Effect of Different Weft Twist Multipliers on the Structural and Mechanical Properties of Plain-Woven Finished Fabrics

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The effect of different weft twist multipliers on the structural and mechanical properties of plain-woven finished fabrics has been investigated. Fabrics with different twist multipliers in the single weft (3.1, 3.3, 3.5, 4.0 and 4.5) were woven using 2/34s polyester-viscose (65:35) warp and weft, keeping the other constructional parameters identical. The fabric assistance, fabric strip strength, yarn and fabric tensile strength, abrasion resistance, stiffness, thickness, air-permeability, crease recovery and yarn crimp of the fabrics were determined. With increase in twist level, the yarn packing coefficient and inter-fibre friction increased initially. Beyond the optimum twist level, the fibre rupture reduced the strength and abrasion resistance because of an insignificant contribution of such fibres towards these properties. Similar trends were observed for fabric stiffness, crease recovery, air-permeability, and fabric assistance.

Materials and Methods

Materials—Polyester and viscose were mixed in the ratio 65:35. Warp and weft of 2/34s count were used in the preparation of the fabric samples. Five samples of single weft with twist multipliers of 3.1, 3.3, 3.5, 4.0 and 4.5 were prepared by using twist wheels of 44, 41, 39, 34 and 30 teeth on a Tex-Maco ring frame. The plied weft yarn already running was at the single's twist multiplier of 3.1. For successful preparation of fabric samples, it was decided to continue running of the doubled yarn since the constant doubling twist imparted would have nearly the same effect on all the weft yarn samples prepared. Five samples of fabric, with the same warp but weft with varied twist multipliers, were prepared on a Cimmco automatic loom, with a reed space of 60 in., and fabric sett of 60 ends per inch and 52 picks per inch.

Test methods—Before testing, all the fabric samples were conditioned in standard atmosphere (RH, 65%; temp., 27±2°C) for 48 hr. Standard test methods, as laid down by the Indian Standards Institution, were used to determine yarn and fabric characteristics. All the yarn properties were measured for the folded yarns.
The instruments used for carrying out the tests to give quantitative prediction of fabric properties and the standardized sample sizes used are given in Table 1.

The strips were drawn from a place at least 1 in. away from the selvedge. They were cut out of the specimen, 0.5 in. wider and 5 in. longer than the size specified (7 x 2 in.), and the side threads were ravelled out to yield a strip of correct width.

The weft flexural rigidity was calculated by using the following relationship:

$$G = 3.39 \frac{W_1 \times L^3}{mg\cdot cm.}$$

where $G$ is the flexural rigidity; $W_1$, the cloth weight in oz/sq.yd; and $L$, the bending length in cm.

The relationship used for the calculation of bending modulus ($g$) is

$$g = \frac{732 G}{g^2} \text{ kg/cm}^2$$

where $g_1$ is the cloth thickness in thousands of an inch and $G_1$, the flexural rigidity in mg-cm.

Fabric assistance, both warp-way and weft-way, was calculated by using the following relationship:

$$F_{w, \%} = \frac{F_a - M_s}{M_s} \times 100$$

where $F_a$ is the fabric assistance; $F$, the mean fabric strip strength; and $M_s$, the mean fabric strip band strength.

The total fabric assistance was measured by taking the geometric mean of warp and weft fabric assistances:

$$\text{Total assistance} = (\text{warp assistance} \times \text{weft assistance})^{\frac{1}{2}}$$

The total crimp was calculated as:

$$\text{Total crimp (\%)} = (\text{warp crimp}%)^{\frac{1}{2}} \times (\text{weft crimp}%)^{\frac{1}{2}}$$

**Results and Discussion**

Data on tensile strength, abrasion resistance, air-permeability, crease recovery and stiffness are given in Table 2.

Data on fabric assistance, mean strip strength, mean strip band strength, and crimp percentage are given in Table 3.

**Tensile strength**—Table 2 shows that as the twist multiplier in weft increases, the tensile strength of the fabric in the weft direction increases almost linearly till 4.0 twist multiplier. With a further increase in weft twist multiplier, the tensile strength falls. The results are supported by similar trends observed in the case of yarn tensile strength for the varying weft twist multipliers. This behaviour may be explained as follows:

With increase in twist multiplier, the yarn packing coefficient is increased owing to increase in inter-fibre friction. But, beyond an optimum twist level, apparently 4.0 in this case, the fibre rupture reduces the tensile strength owing to an insignificant contribution of these fibres. This result is in agreement with that of Sreenivasan and Shankaranarayana, who found that count strength product first increases and then falls to a minimum diameter. The diameter of yarn progressively decreases with increase in twist multiplier.

**Crease recovery**—With an increase in twist multiplier the caricature of the yarn undergoes a change, as the fibres are more firmly wrapped around the core of the yarn. The resulting yarns tend to behave more stiffly. As a result, fabrics made of such yarns used in weft show an increased crease resistance. Therefore, recovery of crease results in a comparatively less time. The observed increase in the crease recovery angle may also be explained likewise. Beyond 4.0 twist multiplier, the crease recovery angle decreases.

**Abrasion resistance**—Abrasion resistance has been described by Tait as the most important single factor in wear. The fabric resistance to abrasion, as may be
seen from Table 2, increases with increase in weft twist multiplier, falling rapidly for 4.5 twist multiplier, even below the number of cycles to abrasion obtained for 3.5 twist multiplier. Similar results were obtained for yarn abrasion resistance. This may be explained as follows:

With increase in the fibre interaction, the initial binding effect due to twist on the yarn increases, and for twist multipliers beyond 4.0, decreases because of disintegration due to fibre rupture.

Fabric stiffness—Table 2 shows that the bending length increases with increase in twist multiplier in the weft. Consequently, the flexural rigidity and bending modulus (calculated by using the fabric sample thickness) also increase. This is because the increased stiffness of yarn impedes the bending of the fabric under its own weight in the fabric. This result is in close agreement with that of Cooper and Shankaranarayana, who found that yarn diameter decreases with increase in twist and CV% of diameter falls up to minimum diameter. These workers explained that spiral diameter is lesser than the yarn diameter and the ratio tends to approach unity as twist increases, up to the optimum level of twist.

Air permeability—Table 2 shows that the air-permeability increases with increase in the weft twist multiplier initially, and falls rapidly beyond the apparent optimum twist level. The increase is because of increase in the packing coefficient of the yarn. The fall in the curve beyond 4.0 twist multiplier is because of the fibre rupture of the yarn. This result is in close agreement with that of Sreenivasan and Shankaranarayana, who found that yarn diameter decreases with increase in twist and CV% of diameter falls up to minimum diameter. These workers explained that spiral diameter is lesser than the yarn diameter and the ratio tends to approach unity as twist increases, up to the optimum level of twist.

Fabric assistance—Table 3 shows that the crossing threads provide positive assistance to the strip strength in all the samples, because in all cases, the strip strength per thread is greater than the band strength per thread. It is also seen that the fabric assistance in both warp and weft directions increases with increase in twist multiplier in the weft. This can be explained as follows. In the case of an unwoven band of threads, the rupture of the individual threads takes place according to their extensibilities. The weaker yarns extend more and cause an uneven extension in the band when the load is applied. According to Morton, this would cause a small relative movement between adjacent threads. When crossing threads are present, this phenomenon is reduced and occurs at short intervals, so that when the load is applied on a fabric sample, each weak spot demands assistance from a number of threads on either side. Fabric assistance also increases in both warp and weft directions as the warp density increases for the above stated reasons.

The total fabric assistance also shows the same pattern as is shown by the warp and weft assistance for
initial levels of twist but falls for twist multiplier beyond 4.0 because of the fibre rupture in the weft yarns and consequential drop in the strength.

**Conclusions**

(1) With increase in twist multiplier of weft, the fabric tensile strength increases almost linearly at first. Beyond the optimum twist multiplier of 4.0, the strength reduces. Since not much strength is required in the weft, yarn with 4.0 twist multiplier may be used as warp in the fabric.

(2) With an increase in twist multiplier in weft, the fabric crease recovery increases initially and then falls. Crease recovery in suitings in the warp direction is of utmost importance and is dependent on weft used. It may therefore, be concluded that since it is desired to maintain the length-wise crease in the suiting fabrics, the twist multiplier in the weft should be low.

(3) The resistance to abrasion of the fabric increases with increase in weft twist multiplier up to 4.0 and then falls rapidly for higher twist multipliers.

(4) The bending length, flexural rigidity and bending modulus increase with initial increase in the twist and then fall for twist multipliers beyond the optimum twist level. The fabric drape is characterized by this.

(5) The increase in twist multiplier from 3.1 to 4.0 results in an increase in the fabric permeability to air and with the further increase in the twist multiplier the air-permeability falls rapidly.

(6) The contribution of weft to the warp in the fabric increases with increase in twist multiplier but, owing to reduced yarn strength, beyond the optimum twist level, shows a decrease.

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