

Xuzhong Su<sup>1</sup>,  
Weidong Gao<sup>2</sup>,  
Xinjin Liu,  
Chunping Xie,  
Bojun Xu

School of Textile and Clothing,

\*Key Laboratory of Eco-Textile,  
Ministry of Education,  
Jiangnan University,  
Wuxi 214122, P. R. China

Corresponding authors,  
1)E-mail:mfguvcv@163.com.  
2)E-mail:gaowd3@163.com.

# Research on the Compact-Siro Spun Yarn Structure

## Abstract

*Compact-Siro spinning technology is one of the most widely used spinning methods. It is conducted on a compact ring frame by simultaneously feeding two rovings into the drafting zone at a predetermined separation. In fact, Compact-Siro spinning incorporates the features of both Compact and Siro-spinning systems. In this paper, the structure of Compact-Siro spun yarn is investigated. By using a DZ3 video microscope, the horizontal structure of Compact-Siro spun yarn, Sirospun yarn, Compact yarn and Ring spun yarn were obtained. It is shown that compared with Compact single yarn, Compact-Siro spun yarn has a more compact and clear surface structure, a more uniform and smooth shape, and less hairiness. Then the cross section structure of Compact yarn and Compact-Siro spun yarn were obtained by using Hardy's Y172 thin cross-section sampling device and the DZ3 video microscope. It is shown that compared with Sirospun yarn, the cross-section of Compact-Siro spun yarn is smoother and closer to being circular. Meanwhile in the Compact-Siro spun yarn body, the fibers of two substrands show axial symmetrical distribution approximately, which is beneficial for spun yarn qualities, especially for improving the yarn evenness and hairiness. Finally the results obtained were illustrated in spinning experiments.*

**Key words:** Compact-Siro spinning, yarn structure, sections.

Siro-spinning is another of the most widely used new spinning methods, invented by the Division of Textile Industry Laboratories of the CSIRO in Australia and IWS together around 1975 – 1976. It is conducted on a conventional ring frame by simultaneously feeding two rovings into the apron zone at a predetermined separation [4]. Compact-Siro spinning technology is the combination of both Compact and Siro-spinning. It is conducted on a compact ring frame by simultaneously feeding two rovings, and incorporates the features of both Compact and Siro-spinning systems. Therefore the advantage of Compact-Siro spinning technology is that it has greater effect on improving spun yarn qualities, and studies of these advantages will be presented by analysing Compact-Siro spun yarn structures in this paper.

Research on Compact Spinning has attracted more and more attention recently [5, 6]. At present, pneumatic compact spinning is the most widely used, utilising the airflow force to condense the fibre bundle in order to decrease and even eliminate the spinning triangle and improve the qualities of spun yarn [5]. Therefore research on the flow field in the condensing zone is always the emphasis and difficulty of pneumatic Compact Spinning [7]. As an effective new spinning technology, research on Siro-spinning has also attracted more and more attention at present, especially convergence point analysis, which plays an important role in controlling the stability of the spinning procedure and qualities of spun yarn

[8], and many interesting results have been established [8 - 10]. Meanwhile a comparison of the properties of cotton combed yarns produced with ring and modified ring spinning methods including compact yarn, Sirospun yarn, and Solospun yarn was presented [11 - 13], and a new approach to predict the migratory properties of these four different kinds of spun yarns were introduced using an Artificial Neural Network in [14]. However, the analysis on Compact-Siro spun yarn is rare, therefore the Compact-Siro spun yarn structure is investigated in this paper.

## Horizontal structure analysis of Compact-Siro spun yarn

The qualities of spun yarn are mainly determined by the properties of fibres and yarn structures. Therefore, in the study, all the yarns are made of cotton fibres with a fibre length of 28.4 mm, fibre

## Introduction

Yarn properties are mainly affected by the yarn structure, which is primarily determined by the spinning process [1]. In fact, each spinning process tends to produce a distinctive yarn structure. In recent years, the technical improvement of spinning has brought great strides in yarn quality, such as Siro-spinning, Compact spinning technology, and so on. Compact Spinning is one of the most important improvements in traditional ring spinning, which is implemented by adding a fibre condensing device on a ring spinning frame to condense the fibre bundle and decrease or even eliminate spinning triangles, with the spun yarn structure and quality having a qualitative development since the fibre tension distributions in the spinning triangle are more uniform [2, 3].

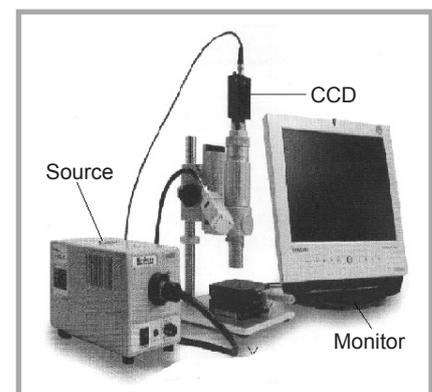


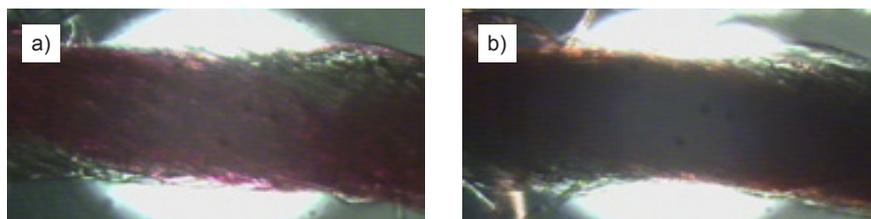
Figure 1. DZ3 video microscope.

strength of 24.3 cN/tex, and Micronaire value of 4.3. And a comparative analysis of a horizontal structure of 29.2 tex Compact-Siro spun yarn and Sirospun yarn will be presented in order to fully understand and predict the performance of yarn.

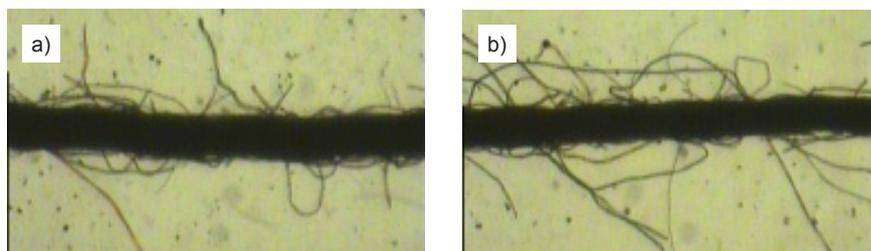
### Horizontal structure analysis before detwisting

In this section, a horizontal structure of yarn before detwisting will be analysed. For capturing images of the yarn surface structure, the DZ3 video microscope was employed, which includes a light source, CCD lens, transmission fibre, X-Y mobile platform, and monitor, as shown in *Figure 1*. Then taking one sample of Compact-Siro spun yarn and Sirospun yarn, respectively, and putting them on a glass slide, images of yarn can be captured by DZ3 video microscope at  $2.5 \times 350$  and  $2.5 \times 25$  times amplification, respectively, as shown in *Figures 2* and *3*. From *Figure 2*, it is easy to see that the two kinds of yarn have obvious helical structures in the Z twist direction. From *Figure 3*, it is easy to see that compared with Sirospun yarn, Compact-Siro spun yarn has less hairiness, and the existing long hairiness is almost end hairiness, whereas Sirospun yarn has much more hairiness, and it is random. One possible explanation is that the more exposed head-end of the fibre would be rolled into the yarn body by the condensing device in Compact-Siro spinning. To illustrate this phenomenon, images of Compact-Siro spun and Sirospun yarn were also captured by H-7000 Electronic Transmission Microscope at  $80\times$ , as shown in *Figure 4*.

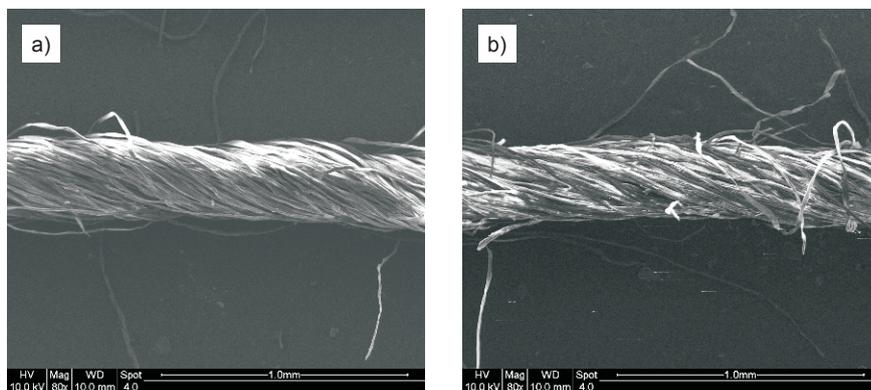
In the following, to fully understand and predict the performance of yarn, the horizontal structures of Compact-Siro spun yarn, Sirospun yarn, Compact yarn and Ring spun yarn will be analysed comparatively. First samples are wound around the glass slide and images of yarn can be captured by DZ3 video microscope at  $2.5 \times 350$  times amplification, as shown in *Figure 5*. It is shown that compared with Compact single yarn, Compact-Siro spun yarn has a more compact and clear surface structure, a more uniform and smoother shape, and less hairiness. Meanwhile it is found that Compact-Siro spun yarns have lower hairiness than Sirospun yarns, and better evenness than ring spun yarns. One possible explanation is that during the Compact-Siro spin-



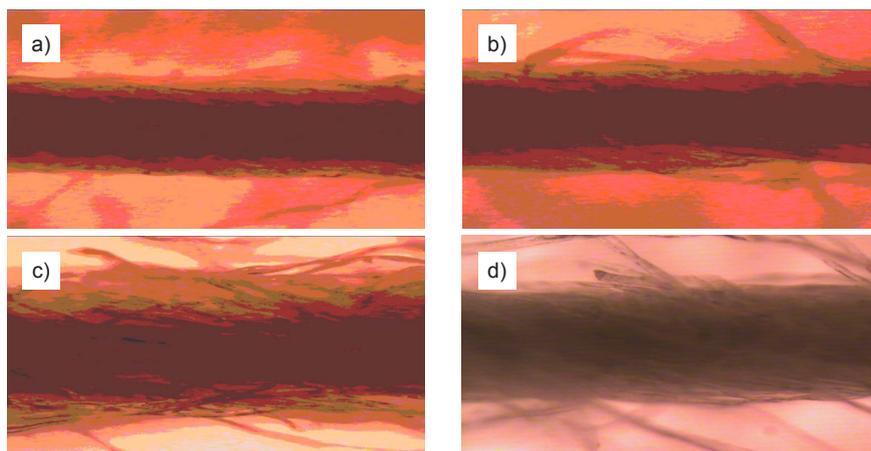
*Figure 2.* Images of yarn captured by DZ3 video microscope at  $2.5 \times 350$  times amplification: a) Compact-Siro spun yarn, b) Sirospun yarn.



*Figure 3.* Images of yarn captured by DZ3 video microscope at  $2.5 \times 25$  times amplification: a) Compact-Siro spun yarn, b) Sirospun yarn.



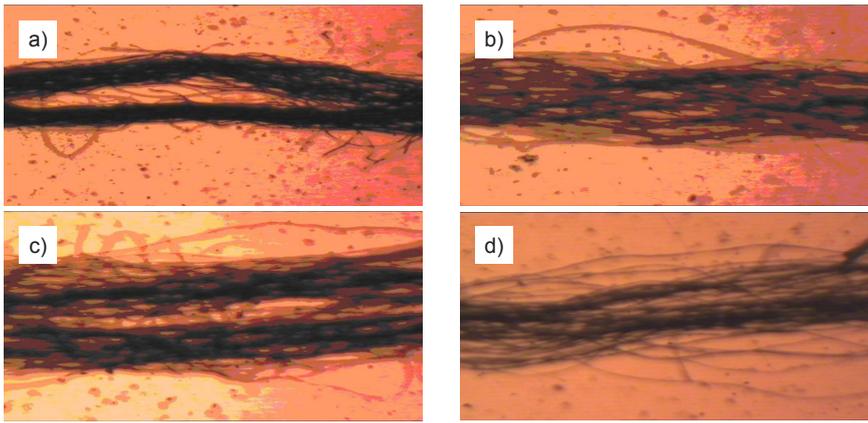
*Figure 4.* Images of yarn captured by H-7000 electronic transmission microscope at 80 times amplification: a) Compact-Siro spun yarn, b) Sirospun yarn.



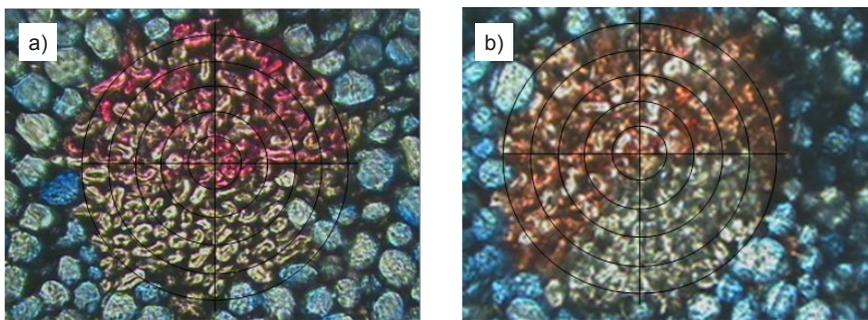
*Figure 5.* Images of yarn captured by DZ3 video microscope at  $2.5 \times 350$  times amplification: a) Compact-Siro spun yarn, b) Compact yarn, c) Sirospun yarn, d) Ring spun yarn.

ning process, the final spinning triangle between the two substrands is greatly decreased by the condensing device, and the separation of fibre from the yarn body or the embedding of fibre from one substrand to another would be greatly de-

creased or even disappear, which makes the fibre neat and straight in the spun yarn body. Meanwhile during the twisting process, the twist in the twisting point can be transferred to two substrands easily due to the final reduction of the spinning tri-



**Figure 6.** Images of yarn captured by DZ3 video microscope at  $2.5 \times 350$  times amplification: a) Compact-Siro spun yarn, b) Compact yarn, c) Sirospun yarn, d) Ring spun yarn.



**Figure 7.** Images of yarn captured by DZ3 video microscope at  $2.5 \times 350$  times amplification: a) Compact-Siro spun yarn, b) Sirospun yarn.

**Table 1.** Spinning parameters.

Yarn types	Linear density, tex	Total draft	TM	Traveller type
Compact	483	16.457	3.9	C1UL 2/0
Ring				
Compact-Siro		33.030		
Sirospun				

**Table 2.** Yarn evenness.

Yarn types	Evenness CV, %	Nep (+200%), $\text{km}^{-1}$	Thick (+50%), $\text{km}^{-1}$	Thin (-50%), $\text{km}^{-1}$
Compact-Siro	10.06	0	0	0
Sirospun	10.44	0	0	4
Compact	10.28	0	1	3
Ring spun	11.01	0	0	3

**Table 3.** Yarn hairiness.

Yarn types	1 - 2 mm hairiness, $10 \text{ m}^{-1}$	3 - 9 mm hairiness, $10 \text{ m}^{-1}$
Compact-Siro	804.7	13.5
Sirospun	914.7	22.0
Compact	829.2	15.4
Ring spun	1081.8	51.4

**Table 4.** Yarn breaking strength.

Yarn types	Breaking force, cN	Breaking force CV, %	Elongation at break rate, %	Elongation at break rate CV, %
Compact-Siro	625.4	4.6	5.1	3.6
Sirospun	580.9	4.0	5.2	3.1
Compact	607.3	4.1	5.1	3.8
Ring spun	562.5	5.8	4.9	5.2

angle, i.e. the twisting of Compact-Siro spun yarn and two substrands carried out simultaneously. In fact, there would be low twist existing in the two substrands before twisting a final Compact-Siro spun yarn, which strengthens fibre control during the spinning process and improves yarn qualities.

#### Horizontal structure analysis after detwisting

In this section, the horizontal structure after detwisting will be analysed, and images of the yarn can be captured by DZ3 video microscope at  $2.5 \times 350$  times amplification, as shown in **Figure 6**. It is shown that after detwisting, compared with Sirospun yarn, Compact-Siro spun yarn clearly has more of a double-ply structure, and fibres in the yarn body are neater and straighter. Moreover the arrangement of fibres in each ply are more orderly. Meanwhile compared with Ring spun yarn, compact spun yarn clearly has more of a one-ply structure, and fibres in the yarn body are also neater and straighter. One possible explanation is that condensing can act upon substrands before twisting the final spun yarn, which can straighten out fibres and make the structure of ply yarn more obvious.

#### Cross section structure analysis of Compact-Siro spun yarn

In this section, a comparative analysis of the cross section structure of 29.2 tex Compact-Siro spun yarn and Sirospun yarn will be presented. Images of the cross section structure of spun yarns can be obtained as follows: First the spun yarns should be parcelled in blue wool fibres. Then the section samples can be obtained by using Hardy's Y172 thin cross-section sampling device, and corresponding images of the yarn section can be captured by DZ3 video microscope at  $2.5 \times 350$  times amplification, as shown in **Figure 7**. It is seen that compared with Sirospun yarn, the cross-section of Compact-Siro spun yarn is smoother and closer to being circular. Meanwhile in the Compact-Siro spun yarn body, the fibres of two substrands show axial symmetrical distribution approximately, which is beneficial for spun yarn qualities, especially for improving the yarn evenness and hairiness. One possible explanation is that compared with Siro-spinning, the fibres can be condensed sufficiently before twisting the final spun yarn in the Compact-Siro spinning process.

## ■ Experiments

In this section, the conclusions obtained above will be verified by experiments. Combed roving of 4.83 g/10 m was used as raw material. Then Ne 20 (29.2 tex) Compact-Siro spun yarn, Sirosun yarn, Compact yarn and Ring spun yarn were spun in a modified EJM 128k ring spinning frame. Details of the spinning parameters are shown in *Table 1*.

Taking ten bobbin yarns as measuring samples, they were conditioned for at least 48 hours under standard conditions before testing ( $65 \pm 2\%$  RH and  $20 \pm 2$  °C). Yarn hairiness, strength, and evenness were measured. The test instruments were as follows: single yarn tester YG063, hairiness tester YG172A, and evenness tester YG135G. For each bobbin yarn, the hairiness was tested ten times using the YG172A hairiness tester at 100 m/min speed and 5 g pre-tension, for a test time of 1 minute. and the average value of ten test results for the hairiness of one bobbin yarn was calculated. The breaking force was also tested ten times on the YG063 fully automatic single yarn strength tester at a speed of 500 mm/min with a pretension 1.8 cN/tex, and the average value of ten test results of the breaking force of this one bobbin yarn was taken. The evenness was established once by the YG135G evenness tester at a speed of 400 m/min for one bobbin yarn. Finally the average values of ten bobbin yarns were taken as the corresponding qualities of spun yarn. The qualities of the spun yarns measured are shown in *Tables 2 - 4*.

From the results measured, it is found that Compact-Siro spun yarn has the best comprehensive qualities. Furthermore it is shown that compact spinning technology can reduce yarn hairiness by 1 - 2 mm and 3 - 9 mm harmful hairiness.

## ■ Conclusions

In this paper, the structure of Compact-Siro spun yarn was studied. From the horizontal structures of spun yarns captured by DZ3 video microscope, we know that compared with Compact single yarn, Compact-Siro spun yarn has a more compact and clear surface structure, a more uniform and smoother shape, and less hairiness. From the cross section structures of spun yarns captured by Hardy's Y172 thin cross-section sampling device and DZ3 video microscope, we know that compared with Sirosun yarn, the

cross-section of Compact-Siro spun yarn is smoother and closer to being circular. Furthermore in the Compact-Siro spun yarn body, the fibres of two substrands show axial symmetrical distribution approximately, which is beneficial for spun yarn qualities, especially for improving the yarn evenness and hairiness. Finally the results obtained were illustrated by spinning experiments.



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# XXI Seminar on 'New Aspects of the Chemistry and Applications of Chitin and Its Derivatives'

## INVITATION

On behalf of the Board of the Polish Chitin Society I have both a pleasure and an honour to invite you to participate in the **XXI Seminar on "New Aspects of the Chemistry and Applications of Chitin and Its Derivatives"** which will be held in **Szczecin, Poland, September 16<sup>th</sup> – 18<sup>th</sup>, 2015**.

The aim of the conference is to present the results of recent research, development and applications of chitin and chitosan.

It is also our intention to give the conference participants working in different fields an opportunity to meet and exchange their experiences in a relaxing environment.

Best regards  
Malgorzata M. Jaworska  
Ph.D., D.Sc., Eng.

### For more information please contact:

CONFERENCE SECRETARY  
M. Sklodowskiej-Curie 19/27,  
90-570 Łódź, Poland  
tel. (+48) 42 638 03 339,  
fax (+48) 42 637 62 14,  
e-mail: ptchit@ibwch.lodz.pl  
www.ptchit.lodz.pl