Rui-Hua Yang [1, 2]
Yuan Xue [3]
Shan-Yuan Wang [1]

Comparison and Analysis of Rotor-Spun Composite Yarn and Sirofil Yarn

[1)] **College of Textile, Donghua University,**
Shanghai, 201620, China
e-mail: yrhlh@mail.dhu.edu.cn

[2)] **Key Laboratory of Eco-Textiles (Jiangnan University), Ministry of Education,**
Wuxi, 214122, China

[3)] **College of Clothing and Art Design, Jiaxing University,**
Jiaxing, Zhejiang, 314001, China

Abstract
As a result of various spinning types, different kinds of yarns have different structures and performances. In this research we developed a composite yarn spinning system that produces different kinds of composite yarns containing filament on a modified rotor spinning frame. Rotor-spun composite yarn and sirofil were produced by a modified rotor spinning machine and a modified ring spinning machine, respectively. Their longitudinal views, abrasion resistance, hairiness and breaking strength were tested and analysed. The conclusion obtained was that, compared with sirofil, rotor-spun composite yarn has a smoother surface, less hairiness, higher abrasion resistance, lower breaking strength and better evenness.

Key words: *rotor-spun composite yarns, sirofil, longitudinal view, abrasion resistance, hairiness, breaking strength.*

Introduction

Compared with conventional staple fibre yarns, composite yarns made of staple fibres and filaments have a higher tenacity and improved irregularity, and they possess the properties of both filament yarns and staple fibre yarns [1]. Composite yarns can be produced by many kinds of machines and processes, such as ring, friction, and air-jet spinning, in which the ring spinning process is more commonly used [2]. Rotor spinning is adopted at present worldwide. Its main advantages over ring spinning are high yarn output rates, reduced production costs, increased bulkiness and improved evenness of yarns. However, the relatively low breaking strength and wrapper fibres of the yarn surface are still matters of concern [3 - 5]. These disadvantages may be improved by combining staple fibres with a continuous filament yarn in the rotor spinning process. Some researchers have studied the spinning conditions and characteristics of rotor-spun composite yarns [6 - 7]. A common problem with sirofil is the slippage of staple fibres relative to the filament, which gives a length of bare filament with a clump of fibres at one end. This effect, known as "strip back" or "barber pole", may lead to incomplete core coverage, and results in end-breaks in subsequent processing [8]. Thus it is necessary to study and research more about the different kinds of filament/staple composite yarn spinning systems.

In this paper, rotor-spun composite yarn and sirofil were produced. Their longitudinal view, abrasion resistance, hairiness and strength were tested and investigated.

Experimental

Preparation of yarn samples

For rotor-spun composite yarn, we used a cotton sliver (mean fibre length - 25.4 mm, fibre linear density - 1.5 dtex, Micronaire value of the fibre - 3.43 and sliver size - 17.533 g/5 m) as the staple fibre, and a polyester filament (50D) as the filament yarn fed into the rotor. A schematic diagram of the rotor spinning process modified is shown in ***Figure 1***. The filament yarn was fed from a supply bobbin by means of a tension device and suitable guides to the filament feed rollers, then passed straight through the filament guide tube and drawn into the rotor freely by suction, in which the filament yarn was combined with the staple fibre strand to form the composite yarn. Then the composite yarn was drawn through the doffing tube and finally on to the take-up roller. The filament guide tube was positioned along the axis of rotation of the hollow rotor shaft, which rotated freely about it. Some of the spinning parameters for the rotor-spun composite yarn were as follows: yarn linear density - 50 tex, opening roller speed - 7000 r.p.m, rotor speed - 45,000 r.p.m (rotor diameter - 50 mm), twist factor - 440.

For sirofil we used a cotton sliver (mean fibre length - 25.4 mm, linear density of the fibre - 1.5 dtex, Micronaire value of the fibre - 3.43 and roving size - 5.0 g/10 m) and a polyester filament (50D) as the filament yarn in the modified ring spun system. A schematic diagram of the ring spun modified is shown in ***Figure 2***. Sirofil spinning uses a filament yarn with a staple fibre roving which are fed separately and kept at a fixed distance to the nip of the front drafting roller, as shown in ***Figure 2***; they make up a triangular zone which is twisted together to form the sirofil composite yarn. Some of the spinning parameters for sirofil were as follows: yarn linear density - 50 tex, twist factor - 440.

Testing the yarn structure and properties

The longitudinal view of the yarn was observed with a Questar Hi-scope video microscope system. Abrasion resistance tests were carried out at a test length of 9 cm and pretension of 0.5 cN/tex on an abrasion resistance tester [15] made by Donghua University. The breaking strength and elongation were determined at a test length of 500 mm, extension rate of 250 mm/min and pretension of 0.5 cN/tex on a YG061 tensile tester.

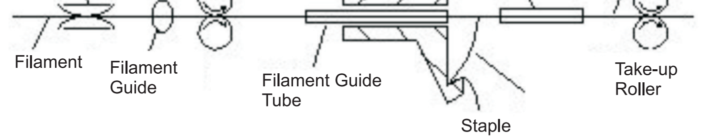

Figure 1. *Schematic diagram of the rotor-spun composite yarn spinning process.*

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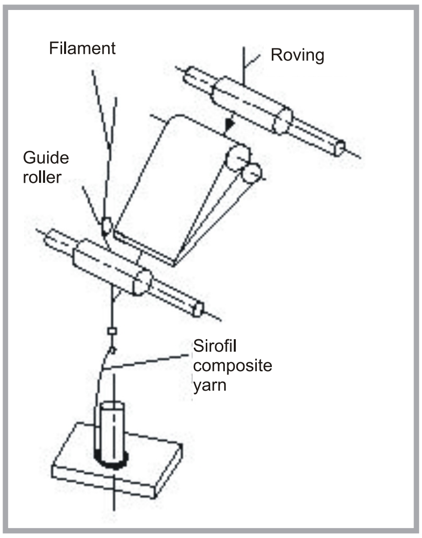

Figure 2. Schematic diagram of the sirofil spinning process.

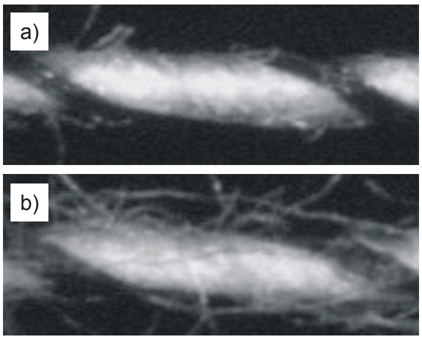

Figure 3. Longitudinal views of composite yarns; a) Rotor-pun composite yarn, b) Sirofil composite yarn.

Hairiness was tested at a testing speed of 30 m/min and test length of 10 m on a YG172 hair tester. The hairiness was measured for 1 - 10 mm per meter. All the tests were performed in a standard atmosphere of 20 ± 2 °C and 65 ± 2% RH.

Results and discussion

Longitudinal view

Magnified longitudinal photographs of rotor-spun composite yarn and sirofil are shown in ***Figure 3***. It can be seen that rotor-spun composite yarn has a smoother surface than sirofil. Rotor-spun yarn is known to have a skin-core structure consisting of a central core that resembles ring spun yarn, as well as an outer sheath containing a random disarray of fibres and wrappers [9 - 12]. During the spinning process of composite yarns, the morphology of wrapper fibres of rotor-spun composite yarn on the cotton strand surface becomes tighter and clearer than that of the sirofil because of the different types of insertion and wrapping of the filament.

Photographs of abraded rotor-spun composite yarn and sirofil are shown in ***Figure 4***. Having been abraded 100 times, both the rotor-spun composite yarn and sirofil had hairiness. While the rotor-spun composite yarn was becoming more hairy, the sirofil was beginning to have long hairiness and neps. After 200 abrasions, the rotor-spun composite yarn had long hairs, becoming more hairy. Between 150 - 200 times, some hairs and neps of the sirofil had been abraded, and their long hairs and neps were still increasing. After 200 abrasions, each sirofil yarn had 3 - 5 neps, five of which were broken.

From ***Table 1*** it can be seen that the hairiness of rotor-spun composite yarn is much less than that of sirofil. The 1-3mm hairiness of rotor-spun composite yarn was decreased by 83.5% compared to that of sirofil; 4 - 6 mm, 93.8%; and 7 - 9 mm, 92.65%. In ***Table 1***, when the length of hair increases by 1 - 5 mm, the CV% of rotor-spun composite yarn has a tendency to increase; however, when it is by 5 - 9 mm, it decreases. At the same length of hair from 1 - 6 mm, the CV% of sirofil is much lower than that of rotor-spun composite yarn. At the same length of hair from 7 - 9 mm, the CV% of sirofil is much higher than that of rotor-spun composite yarn, which means that the rotor-spun composite yarn spinning process is effective in decreasing the long length of hair. Furthermore, the force of pulling fibre from rotor-spun composite yarn and the CV% were higher than those for sirofil, as in ***Table 2***. The cotton fibre breaking strength was 3.5 - 4.5 cN [13], hence the force of pulling fibre from the yarn was lowerthan the average breaking strength of the fibre, Thus, pulling fibre from the yarn was achieved without breakage. From these results it can be seen that, compared with sirofil, the

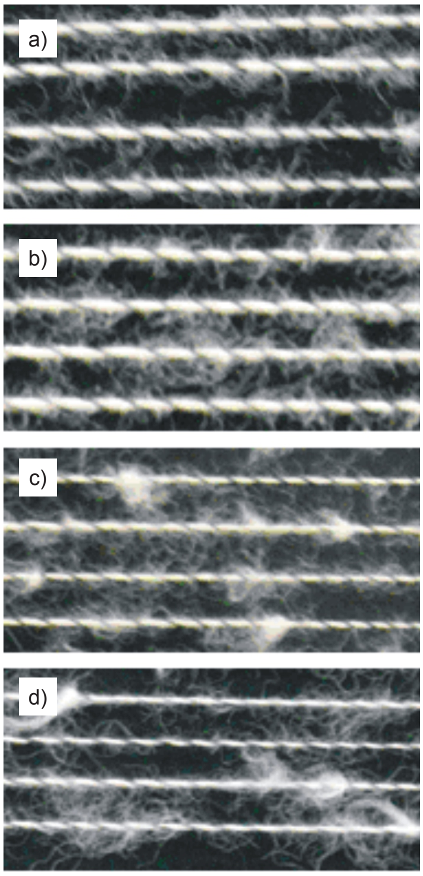

Figure 4. Abraded composite yarns; a) rotor-spun composite yarn after being abraded 100 times, b) rotor-spun composite yarn after being abraded 200 times, c) sirofil yarn after being abraded 100 times, d) sirofil yarn after being abraded 200 times.

Table 1. Hairiness test results of composite yarns.

Length of hair, mm	Rotor-spun composite yarn		Sirofil	
	Hairiness	CV, %	Hairiness	CV, %
1	15.02	11.71	83.67	5.42
2	1.44	32.63	14.24	11.94
3	0.22	82.78	2.93	21.41
4	0.04	187.76	0.73	42.28
5	0.02	218.33	0.24	70.29
6	0.01	207.50	0.12	85.96
7	0.01	155.83	0.06	212.10
8	0.00	0.00	0.02	163.33

Table 2. Test results of the tensile of pulling fibre from composite yarn.

Test Items	Tensile of pulling fibre from surface of yarn, cN	CV, %
Rotor-spun composite yarn	3.59	65.60
Sirofil	3.48	60.29

Table 3. *Breaking strength test results of composite yarns.*

Test Items		Breaking strength, cN	Breaking intensity, cN/tex	Breaking elongation, mm	Work of breaking, cN·mm	Time of breaking, s	Initial modulus, N/mm^2
Rotor-spun composite yarn	Average value	727.85	14.557	47.355	174.35	11.365	1.943
	CV%	4.946	4.946	5.053	10.065	5.054	8.138
Sirofil	Average value	778	16.731	40.254	160.863	9.661	2.426
	CV%	8.657	8.657	9.429	13.27	9.43	11.175

structure of rotor-spun composite yarn is more compact with lower evenness.

As for the differences in spinning types, various kinds of yarns have different properties. During the spinning process of sirofil, the friction and colliding of yarns, as well as the balloon and separator made it easier for the yarns to attain hairiness and pilling. Because of the high speed of the rotor, the filaments and fibres of the rotor-spun composite yarn combined in their own special way. From the results of hairiness tests, it can be seen that this special way greatly improved the abrasion resistance of rotor-spun composite yarn.

Strength

Results of the breaking strength tests are listed in ***Table 3***. Compared with sirofil, the breaking strength of rotor-spun composite yarn decreased by 13%; the CV% decreased by 43% (the breaking uniformity was much improved); the initial modulus decreased by 20%; the elongation at break improved by 17%; the work of breaking increased by 8.4%, and the flexibility was enhanced. The breaking strength of rotor spun yarns decreased by 10% - 20% compared with that of ring spun yarn [14]. Comparing the results, it can be seen that the spinning style is the most important factor for the breaking strength of yarns. Furthermore, with filament, the breaking uniformity of rotor spun yarn greatly improved.

Summary

Rotor-spun composite yarn was produced on a modified rotor spun machine. Sirofil yarn was produced on a modified ring spun machine. The results showed that the appearance of rotor-spun composite yarn is clearer and tighter than that of sirofil. The abrasion resistance of rotor-spun composite yarn was higher than that of sirofil. The force of pulling fibres from rotor-spun composite yarn was higher than that for sirofil. Sirofil developed hairiness and pilling more easily. The hairiness of rotor-spun composite yarn was much less than sirofil. The 1 - 3 mm hairiness of rotor-spun composite yarn decreased by 83.5% compared to that of sirofil; 4 - 6 mm, 93.8%; and 7 - 9 mm, 92.65%. The breaking strength of rotor-spun composite yarn decreased by 13%. The initial modulus decreased by 20%. It was also shown that the rotor-spun composite yarn had improved evenness. Compared with sirofil, rotor-spun composite yarn has a smoother surface, less hairiness, higher abrasion resistance and less strength with improved eveness.

Acknowledgment

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