Effects of Solospun Roller on Properties of Cotton/Polyester Solo-Sirofil Composite Yarn

Rui-Hua Yang, Ph.D., Wei-Mian Wu, Hong-Bo Wang, Ph.D.,
Yu-Qin Wan, Ph.D., Chun-Ping Xie, Wei-Dong Gao

Jiangnan University, Wuxi, Jiangsu Province CHINA

Correspondence to:
Rui-Hua Yang email: yangrh@jiangnan.edu.cn

ABSTRACT

The surface characteristics of a solospun roller are important to the properties of solo-sirofil yarns. In this research, a three-level, three-factor, orthogonal experimental design (3^3) was used to investigate the effect of a solospun roller diameter, groove width and groove depth on the hairiness of cotton/polyester composite yarn. Solo-sirofil yarns with different solospun rollers were produced, and the hairiness was tested. It was shown that the hairiness of the solo-sirofil composite yarn was reduced by 44% compared to that of the sirofil. The structure of the solo-sirofil was improved when the thickness of the groove is 0.2 mm, with an alternating depth of 0.3 mm and 0.4 mm, a width of 0.5 mm and a roller diameter of 13 mm.

Keywords: solo-sirofil, cotton/polyester composite yarn, solospun roller, hairiness, structure.

INTRODUCTION

The hairiness of the staple-spun yarn should be controlled to meet the requirements of the high-grade fabric and weave. It has already become the focus of the spinning process and new spinning technologies based on a conventional ring spinning process. Compact spinning, siro-spinning, sirofil spinning and solospun spinning have been invented to reduce the hairiness of the yarns [1-6]. The most significant advantage of solospun yarns over conventional ring spun yarns is that the fibers are securely trapped within and between strands. The hairiness of the yarn is thus greatly reduced due to the specially designed solospun roller [7-9] reducing the fiber migration. Hearle, et al [10-12], indicated that the patterns of fiber migration within a yarn greatly influence the yarn properties, and controlling the fiber migration during spinning is an efficient way of controlling the yarn properties. The Solospun systems could control the fiber migration behavior with grooved solospun rollers mounted under the front bottom roller, as indicated in *Figure 1*. But, the strength and evenness of the solospun yarn is reduced [13-15]. By adding a filament to the spinning process, the strength and the characteristics of the yarn, which is called Solo-Sirofil composite yarn, can be greatly improved [16]. The main characteristics of solo-sirofil yarn are determined by the structure parameters of the solospun rollers, which affect the twist transfer degree and the twist triangle. In this paper, the structure parameters of the solospun rollers were optimized for the first time to produce a better solo-sirofil composite yarn.

EXPERIMENTAL

The parameters of the rollers are of critical importance to the characteristics of the solo-sirofil yarns, such as the thickness of the teeth, the diameter of the roller, and the width and depth of the groove. For thin teeth (as shown in *Figure 1*), fibers are easily damaged, therefore the teeth are frequently deformed, while for thick teeth, the dividing effects of the roller on a fiber strand weaken. According to our pre-experiments, 0.2 mm was chosen as the thickness of the teeth as shown in *Figure 2*.

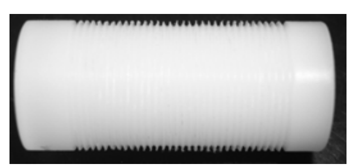

FIGURE 1. Solospun roller with thick teeth of 0.1mm.

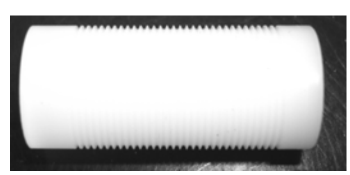

FIGURE 2. Solospun roller with thick teeth of 0.2 mm.

A three-level, three-factor, orthogonal design was used to investigate the effect of the roller diameter, groove width and groove depth on the yam hairiness. *Table I* gave the levels of the diameter, groove width and groove depth.

Pairs of solospun rollers and a filament guide were fitted onto an EJM-128K ring spinning frame for the solo-sirofil spinning process, as shown in *Figure 3*. A cotton sliver (mean fiber length: 25.4 mm, linear density: 1.5 dtex, Micronaire value: 3.43 and roving size: 5.0 g/10 m) and a polyester filament (25D) as the filament yarn were used to produce a 30tex/25D composite yarn. The spinning method was similar to the conventional core spun yarn. The pressure of the tongs mouth is 170 cN and the distance is 4.1 mm, while the back zone drafting is 1.32.

The yam samples were conditioned for at least 48 hours under standard conditions (65±2% RH and 20±2℃). In each experiment, three bobbins of each yam were spun simultaneously under the same conditions. Each bobbin was tested twice. Hairiness was tested at a speed of 30 m/min and length of 10m on an YG172 hair tester. Since 1-2 mm was considered to be a useful hairiness which contributes to the hand feel and 3-9 mm was a harmful hairiness which would be blocked when weaving or knitting [1]. The hairiness of the yarns was measured for 3-9 mm per 10 m.

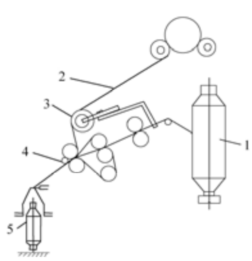

FIGURE 3. Schematic of solo-sirofil spinning process; 1) Roving, 2) Filament, 3) Filament guide roller, 4) Solospun roller, 5) Composite yarn.

RESULTS AND DISCUSSION

The experimental results demonstrated that the transfer of twist and the frequency of the yarn broken during the spinning process are affected by the diameter of solospun roller. The dividing effects of the drafted ribbon can be enhanced with a larger diameter, but on the other hand, the transfer of twist will be blocked.

To make sure that the drafted ribbon was divided well, 13 mm, 14 mm and 15 mm were chosen as the diameter of the rollers. *Table I* shows the level of the factors. *Table II* shows the results of the experiments. It revealed that the hairiness was the lowest when the diameter was 13 mm reducing the hairiness of 3-9 mm by 10.2 compared with 15 mm.

The width of the ribbon above the solospun roller was about 2.7 mm. We first tried 0.6, 0.7 and 0.8 mm respectively for the groove width. It was found that the hairiness was the lowest at 0.6 mm while the other parameters had the same results despite the groove width. Therefore, in the orthogonal design experiment, 0.4, 0.5 and 0.6 mm were chosen as the groove widths. From *Table II*, it could be found that the hairiness was the lowest when the width was 0.5 mm, a 37.5 reduction compared to the 0.4 mm groove width.

From *Table II*, it also can be seen that when the depth was alternately 0.4 mm and 0.3 mm, the transfer of the twist was smoother and the drafted ribbon could be divided into strands more easily and the hairiness was reduced by 72.9. Thus, the best parameters for the solo-roller are a diameter of 13 mm, a groove width of 0.5 mm and an alternating depth of 0.4/0.3 mm as shown by *Figure 4.*

FIGURE 4. Physical figure of solospun roller.

TABLE I. Factor levels.

Factor	Diameter (mm)	Width (mm)	Depth (mm)
Level 1	13	0.4	0.3/0.4 alternated
Level 2	14	0.5	0.4
Level 3	15	0.6	0.3

TABLE II. Experimental results.

Tests	Diameter (mm)	Width (mm)	Depth (mm)	3-9mm Hairiness/10m
1	1	1	3	53.50
2	1	2	1	31.10
3	1	3	2	65.8
4	2	1	1	44.5
5	2	2	2	52.60
6	2	3	3	56.3
7	3	1	2	71.3
8	3	2	3	48.10
9	3	3	1	41.2
S 1	150.4	169.3	116.8	
S 2	153.4	131.8	189.7	
S 3	160.6	163.3	157.9	
△	10.2	37.5	72.9	

Note: S1 = Summery of level 1, S2 = Summery of level 2, S3 = Summery of level 3.

CHARACTERISTICS OF SOLO-SIROFIL AND SIROFIL

30tex/25D composite yarns were produced using the sirofil spinning system with and without the optimized solospun roller. The hairiness was tested by a YG172 hair tester. The breaking characteristic was tested by a YG061 tensile tester under the extension rate of 250 mm/min and a pretension of 0.5 cN/tex. The yarn evenness was tested by YG135G with the yarn speed of 400 m/min and a testing time of 1 minute. In each experiment, three bobbins of each yarn were spun simultaneously under the same conditions. Each bobbin was tested twice. *Figure 5* demonstrates the averages of the results. Above 3 mm, the hairiness of the solo-sirofil was effectively reduced, compared to the sirofil at 68%. The breaking strength and yarn evenness of the two kinds of yarn were almost the same level. Breaking elongation and breaking work of solo-sirofil were higher than that of sirofil.

There were two important points to explain the result. Firstly, the fiber migration route was changed since the twist triangle zone was altered. Secondly, the fiber strands were twisted twice which reduced the hairiness. Due to the dividing effects of the solospun roller, a few twists were first added to the fiber strands that were divided from the drafted ribbon as they passed through the groove. Most of the twists were added as they passed over the groove at the apex of the twist triangle zone as shown in *Figure 6*.

Sirofil yarn has a filament in the core and staples in the sheath, which are used to achieve multi-functional performance. In general, the filaments carry the mechanical performance of the core yarn such as strength, elasticity, durability and dimensional stability. The staples determine the performance such as hand feel and moisture. So, the wrapping uniformity on polyester by the staples is critical to the characteristics of polyester/staple composite yarn.

The cross-sectional structure of both composite yarns was studied by making slices with a Harrington slicer to explore the wrap effect of the staples. In *Figure 7* and *Figure 8*, the red is dyed wool, the kidney is cotton and the round is polyester. It is demonstrated that the filament in the solo-sirofil composite yarn can be wrapped better than that of the sirofil. During the spinning process, with the located filament guide, the route of the filament can be guided much better by the groove of the solospun roller.

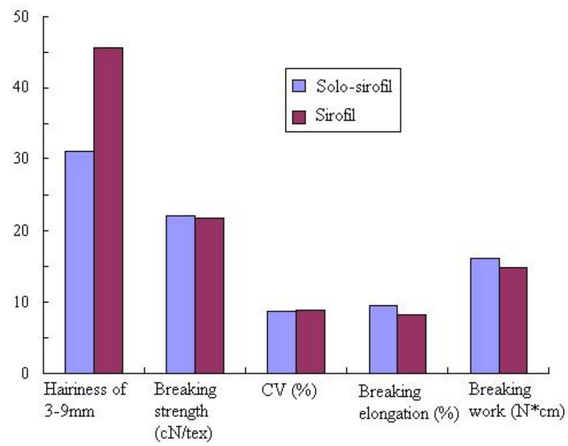

FIGURE 5. Characteristics of Solo-sirofil and sirofil.

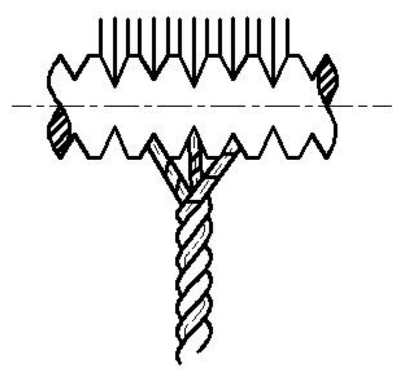

FIGURE 6. Twist analysis of solospun yarn

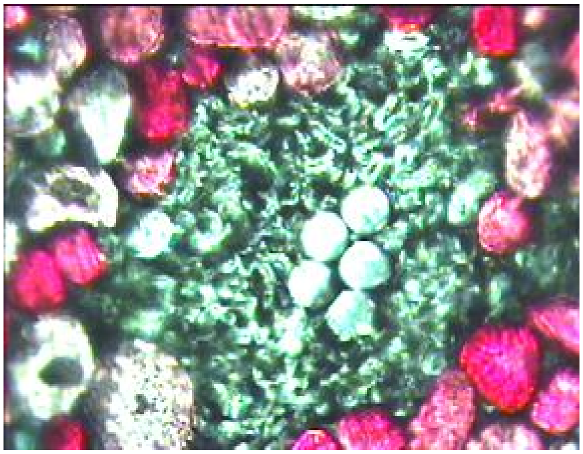

FIGURE 7. Cross section of solo-sirofil.

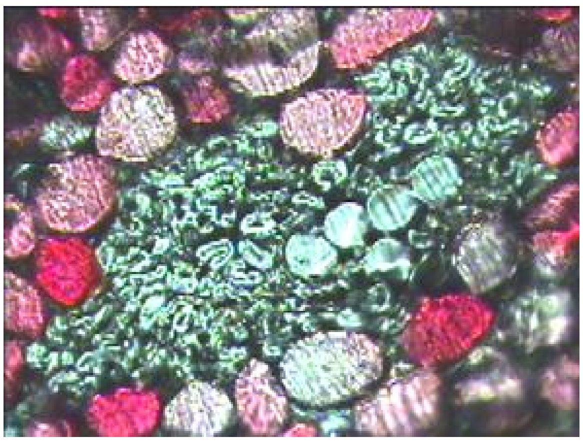

FIGURE 8. Cross section of sirofil.

SUMMARY AND CONCLUSIONS

The solospun roller of the solo-sirofil composite yarn for a cotton spinning system was studied and optimized. We came to the conclusion that the best parameters for the solospun roller are a teeth thickness of 0.2 mm, an alternating groove depth of 0.3 mm and 0.4 mm, a groove width of 0.5 mm and a roller diameter of 13 mm. With this solospun roller, the hairiness of the composite yarn was reduced to 68% of the sirofil with the same spinning parameters. The polyester of the solo-sirofil was better wrapped than that of the sirofil. Compared to sirofil, the breaking strength and yarn evenness of the solo-sirofil were almost the same, while the breaking elongation and breaking work were higher.

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AUTHORS' ADDRESSES
Rui-Hua Yang, Ph.D.
Wei-Mian Wu
Hong-Bo Wang, Ph.D.
Yu-Qin Wan, Ph.D.
Chun-Ping Xie
Wei-Dong Gao
Jiangnan University
1800 Lihu Avenue
Wuxi, Jiangsu Province 214122
CHINA