft sett would start exhibiting the reverse trend, as happened with 6466 LM and 6466 HM fabrics.

Crimp—The warp, weft and total crimp values for the various experimental fabrics given in Table 3 show that the warp crimp is higher than the weft crimp, except in the case of fabric 7854 HG, where both the crimps are of the same magnitude. This may be due to the relatively higher tension prevailing in warp than in weft, which, in turn, results in higher relaxation in the warp direction of the fabric during wet processing. This finally increases warp crimp.

The warp crimp values for polyester fabrics of different tenacities having the same construction and weave show that in each comparable set of fabrics, warp crimp of high tenacity polyester fabric is lower than that for the low tenacity polyester fabric. Further, the high tenacity polyester fabrics have lower or same

<table>
<thead>
<tr>
<th>Code No.</th>
<th>Fabric weight g/m²</th>
<th>Cover, %</th>
<th>Increase in cover, %</th>
<th>Crimp, %</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Loom sett</td>
<td>Finished fabric</td>
<td></td>
<td>Warp</td>
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<tr>
<td>7854LG</td>
<td>162.13</td>
<td>82.74</td>
<td>86.28</td>
<td>4.27</td>
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<td>7854HG</td>
<td>156.44</td>
<td>82.74</td>
<td>86.15</td>
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<td>167.80</td>
<td>84.42</td>
<td>87.86</td>
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<td>84.42</td>
<td>87.54</td>
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<td>86.11</td>
<td>89.66</td>
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<td>86.11</td>
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<td>76.28</td>
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<td>80.91</td>
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<tr>
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<td>80.91</td>
<td>84.51</td>
<td>4.45</td>
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</table>
weft crimp, except 6466 LM and 6466 HM fabrics. The general effect of fibre tenacity on crimp is obvious from Fig. 3 where the total crimp is plotted against weft sett. It is seen that the total crimp is less in the high tenacity polyester fabric. The reason for such a trend is the same as for fabric weight and increase in cover.

It is also seen from Fig. 3 that both warp and weft crimps as well as the total crimp increase with increase in weft sett, which may be due to the higher warp tension for higher weft sett; this, in turn, relaxes warp tension and also causes relaxation of crimp. The crimp Relaxation is more in higher weft sett fabric; consequently, higher warp crimp is exhibited by heavier weft sett fabrics. Bhargava and Yadav reported similar findings in respect of the effect of blend and weft sett on dimensional change in fabrics.

Breaking strength—The values of warp, weft and overall breaking strength for the various fabrics are given in Table 4. In each case, the warp strength is higher than the weft strength. This is possibly due to the fact that if yarns used in both the directions of a fabric are of the same quality, the number of threads in the test direction will have a dominant role in deciding the breaking strength in that particular direction. Though fabrics 6466 LM and 6466 HM by way of nominal construction have more picks than ends per inch, due to difference in shrinkage, they actually contain higher ends than picks per inch. Therefore, all the experimental fabrics have higher ends per inch than picks per inch, thereby exhibiting higher strength in warp direction. The other probable reason for the higher warp-way strength is that the weft crimp is lower than warp crimp, which, in turn, would lead to relatively higher frictional forces at the crossover points towards warp than weft directional loading. This is in agreement with the findings of Taylor.

In respect of breaking strength, the high tenacity polyester fabric is stronger than the low tenacity fabric. This is an expected result, since the high tenacity polyester yarn has higher breaking strength (919 g) compared to the low tenacity polyester yarn (709 g) and the fabric strength is primarily dependent on fibre and yarn strength. The overall breaking strength, which is an index of the general influence of fibre tenacity on fabric strength, is higher in the high tenacity fabric.

Increase in weft sett caused a relatively higher increase in the weft-way strength than in the warp-way strength; there is also increase in the overall breaking
strength (Fig. 4). This is due to the increased fabric cohesion and greater fibre-to-fibre binding in yarn and yarn-to-yarn binding in fabric. Taylor\textsuperscript{7} and Pierce\textsuperscript{8} reported similar findings.

Breaking extension—Values of warp, weft and overall breaking extension of the various fabrics are given in Table 4. It is seen that the warp-way breaking extension is higher than the weft-way extension. The possible reason for this is that for all the fabrics, the warp crimp is higher than the weft crimp and the extensibility of a fabric depends primarily on the crimp level of the test direction. According to Pierce\textsuperscript{8}, crimp distribution is a factor of prime importance in determining fabric extension.

It is seen from Fig. 5 that the high tenacity polyester fabric is less extensible in both warp and weft directions; it also has lower value of overall breaking extension. There are two reasons for such a trend: (i) the high tenacity polyester fibre and yarn have lower extension at break (30.0 and 15.0) compared to the low tenacity fibre and yarn (48.0 and 23.75), and (ii) warp and weft crimp are lower in the high tenacity fabric. It follows that the extensibility of a fabric is highly dependent on fibre extensibility.

With increase in weft sett, other parameters being the same, there is a gradual increase in warp-way extensibility associated with a marginal decrease in weft-way extensibility. From the plots of overall breaking extension against weft sett (Fig. 5) it is seen that the initial increase in weft sett causes an increase in the overall extension of the fabric up to a certain limit beyond which there is reduction in the case of gaberdine and increase in the case of matti fabrics. This shows that with a particular construction of fabric, increase in weft sett beyond a certain limit would affect the extensibility of the fabric adversely.

The possible reason for getting higher warp breaking extension in higher weft sett fabric is that the higher pick density in the fabric demands higher warp tension on the loom, which, in turn, relaxes more in the warp direction on wet processing, causing an increase in the warp-way crimp as well as in warp-way breaking extension.

Tear strength—The data presented in Table 4 indicate that in most of the comparable sets of fabrics, the difference between warp and weft tear strengths is larger in the high tenacity polyester fabrics than in the low tenacity fabrics. This may be on account of the small difference between warp and weft crimps in the high tenacity polyester fabric, which, in turn, exhibits a large difference between warp and weft tear strengths. On the other hand, the difference in the warp and weft crimps in the low tenacity polyester fabric is large, while the difference between the warp and weft tear strengths is small.

It is seen from Fig. 6 that both warp and weft way tear strengths as well as the overall tear strength of the high tenacity polyester fabric are higher compared to those for the low tenacity polyester fabric. This may be due to the fact that the high tenacity polyester fabric is prepared from a stronger fibre and consequently has lower sett and lower level of crimp in both the directions compared to the low tenacity fabric. According to earlier reports\textsuperscript{9–11}, single yarn strength, fabric sett and yarn crimp are some of the factors on which the tear strength of a fabric largely depends. Both lower fabric sett and lower crimp level facilitate gliding of threads, thereby allowing relatively more number of threads to share the tear force and resulting in higher tear strength in the high tenacity fabric.

The trend of the curves in Fig. 6 also shows that increase in weft sett lowers the tear strength of the fabric. The reasons for this are the same as stated above with regard to the influence of fabric sett and crimp on tear strength.

Fabric stiffness—It is obvious from Table 5 that all the fabrics, except 6466 LM and 6466 HM, are appreciably stiffer in the warp direction than in the weft direction. The probable reason for this is that all the fabrics, except the above stated two fabrics, have a higher number of ends per inch than picks per inch and the stiffness in the test direction depends more on thread density in the test direction than that in the cross-direction.

The high tenacity fabrics, in spite of being of low sett, low cover and light weight, are stiffer than the low tenacity polyester fabrics. Though the difference is marginal, the same trend is observed in all the comparable sets of fabrics (Fig. 7). The reason for this is that the high tenacity polyester fibre has a higher degree of orientation of crystallites in the direction of the fibre axis, which makes the fibre, yarn and fabric more rigid.

<table>
<thead>
<tr>
<th>Code No.</th>
<th>Flexural rigidity mg cm</th>
<th>Overall flexural rigidity mg cm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Warp</td>
<td>Weft</td>
</tr>
<tr>
<td>7854LG</td>
<td>71.5</td>
<td>45.4</td>
</tr>
<tr>
<td>7854HG</td>
<td>71.6</td>
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<td>7860LG</td>
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</tr>
<tr>
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<td>6466HM</td>
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</tr>
</tbody>
</table>

Table 5—Flexural Rigidity Data for Different Experimental Fabrics
stiffer. Earlier workers\textsuperscript{14,15} got similar results while working with different kinds of fibres with varying fibre tenacity.

Increase in weft sett leads to a stiffer fabric (Fig. 7). This increase in stiffness of a fabric may be attributed to the tighter fabric construction, which adds constraints and friction resistance at the crossover points of warp and weft. Similar findings have been reported by earlier workers\textsuperscript{12-15}.

\textbf{crease recovery}—The results presented in Table 6 and Fig. 8 show that among all the comparable sets of fabrics, the high tenacity polyester fabric exhibits higher warp, weft and total crease recovery angles. Though the difference in the values is marginal, it is obvious that the tenacity of the polyester component influences the crease resistance of a polyester-viscose blend fabrics. Another possible reason for the higher crease recovery in the high tenacity fabric is the low sett and low cover compared to the low tenacity polyester fabric\textsuperscript{16}.

Decrease in weft sett causes an increase in warp, weft and total crease recovery angles. Buck and Mc Cord\textsuperscript{16} also reported similar findings.

It is notable that all the experimental fabrics exhibit total crease recovery angle higher than 260\degree, which is the minimum requirement for market varieties of polyester-viscose blend suitings as per Indian standards specification IS: 9517-1980.

\textbf{Dye uptake}—In the opinion of the judges, fabrics with high tenacity polyester have a lighter shade compared to those with low tenacity polyester on dyeing them by a similar procedure under identical conditions. According to Faterpek and Potnis\textsuperscript{17}, high tenacity fibres have better orientation of crystallites in the direction of fibre axis. Therefore, they allow the dye molecules to penetrate in the polymer matrix at a slower rate, resulting in a lighter shade on the fabric. Munden and Palmer\textsuperscript{18} also confirmed that the higher the orientation, the slower will be the diffusion and rate of dyeing.

Increase in weft sett caused no noticeable variation in the depth of the shade.

\textbf{Air permeability}—Data in Table 6 and Fig. 9 show that the fabric with high tenacity polyester, in spite of having a lower sett and lower cover, is less permeable to air compared to the fabric with the low tenacity polyester. The reason for the lower air permeability of

\begin{table}[h]
\centering
\caption{Crease Recovery, Air Permeability and Residual Shrinkage Data for Different Experimental Fabrics}
\begin{tabular}{|c|c|c|c|c|c|c|c|c|}
\hline
Code No. & Crease recovery angle, deg & Air permeability & Residual shrinkage, % & & & & &
| & | & | & & | & | |
| & | | & | & | & | |
| Warp & Weft & Total & cm\(^3\)/cm\(^2\)/sec & & & | & |
| | | | & & & | & |
| 7854LG & 146.5 & 145.9 & 292.4 & 50.38 & 1.33 & 1.26 & 2.57 |
| 7854HG & 150.0 & 151.7 & 301.7 & 47.52 & 1.43 & 1.26 & 2.67 |
| 7860LG & 142.6 & 145.0 & 287.6 & 38.50 & 1.26 & 1.43 & 2.67 |
| 7860HG & 147.6 & 147.8 & 295.4 & 34.70 & 1.33 & 1.42 & 2.73 |
| 7866LG & 140.2 & 144.0 & 284.2 & 25.35 & 1.43 & 1.41 & 2.82 |
| 7866HG & 143.1 & 145.4 & 288.5 & 24.67 & 1.47 & 1.41 & 2.86 |
| 6454LM & 151.9 & 151.0 & 302.9 & 77.50 & 1.21 & 1.12 & 2.31 |
| 6454HM & 153.1 & 152.4 & 305.5 & 68.47 & 1.26 & 1.14 & 2.38 |
| 6460LM & 149.1 & 148.1 & 297.2 & 62.05 & 1.26 & 1.19 & 2.43 |
| 6460HM & 150.0 & 149.2 & 299.2 & 50.60 & 1.23 & 1.26 & 2.47 |
| 6466LM & 145.1 & 144.7 & 289.8 & 38.92 & 1.17 & 1.34 & 2.49 |
| 6466HM & 147.8 & 147.0 & 294.8 & 27.95 & 1.33 & 1.38 & 2.69 |
\hline
\end{tabular}
\end{table}
the fabrics having high tenacity polyester in the blend is that a lower sett and lower cover (i.e. large size pore) fabric may have relatively more resin uptake when the fabrics are subjected to resin finish in an identical manner.

As expected, increase in weft sett caused a decrease in air permeability (Table 6, Fig. 9). This is due to the fact that air permeability is highly dependent upon the construction of the fabric. Backer\(^{19}\) had earlier reported similar findings.

**Residual shrinkage** – The data presented in Table 6 show that in all the comparable sets of fabrics, except 64 x 60 matte, warp shrinkage is higher in the high tenacity polyester fabric. The matte fabrics showed the same trend for both weft-way and warp-way shrinkage. Out of the three comparable sets of gaberdine fabrics, two exhibited the same extent of shrinkage; the reverse trend was shown by the third one. The values of area residual shrinkage for different fabrics are plotted against weft sett in Fig. 10. It is obvious that the percentage area residual shrinkage is higher in the fabrics prepared using the high tenacity polyester. It may be concluded that high tenacity fabrics would be inferior in dimensional stability to the low tenacity fabrics, if both are subjected to heat-setting at 200°C. To maintain the level of residual shrinkage, the high tenacity fabric should be heat-set at a slightly higher temperature. The possible reason for this is that when polyester fabrics of different tenacities are heat-set at the same temperature, molecular chains of the high tenacity fibre would relax to a lesser extent than the low tenacity polyester fibre. This causes greater area shrinkage during washing in the former case.

It is also seen from Fig. 10 that the higher weft sett fabric exhibits higher area residual shrinkage. Washing causes swelling of the viscose component, demanding additional yarn length, which is not available, and since the cloth is not constrained at both the ends, the fabric area decreases\(^{20}\). This decrease in area will be higher in heavy sett fabric due to the lesser space between the yarns.

All the experimental fabrics in the present study exhibited percentage residual shrinkage below the limits laid down by the Indian Standards Institution. According to IS:9517-1980\(^6\), for market varieties of polyester-viscose blend suitings, the residual shrinkage should not exceed 2\(\%\) in either direction to get ISI certification mark.

**Conclusion**

Use of high tenacity polyester fibre in polyester-viscose blends may reduce the cost of production significantly by lowering the polyester component in the blends without affecting adversely the main product qualities and features of consumer interest. However, the reduction in polyester content must be done judiciously by selecting suitable fibres and their blends, yarn constructional parameters and type of weave. Further, the fabric should be heat set and resin finished under suitable conditions using appropriate methods.

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**References**