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# Research on the Qualities of Cellulosic Yarn

DOI: 10.5604/01.3001.0010.7793

## Abstract

Cellulosic fibre is a kind of renewable fibre that has attracted more and more attention in textile processing recently. Yarn spinning is the first fundamental process in textile processing. Therefore, in this paper, taking viscose fibre and tencel fibre as examples, the qualities of cellulosic yarn were studied. Three kinds of pure viscose and tencel yarn: 14.6 tex (40<sup>s</sup>), 9.7 tex (60<sup>s</sup>) and 7.3 tex (80<sup>s</sup>), were spun on a ring spinning system modified with lattice apron compact spinning (LACS) and complete condensing spinning (CCS), respectively. The spun yarn qualities, yarn evenness, breaking strength and hairiness, were tested and comparatively analysed. Then two kinds of cellulosic blend yarn including 14.6 tex, 9.7 tex and 7.3 tex JC/R 60/40 yarn, and 14.6 tex, 9.7 tex and 7.3 tex JC/T 70/30 yarns were spun on a ring spinning system modified with CCS. The spun yarn evenness, breaking strength and hairiness were tested, and the cross sections of the spun yarns were presented using a Y172 Hardy's thin cross-section sampling device. The results show that for both the pure viscose and tencel yarn, compared with LACS, CCS has better yarn evenness, a little lower yarn breaking strength and a little more hairiness, while the uniformity of yarn qualities are all improved. For the cellulosic blend yarn, compared with the pure cellulosic yarn, yarn evenness is worse, especially for the cotton and tencel blend yarn.

**Key words:** cellulosic yarn, yarn quality, compact spinning, super high draft ring spinning.

## Introduction

Cellulosic fibre is a kind of renewable fibre which is produced by using cellulose [1]. Recently cellulosic fibre has attracted more and more attention in textile processing due to its advantages with respect to healthy environmental protection. The cellulosic fibres commonly used are tencel, viscose, modal, and so on. Yarn spinning is the first fundamental process in textile processing [2, 16]. At present, ring spinning is the most widely used spinning method [3]. In ring spinning, yarn is formed on a spinning triangle, the geometry of which influences the distribution of fibre tension in the spinning triangle and affects the properties of spun yarn directly [4]. On the spinning triangle, yarn hairiness will be produced since the head and tail of the border fibre cannot be rolled into the yarn body easily. Therefore, taking appropriate measures to change the spinning triangle geometry actively and thus improve the quality of yarn has attracted great interest in the spinning of yarn [5, 6, 14].

Compact spinning is one of the most widely used improvements in traditional ring spinning at present, in which one kind of fibre condensing device is employed on a ring spinning frame in order

to decrease the spinning triangle, due to which the spun yarn quality shows great improvement [7-9]. The pneumatic compacting system is the most widely used compact system at present, which is implemented by air flow to condense the fibre bundle [10]. Compact spinning with a perforated drum and lattice apron are the two main kinds of pneumatic compacting devices, in which the perforated drum and lattice apron are used for fibre condensing, respectively [11].

Complete condensing spinning (CCS) is a kind of compact spinning with a perforated drum, in which a kind of perforated drum with a strip groove structure on the surface is equipped [12]. Lattice apron compact spinning (LACS) is one of the most widely used compact spinning systems at present [13, 15]. Therefore, in this paper, taking viscose fibre and tencel fibre as examples, the qualities of cellulosic yarn spun by compact spinning CCS and LACS were investigated and comparatively analysed.

## Pure cellulosic yarn

### Pure viscose yarn

CCS is a kind of pneumatic compact spinning, in which the front roller of the original ring spinning frame is replaced by a kind of perforated drum with a strip groove structure on the surface (**Figure 1**). The perforated drum is made of stainless steel with 56HRC hardness, and the diameter is 50 mm, which is different from that used in COM4. There are two top rollers above the perforated drum: the

front top roller and output top roller, and a corresponding front nip and output nip can be produced. The area between the front nip and output nip is the condensing zone. In the spinning, airflow can be directed on fibres located in the condensing zone. Meanwhile, for improving the condensing effect, a kind of guiding device is installed above the perforated drum.

In the following section, pure viscose yarns were spun on the ring spinning system modified with LACS and CCS, respectively. The spun yarn qualities were tested and comparatively analysed. Combed viscose roving of 512 tex was used as raw material. Then 14.6 tex, 9.7 tex and 7.3 tex pure viscose yarns were spun on the ring spinning system modified with LACS and CCS, respectively. The detailed spinning parameters are shown in **Table 1**. Taking ten bobbin yarns as measuring samples, all were conditioned for at least 48 hours under standard conditions ( $65 \pm 2\%$  RH and  $20 \pm 2$  °C). The evenness (CV), hairiness index and breaking strength of the spun yarn were tested. For each bobbin yarn, the hairiness was tested ten times using a YG173A hairiness tester (Suzhou Changfeng Textile Electromechanical Technology Co., Ltd., China) at a speed of 100 m/min, for a test time of 1 minute. Then the average value of ten test results for the hairiness of one bobbin yarn was taken. The breaking force of yarns was also tested ten times on a YG068C fully automatic single yarn strength tester (Suzhou Changfeng Textile Electromechanical Technology Co., Ltd., China) at a speed of 500 mm/min, and the average value of ten test results

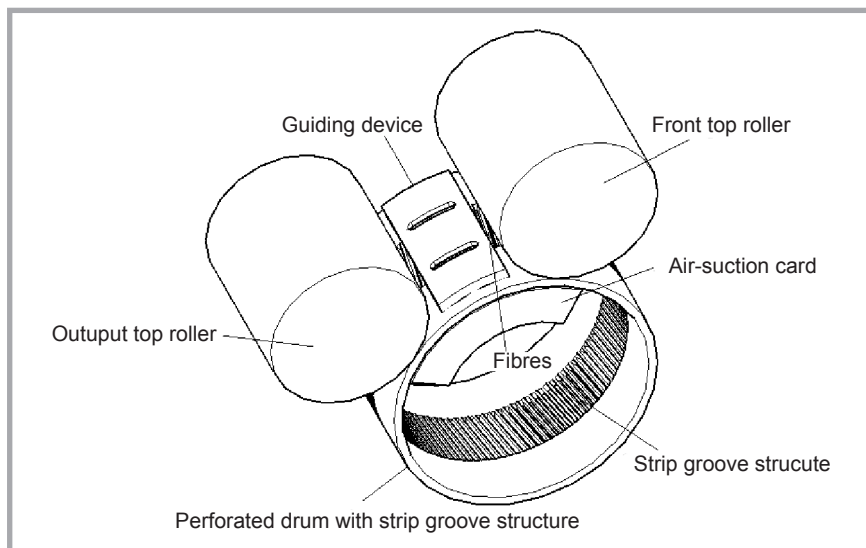
for the breaking force of one bobbin yarn was taken. Meanwhile the evenness was obtained once by an Uster tester 5-S800 (Uster Technologies, Switzerland) evenness tester at a speed of 400 m/min. for a test time of 1 minute, and the average value of the evenness for one bobbin yarn was taken. Finally the average values of ten bobbin yarns were taken as the corresponding qualities of the spun yarn, corresponding results for which are given in **Tables 2-4**.

From the spinning parameters in **Table 1**, we can see that, compared with the LACS, the negative pressure in the CCS is lower for the same spun yarn count; that is, compared with LACS, CCS is beneficial for reducing energy consumption.

Evenness is one of the most important properties of yarn. The results of spun yarn evenness measured are presented in **Table 2**. According to Uster Statistics 2013, results of spun yarn evenness can be achieved at a 25% significance level. As shown in **Table 2**, it is obvious that compared with LACS, CCS has better evenness CVm and CVb, and corresponding -50% thin places, +50% thick places and +200% neps were also a little less; that is, compared with LACS, CCS is beneficial for improving viscose yarn evenness.

Yarn strength is another of the most significant properties of yarn. The results of spun yarn breaking strength measured are given in **Table 3**. According to Uster Statistics 2013, results of spun yarn breaking strength can be achieved at a 25% significance level. As shown in **Table 3**, it is obvious that compared with LACS, CCS has a little lower yarn breaking strength, but the breaking strength CV of yarn is a little better. For the elongation at break of yarn, the difference between the LACS and CCS is tiny, but the elongation at break CV of CCS is a little lower; that is, compared with LACS, although the average breaking strength value of yarn spun using the CCS is decreased, the uniformity is increased.

Hairiness is also one of the most important properties of spun yarn. The results of spun yarn hairiness measured are given in **Table 4**. According to Uster Statistics 2013, the results of spun yarn breaking strength can be achieved at a 50% significance level. From **Table 4**, it is evident that compared with LACS, CCS has a little more harmful long hairiness ( $\geq 3$  mm)



**Figure 1.** Condensing zone of CCS.

**Table 1.** Spinning parameters of pure viscose yarn.

Spinning method	Yarn count, tex	Negative pressure, Pa	Twist factor	Draft multiple
CCS	14.6	2800	360	36.52
	9.7	2600	380	54.77
	7.3	2400	400	69.38
LACS	14.6	3200	360	36.52
	9.7	3000	380	54.77
	7.3	2800	400	69.38

**Table 2.** Test results of pure viscose yarn evenness.

Spinning method	Yarn count, tex	CVm, %	CVb, %	Thin (-50%), km <sup>-1</sup>	Thick (+50%), km <sup>-1</sup>	Neps (+200), km <sup>-1</sup>
CCS	14.6	11.76	1.64	0	20	5
	9.7	12.87	2.32	0	10	30
	7.3	13.86	2.84	0	40	65
LACS	14.6	11.93	1.78	0	25	45
	9.7	12.92	2.67	0	15	50
	7.3	13.92	3.09	0	50	80

**Table 3.** Test results of pure viscose yarn breaking strength.

Spinning method	Yarn count, tex	Elongation at break, %		Breaking strength, cN		Yarn tenacity, cN/tex
		AVG	CV	AVG	CV	AVG
CCS	14.6	15.70	10.12	284.72	10.31	19.50
	9.7	13.81	13.64	186.74	9.95	19.25
	7.3	12.86	18.53	132.91	11.34	18.21
LACS	14.6	15.55	14.02	287.96	10.98	19.72
	9.7	13.94	14.47	185.74	10.07	19.15
	7.3	12.70	19.19	135.86	12.03	18.61

**Table 4.** Test results of pure viscose yarn hairiness.

Spinning method	Yarn count, tex	$\geq 1$ mm, (10 m) <sup>-1</sup>		$\geq 2$ mm, (10 m) <sup>-1</sup>		$\geq 3$ mm, (10 m) <sup>-1</sup>	
		AVG	CV	AVG	CV	AVG	CV
CCS	14.6	475.8	4.32	65.4	7.18	10.5	11.79
	9.7	373.7	7.22	48.8	9.19	6.5	15.58
	7.3	308.1	7.57	45.2	13.48	5.1	19.45
LACS	14.6	455.6	6.81	61.3	13.12	9.2	12.41
	9.7	369.8	7.31	45.7	14.07	6.6	18.97
	7.3	311.8	7.78	43.0	16.06	4.3	20.71

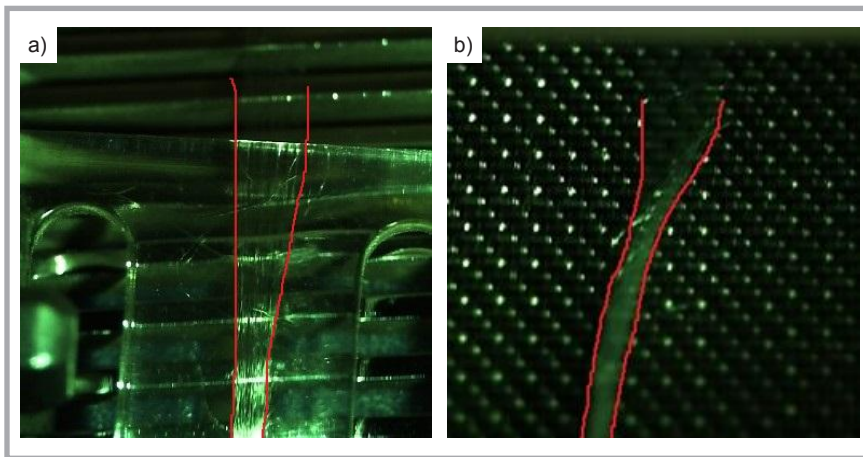


Figure 2. Viscose fibre movement in the condensing zone of 9.7tex yarn: a) CCS, b) LACS.

Table 5. Test results of pure tencel yarn evenness.

Spinning method	Yarn count, tex	CVm, %	CVb, %	Thin (-50%), km <sup>-1</sup>	Thick (+50%), km <sup>-1</sup>	Neps (+200), km <sup>-1</sup>
CCS	14.6	12.32	1.35	0.3	7	21
	9.7	13.07	2.13	6	15	40
	7.3	13.68	2.94	17	25	52
LACS	14.6	12.49	1.48	1	14	20
	9.7	13.30	2.26	9	19	48
	7.3	14.12	3.01	20	31	59

Table 6. Test results of pure tencel yarn breaking strength.

Spinning method	Yarn count, tex	Elongation at break, %		Breaking strength, cN		Yarn tenacity, cN/tex
		AVG	CV	AVG	CV	AVG
CCS	14.6	7.72	10.12	264.48	7.83	18.12
	9.7	6.53	13.64	211.52	8.65	21.81
	7.3	5.81	18.53	162.69	11.79	22.29
LACS	14.6	7.96	12.02	267.86	8.31	18.35
	9.7	6.84	13.47	213.57	9.24	22.02
	7.3	5.62	22.19	165.89	11.39	22.73

Table 7. Test results of pure tencel yarn hairiness.

Spinning method	Yarn count, tex	≥1 mm, (10 m) <sup>-1</sup>		≥2 mm, (10 m) <sup>-1</sup>		≥3 mm, (10 m) <sup>-1</sup>	
		AVG	CV	AVG	CV	AVG	CV
CCS	14.6	495.6	4.58	60.3	6.89	11.6	9.68
	9.7	396.5	6.59	45.6	7.58	8.4	8.58
	7.3	320.7	7.23	42.9	8.69	6.3	8.05
LACS	14.6	479.8	6.17	59.6	7.56	10.9	11.26
	9.7	379.5	7.49	44.9	8.78	7.5	10.05
	7.3	314.6	7.85	43.1	9.65	5.9	9.68

Table 8. Spinning parameters of cellulosic blend yarn.

Yarn kind	Yarn count, tex	Negative pressure, Pa	Twist factor	Draft multiple
JC/R 60/40	14.6	2800	360	35.3
	9.7	2600	380	52.92
	7.3	2400	400	70.53
JC/T 70/30	14.6	2800	360	32.63
	9.7	2600	380	48.93
	7.3	2400	400	65.21

and beneficial short hairiness (1-2 mm), but the hairiness CV is improved a little. That is, compared with CCS, LACS is more beneficial for reducing yarn hairiness, including 1-2 mm short hairiness and ≥3 mm long hairiness.

### Pure tencel yarn

In the next section, pure tencel yarns were spun on the ring spinning system modified with LACS and CCS, respectively. Combed tencel roving of 512 tex was used as raw material. Then 14.6 tex, 9.7 tex and 7.3 tex pure tencel yarns were spun. The detailed spinning parameters are shown in Table 1.

The results of spun tencel yarn evenness measured are presented in Table 5. According to Uster Statistics 2013, the results of spun yarn evenness can be achieved at a 25% significance level. From Table 5, it is obvious that compared with LACS, CCS has a little better evenness CVm and CVb, and corresponding -50% thin places, +50% thick places and +200% neps were also a little less. That is, compared with LACS, CCS is beneficial for improving tencel yarn evenness. The results of spun tencel yarn breaking strength measured are given in Table 6. According to Uster Statistics 2013, the results of spun yarn breaking strength can be achieved at a 25% significance level. From Table 6, it is obvious that for the breaking strength, compared with LACS, the yarn spun on CCS is a little lower, but the breaking strength CV is a little better. For the elongation at break of yarn, the difference between the LACS and CCS is tiny, but the elongation at break CV of CCS is a little lower.

The results of spun yarn hairiness measured are given in Table 7. According to Uster Statistics 2013, the results of spun yarn breaking strength can be achieved at a 50% significance level. From Table 7, it is evident that compared with LACS, CCS has a little more harmful long hairiness (≥3 mm) and beneficial short hairiness (1-2 mm), but the hairiness CV is improved a little.

In a word, the test results of pure viscose and tencel yarn qualities show that compared with LACS, CCS has better yarn evenness, a little lower yarn breaking strength and a little more hairiness, with the uniformity of yarn qualities all being improved. The possible reason is that in the condensing zone of LACS, the

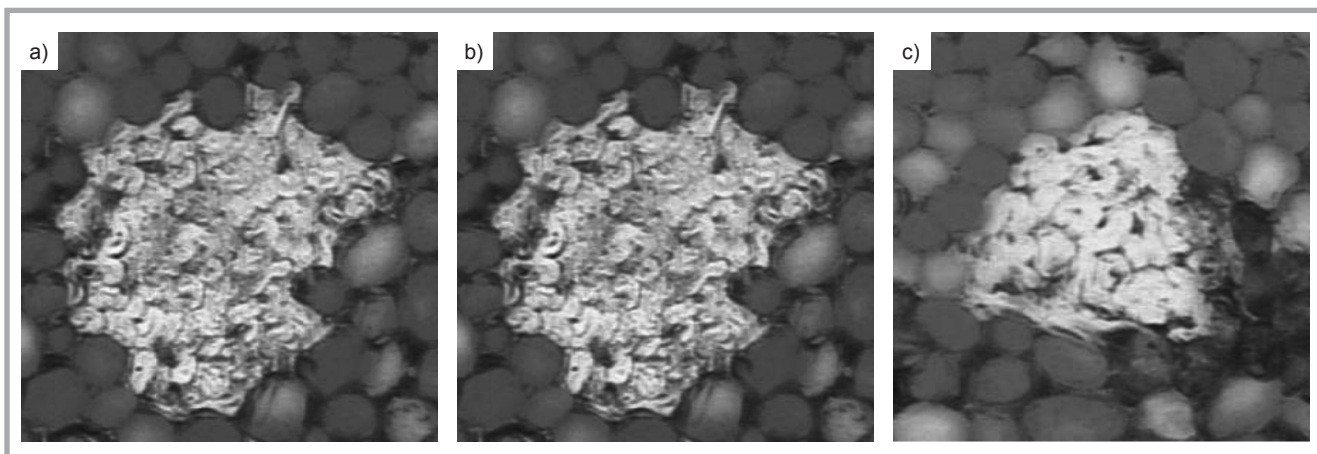


Figure 3. Cross sections of JC/R 60/40 yarns: a) 14.6 tex, b) 9.7 tex, c) 7.3 tex.

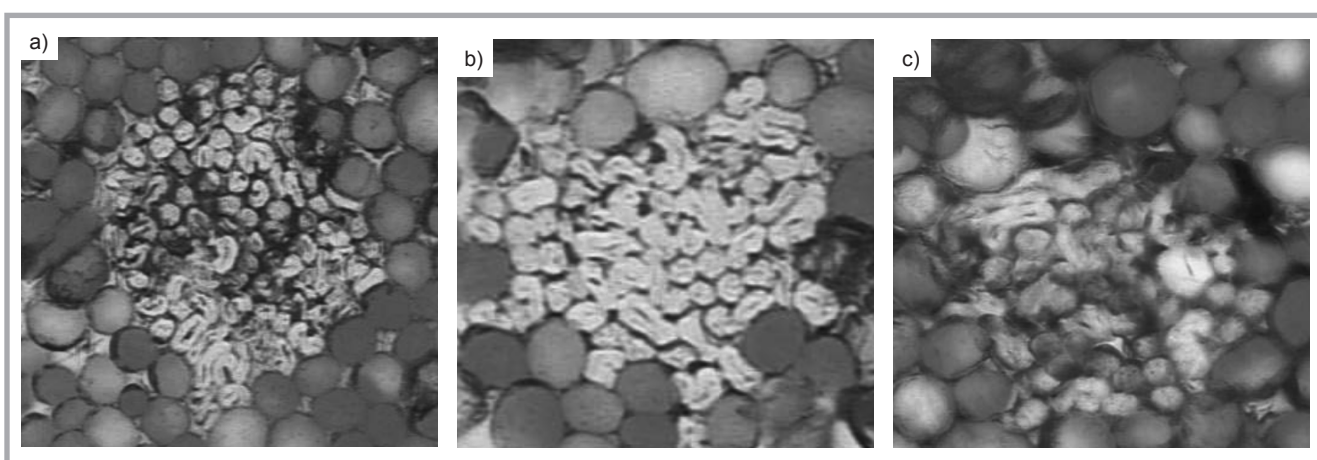


Figure 4. Cross sections of JC/T 70/30 yarns: a) 14.6 tex, b) 9.7 tex, c) 7.3 tex.

fibres are made to cling to the surface of the lattice apron under the force of negative airflow, and the right border fibres begin to flip to the left and cover the left border fibres, producing weak twisting and making the fibre strand compact, see **Figure 2.b**. However, in the condensing zone of CCS, the fibres are made to cling to the surface of the perforated drum and are arranged parallel to each other. Then the fibres move forward along with the rotation of the perforated drum, and the width of the strand decreases gradually under the transverse condensing force, making the fibre strand compact, see **Figure 2.a**, which is beneficial for improving the uniformity of spun yarn qualities. For viscose fibre, the length of the fibre is a little larger, and the friction between fibres is also larger, which makes fibre compaction towards the center of the yarn body a little more difficult. Therefore, compared with the twist condensing in LACS, the transverse condensing force of the parallel condensing in CCS

Table 9. Test results of cellulosic blend yarn evenness.

Yarn kind	Yarn count, tex	CVm, %	CVb, %	Thin (-50%), km <sup>-1</sup>	Thick (+50%), km <sup>-1</sup>	Neps (+200), km <sup>-1</sup>
JC/R 60/40	14.6	12.18	10.46	0.0	30.0	70.0
	9.7	14.33	11.85	20.0	110.0	230.0
	7.3	15.46	12.81	70.0	200.0	265.0
JC/T 70/30	14.6	12.75	10.14	0.00	15.00	15.00
	9.7	14.34	11.42	55.00	60.00	80.00
	7.3	15.30	12.83	70.00	110.00	125.00

Table 10. Test results of cellulosic blend yarn breaking strength.

Yarn kind	Yarn count, tex	Elongation at break, %		Breaking strength, cN		Yarn tenacity, cN/tex
		AVG	CV	AVG	CV	AVG
JC/R 60/40	14.6	5.45	8.85	257.84	10.29	17.6
	9.7	4.73	10.98	158.17	11.36	16.19
	7.3	4.05	11.46	116.55	12.05	15.90
JC/T 70/30	14.6	6.61	7.78	266.48	11.02	18.19
	9.7	6.25	12.37	169.31	12.44	17.33
	7.3	5.59	11.49	121.09	12.95	16.52

**Table 11.** Test results of cellulosic blend yarn hairiness.

Yarn kind	Yarn count, tex	≥1 mm, (10 m) <sup>-1</sup>		≥2 mm, (10 m) <sup>-1</sup>		≥3 mm, (10 m) <sup>-1</sup>	
		AVG	CV	AVG	CV	AVG	CV
JC/R 60/40	14.6	495.2	6.97	59.5	10.75	8.7	12.19
	9.7	453.1	9.15	47.3	11.95	6.0	13.17
	7.3	400.6	10.36	42.6	12.65	4.8	14.47
JC/T 70/30	14.6	491.8	5.84	69.0	11.37	6.5	13.19
	9.7	434.1	6.58	43.2	12.48	5.3	13.88
	7.3	400.3	8.83	41.2	13.04	4.7	14.89

**Table 12.** Fibre properties.

Properties	Tencel	Viscose	Cotton
Dry tenacity, cN/tex	42-48	20-25	25-30
Wet tenacity, cN/tex	26-36	10-15	26-32
Dry elongation at break, %	10-15	18-23	14-16
Wet elongation at break, %	10-18	22-28	12-14
Wet initial modulus, cN/tex	250-270	40-50	100-150

is a little smaller, making it more difficult for border viscose fibre to roll into the yarn body, and producing a little more hairiness correspondingly. For the yarn breaking strength, in the condensing process of LACS, weak twist is produced, making the twist of the final yarn also increase and possibly the yarn strength larger. For the yarn evenness, the parallel condensing in CCS can make the fibre condensed more stable, which is beneficial for improving yarn evenness.

### Cellulosic blend yarn

In this section, cellulosic blend yarns were spun on a ring spinning system modified with CCS. JC/R 60/40 yarn (60% combed cotton fibre and 40% viscose fibre) and JC/T 70/30 yarn (70% combed cotton fibre and 30% tencel fibre) were spun. For the JC/R 60/40 yarn, combed roving of 517 tex was used as raw material, and 14.6 tex, 9.7 tex and 7.3 tex yarns were spun. For the JC/T 70/30 yarn, combed roving of 478 tex was used as raw material, and 14.6 tex, 9.7 tex and 7.3 tex yarns were spun. Details of the spinning parameters are shown in **Table 8**. The results of spun yarn qualities measured are given in **Tables 9-11**.

The results of the cellulosic blend spun yarn qualities tested, i.e. yarn evenness, breaking strength and hairiness are given in **Tables 9-11**, respectively. From the test results, we can see that compared with the pure viscose and tencel yarn, the blend yarn evenness is worse, especially for cotton and tencel blend yarn. The fibres properties used are presented in **Table 12**. from which we can see that com-

pared with the viscose and cotton fibre, the wet initial modulus of tencel fibre is the largest, but the dry and wet elongation at break is the smallest, which makes tencel fibre in the drafting zone brittle fracture easily, produces more neps, and possibly makes the yarn evenness worse. Meanwhile compared with the pure yarn, the blend yarn breaking strength is also slightly worse. For the hairiness, the difference between the pure cellulosic yarn and cellulosic blend yarn is tiny.

To study the blend yarn qualities further, using a Y172 Hardy thin cross-section sampling device, cross sections of the spun yarns are presented in **Figures 3, 4**. From the figures, we can see that in the yarn body, the arrangements of two fibres are centralised, that is, fibre migration in the yarn body is less. The possible reason is that in the CCS, the spinning triangle is reduced greatly, and the difference in fibre tensions in the spinning triangle is decreased greatly. Therefore the uniformity of fibres in the yarn body is improved greatly, which is beneficial for improving yarn qualities.

### Conclusions

In this paper, taking viscose fibre and tencel fibre as examples, the qualities of cellulosic yarn were studied. Three kinds of pure viscose and tencel yarn, 14.6 tex, 9.7 tex and 7.3 tex, were spun on a ring spinning system modified with LACS and CCS, respectively. The spun yarn qualities, yarn evenness, breaking strength and hairiness were tested. The results show that for both pure viscose and tencel yarn, as compared with

LACS, CCS has better yarn evenness, a little lower yarn breaking strength, and a little more hairiness, with the uniformity of yarn qualities is improved for all. The possible reason is that in the LACS, weak twisting is produced, which makes the fibre strand compact, while in the CCS, the transverse condensing force of the parallel condensing affects the fibre and makes the fibre strand compact, which is beneficial for improving the uniformity of spun yarn qualities.

Two kinds of cellulosic blend yarn, including 14.6 tex, 9.7 tex and 7.3 tex JC/R 60/40 yarn as well as 14.6 tex, 9.7 tex and 7.3 tex JC/T 70/30 yarn, were spun on a ring spinning system modified with CCS. The spun yarn evenness, breaking strength and hairiness were tested. It is shown that compared with pure cellulosic yarn, the cellulosic blend yarn evenness is worse, especially for the cotton and tencel blend yarn. The possible reason is that compared with the viscose and cotton fibre, the wet initial modulus of tencel fibre is the largest, but the dry and wet elongation at break is the smallest, which makes the tencel fibre in the drafting zone brittle fracture easily, produces more neps, and makes the yarn evenness worse. Then by using a Y172 Hardy thin cross-section sampling device, cross sections of the spun yarns were obtained. It is shown that in the compact yarn body, the arrangements of two fibres are centralised, that fibre migration in the yarn body is less, and that the uniformity of fibres in the yarn body can be improved greatly.

### Acknowledgements

This work was supported by the Natural Science Foundation of Jiangsu Province (BK20170169), Henan Collaborative Innovation of the Textile and Clothing industry (hnfz14002), National Engineering Laboratory for Advanced Textile Processing and Clean Production (GCSYS201701), State Key Laboratory for Hubei New Textile Materials and Advanced Processing Technology (ZDSYS201701), Prospective industry-university-research project of Jiangsu Province (BY2016022-27), Prospective industry-university-research project of Guangdong Province (2013B090600038), A project of the Xinjiang Uygur Autonomous Region Key Research and Development (2016B02025-1), A project funded by the Priority Academic Program Development of Jiangsu Higher Education Institutions (PAPD), the Industrial Support Project of Suqian City (H201612, H201607), and Fundamental Research Funds for the Central Universities (JUS-RP51731B).

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Received 04.05.2016      Reviewed 19.09.2016



# 8TH EUROPEAN ALGAE INDUSTRY SUMMIT

25-26 APRIL 2018 - VIENNA, AUSTRIA

ACI

Following the success of its previous editions, **ACI's 8<sup>th</sup> European Algae Industry Summit** will explore the ongoing developments of **the algae industry**. With insights from key industry players, the conference will address **both the technical and commercial aspects of algae production and its end-uses**, in Europe and across the globe.

This edition of the summit will highlight **different case studies on the various uses & products** made from algae, during dedicated sessions.

The two day event will also propose an in-depth look into the **technologies supporting the industry**. The participants will also have the chance to discuss how to **keep the industry thriving as a whole**, through **best practices & lessons learnt**, as well as ensuring sustainability.

Join us in **Vienna** for a **highly interactive & informative conference**, whilst enjoying the **networking opportunities with your peers**.

**More information:**  
<http://www.wplgroup.com/aci/event/european-algae-industry-summit/>