Effects of Yarn Twist on the

Plied Yarn

Mechanical Properties of

Fabrics

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Abstract

Twisting effect is an important factor determining the mechanical properties and structure of fabrics. An investi-gation was made of the relation between yarn and fabrics properties in terms of their tensile and bending properties when the resultant count of the plied yarn was varied.
1) A high correlation was found between yarn and fabric properties such as tensile, bending, and physical properties (thickness, and weight).
2) Surface roughness increases with increasing resultant count of piled yarn. Superficial crepe effect was obtained in coarse yarn fabrics when the constituent single yarns differed greatly in count.
3) The bending rigidity of gray and finished fabrics of coarse yarns were greater than those of fine yarn fabrics. The constant (R) indicating the degree of correlation between yarn and fabric in their bending rigidities is expressed as: R=Xf/N' X1,
where, Xj : bending rigidity of fabrics,
x, : bending rigidity of yarns, and bending rigidity of fabrics,
N: number of yarns per unit width of fabric.
The value of R for cotton/cotton plied yarn fabrics is larger than those for cotton/polyester multi-filament plied yarn fabrics irrespective of the resultant yarn count.

1. Introduction

Multi-product and small quantity production is the recent trend
in textile industry, as the consumption tends to more diversifica-tion and high qualities. Diversification by means of composite fibers is becoming increasingly popular with the recent progress in mixed spinning technology, and investigations are conducted widely to improve the feeling and functions of fabrics'° . The evaluation of feeling has become an important measure of fabric

performance, and used widely to evaluate fabrics of different end-usest2t . While many paperst<3~ are available simulating the effect of twist on yarn properties but few papers systematically correlate yarn twist with fabric characteristics. In the present study fabric were woven using plied yarns of different count and twist and mechanical properties of fabrics (extension, bending, shearing, and compression), and surface characteristics were measured in relation to yarn properties. It was found that (1) sur-face morphology of plied yarn fabrics is greatly affected by the properties of constituent plied yarns and (2) a good correlation was found between the tensile and bending characteristics of fabrics and those of constituent yarns.

2. Experimental

2.1 Preparation of plied yarns
Specifications of single yarns as stating material are listed in Table 1(a). Cotton yams of 7, 10, 20, 30, and 40s and polyester multi-filament yarns (150 and 250 d, hereafter called EF 150, EF250) were used. Single yarns were paralleled on a doubter and S-twisted by an up-twister to become plied yams. The plied yarns were dry-heat treated at 100°C for 30 minutes in a dryer to set

the twist. Number of twists for cotton/cotton plied yarns (here-after called C/C) were determined by the standard equation (1)

T=a~IN,N2/(N,+N~) ....i1)
where T, a , N1 and N2 are standard twist, twist coefficient and count of respective plied yarns. While the twist coefficient a ranges in value from 3.25 to 4.0 for cotton yarns, a value of 3.5 was used in the present study. Since there is no standardized

yarn count for C/EF plied yarns, EF yarn denier was converted to equivalent cotton count and the apparent resultant count was de-termined using the expression for C/C piled yarn. As with C/C

plied yarns (Y = 3.5 was used for C/EF plied yarns.

2.2 Preparation of sample fabrics
Specifications of warp and weft yarns for fabric specimens are listed in Table 1(b). Specimens are all plain woven fabrics using cotton 30/3 yarn as warp and C/C and C/EF plied yarns prepared by the up-twister as weft. The pick density (n) was determined by the following equation assumed that the cover factor (K) took on a constant value.
K=n N,Nz/ (N, +NZ) ....(2)
Commercially available yarns were used without sizing before weaving. Fabrics, both gray and scored and finished, were tested.
Scouring and finishing procedures: gray fabrics were treated in a
bath containing 1 % of NOIGEN HC at 95 ±3°C for one hour with
a bath ratio of 1/40, and subsequently finished with a nonionic
softener. Hereafter the scoured and finished fabrics are called
simply finished fabrics.

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2.3 Mechanical properties of plied yarns
Plied yarns listed in Table 1(b) were measured for tensile and bending properties.
(Procedures) Tensile: tensile hysteresis curve were measured using the number of yarns contained in 1 cm wide fabrics. Bending: measured using the number of yarns contained in 2 cm width fabrics.

2.4 Properties of piled yarn fabrics
Mechanical properties (tensile, bending, compression, and shearing), surface performance, thickness and weight, as listed in Table 2 were measured121.

3. Result

Measured properties of plied yarn fabrics are listed in Table 3. Two different experimental formulas are introduced to represent the correlation between resultant weft count (X) and properties of fabrics (Y).
1) Y = aX+b, 2) Y = c/X+d ....(3)
In above equations a, b, c and d are regression coefficients. Equation 1) is applicable to WT (warp, weft) and W. On the other hand equation 2) is used to express RT (weft), B (weft), 2HB (weft) and TM. The result of regression analysis is sum-marized in Table 4.

4. Discussion

4.1 Morphology of plied yarns
Shown in Fig. 1 are microphotographs of different C/C plied

yarns and C/EF150 plied yams listed in Table 1(b). When the two constituent single yarns in a plied yarn are close in count as in 7/1 x 1O/1s and 30/1 X40/1s the plied yarn was found not to ex-hibit a pronounced helical form. This is presumably because the two single yarns are similar in shape to make the plied yarn look like a cyclinder as molded in Fig. 2(a).
On the other hand when the two single yarns greatly differ in

(a) Twisting

Table 1

yams

Yarns and fabrics.

Table 2 Mechanical properties measured.

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Table 3Mechanical properties of sample fabrics.
Table 4Analysis of the regression and variance table.
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count as in 7/1 X40/1s and 10/1 X40/1s the finer yam tends carry most of the tension while in plying to make the finished yarn look like the model shown in Fig. 2(b) in which the thicker yarn wraps more or less wraps around the thinner yarn.
C/EF plied yarns exhibit similar effect with the EF yarn re-maining almost straight and the C yarn wrapping around it to make the plied yarn "cork screw" in shape. The corkscrew shape becomes more pronounced with increasing C yarn count. Next the wave height14' of the corkscrew shape is defined as shown schematically in Fig. 2(a) and the yarn count ratio (A) in a plied yarn is defined as
A = (count of thinner yarn)/(count of thicker yarn)
...C/C plied yarn
A = (count of EF yarn)/(count of cotton yarn)
...C/EF plied yarn
As Fig. 2(b) shows clearly the wave height and the crimp of C/C plied yarns increase with increasing A value. The wave height of plied yarns containing EF250 is greater than those con-

taming EF 150.

4.2 Twisting effect on fabric properties
A. Surface characteristics
Some outstanding surface characteristics of plied yarn fabrics

Fig. 1 Microphotographs of plied yarns.

(b) Relation wave hight and A of pled
Fig. 2 Morphology of plied yarns.
(~ : C/EF250; X: C/EF 150;

yarns

C/C)

Fig. 3 The surface of plied yam fabrics.

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listed in Table 1(b) are shown in Fig. 3. On the surface of No. 4 and No. 12 fabrics "yoryu" like "crepe" effect is observed. The

"yoryu" effect tends to increase with increasing A value. The "yoryu" effect is not clear in No. 16, and no characteristic sur-
face pattern is observed in No. 10. Concerning the relation be-tween the surface roughness (SMD) and weft resultant count, it is observed that SMD (weft) ranges from 7 to 10 µ and decreases with increasing resultant yarn count. On the other hand SMD (warp) decreases stepwise from 10-20 µ to about 5 µ at the re-sultant count of 8. In this case relatively clear "yoryu" pattern is observed in the resultant count range below 8. The relation be-tween SMD (warp) and resultant count is shown in Fig. 4 for gray and finished fabrics.

B. Bending properties
Fabric properties are sensitive to the properties of plied yarns constituting the fabrics. The following ratios Ra and Rb are defined to express the correlation between the fabric properties and yarn properties.
Ra=B/N • B*y Rb=2HB/N • 2HBy ...(4)
In above equation (4), B, B*y, By and N are fabric bending rigidity per unit fabric width, bending rigidity of yarn after weaving, bending rigidity of yarn before weaving, and number of yarns per unit fabric width respectively.
Fig. 5 shows the relation between the bending rigidity of plied yarns and that of fabrics for gray fabrics and finished fabrics. In Table 5, Ra and Re of gray fabrics and finished fabrics are listed. For gray fabrics, Ra values for C/C, C/EF150, and C/EF250 were 1.75, 1.46 and 1.10 respectively. The scatter may be

attributable to the strain history during weaving and contact fric-tion at the cross point Rb values of C/C, C/EF150 and C/EF250 for unwoven yarn were 0.83, 0.52 and 0.41 respectively. Grosberg'51 measured the ratio of fabric bending rigidity per yarn over the bending rigidity of the constituent yarn and found the values range from 1.0 to 2.8 with gray cotton fabrics.
C. Tensile properties
Figure 6 shows the relation between WT and resultant weft count. WT in warp direction decreases with increasing weft

count. On the other hand WT of C/C plied yarn fabrics is lower than that of C/EF plied yarn fabrics. These observations may be explained by the Ra and Rb described in the previous section. In gray fabrics inter-yarn and inter-fiber fractions are both greater for C/C plied yarn fabrics, and consequently WT is smaller. Further-

Fig. 4 Relation surface roughness and weft resultant count. (~: Gray; 0: Finished)

Table 5 Ra
, Rb of bending rigidity

Fig. 5 Relation properties of plied yarns and properties of fabrics.
(S: C/EF250; X: C/EF 150; 0: C/C)

Fig. 6 Regulation WT and weft resultant count.
Warp--- 0: C/EF250; s: C/EF150; O: C/C Weft- •: C/EF250; o : C/EF150; C): C/C

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more the contact pressure between warp and weft yarns increase with increasing yarn count, and consequently LT increases, the increased LT also causes the decrease in WT. Next the com-

parison of WT between gray and finished fabrics is shown in Table 6. WT of finished fabrics is generally greater than that of

gray fabrics. This fact suggests that the strain history accumulat-ed during weaving is relaxed upon finishing process making the fabric to swell. Okamoto~s' reported similar observation in the initial stage of repeated laundering. For the weft direction the following results were obtained. WT increases with increasing count of plied yams, and WT of C/ET plied yam is greater than that of C/C plied yarns. This fact is consistent with the measured

properties of C/C and C/EF plied yams.

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Table 6 WT of gray and finished fabrics.

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