R. Ghasemi,
R. Mozafari-Dana,
S. M. Etrati,
S. Shaikhzadeh Najar

Comparing the Physical Properties of Produced Sirospun and New Hybrid Solo-Siro Spun Blend Wool/Polyester Worsted Yarns

Department of Textile Engineering, Amirkabir Univ. of Technology,
Tehran, Iran
E-mail: elham@aut.ac.ir
saeed@aut.ac.ir

Abstract
The aim of this paper is to present the utilisation of a Solospun roller in the Sirospun spinning system in order to improve the properties of worsted wool/polyester yarns, especially the yarn hairiness. In this work, a Solospun roller was used and different worsted yarns (45% wool, 55% polyester) with a yarn linear density (count) of 50 tex and twist factors (α_{Tt}) of 2530, 2846, 3162, 3478, and 3795 were produced using the Sirospun spinning system with and without a Solo-spun roller. Afterwards, the yarn physical properties including hairiness, tensile strength, elongation, unevenness and abrasion resistance were measured and compared. The results indicate that increasing the yarn twist factor within the range of 2530 to 3478 decreases the hairiness of Solo-Siro spun yarn. It is also shown that the hairiness of Solo-Siro spun yarns is significantly less than that of Sirospun yarns. The evenness, count and twist of Solo-Siro spun yarns change slightly in comparison with Sirospun yarns. However, other yarn specifications, such as tensile strength, elongation and abrasion resistance remain almost un-changed.

Key words: *Solospun roller, Wool/Polyester fibres, Sirospun, Solo-Siro spun, hairiness, yarn properties.*

Introduction

The Solospun™ system is a new kind of spinning technology developed by CSIRO, WRONZ and the Woolmark Company. This technology can spin weaveable single yarns with a higher breaking strength and less hairiness without the need for plying and sizing [1 - 4].

Several studies investigated the hairiness and breaking strength of Solospun yarns [5 - 7]. The hairiness of Solospun and ring spun worsted yarns were compared by Chang and Wang [7]. They found that Solospun yarns have fewer hairs in different hair length groups and lower variations in hairiness. Cheng et. al.,[5] used a set of structural and mathematical yarn models and compared the breaking strength of Solospun and ring spun yarns. Their investigation showed that the twist amplitude of Solospun yarns is distributed more evenly, which causes the breaking strength of Solospun yarns to be 15% higher than that of ring spun yarns. In their recent work [6] these authors used a geometrical model to analyse the structure of Solospun yarn, and to explain the lower hairiness of these yarns compared with ring spun yarns. A recent study showed that combining Solospun and Sirospun technologies can improve the hairiness properties of pure wool yarns [8]. However, there is no published paper which outlines how to use a Solospun roller in the Sirospun spinning system in order to improve the properties of worsted blended wool/polyester yarn. Blended wool/polyester worsted yarns are mainly used in worsted dress fabrics. Based on previous studies [8 - 10], the objective of this paper is to investigate if utilising a Solospun roller in the Sirospun spinning system will further improve the resultant wool/polyester blended worsted yarn properties. In this work, worsted blended wool/polyester (45%/55%) yarns with a yarn count of 50 T_t and twist factors (α_{Tt}) of 2530, 2846, 3162, 3478, and 3795 were produced in Sirospun and new hybrid Solo-Siro spinning systems and the physical properties of the produced yarns were then investigated.

Experimental

Spinning Processing

In this research, a finisher (un-twisted) worsted roving with a linear density of 495 tex (2.02 Nm) was used. The roving was comprised of 55% Polyester and 45% wool fibres. The fibre specifications were as follows: the average fibre length for wool and polyester were 73.1 and 74.9 mm respectively, the average wool fibre diameter was 21.74 μ_m (CV.% was 62%), and the average fineness of the polyester fibre was 3 den. To produce Sirospun and Solo-Siro spun yarns, a worsted ring spinning machine (SACM) was used. First, we used standard Sirospun guides and condensers with a 14 mm strand spacing [11], as depicted in Figure 1, and then Sirospun yarns with a yarn count of 50 T_t and twist factors (α_{Tt}) of 2530, 2846, 3162, 3478, and 3795 were produced. The ring diameter and spindle speed used in this study were 56 mm and 8000 r.p.m, respectively. In the second experiment, a Solospun™ roller [2] (Figure 2) was mounted on the Siro-spinning machine head and Solo-Siro spun yarns with a yarn count of 50 T_t and twist factors (α_{Tt}) of 2530, 2846, 3162, 3478, and 3795 were pro-

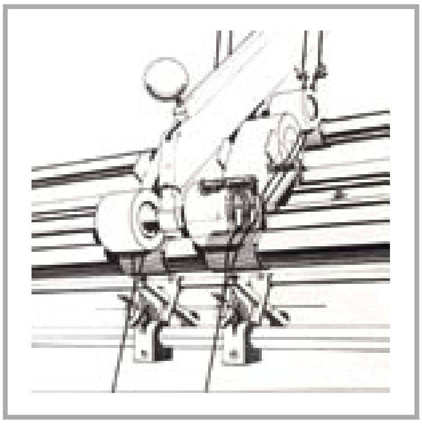

Figure 1. *The Sirospun process [11].*

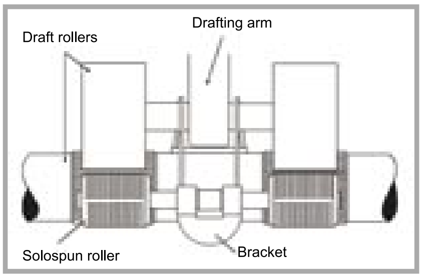

Figure 2. *The Solospun™ roller [2].*

__Table 1.__ Sample size for yarn experimental investigations.

Test type	Sample size (K)
Yarn count	5
Yarn twist	30
Tensile strength	30
Elongation	30
Yarn abrasion resistance	50
Yarn unevenness	5
Yarn hairiness	6

duced. The machine specifications (ring diameter and spindle speed) were the same as in the Sirospun yarn process.

Yarn testing

The yarn samples were conditioned for 24 hours under standard conditions (65% R.H. and 22 °C) and then the yarn physical properties including yarn count and twist, tensile strength, unevenness, abrasion resistance and hairiness were measured [9, 10]. The sample size for yarn tests was calculated using the following formula [9]:

$$K = \left(\frac{t \cdot CV}{A}\right)^2 \qquad (1)$$

where, K is the number of tests, t is the probability factor (1.96 for 95% probability), CV is the coefficient of variation and A is the allowance error (5%). Table 1 shows the sample sizes for yarn experimental investigations. All experiments were carried out under standard conditions (22 ± 2 °C and 65 ± 2% R.H.).

The yarn count and twist of the yarns produced were measured using standard test methods [12 - 14]. The yarn tensile strength was measured using an Uster Dynamat Tester II. The yarn test length and pre-tension were 50 cm and 0.5 g/tex, respectively. The rate of loading was adjusted to give the specimen a time to break of 20 second [12 - 14]. The yarn abrasion resistance was investigated by using a Shirley yarn abrasion tester. The tester consists of two reciprocating bars: one is made of hardened steel and the other is covered with a standard abradant (P1500). Ten yarn specimens were tested simultaneously. The yarns were threaded from the fixed holders and clipped onto the flexible holders where sensors are attached. The initial tension exerted on each yarn was 0.5 N. When a yarn breaks, the flexible holder falls, a signal is sent to the control unit, and the number of rubs for that particular yarn is recorded. The yarn irregularity (CV%) per 1000 meter yarn length were obtained on an Uster Tester 3. To investigate yarn hairiness, we used a Zweigle G565 hairiness tester. The test speed was 50 m/min and yarn length was 100 m. Thus, the number of hairs longer than or equal to 3 mm per unit yarn length were investigated.

Results and discussions

The average test results of yarn count, twist, hairiness, tensile, evenness and abrasion properties for both Sirospun and Solo-Siro spun wool/polyester yarns are depicted in Table 2. The experimental results were statistically analysed using the "Paired T-test" method [9]. The results are discussed in proceeding sections.

Hairiness properties

The effect of the twist factor on Solo-Siro spun yarn hairiness is shown in Figure 3. It may be seen that the differences in the S3 hairiness values of Solo-Siro spun yarns at a 95% confidence limit are statistically significant. It may be considered that with an increasing twist factor within the range of 2530 to 3478, the yarn hairiness decreases. The reduction in yarn hairiness in Solo-Siro spun yarn with an increase in twist is in agreement with Chang and Wang [7]. However, at

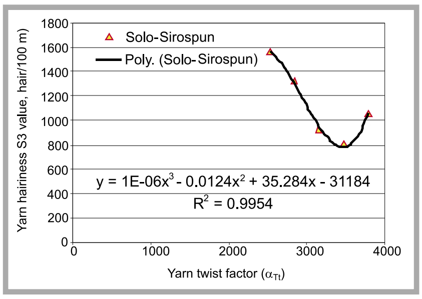

__Figure 3.__ Effect of yarn twist factor on hairiness properties (S3 Value) of Solo-Siro spun wool/polyester yarn.

a twist factor of 3795, the yarn hairiness in Solo-Siro spun yarn increases. It is postulated that at the highest value of the twist factor, the convergence point of two strands is displaced towards the front roller nip, and in turn causes the length of individual strands in contact with the Solospun roller to be decreased, and thus leads to an increase in yarn hairiness.

The S3 hairiness values of two yarn types are compared in Figure 4. Significance test results indicate that except for twist factors of 2530 and 2846, there is a statistically significant difference between the hairiness properties of Solo-Siro spun and Sirospun yarns. The significant reduction of yarn hairiness for blended wool/polyester Solo-Siro spun yarn compared with normal Sirospun yarn is in agreement with Shaikhzadeh Najar et.

*__Table 2.__ Sirospun and Solo-Siro spun wool/polyester yarn properties * (the CV% values are indicated in brackets).*

Yarn Characteristic	Yarn Type	Twist Factor (α_{Tt})				
		2530	2846	3162	3478	3795
Yarn count, tex	Sirospun	49.60 (0.74)	50.07 (0.63)	50.27 (0.87)	50.63 (0.54)	50.88 (1.40)
	Solo-Sirospun	47.93 (0.89)	48.40 (1.36)	49.04 (1.24)	48.85 (0.91)	49.87 (1.12)
Yarn twist, t.p.m.	Sirospun	352.63 (4.09)	369.27 (4.77)	450.14 (5.14)	501.72 (4.19)	555.67 (3.66)
	Solo-Sirospun	338.4 (3.6)	372.67 (4.59)	439.32 (3.19)	491.97 (3.47)	525.73 (4.35)
Hairiness, S3 value/100 m	Sirospun	1506.67 (19.43)	1639.5 (16.97)	1714 (23.0)	1452.33 (15.54)	1703.67 (12.28)
	Solo-Sirospun	1564.17 (11.95)	1322.67 (21.64)	992.33 (10.19)	803.83 (24.22)	1058.5 (15.43)
Yarn tenacity, cN/tex	Sirospun	14.3 (6.24)	14.12 (23.2)	14.5 (11.25)	14.3 (18.56)	13.66 (8.43)
	Solo-Sirospun	14.88 (8.28)	15.13 (8.46)	14.59 (8.87)	14.64 (15.51)	14.08 (16.36)
Elongation, %	Sirospun	22.29 (4.91)	22.45 (8.15)	22.17 (10.92)	23.84 (8.95)	22.54 (12.23)
	Solo-Sirospun	22.72 (6.4)	23.19 (6.56)	22.61 (8.32)	23.8 (8.15)	24 (8.13)
Evenness, CV_m, %	Sirospun	12.80 (2.31)	12.41 (2.73)	12.46 (0.70)	12.30 (1.66)	12.41 (1.46)
	Solo-Sirospun	14.1 (4.31)	12.98 (2.46)	12.82 (2.23)	12.9 (1.9)	12.9 (1.09)
Abrasion resistance	Sirospun	34.16 (73.44)	43.3 (75.81)	40.5 (62.68)	37.52 (57.94)	40.36 (53.89)
	Solo-Sirospun	34.52 (62.15)	42.4 (50.54)	38.12 (68.94)	45.54 (52.63)	40.88 (49.19)

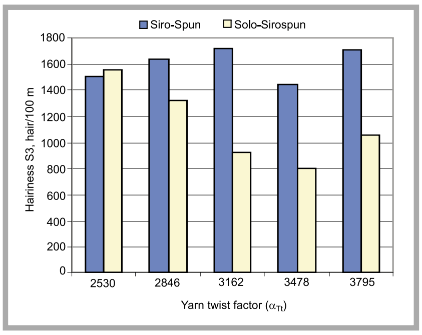

Figure 4. *Comparison of hairiness (S3 Value) of Sirospun and Solo-Siro spun wool/polyester yarns.*

al., [8]. It was shown that due to the small grooves of a Solospun roller, as a drafted strand enters into the nip of this roller, multi-strands are twisted and hence several smaller twist triangles are produced as a result of final twist transition [2, 4, 6]. Multi-strand twisting is also observed in a conventional ring spinning triangle [15]. It is implicated that this multi-strand twisting behaviour is more intensive and controllable for Solo-Siro spinning, resulting in yarn hairiness reduction. In addition, in Sirospun spinning more of the fibre ends appeared to be trapped by the "yarn-formation trapping mode", resultingin a reduction in yarn hairiness [16]. It is also reasonable to deduce

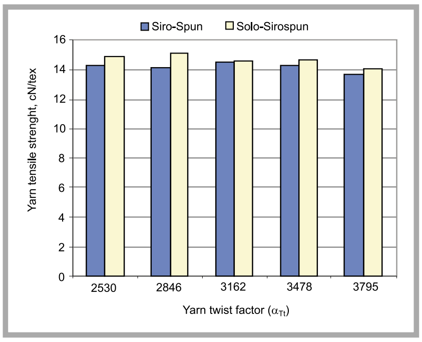

Figure 5. *Comparison of tensile strength of Sirospun and Solo-Siro spun wool/polyester yarns.*

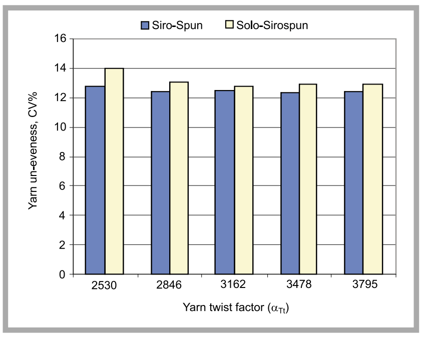

Figure 6. *Comparison of elongation of Sirospun and Solo-Siro spun wool/polyester yarns.*

that using a Solospun roller in Sirospun spinning causes the twist equilibrium at the twist triangle of Solo-Siro spinning to be cyclically perturbed. This cyclic twist perturbation is known to increase fibre trapping [17], which in turn is responsible for yarn hairiness reduction.

Tensile Properties

Figures 5 and 6 show the tensile strength and elongation of Sirospun and Solo-Siro spun yarns for different twist factors. Statistical analysis results show that at a 95% confidence limit the differences in the tensile property values are not statistically significant in the two yarn types.

Yarn unevenness:

Figure 7 compares the unevenness values of Sirospun and Solo-Siro spun yarns for different twist factors. It is shown that at a 95% confidence limit the differences in these values are statistically significant in the two yarn types. This is because the application of a Solospun roller in the Sirospun spinn-ing system slightly reduces both yarn twist and linear density. The reduction in yarn twist is due to the twist blockage mechanism of a Solospun roller. The slight reduction in yarn twist for Solo-Siro spun yarn results in a decrease in yarn linear density. As shown in Figure 7, the evenness of Solo-Siro spun yarns deteriorate more at the lowest twist factor. Experimental observations have also shown that there are a few end-breakages at this twist factor [9]. However, at twist factors of 2846 and 3162, the difference between the unevenness values of Solo-Siro spun and Sirospun yarns is not statistically significant. The slightly increased unevenness for Solo-Siro spun yarns could also be related to the large reduction in yarn hairiness [8]. An increase in yarn irregularity in conjunction with a significant reduction in hairiness was reported also by Cheng and Li [18] and Khan and Wang [19]. It was deduced that when coarse and long hair fibres are incorporated into the yarn body, localised unevenness may increase as a result of an increased concentration of fibre mass and the associated change in yarn thickness in the region [8].

Abrasion resistance

Figure 8 shows the abrasion resistance values of Sirospun and Solo-Siro spun yarns for different twist factors. It may be considered that at 95% confidence limit the differences in these values are

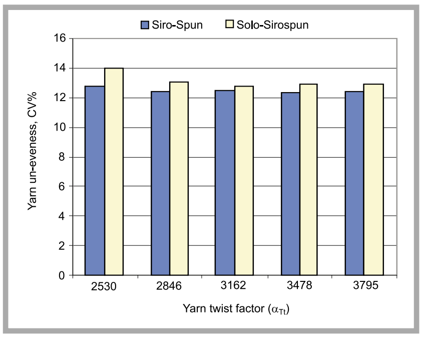

Figure 7. *Comparison of un-evenness (CV%) of Sirospun and Solo-Siro spun wool/polyester yarns.*

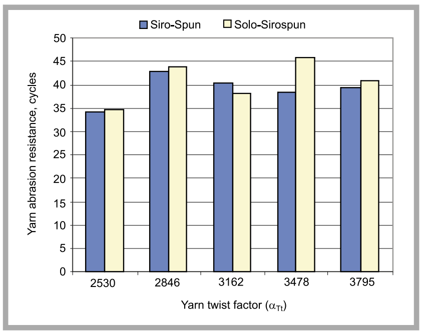

Figure 8. *Comparison of abrasion resistance of Sirospun and Solo-Siro spun wool/polyester yarns.*

not statistically significant for the two yarn types. However, at twist factor of 3478, the abrasion resistance of Solo-Siro spun yarn is significantly more than that of Sirospun yarn. The significantly increased abrasion resistance in the case of Solo-Siro spun yarn at a twist factor of 3478 could be related to the large reduction in yarn hairiness

Conclusion

The experimental results of this research indicate that wool/polyester blended worsted yarn is successfully produced in the new hybrid Solo-Siro spinning system in such a way that yarn specifications such as tensile strength, elongation and abrasion resistance remain almost un-changed. The results of this paper suggest that utilising a Solospun roller in the worsted Sirospun spinning system significantly improves worsted blended wool/polyester yarn hairiness. Further studies are needed to investigate the effect of spinning speed, the twist factor and blend ratio on the structural properties of Solo-Siro spun worsted blend yarns.

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