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# Properties of Wool/Spandex Core-Spun Yarn Produced on Modified Woolen Spinning Frame

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**Abstract:** Spandex has been successfully applied on modified worsted spinning system to produce spandex core spun yarn. However it's difficult to produce wool/spandex core-spun yarn on woolen spinning system with the same modified device because the drafting device of the two systems is quite different. A new method is introduced to apply spandex on woolen spinning system in this paper. Core-spun yarn produced in this way has good appearance and quality by comparing with normal yarn. A series of experiments were carried out to study the influence of spandex drafting ratio and yarn twist factor on tensile properties and elasticity of core-spun yarns. The results indicate that core-spun yarn with spandex drawing ratio of 2.5 and twist factor of 13.63 has highest value of tenacity and breaking elongation.

**Keywords:** Core-spun yarn, Spandex, Woolen spinning, Drawing ratio, Yarn twist

## Introduction

Elastic products have been widely used in clothing industry since spandex is developed and produced. The most common methods of producing elastic yarns are core-spinning on a modified ring frame, Siro spinning, air entangling, hollow spindle spinning, rotor spinning, friction spinning and tandem spinning [1-6]. These processes can be adopted according to different yarn end-use. The modified ring spinning frame included a positive feed roller as spandex delivery unit and a V-groove guide to feed spandex to front roller. Spandex is stretched between the positive feed roller and front roller, which will provide elasticity in core-spun yarn.

On woolen spinning frame, porcupine roller is used to draw and control roving. Spandex would easily touch porcupine roller and break down if we choose the same spandex path as worsted spinning frame. So modification should be considered to ensure spandex position centrally on the wool roving ribbon and produce good quality woolen core-spun yarn.

In this paper, we produced woolen elastic core-spun yarn on modified spinning frame. We contrast the property of elastic yarn with normal yarn and analyze the impact of processing parameters on core-spun yarn properties.

## Experimental

### Spinning Method

Spandex should be pre-drawn before it enters front roller. The velocity difference between spandex positive feed roller and front roller results in the pre-drawing of spandex. As shown in Figure 1, a V-groove guide wheel 8 is used to control the position of spandex and change the angle into front roller. Spandex won't touch porcupine roller in this way and in turn avoid breaking down during spinning. Another V-groove guide wheel 6 is equipped to control the position of wool roving. The two guide wheels are fixed at the same cradle so that spandex always lies at the centre of wool roving.

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### Material and Methods

We used spandex made by Dupont (Lycra®) as the core and 66 s wool fiber as the wrapping material in this experiment. Wool roving and core spandex is processed into 71.4 tex core-spun yarn on modified woolen spinning frame BC584. 71.4 tex normal yarns are produced too. The spinning condition were 0.086 g/m wool roving and 4500 rpm spinning speed.

The yarn longitudinal view and cross-section view were observed by Questar Hi-scope video microscope system. We tested core-spun yarn properties of tenacity, breaking elongation and elastic recovery percentage. Yarn tenacity and breaking elongation values were determined from the mean of 50 tests on yarn tensile tester with testing gauge of 50 cm and tensile speed of 550 mm/min. A pretension of 1 cN/tex is applied

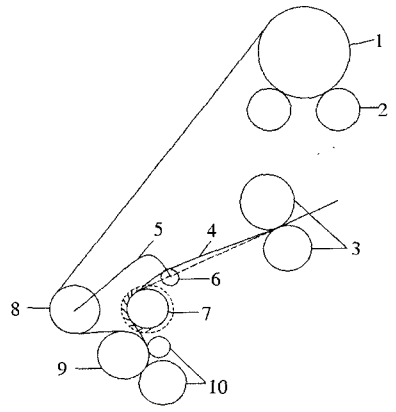



**Figure 1.** Schematic diagram of spinning process; 1. spandex package, 2. positive feed roller, 3. back roller, 4. wool roving, 5. cradle, 6,8. V-groove guide wheel, 7. porcupine roller, 9. front top roller, 10. front bottom roller.

on core-spun yarn to make it straight but no elongation. Elastic recovery percentage was measured on Shimadzu AG-10 Precision Universal Tester with testing gauge of 100 mm, tensile speed of 50 mm/min, initial extension of 5 % and retention period of 30 s. All tests were performed under standard condition of 20±2 °C and 65±2 % RH.

Percentage of spandex in core-spun yarn varies with different spandex drawing ratios. Percentage of spandex can be calculated as equation (1).

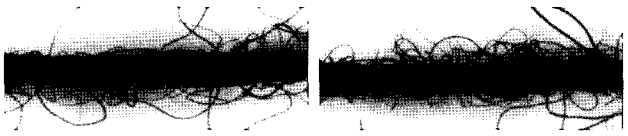
$$P(\%) = \frac{T_2 K}{T_1 D} \times 100\% \quad (1)$$

Where $P$: percentage of spandex (%), $T_1$: linear density of core-spun yarn (tex), $T_2$: linear density of spandex (tex), $K = 1.16$, is correcting factor to modify the retraction of spandex between front nip and traveler during spinning, $D$: spandex drawing ratio.

## Results and Discussion

### Appearance and Structure

Figure 2 shows the longitudinal photographs of core-spun yarn and normal yarn. Compared with normal yarn, the appearance of core-spun yarn is clearer with less hairiness. This is because concentric sheath-core structure of core-spun yarn make wrapper fibers distribute around core fiber tighter than normal yarn. Figure 3 is the cross-sectional view of core-spun yarn. We can see that the core is almost completely covered.



(a) Core-spun yarns (b) Normal yarns

**Figure 2.** Longitudinal view of yarns.

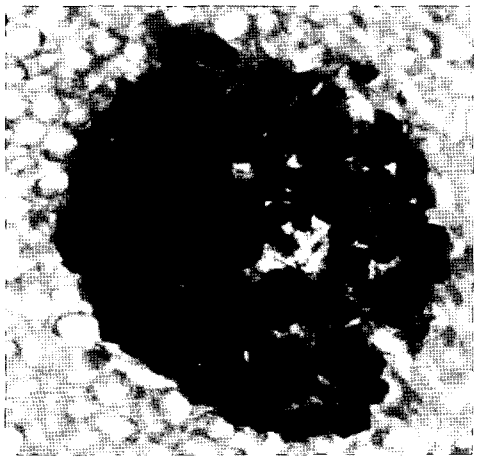


**Figure 3.** Cross section of woolen core-spun yarn.

### Effect of Spandex Drawing Ratio

We used 71.4 tex normal yarn with twist factor of 12 and 71.4 tex core-spun yarn with the same twist factor, spandex of 70 den and spandex drawing ratio of 2.0, 2.5, 3.0, 3.5 to study the effect of spandex drawing ratio. Table 1 lists the specification of yarns.

Figure 4 shows the tensile curve of yarns. The initial modulus of all yarns is almost the same. However when elongation of yarn increases further, modulus of core-spun yarn decreases with increment of spandex drawing ratio and modulus of normal yarn is larger than that of any core-spun yarn, which indicates that elastic core-spun yarn is ease to stretch at large yarn extension compare with normal yarn. The higher the spandex drawing ratio is the easier core-spun yarn to stretch.

Table 2 shows the properties of yarns. Normal yarn has smallest breaking elongation and medium tenacity comparing with elastic core-spun yarn. When spandex drawing ratio is 2.5, tenacity and breaking elongation of yarns is higher than that of other yarns. This can be explained as follows: most of the loading stress in core-spun yarn is mainly taken up by the less extensible wool fiber, which has been confirmed by Babaarslan [7]. The percentage of wrapped wool fiber increases with the increasing of spandex drawing ratio. So there is more wool fiber taking up load in core-spun yarn with spandex drawing ratio of 2.5 than that with 2.0 and in turn lead to higher tenacity and breaking elongation. When drawing ratio of spandex increases further, the stretchable range of spandex decreases. Core-spun yarn break down

**Table 1.** Specification of yarns with various spandex drawing ratios

| Spandex drawing ratio | 2.0 | 2.5 | 3.0 | 3.5 |
|---|---|---|---|---|
| Core-spun yarn | D1 | D2 | D3 | D4 |
| Normal yarn | | N | | |

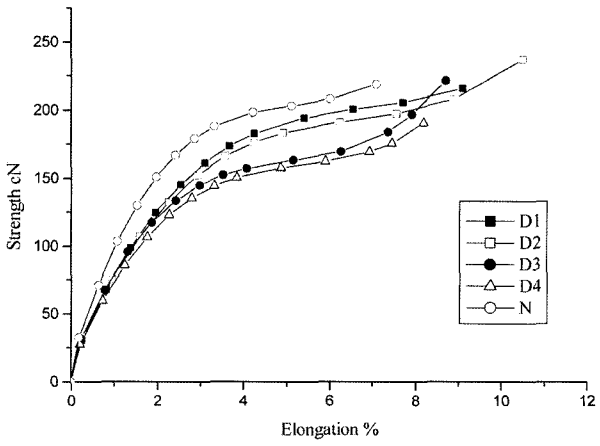



**Figure 4.** Tensile curves of normal yarn and elastic core-spun yarn with various spandex drawing ratios.

**Table 2.** Properties of woolen core-spun yarns with various spandex drawing ratios

| Samples | Percentage of spandex (%) | Tenacity | | Breaking elongation | | Elastic recovery percentage (%) |
|---|---|---|---|---|---|---|
| | | (cN/tex) | (CV%) | (%) | (CV%) | |
| D1 | 6.32 | 3.02 | 10.77 | 9.1 | 10.33 | 97.28 |
| D2 | 5.06 | 3.32 | 9.36 | 10.5 | 10.96 | 98.04 |
| D3 | 4.21 | 3.10 | 7.78 | 8.7 | 11.81 | 98.26 |
| D4 | 3.61 | 2.67 | 9.22 | 8.2 | 12.28 | 98.40 |
| N | – | 3.06 | 10.34 | 7.1 | 10.91 | – |

when wool fibers are stretched straight up to their breaking point during yarn extension. Elastic recovery percentage increases with increasing of spandex drawing ratio. This can be explained by the fact that the higher drawing ratio of spandex is, the more the ability of retraction is. Also we can conclude that high value of spandex drawing ratio will do bad to yarn quantity from the value of CV% of yarn tenacity and breaking elongation.

### Effect of Yarn Twist Factor

Core-spun yarns of 71.4 tex with spandex of 40 den, spandex drawing ratio of 2.5 and twist factor of 8.82, 10.42, 12.03, 13.63, 15.23 were produced. Normal yarn of 71.4 tex with the five twist factors are produced as comparison. Table 3 lists the specification of yarns.

Figure 5 shows tensile curves of yarns with twist factor of 13.63. The tensile curve of core-spun yarn and normal yarn largely overlap each other. The most distinct difference lies

**Table 3.** Specification of yarns with various twist factors

| Twist factor | 8.82 | 10.42 | 12.03 | 13.63 | 15.23 |
|---|---|---|---|---|---|
| Core-spun yarn | T1 | T2 | T3 | T4 | T5 |
| Normal yarn | N1 | N2 | N3 | N4 | N5 |

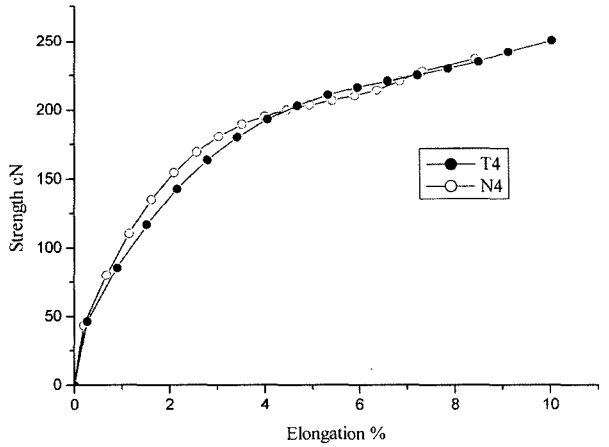



**Figure 5.** Tensile curves of normal yarn and elastic core-spun yarn.

**Table 4.** Properties of woolen yarns with various twist factors

| Samples | Tenacity | | Breaking elongation | | Elastic recovery percentage (%) |
|---|---|---|---|---|---|
| | (cN/tex) | (CV%) | (%) | (CV%) | |
| T1 | 2.21 | 11.36 | 7.3 | 10.77 | 97.92 |
| N1 | 1.72 | 10.75 | 5.1 | 11.05 | – |
| T2 | 2.67 | 9.91 | 7.9 | 8.24 | 98.05 |
| N2 | 2.20 | 10.22 | 5.7 | 10.25 | – |
| T3 | 3.02 | 8.88 | 9.2 | 7.88 | 98.14 |
| N3 | 2.34 | 8.33 | 6.6 | 10.17 | – |
| T4 | 3.49 | 7.44 | 10.0 | 8.11 | 98.27 |
| N4 | 3.32 | 8.35 | 8.4 | 9.85 | – |
| T5 | 3.06 | 7.34 | 9.3 | 10.41 | 98.38 |
| N5 | 2.77 | 8.24 | 8.2 | 10.43 | – |

in the fact normal yarn break down at comparatively low extension.

Table 4 shows the impact of twist factor on yarn properties. Core-spun yarn with twist factor of 13.63 has maximum breaking elongation and tenacity. Elastic recovery percentage of yarns increases with increasing of twist factor. Table 4 also shows that the tenacity and breaking elongation of normal yarns are much lower than that of core-spun yarns, which reveal the advantages of elastic core-spun yarns.

We explain the changes of tenacity and breaking elongation as follows: wool fiber in core-spun yarn is slack with comparative low twist factor, which result in low cohesion between fibers. On the country, large twist angles of wool fibers in higher twist yarns will cause increased tenacity of yarns. However, too much twist will lead to too tight wrapping of fibers and too much cohesion between fibers, which will prevent yarn elongation and lead to lower tenacity and breaking elongation.

## Conclusion

Woolen core-spun yarn has been produced on modified woolen spinning frame. Elastic core-spun yarn has better properties comparing with normal yarn. Yarn twist and spandex drawing ratio have great influence on yarn properties. Experiments show that tenacity and breaking elongation firstly increase and then decrease with increasing of twist factor and spandex drawing ratio. Elastic recovery percentage of core-spun yarns increases with increasing of the two parameters. Core-spun yarn with twist factor of 13.63 and spandex drawing ratio of 2.5 has highest value of tenacity and breaking elongation.

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