Effect of twist on mechanical and dye sorption properties of twisted textured polyester fabric

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The effect of twist on the mechanical and dye sorption properties of twisted textured polyester fabric was studied. 80 denier textured polyester yarns twisted to various twisting levels were used as weft. With increase in weft twist factor, the fabric tenacity initially remained nearly constant and then gradually decreased, the air permeability first increased and then remained nearly constant, the bulk density and intrinsic modulus remained constant up to a twist factor of 81 and then increased, the abrasion resistance gradually decreased, and the K/S value initially increased and then remained nearly constant.

Keywords: Abrasion resistance, Air permeability, Bulk density, Fabric tenacity, Intrinsic modulus, K/S value

1 Introduction
Consumer's choice for fabrics depends upon many factors of which handle and appearance of the fabrics are the most important. Fabric with softer handle can be made using textured yarn. But, in practice, the warp and weft textured polyester yarns with a wide range of twist are being used to get various types of effects such as Dani chiffon, Dechine, etc. An encouraging correlation can be found between fabric handle and some of the fabric properties such as crease recovery, stiffness, weight and thickness, which are known to be monotonically dependent upon twist. Twist has also wide influence on dyeing characteristics of the fabric. The effect of twist on the mechanical properties of twisted textured polyester yarn has been reported earlier. This paper reports the dyeability and mechanical properties of fabrics made with a wide range of twisted textured polyester yarns used as weft.

2 Materials and Methods
80 denier twisted textured polyester yarns having a wide range of tex twist factor were used as weft. The particulars of the yarns used are given in Table 1. The fabric construction parameters are given below:

| Ends/in | 80 |
| Pcs/in | 80 |
| Warp | Textured yarn (sized) |
| Weft  | Twisted textured yarn |
| Linear density of warp yarn | 80 denier |

The fabric samples were heat set on stenter at 170°C. Fabric tenacity in weft direction was measured with the help of an Instron (model 6021) by using the following relationship:

\[
\text{Fabric tenacity} = \frac{\text{Breaking load (g)}}{\left(9.80 \times \frac{\text{Fabric area density (g/m}^2\text{)}}{\text{Specimen width (mm)}}\right)}
\]

Air permeability was measured using the Karl-Frank air permeability tester with pressure difference of 10 mm of water. Bulk was calculated according to ASTM D-1518 (1983).

| Table 1—Particulars of weft yarns used |
| Nominal tex twist factor | Linear density, dtex |
| First quality yarn | Second quality yarn |
| 0 | 89.2 | 89.8 |
| 9 | 91.6 | 92.5 |
| 18 | 94.0 | 93.7 |
| 27 | 94.5 | 94.1 |
| 36 | 95.5 | 95.6 |
| 45 | 98.6 | 97.7 |
| 54 | 101.7 | 100.6 |
| 63 | 104.2 | 104.5 |
| 72 | 107.7 | 107.8 |
| 81 | 109.6 | 110.3 |
| 90 | 113.7 | 112.8 |
| 99 | 116.4 | 117.5 |
| 108 | 119.3 | 119.2 |
Bulk density \((kN.m^{-3}) = \frac{w}{t \times 102}\)

where \(w\) is the mass/unit area of fabric in g/m²; and \(t\), the thickness of fabric in mm.

Bending modulus was calculated from the following equation:

\[
\text{Bending modulus (kN.m.m}^{-3}) = \frac{12G \times 10^{-4}}{g_2}\]

where \(G\) is the flexural rigidity in mg-cm; and \(g_2\), the fabric thickness in cm.

Flexural rigidity was calculated from fabric weight and bending length. Abrasion resistance was measured in terms of abrasion cycles with the help of Eureka abrasion tester. K/S value was measured by Datacolor computer colour matching system. This value is directly proportional to the dye uptake of the sample.

3 Results and Discussion

3.1 Effect of Twist on Fabric Tenacity and Elongation

Figs 1 and 2 show that with increase in twist, the fabric tenacity initially remains more or less constant and then decreases sharply, while the breaking elongation first increases gradually and then remains nearly constant. The initial constancy of fabric tenacity is probably due to the two opposing effects of binding of warp and weft and obliquity effect. The sharp decrease in stress could be due to the combined effect of microscopic breakages and obliquity effect. The sharp decrease in stress could be due to the decrease in the diameter of the twisted yarn, because as twist increases, the yarn becomes more compact and dense, increasing fabric permeability. But after that, though twist increased, the yarn diameter remained constant, resulting in constant air permeability of the fabric. Zurek et al.² also observed that the air permeability of textured fabrics is half that of fabrics made of twisted yarn.

3.2 Effect of Twist on Air Permeability

Fig. 3 shows that the air permeability of the fabric first increases sharply and then remains constant with increase in twist. The air permeability of the fabric having zero twist textured yarn is minimum due to the better cover of the fabric. The initial sharp increase in air permeability is due to the decrease in the diameter of the twisted yarn², because as twist increases, the yarn becomes more compact and dense, increasing fabric permeability. But after that, though twist increased, the yarn diameter remained constant, resulting in constant air permeability of the fabric, Zurek et al.² also observed that the air permeability of textured fabrics is half that of fabrics made of twisted yarn.

3.3 Effect of Twist on Bulk Density

Fig. 4 shows that with increasing twist, there is hardly any change in the bulk density of fabric at the initial stage. But at higher twist level, the bulk density of the fabric increases. At higher twist level, increase in fabric weight is more as compared to that in fabric thickness because of more and more compact yarn resulting in an increase in bulk density.
3.4 Effect of Twist on Bending Modulus

Fig. 5 shows that the bending modulus remains almost constant up to a twist factor of 81 and then increases sharply with further increase in twist. Bending modulus is independent of the dimensions of the strip tested and may be regarded as the intrinsic stiffness. With increase in twist, both the fabric stiffness and fabric thickness increase, keeping the modulus value constant up to a certain twist. The increase in fabric thickness is mainly attributed to the contraction of fabric during heat setting. The higher the twist level the higher will be the fabric contraction, which ultimately results in increase in fabric thickness.

3.5 Effect of Twist on Abrasion Resistance

Although as twist increases in spun yarn, the abrasion resistance of fabrics increases because of better binding of fibres. The abrasion resistance of fabric gradually decreases with increasing twist in the textured weft yarn as seen in Fig. 6. The abrasion resistance of the fabrics depends on many factors such as the mechanical properties of fibre, yarn structure and the weave of fabric. Due to insertion of more and more twist, the warp angles increase, resulting in a more rough surface of the fabric. This may be the reason for decrease in the abrasion resistance of the fabric with increase in twist in textured weft yarn.

3.6 Effect of Twist on Dye Uptake

Fig. 7 shows that with increase in twist, the K/S value increases up to a certain twist level and then remains constant. At higher twist level, there is no change in dye uptake. The specific surface area increases because of the reduction in yarn diameter due to insertion of twist in the textured yarn. The dye uptake is directly proportional to the specific surface area of the yarn. This may be the plausible explanation for increase in K/S values with increase in yarn twist. At higher twist level, the specific surface area becomes constant and it is difficult for the dye molecule to penetrate into the yarn because of more compactness. This may be the reason for constancy of K/S values at higher twist level.

4 Conclusions

4.1 With increase in twist, the fabric tenacity initially remains nearly constant and then decreases sharply.
4.2 The breaking elongation of fabric gradually increases with the increasing twist.
4.3 The air permeability of fabric initially increases sharply and then remains constant with increase in twist.
4.4 The bulk density of fabric remains nearly constant up to a certain twist level and then increases with further increase in twist.
4.5 The bending modulus remains nearly constant up to a twist factor of 81 and then increases sharply with further increase in twist.
4.6 The abrasion resistance of the fabric gradually decreases with increase in twist.
4.7 The K/S value initially increases and then remains nearly constant with increase in twist.
4.8 There is hardly any difference in the mechanical properties of the fabrics made from first and second quality polyester yarns.

References