

Influence of Selected Process Variables on the Mechanical Properties of Core-Spun Vortex Yarns Containing Elastane

Abstract

In this experimental study, we investigated the effects of nozzle pressure, delivery speed and elastane content on the mechanical properties of core-spun yarns produced using the Murata vortex spinning system. Our findings show that the nozzle pressure, delivery speed, elastane content as expressed by the linear density of elastane yarn and the interactions of these factors are all significant factors affecting the mechanical properties of core-spun vortex yarns. Core-spun vortex yarns containing elastane show higher elongation at break and lower tenacity values than vortex yarns which contain no elastane. Increases in the nozzle pressure and decreases in the delivery speed resulted in significantly deteriorated mechanical properties of core-spun vortex yarns containing elastane.

Key words: elastane, core-spun yarn, vortex spun yarn, cotton yarn.

they have the same feel as the shield fibres, and possess good moisture absorption dependent on the fibres which cover the outer layer. We can also modify their elasticity to fit different end-products [3]. Therefore, core-spun yarns containing elastane have found a wide range of application areas in the textile industry.

Core-spun yarns containing elastane have been the subject of limited research [3 - 5]. Su et al. investigated the effects of draw ratio and feed-in angle of the elastane on the core-spun yarns' structure and performance at the modified ring spinning frame. They concluded that a higher feed-in angle provides a better cover effect, and a draw ratio of 3.5 yields better dynamic elastic recovery [3]. Babaarslan showed that elastane positioning has a direct effect on the properties, structure and performance of core-spun yarns produced on a modified ring spinning frame [4].

However, there has been no research about core-spun yarns produced on the Murata Vortex Spinning (MVS) system. The aim of this study is to examine the effects of nozzle pressure, delivery speed and elastane content as expressed by the linear density of elastane yarn on the mechanical properties of core-spun vortex yarns, which should be an indication not only for selecting the proper yarn composition for a given application, but also enables us to choose the best machine settings for obtaining optimum features of the product manufactured.

Production method

The MVS method based on the air jet spinning technology has been developed

by the Japanese firm, Muratec. The obvious advantage of the MVS method is its very high spinning speed, when compared to other spinning technologies, coupled with an acceptable yarn quality [6 - 8]. In the MVS method, drafted fibres are introduced into the spiral orifice by an air vortex. While entering and passing through the orifice, fibres that are twisted by the swirling air are also introduced into the outer side of the orifice. The twist motion tends to flow upwards. Since the needle protruding from the orifice prevents any upward twist penetration, the upper parts of some fibres are kept open as they depart from the nip line of the front rollers. After the fibres have passed through the orifice, the upper parts of the fibres begin to expand, due to the whirling force of the air jet stream, and twin over the hollow stationary spindle. The fibres twined over the spindle are whirled around the fibre core and made into vortex yarn as they are drawn into the hollow spindle [9 - 11].

The basic requirement for producing a core-spun yarn containing elastane is to stretch an elastane thread before it enters the spinning unit, so that the elastane thread is situated in the centre of the core-spun yarn and is covered completely by the staple fibres. The core-spun yarn containing elastane can be extended to the point where the non-elastic part is stretched to its limit [12]. The MVS frames must have knitter- or splicer-type binding equipment and an elastane feed device for the producing core-spun vortex yarn.

The elastane and drafted staple fibres are brought together at the nip point of front rollers of the drafting unit. The elastane

Introduction

Elastane fibres are synthetic fibres which are built up of linear macromolecules. At least 85% of their composition by weight is segmented polyurethane. Elastanes have superior stretch and elastic recovery ability. Elastanes can be stretched by a factor of 4 to 8. Elastanes are used exclusively in conjunction with other textile fibres, since high extensibility is not desired with most textiles, and to protect the elastane from mechanical damage [1, 2].

There are many methods for merging elastane with other textile fibres, such as core spinning, cover spinning, siro spinning, and air entangling. Core spinning is one of these methods, and can be applied by the ring, Murata vortex, and friction spinning techniques. Core-spun yarns, which use elastane as the core and are covered with natural fibres or other staple fibres, have important properties:

thread is stretched between the positive feed roller and the front rollers of the drafting unit.

Material and test method

In this study, eighteen different types of yarn samples were produced on the MVS 810 type vortex spinning machine modified with an elastane feed device to examine the effects of delivery speed, nozzle pressure and elastane content on the mechanical properties of core-spun vortex yarns containing elastane.

We used Manisa ST 1 type cotton, which had the following properties: 4.31 micronaire reading, 16.27 mm 50% span length, 24.89 mm ML, uniformity ratio of 52.3, 4.6% elongation at break and 30.43 cN/tex tenacity for producing the yarn samples. The cotton bales were processed on the traditional short-staple combed system using standard mill procedures, adjustments and practices. After second passages of drawing, the slivers with a linear density of 4.92 ktex were transferred to an MVS 810 machine.

In order to determine the effects of delivery speed, nozzle pressure and elastane content on the mechanical properties of core-spun vortex yarns, two levels of delivery speed (300 and 330 m/min), three levels of nozzle pressure (0.50, 0.55, 0.60 MPa) and three levels of elastane linear density (0 - no elastane, 44 dtex, 78 dtex) were selected. The trials were run in a commercial spinning mill. The pressure values were determined according to the limitations dictated by the instruction manual of the MVS 810 [10]. The delivery speeds of the MVS machine were chosen on the basis of manufacturing experiences. The selected elastane counts (linear density) are those widely used in the industry for such core-spun yarns.

The list of the yarn samples and process parameters are given in Table 1. Ten baby cones of about 200 grams each were prepared under each set of experimental conditions. In addition, the yarn samples with different parameters were spun at the same position to avoid any drum-to-drum variations.

All the yarn samples were produced under the following spinning conditions: 70° nozzle discharge angle, 1P130°L7-9.3 type needle holder, 1.4 mm spindle inner diameter, 36-36-48.5 mm top roller gauges and 36-36-44.5 mm bottom roller

Table 1. Yarn samples and process parameters.

Yarn Code	Delivery speed, m/min	Nozzle pressure, MPa	Elastane's linear density, dtex
1	300	0.50	-
2			44
3			78
4	300	0.55	-
5			44
6			78
7	300	0.60	-
8			44
9			78
10	330	0.50	-
11			44
12			78
13	330	0.55	-
14			44
15			78
16	330	0.60	-
17			44
18			78

Table 2. Properties of yarn samples.

Yarn Code	Actual linear density, tex	Elongation at break, %	CV of elongation at break, %	Tenacity, cN/tex	CV of tenacity, %
1	42.8	6.72	9.44	10.15	5.65
2	40.4	6.7	9.21	7.47	7.51
3	41.9	7.6	10.14	7.01	6.81
4	42.8	6.63	6.86	9.97	5.58
5	40.4	6.66	13.05	7.33	9.73
6	41.9	7.52	16.45	7.01	7.66
7	42.8	6.51	6	9.66	4.62
8	40.7	6.45	9.71	7.22	8.6
9	41.9	6.66	15.4	6.95	7.85
10	42.8	7.17	6.28	10.97	5.98
11	40.7	6.86	9.14	8.12	8.04
12	42.2	7.91	13.35	7.49	6.94
13	42.8	6.83	5.92	10.58	6.33
14	40.7	6.77	8.07	8	7.95
15	42.2	7.78	17.65	7.41	6.48
16	42.8	6.55	5.65	10.34	4.97
17	40.7	6.59	8.46	7.77	7.69
18	42.2	7.03	15.02	7.56	8.08

gauges, 18.5 mm front roller to spindle distance, 0.98 take-up ratio, 1.0 feed ratio, on the MVS 810 vortex spinner. Two different counts of Dupont Lycra® elastane were used for the core filament. The core draft ratio was selected as 2.5.

We tested all the yarn samples and evaluated them for their tensile properties such as tenacity and elongation at break values. Elastic core-spun yarn counts were determined according to the Dupont Technical Bulletin [12]. Yarns were tested for tenacity and elongation at break on the Uster Tensorapid. The test results were analysed for significance in differences, using the analysis of variance (ANOVA) and Student-Newman-Keuls (SNK) tests at a 0.05 level in the Costat statistical package.

Results and discussion

The mechanical properties of yarn samples are listed in Table 2. Variance analysis indicated that elongation at break and tenacity values of core-spun vortex yarns were all significantly affected by the various levels of nozzle pressure, delivery speed, elastane linear density and the interactions of these factors. Figures 1 and 2 demonstrate the effects of nozzle pressure, delivery speed and elastane linear density on elongation at break and tenacity values respectively.

The elongation at break values of yarn samples increases slightly as the nozzle pressure decreases. Also, an increase in the elongation at break value as the delivery speed increased from 300 m/min

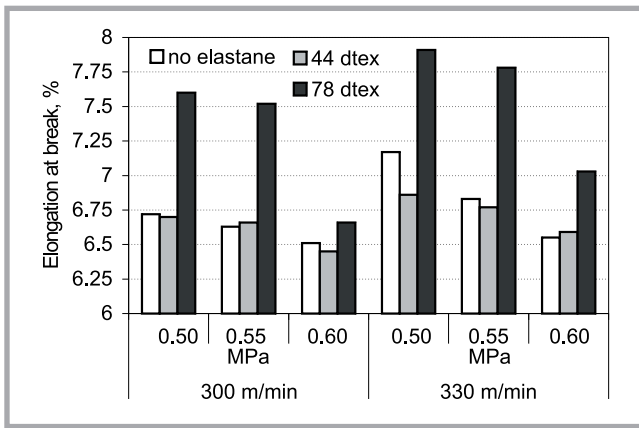


Figure 1. The effects of delivery speed, nozzle pressure and elastane count on elongation at break value of yarn samples.

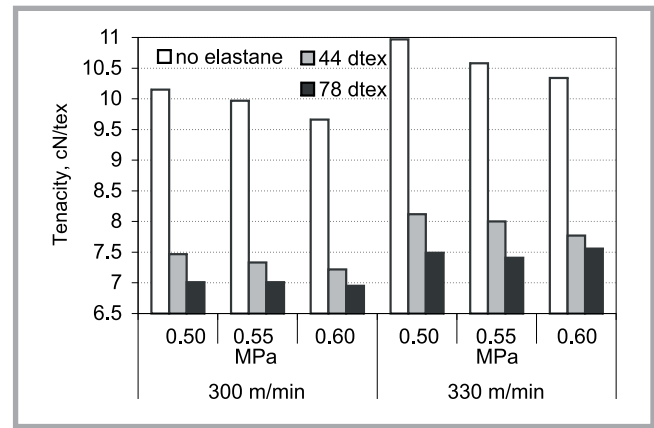


Figure 2. The effects of delivery speed, nozzle pressure and elastane count on tenacity value of yarn samples.

to 330 m/min could be observed (see Figure 1). The elongation at break values of core-spun vortex yarns containing 78 dtex elastane were higher than that of other yarn samples. It should be emphasised that only the content of 78 dtex of spandex yarn significantly increases the elongation at break, whereas the content at 44 dtex practically does not increase the elongation at break, and may or even decrease it (Figure 1). According to the ANOVA and SNK test results, there is no difference between the elongation at break values of core-spun vortex yarns containing 44 dtex elastane and vortex spun yarns containing no elastane. This can be explained by the small difference between the amount of staple fibres at the structure of core-spun vortex yarn containing no elastane and 44 dtex elastane. The highest elongation at break value was obtained from yarn samples produced with a 330 m/min delivery speed, 0.5 MPa nozzle pressure and 78 dtex elastane.

All core-spun vortex yarns containing elastane had lower tenacities than vortex spun yarns containing no elastane. Also, core-spun vortex yarns containing 78 dtex elastane had lower tenacities than core-spun vortex yarns containing 44 dtex elastane. As the number of staple fibres in the cross section of yarn decreased, the tenacity of yarns also decreased. In other words, elastane does not contribute much to yarn strength.

As the nozzle pressure increased, the tenacities of yarn samples showed a decreasing trend. In addition, the tenacities of yarn samples increased as the delivery speed increased. The increase in the nozzle pressure and the decrease in the delivery speed affects the waste fibre

rate. Increasing the lost fibres results in a decreasing trend in all the mechanical properties of core-spun vortex yarns.

Conclusions

This study provides a window into the production system of core-spun vortex yarn. As a result of the experimental investigation, the following conclusions can be drawn;

- Most of the loading stress applied to the core-spun vortex yarns is mainly taken up by the staple fibres, and the elastane does not contribute much to yarn tenacity. Hence, the number and arrangement of staple fibres within the core-spun yarn are of critical importance in core-spun vortex spinning.
- Increases in the nozzle pressure and decreases in the delivery speed resulted in significantly deteriorated mechanical properties of core-spun vortex yarns containing elastane. This is due to the increasing number of lost fibres, which is caused by increasing nozzle pressure and decreasing delivery speed.
- The reduction of yarn tenacity in the producing core-spun vortex yarns containing elastane can be minimised by the proper adjustment of the MVS spinning settings.

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