

*Xuzhong Su^{1,2},
**Weidong Gao^{1,2},
Xinjin Liu^{1,2},
Chunping Xie^{1,2},
Bojun Xu^{1,2}

Research on the Performance of a Drafting Device for the Four-Line Compact Spinning System

DOI: 10.5604/12303666.1191426

¹School of Textile and Clothing,
Jiangnan University,
Wuxi 214122, P. R. China
*E-mail: mfgucv@163.com

²Key Laboratory of Eco-Textile,
Ministry of Education,
Jiangnan University,
Wuxi 214122, P. R. China
**E-mail: gaowd3@163.com

Abstract

Compact spinning is one of the most important improvements of traditional ring spinning, which is implemented by adding a fibre condensing device to condense the fibre bundle and decrease the spinning triangle, thereby improving the qualities of yarn. Pneumatic compact spinning is the most widely used compact spinning method at present. Four-line compact spinning is one of the most important kinds of pneumatic compact spinning, which is implemented by using a Lattice apron to achieve fibre condensing, decrease the spinning triangle and improve the yarn qualities, especially reducing yarn hairiness. In this paper, the performances of drafting devices for Four-line compact spinning were studied. First the structure and performance of an SDDA2122PH pneumatic cradle equipped with a new kind of block top roller retaining bar were discussed and the pressure distribution of the cradle presented firstly. Then 7.3 tex T65/JC35 was spun on an EJM128K spinning frame equipped with an SDDA2122PH pneumatic cradle, the pressure distributions measured, and the spun yarn qualities were measured and analysed accordingly. Then the acting mechanism of three kinds of top pin: a common top pin without a press bar, a top pin with a front pressure bar, a top pin with a back pressure bar, with respect to yarn qualities was analysed firstly, and then JC 18.2 tex, JC60/T40 18.4 tex and T 18.4 tex yarns were spun on an EJM128K spinning frame equipped with different top pins. Then the qualities of the spun yarns were analysed according to the acting mechanism of the top pin. The results show that by using the new block top roller retaining bar, the pressure of the pneumatic cradle is larger and more stable, thereby improving the spun yarn's comprehensive qualities. For cotton yarn, we can reduce yarn hairiness by using a top pin with a pressure bar; for chemical fibre and cotton blended yarn, yarn strength can be improved by using a top pin with a pressure bar; and for chemical fibre pure yarn, the usage of a top pin with a pressure bar is beneficial for improving yarn strength and evenness, but not for yarn hairiness and yarn thin and thick places.

Key words: Four-line compact spinning system, yarn quality, top pin, cradle, drafting devices.

Introduction

Ring spinning is the yarn spinning method most widely used at present. There are nearly 1.5 billion spindles in China [1]. However, in the ring spinning process, there is a relatively large spinning triangle, which is not beneficial for spun yarn qualities, especially yarn hairiness [2]. Therefore taking appropriate measures to change the spinning triangle geometry in the ring spinning to improve the quality of yarn has attracted more and more interest recently [3 - 5,10]. Compact Spinning is one of the most important improvements in traditional ring spinning, which is implemented by adding a fibre condensing device to a ring spinning frame in order to decrease the spinning triangles, and consequently the spun yarn quality has great improvement, especially reducing yarn long hairiness [5, 6, 11].

In the general case, according to the condensing method, there are two kinds of compact spinning system: the pneumatic compact and mechanical compact spinning systems [6]. The pneumatic compact system is the compact system most widely used at present, in which the fibre bundle is condensed by airflow [7]. Compact spinning with a hollow roller and lattice apron are the two main kinds of pneumatic compact spinning systems, in which a hollow roller and lattice apron are used for fibre condensing, respectively [6].

Compact spinning with a lattice apron is the pneumatic compact spinning method most widely used now, which comprises nearly 95% of the spinning market [8]. The Three-line and Four-line compact spinning systems are the two main kinds

of Lattice apron compact spinning systems [9]. Recently the Four-line compact spinning system has been used more and more widely due to its better performance for improving yarn comprehensive qualities and its relative low price. In the Four-line compact spinning system, one kind of shaped tube is installed at the front of the front roller, and the lattice apron is covered with a shaped tube. In compact spinning, the fibre strand coming from the draft zone can be condensed firstly, and then rolled into a yarn body under the twist effects, and then the final yarn is spun. Therefore, besides the condensing device, the performance of the drafting device in the compact spinning system also has a great influence on spun yarn qualities. In view of this, the performances of drafting devices of Four-line compact spinning were studied in this paper.

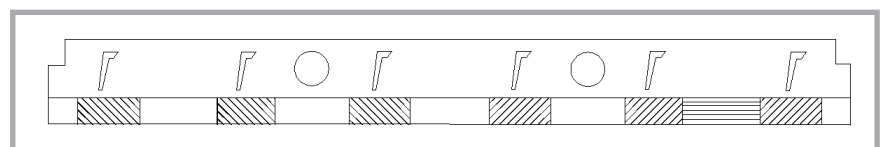


Figure 1. Shaped tube.

Two important drafting devices, cradle and top pin, were studied in detail.

Four-line compact spinning system

The Four-line compact spinning system (FLCCS) is one of the important kinds of pneumatic compact spinning systems. In the FLCCS, one kind of shaped tube is installed at the front of the front roller, and the lattice apron is covered with a shaped tube (see *Figure 1*). There is one small roller in the shaped tube, which is connected with the front roller via the carrier wheel (see *Figure 2*). There is one block top roller above the shaped tube and a drafting front top roller above the front roller, and a corresponding output nip and front nip can be produced. The area between the front nip and output nip is the condensing zone. In yarn spinning, the feeding roving comes into the back drafting zone firstly; the break draft acts upon the roving, and the fibre strand would be detwisted. Then the fibre strand comes into the front drafting zone, and the main drafting effects act upon the fibre strand, with fibres in the strand being loose in this case. Then the fibre strand coming from the draft zone is condensed by the airflow negative pressure in the shaped tube, and a columnar structure of the fibre strand is formed. In this case, the width of the fibre strand is nearly equal to the diameter of the final yarn, and the spinning triangle is greatly reduced. Finally under the twist the fibre strands rotate around the axis, and then the fibres on both sides fold gradually and roll into the centre of the spun yarn.

In the FLCCS, one block top roller is attached above the shaped tube; therefore the drafting process is different from common ring spinning. The cradle is one of the key drafting devices of the spinning frame. An SDDA2122PH-type pneumatic cradle is one of the bellows cradles most widely used at present (see *Figure 3*). In the spinning, the pressure distributions can be regulated more conveniently by using an integral longer gasbag. Meanwhile the pressure is more stable since its source is air pressure. However, in the FLCCS, a block top roller retaining bar is required to be installed on the cradle, which makes the pressure distributions on the block top roller and front top roller unstable, which is not beneficial for the yarn qualities. Therefore, in this paper, a new kind of block

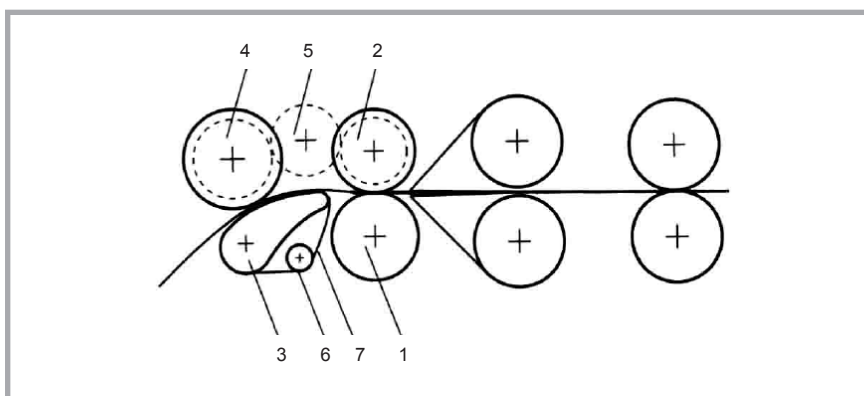


Figure 2. Structure of Four-line compact spinning system; 1) front roller; 2) front top roller; 3) shaped tube; 4) block top roller; 5) transmission parts; 6) pop mechanism; 7) lattice apron.

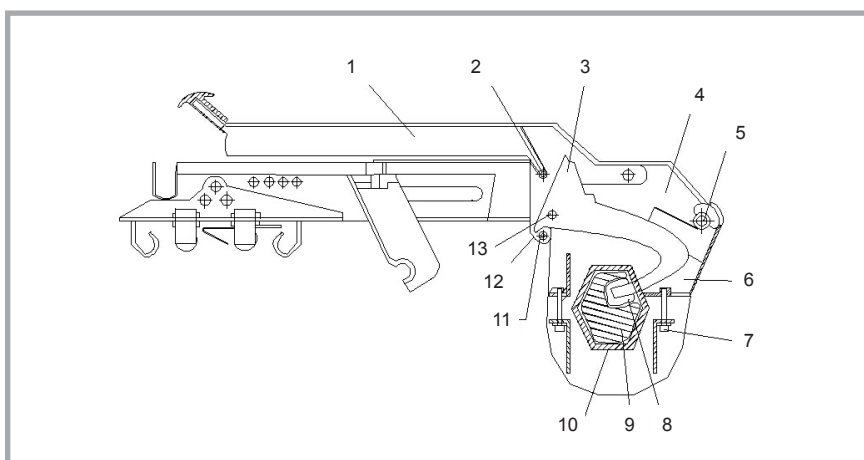


Figure 3. Structure of SDDA2122PH-type cradle; 1) handle, 2) handle shaft, 3) transfer lever; 4) cradle body; 5) stent axis; 6) screw; 7) pressure plate; 8) gasbag; 9) locking set; 10) hexagon gripping pipe; 11) locking axis; 12) locking set; 13) lever axis.

top roller retaining bar was chosen and installed on an SDDA2122PH-type pneumatic cradle, and its performance was discussed. A top pin is another of the key drafting devices, and the common top pin is shown in *Figure 4*. At present, top pins used are mostly made from carbon fibre, and in the FLCCS, a top pin with a press bar is often used in order to control the fibres in the drafting zone better. In this paper, the performances of three kinds of top pin including a common top pin without a press bar, a top pin with a press bar in the front zone, a top pin with a press bar in the back zone, for yarn were analysed, respectively.

Performance of the cradle

At present, the pneumatic cradle, spring cradle and leaf spring cradle are the three kinds of cradles widely used in spinning. In the pneumatic cradle, there is interaction between the pressures acting on the three top rollers, which is different from the spring and leaf spring cradles.

Therefore, in this paper the performances of a pneumatic cradle on spun yarn qualities were studied. Moreover in this study, taking an SDDA2122PH pneumatic cradle as an example, its structure and performance were discussed, and the pressure distribution thereof presented. The structure of the SDDA2122PH pneumatic cradle is shown in *Figure 3*. In the cradle, the pressure produced by the gasbag is transferred to the pressure

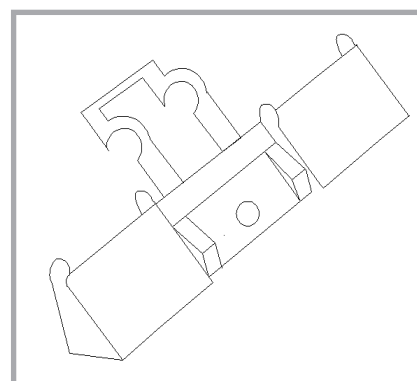


Figure 4. Structure of common top pin.

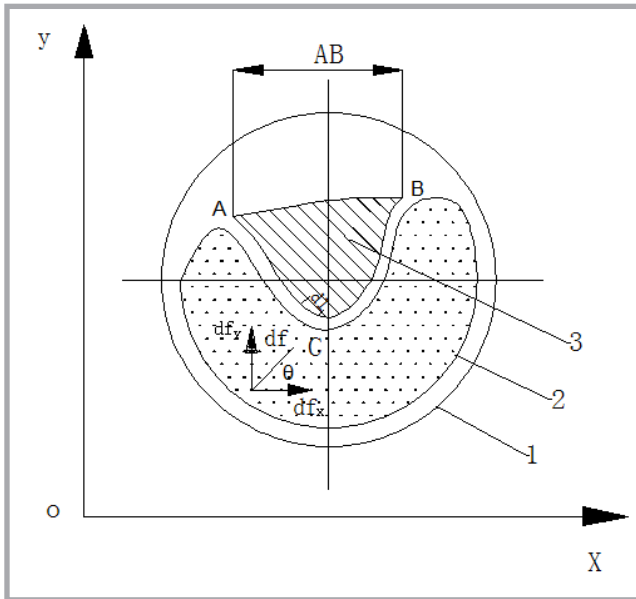


Figure 5. Working principle of the gasbag; 1. Support tube of the gasbag. 2. Gasbag. 3. Pressure plate.

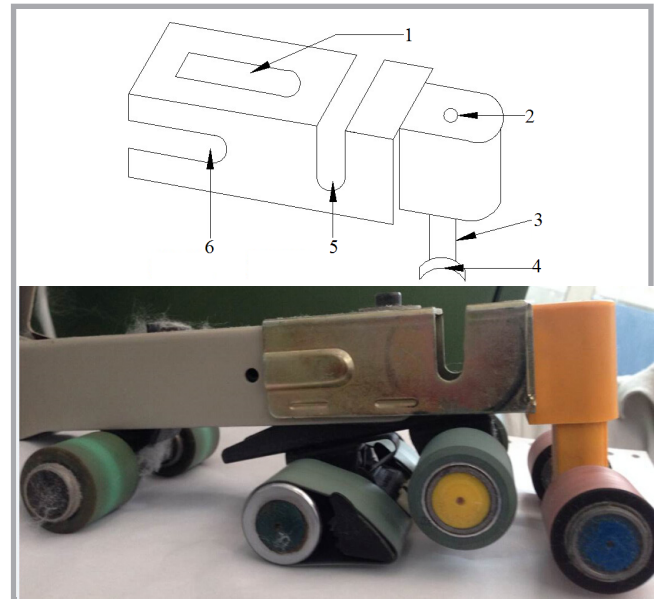


Figure 8. New block top roller retaining bar; a) Structure of block top roller retaining bar, b) Installation of block top roller retaining bar. 1. Fixing hole. 2. Regulation hole. 3. Gripping arm. 4. Gripping port, 5. Roller port, 6. Slot.

plate firstly (see **Figure 5**, which then acts on the transfer lever, and the pressure is amplified. Then the larger pressure is transferred to the cradle body, which can be rotated around the stent axis, and the pressure can be transferred

to the top rollers and act on the yarn in the drafting zone.

In the FLCCS, there is one block top roller above the shaped tube. Therefore one block top roller retaining bar should

be used to make the block top roller and front top roller connected. The structure of a usual block top roller retaining bar is shown in **Figure 6.a**. In the retaining bar, the block top roller and front top roller are connected by the gear, and the block top roller can be rotated by the front top roller accordingly. In practice, in order to keep the rotating speed the same between the block top roller and front top roller, the diameter of the block top roller is often a little larger than that of the front top roller. The installation of the block top roller retaining bar is shown in **Figure 6.b**. From the figure, it is easy to see that the pressure of the block top roller is produced by that in the front top roller, while the front top roller is gripped by the cradle and located on the head of the cradle, which makes the front top roller unstable. Therefore the installation of a block top roller retaining bar would make the pressure distributions on the block top roller and front top roller unstable, and hence not beneficial for the yarn qualities.

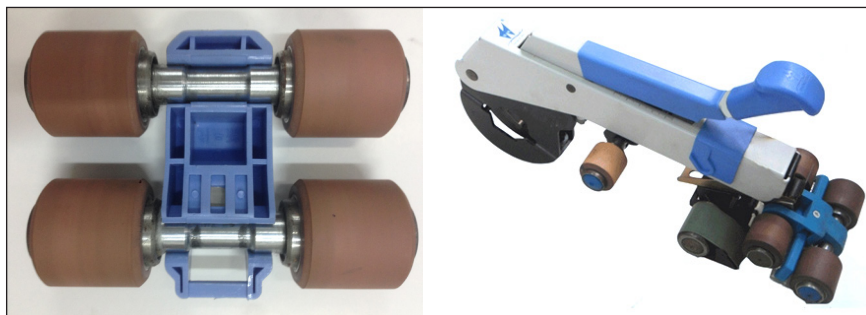


Figure 6. Usual block top roller retaining bar; a) Structure of block top roller retaining bar. b) Installation of block top roller retaining bar.

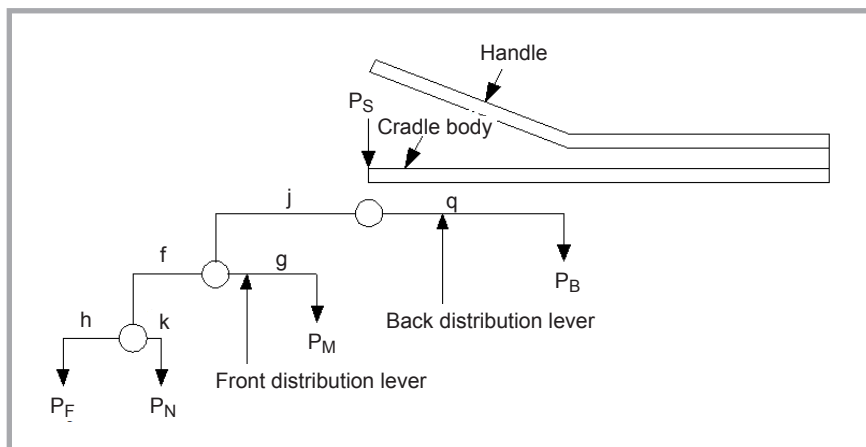


Figure 7. Pressure distribution by using a usual block top roller retaining bar.

The pressure distribution while using a usual block top roller retaining bar is shown in **Figure 7**. According to the moment balance principle, we have

$$P_B = \frac{j}{q+j} P_S$$

$$P_M = \frac{q}{j+q} \cdot \frac{f}{f+g} P_S$$

$$P_N = \frac{q}{q+j} \cdot \frac{g}{g+f} \cdot \frac{h}{h+k} P_S$$

$$P_F = \frac{q}{q+j} \cdot \frac{g}{g+f} \cdot \frac{k}{h+k} P_S$$

here, P_S is the pressure produced by the gasbag. P_F , P_N , P_M and P_B - the pressure of the block, front, middle and back top rollers respectively, and h , k , f , g , j , q are the ratios of the levers. From the equations, it is easy to see that the pressure distributions of the top rollers can be determined by the ratios. In the general case, ratio k is small, which makes the difference in pressure of the block top roller and front roller large, and hence not beneficial for the yarn qualities.

In this paper, a new kind of block top roller retaining bar was used, as shown in **Figure 8.a**. In the tail of the new retaining bar, there is a fixing hole, and the retaining bar can be installed on the head of the cradle directly via the fixing hole and screw. In the head of the retaining bar, there is a gripping arm, which is connected with the cradle. In the lower gripping arm, there is a gripping port, and the block top roller is installed on the gripping port (see **Figure 8.b**). In the gripping arm, there is a spring, which makes the gripping of the block top roller better. The elastic force of the spring can be regulated by the regulation hole, and the pressure of the block top roller can be regulated accordingly.

The pressure distribution while using the new block top roller retaining bar is shown in **Figure 9**. According to the moment balance principle, we have

$$P_F + P_{NM} + P_B = P_S$$

$$P_F \cdot (h + j) + P_{NM} \cdot j = P_B \cdot q$$

$$P_N + P_M = P_{NM}$$

$$P_N \cdot f = P_M \cdot g$$

$$P_F \cdot h + P_B \cdot j = P_B \cdot j$$

$$P_B = \frac{h+j}{h+j+q} P_S$$

$$P_N = \frac{g \cdot q \cdot (h-j)}{h \cdot (f+g) \cdot (h+j+q)} P_S$$

$$P_M = \frac{g \cdot q \cdot (h-j)}{h \cdot (f+g) \cdot (h+j+q)} P_S$$

$$P_F = \frac{q \cdot j}{h \cdot (h+j+q)} P_S$$

Here, P_S is the pressure produced by the gasbag. P_F , P_N , P_M and P_B - the pressure of the block, front, middle and back top rollers, respectively, and h , f , g , j , q are the ratios of the levers. From the equations, it is also easy to see that

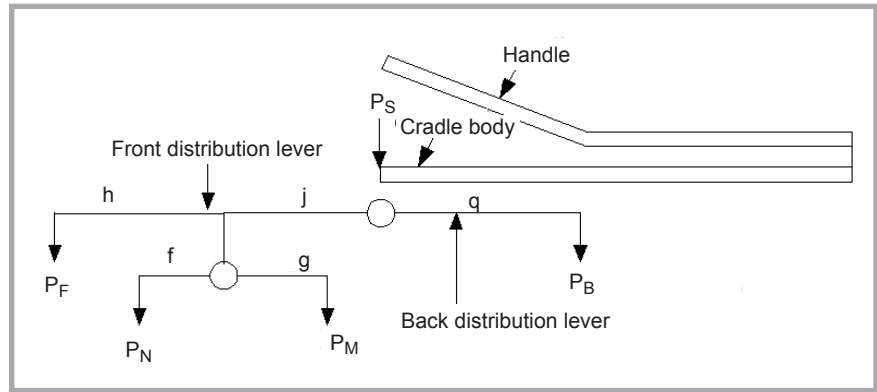


Figure 9. Pressure distribution when using a new block top roller retaining bar.

the pressure distributions of the top rollers can be determined by the ratios, and the difference in pressure of the block top roller and front roller is smaller than for the usual block top roller remaining bar.

Subsequently a spinning experiment was made. 7.3 tex T65/JC35 was spun on an EJM128K ring spinning frame modified by a Four-line compact device, and a SDDA2122PH pneumatic cradle with the usual and new block top roller remaining bars were attached, respectively. Roving 350 tex was used as raw material. The key spinning parameters were as follows: roller gauge 18×25 mm, spindle speed 13,200 r.p.m., total draft multiple 47.9, draft multiple of the back zone 1.24, ring traveler LRT10/0, and yarn twist 1400 t.p.m. Taking ten bobbin yarns as measuring samples, all were conditioned for at least 48 hours under standard conditions ($65 \pm 2\%$ RH and 20 ± 2 °C). The evenness (CV), hairiness index and breaking strength of the spun yarns were measured. For each bobbin yarn, the hairiness was tested ten times using a YG172A hairiness tester at 100 m/min speed, 5 g pretension and test time of 1 minute. The hairiness (H) was tested once using an Uster tester 5-S800 at a speed of 400 m/min and test time of 1 minute. The breaking

force of yarns was also tested ten times on a YG063 fully automatic single yarn strength tester at a speed of 500 mm/min and pretension of 1.8 cN/tex. The evenness was measured once by a Uster tester 5-S800 evenness tester at a speed of 400 m/min and test time of 1 minute. Finally the average values of ten bobbin yarns were taken as the corresponding qualities of the spun yarn.

The pressure distributions of the top rollers tested are given in **Table 1**. It is evident that comparing with the usual retaining bar, the pressures of all top rollers are larger when using the new retaining bar, while the differences in pressures among the top rollers are smaller. The possible reason is that the block top roller is connected with the cradle directly in the new retaining bar, and pressure is produced by the cradle directly, making the pressure more stable, while in the usual retaining bar, the block top roller is connected with the front top roller, and the pressure is produced by the front top roller, making the pressure unstable.

The yarn qualities tested are given in **Table 2**. It is evident that comparing with the usual retaining bar, by using the new retaining bar, the comprehensive qualities of the spun yarn were improved,

Table 1. Comparison of pressure distributions.

Top roller	New retaining bar				Usual retaining bar			
	Block	Front	Middle	Back	Block	Front	Middle	Back
Pressure, Pa	51	180	200	150	45	164	198	146

Table 2. Yarn qualities.

	Evenness CV, %	Hairiness, H	CVb, %	Breaking strength, cN	Breaking strength, (CV), %	Elongation at break, %
New retaining bar	14.76	2.36	1.4	149.7	10.56	7.56
Usual retaining bar	14.82	2.43	3.0	147.6	11.32	7.65

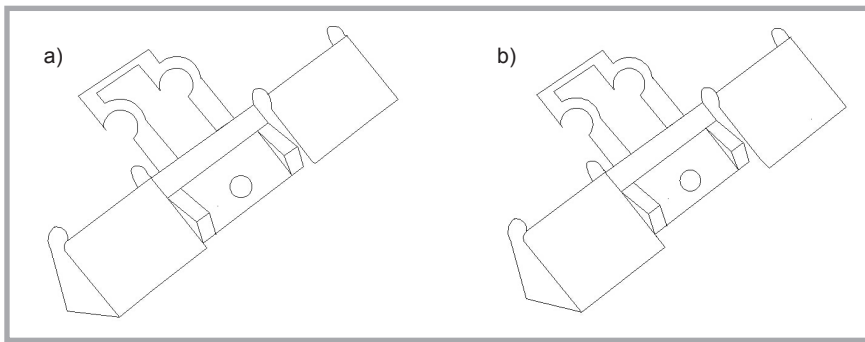


Figure 10. Top pin without pressure bar; a) common, b) top pin with large leading distance.

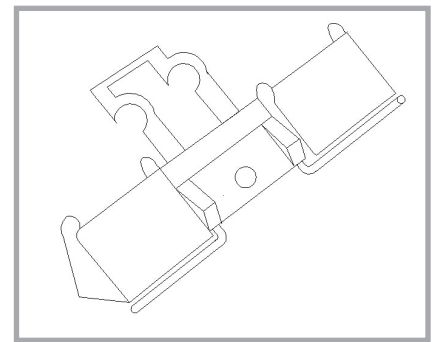


Figure 11. Top pin with front pressure bar.

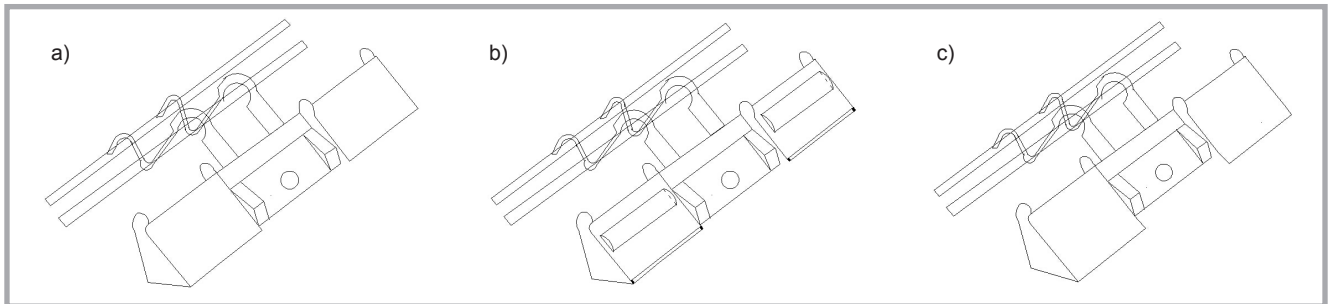


Figure 12. Top pin with back pressure bar; a) common, b) improved, c) top pin with large leading distance.

especially the Cvb of the yarn evenness and the CV of the yarn breaking strength. That is, by using the new retaining bar, the qualities of the spun yarn are more stable.

■ Performance of top pin

In this section, the performance of another important drafting device - a top pin, on yarn qualities was studied. In the drafting zones, nips can be formed by the top pin, bottom pin and roller, which play important roles in fibre con-

trol. The nip located in the back drafting zone is the drafting nip, and that located in the front drafting zone is the gripping nip. Therefore the top pin is one of the most important drafting devices in yarn spinning which influence the gripping force and friction field in the drafting zone directly, determining the yarn qualities. At present, the top pin is made from carbon fibre, and there are mainly three kinds of top pin: the common top pin without a press bar, the top pin with a front press bar, and the top pin with a back press bar.

Subsequently the three kinds of top pin were analysed, respectively.

At present, the SX2-6833B top pin is a widely used kind of top pin made from carbon fibre. The common SX2-6833B top pin without a pressure bar is shown in *Figure 10.a*. Comparing with the top pin made from metal, the rotation of the apron covering the top pin made from carbon fibre is more stable, and the gripping force of the nips acting on the fibres is more uniform, which can strengthen fibre control in the drafting zone, hence

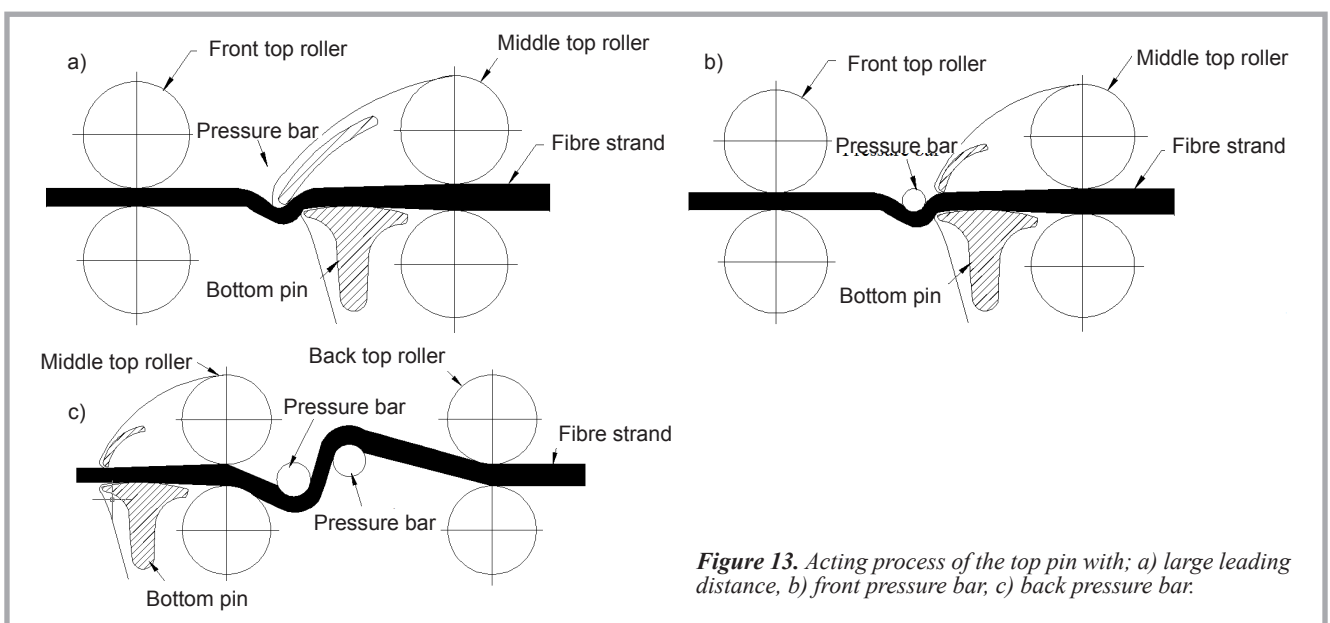


Figure 13. Acting process of the top pin with; a) large leading distance, b) front pressure bar, c) back pressure bar.

improve yarn evenness and reduce yarn hairiness. A top pin with a large leading distance is an important kind of improved top pin, in which the leading distance is larger than the common top pin, with the floating zone length being reduced, and the friction field distribution changed. One type of top pin with a large leading distance - BYSX2-6833B is shown in **Figure 10.b**. In the top pin with a large leading distance, when the fibre strand leaves the gripping nip, there is force produced by the top pin acting on the fibre strand, since the length of the top pin is increased, a new friction field produced, and the control of fibre is strengthened (see **Figure 13.a**). However, the floating zone length is reduced. Therefore the usage of a top pin with a large leading distance is not always beneficial for improving yarn qualities. For example, in pure chemical fibre yarn, the hairiness would be increased. In the subsequent part of the research, a spinning experiment was made to verify the conclusion.

The top pin with a pressure bar is another important kind of improved top pin, including the top pin with a front pressure bar and top pin with a back pressure bar. The SX2-6833E top pin with a front pressure bar is shown in **Figure 11**. In the common SX2-6833B top pin, the pressure bar should be equipped with a spacer if a pressure bar is needed, and the pressure bar is connected to the top pin via the spacer, with the pressure being unstable. In the top pin with a front pressure bar, the pressure bar is fixed on the top pin directly, hence the pressure bar is more stable and can control the floating fibre in the front drafting zone better. Meanwhile the pressure is fixed on both sides of the top pin, which makes the space in the middle of the top pin larger, thereby complying with spinning process regulations. In the top pin with a front pressure bar, when the fibre strand leaves the gripping nip, it passes through the pressure, and an arc of contact and new friction field is produced (see **Figure 13.b**). Under the effect of the pressure bar, the vertical pressure would act on the fibre, which makes the fibres in the strand more compact and the friction between fibres increase correspondingly, as well as changes the speed change point of fibres and influences the yarn qualities.

The top pin with a back pressure bar is shown in **Figure 12**, in which two pressure bars are fixed on the tail of the top pin. Under the action of the two pressure

Table 3. Spinning process parameters.

Yarn count, tex	Roving count, tex	Yarn twist factor	Total draft multiple
JC 18.2	355.0	340	19.50
JC60/T40 18.4	434.5	341	25.98
T 18.4	283.3	342	18.48

Table 4. Test results of yarn hairiness.

	Top pin type	Yarn and linear density, tex	1, mm	2, mm	3, mm	H
Without pressure bar	BYSX2-6833B	JC 18.2	1690.5	381.4	100.7	5.50
		JC60/T40 18.4	1357.5	245.1	54.0	4.18
		T 18.4	855.1	135.5	26.0	2.56
	SX2-6833B	JC 18.2	1797.3	446.5	115.0	6.00
		JC60/T40 18.4	845.1	202.1	44.4	2.76
		T 18.4	976.2	129.9	25.3	2.84
With front pressure bar	SX3-6833E	JC 18.2	1060.0	247.5	52.6	3.50
		JC60/T40 18.4	905.4	221.5	49.5	2.98
		T 18.4	998.3	139.3	24.4	2.98
With back pressure bar	BYSX3-6833B	JC 18.2	1306.2	340.4	70.1	4.30
		JC60/T40 18.4	1621.1	320.3	70.4	5.08
		T 18.4	1236.3	158.7	29.5	3.58
	JJ-6833J	JC 18.2	1018.6	278.0	65.7	3.50
		JC60/T40 18.4	1449.4	267.4	59.6	4.49
		T 18.4	921.6	154.7	31.2	2.79
	SX2-6833B	JC 18.2	1727.0	390.5	79.7	5.60
		JC60/T40 18.4	1259.1	265.2	58.5	4.00
		T 18.4	949.9	146.9	23.6	2.82

bars, a curvilinear drafting of the fibre strand would be produced, and a new friction field is formed (see **Figure 13.c**), strengthening the control of the fibre strand in the back drafting zone as well as improving the draft of the fibre strand in the front drafting zone and yarn qualities. **Figure 12.a** shows a common SX2-6833E top pin with a back pressure bar and **Figure 12.b** shows one improved JJ-6833J top pin, in which the function point of the apron is located on the top of the top pin. **Figure 12.c** shows another improved BYSX3-6833B top pin, which has a large leading distance.

Next a spinning experiment was made where JC 18.2 tex, JC60/T40 18.4 tex and T 18.4 tex were spun on an EJMI28K ring spinning frame modified with a Four-line compact device and six different types of top pin: a common top pin without a pressure bar – SX2-6833B, one improved type with a large leading distance - BYSX2-6833B, a top pin with a front pressure bar – SX3-6833E, a top pin with a back pressure bar – SX2-6833E, one improved type with a large leading distance - BYSX3-6833B and another improved type - JJ-6833J, respectively. The key spinning parameters were as follows: roller gauge 18 × 35 mm, spindle speed 12600 r.p.m., draft multiple of

the back zone 1.23, ring traveler LRT4/0. Other details of the spinning parameters are given in **Table 3**.

Hairiness is one of the most important properties of spun yarn. The test results of yarn hairiness are given in **Table 4**. For cotton pure yarn, it is evident that it has the least beneficial short hairiness (< 3 mm) and harmful long hairiness (≥ 3 mm) when using a top pin with front pressure bar; the yarn takes second place when using a top pin with back pressure bar, while it has the most short and long hairiness when using a top pin without pressure bar. Hence for pure cotton yarn, it is beneficial for reducing yarn hairiness to use a top pin with pressure, especially front pressure. The possible reason for this is that the length of cotton fibre is relatively small, and when using a front pressure bar, the friction field in the front drafting zone is increased, and the floating zone length is reduced, which is beneficial for short cotton fibre rolling into the yarn body and for reducing yarn hairiness. Meanwhile the tension of fibres can be increased in the drafting zone by using a back pressure bar, and the floating zone length can be reduced by using a top pin with a large leading distance, which is beneficial for reducing cotton yarn hairiness.

Table 5. Test results of yarn strength.

	Top pin type	Yarn and linear density, tex	Breaking strength, cN	Elongation at break, %	Work of break, cN×cm	Tenacity, cN/tex
Without pressure bar	BYSX2-6833B	JC 18.2	358.3	6.38	557.1	19.69
		JC60/T40 18.4	342.5	7.51	766.8	18.61
		T 18.4	681.8	12.44	1905.1	37.06
	SX2-6833B	JC 18.2	351.4	6.61	561.6	19.31
		JC60/T40 18.4	348.1	7.51	764.4	18.52
		T 18.4	695.7	12.96	1988.7	37.81
With front pressure bar	SX3-6833E	JC 18.2	357.6	6.73	587.4	19.65
		JC60/T40 18.4	349.3	7.49	765.6	18.63
		T 18.4	701.3	12.98	1997.6	37.84
With back pressure bar	BYSX3-6833B	JC 18.2	361.5	6.16	542.5	19.86
		JC60/T40 18.4	352.3	6.53	647.2	19.15
		T 18.4	702.1	11.31	1849.2	38.16
	JJ-6833J	JC 18.2	348.4	6.76	564.1	19.14
		JC60/T40 18.4	345.2	6.96	690.3	18.76
		T 18.4	710.9	11.64	1914.2	38.64
	SX2-6833B	JC 18.2	365.0	6.24	559.3	20.06
		JC60/T40 18.4	349.0	6.80	680.4	18.97
		T 18.4	718.2	11.75	1947.5	39.03

Table 6. Test results of yarn evenness

	Top pin type	Yarn and linear density, tex	Evenness CV, %	Thin (-50%), km ⁻¹	Thick (+50%), km ⁻¹	Nep (+200), km ⁻¹
Without pressure bar	BYSX2-6833B	JC 18.2	11.39	0	22.5	75.0
		JC60/T40 18.4	11.30	0	2.5	58.8
		T 18.4	10.39	0	0.0	2.5
	SX2-6833B	JC 18.2	11.58	2.5	2.5	90.0
		JC60/T40 18.4	11.36	0	3.75	51.2
		T 18.4	10.28	0	1.25	6.2
With front pressure bar	SX3-6833E	JC 18.2	11.48	0	2.5	52.5
		JC60/T40 18.4	11.26	0	2.5	50.0
		T 18.4	10.27	0	0.0	3.8
With back pressure bar	BYSX3-6833B	JC 18.2	11.49	0	5.0	97.5
		JC60/T40 18.4	11.12	0	1.25	33.8
		T 18.4	10.40	0	0.0	3.8
	JJ-6833J	JC 18.2	11.82	5	15.0	100.0
		JC60/T40 18.4	11.35	0	7.5	62.5
		T 18.4	10.06	0	0.0	6.2
	SX2-6833B	JC 18.2	11.50	0	12.5	82.5
		JC60/T40 18.4	11.18	0	5.0	42.5
		T 18.4	10.21	0	2.5	15.0

For cotton polyester fibre blended yarn, it is evident that it has the least beneficial short hairiness (< 3 mm) and harmful long hairiness (≥ 3 mm) when using a top pin without a pressure bar; the yarn takes second place when using a top pin with a front pressure bar, while it has the most short and long hairiness when using a top pin with a back pressure bar, especially the top pin with a back pressure bar and large leading distance. Hence for cotton blend yarn, it is not beneficial for reducing yarn hairiness to use a top pin with pressure, especially back pressure. The possible reason for this is that by using a pressure bar, the cohesion force

between fibres in the strand is increased, and when cohesion takes effect between long polyester fibre and short cotton fibre during production, the long polyester fibre moves to the centre of the yarn easily, while the short cotton fibre moves to the border of the yarn, making the head and tail hard to roll into the yarn body, and hairiness is produced. Meanwhile when using a top pin with a large leading distance, the floating zone length is reduced, which is not beneficial for blend yarn drafting.

For the pure polyester fibre yarn, it is evident that the yarn has the least benefi-

cial short hairiness (< 3 mm) and harmful long hairiness (≥ 3 mm) when using a top pin without a pressure bar; the yarn takes second place when using a top pin with a front pressure bar, while it has the most short and long hairiness when using a top pin with a back pressure bar. Hence for pure polyester fibre yarn, it is not beneficial for reducing yarn hairiness to use a top pin with pressure, especially back pressure.

In conclusion, for pure cotton yarn, it is beneficial for reducing yarn hairiness to use a top pin with pressure bar or large leading distance. For cotton blend yarn, it is possible to reduce yarn hairiness by using a top pin with a pressure bar or large leading distance. For polyester fibre pure yarn, yarn hairiness may increase when using a top pin with pressure bar or large leading distance.

Yarn strength is another of the properties of most concern in evaluating yarn performance. Test results of yarn strength are given in **Table 5**. For pure cotton yarn, it is evident that the yarn has the best strength properties when using a common top pin with back pressure bar. On the whole, yarn strength can be improved by using a top pin with a pressure bar or large leading distance, the possible reason for which is that by using a pressure bar, the friction field of the fibre strand would be increased, and fibres in the strand are more compact, which is beneficial for improving yarn strength directly. By using a top pin with a large leading distance, the length of the floating zone is decreased, strengthening fibre control in the drafting zone, which is beneficial for improving yarn strength directly. However, the yarn has the poorest strength properties when using the improved type JJ-6833J, the possible reason for which is that although the friction field of the fibre strand is increased, the location of the nip is put rearwards, which is not beneficial for fibre control.

For cotton polyester fibre blended yarn, it is evident that the yarn has the best strength when using a top pin with back pressure bar and leading distance. On the whole, yarn strength can be improved by using a top pin with a pressure bar, while the yarn has a little better breaking elongation and work of break when using a top pin without pressure bar. The possible reason for this is that when using a back pressure bar, the cohesion force between fibres in the strand is increased,

as well as the torque of yarn, which is beneficial for improving yarn strength. However, large torque is not beneficial for yarn breaking elongation.

For pure polyester fibre yarn, it is evident that it has the best strength when using a top pin with a back pressure bar, and the yarn takes second place when using a top pin with front pressure bar, while it has the poorest strength when using a top pin without a pressure bar. However, the yarn has a little better breaking elongation and work of break when using a top pin without a pressure bar, the possible reason for which is that by using a back pressure bar, the cohesion force between polyester fibres in the strand is increased, which beneficial for improving yarn strength. However, the large cohesion force is not beneficial for yarn breaking elongation.

In conclusion, yarn strength can be improved by using a top pin with a pressure bar, while the leading distance of the top pin has little influence on yarn strength.

Yarn evenness is also one of the properties of most concern. Test results of yarn evenness are given in **Table 6**. For pure cotton yarn, it is evident that it has the best evenness when using a top pin with a large leading distance, but the thick places and neps of the yarn are the poorest. On the whole, it has the best comprehensive properties of evenness when using a top pin with front pressure bar, and the yarn takes second place when using a top pin with back pressure bar, while it has the poorest when using a top pin without a pressure bar. The possible reason for this is that the location of the nip plays a key role in yarn evenness. When using a top pin with a large leading distance, the location of the nip moves forward, strengthening the control of the fibre, which is beneficial for improving yarn evenness. By using a top pin with front pressure bar, the friction field is increased in the front drafting zone, strengthening fibre control in the floating zone and improving the comprehensive properties of evenness.

For cotton polyester fibre blended yarn, it is evident that it has the best comprehensive properties of evenness when using a top pin with back pressure bar, and the yarn takes second place when using a top pin with front pressure bar, while it has the poorest when using a top pin without a pressure bar.

For pure polyester fibre yarn, it is evident that it has better evenness when using a top pin with pressure bar, while it has fewer thick places and neps when using a top pin without a pressure bar.

In conclusion, for all three kinds of yarn, the large leading distance of the top pin can obviously improve yarn evenness. Meanwhile it is also beneficial for improving yarn evenness to use a top pin with pressure bar, especially for pure polyester fibre yarn, and the thick places and neps of yarn may be increased.

■ Conclusions

In this paper, the performances of two important kinds of FLCCS drafting devices, a cradle and top pin, were studied with respect to yarn qualities. In the FLCCS, there is one block top roller above the shaped tube, and one block top roller retaining bar should be used to make the block top roller and front top roller connected. In the usual retaining bar, the block top roller is connected to the cradle via the front top roller, making the pressure distributions on the block top roller and front top roller unstable, which is not beneficial for the yarn qualities. In the paper, a new kind of retaining bar was designed to connect the block top roller to the cradle directly. Then the performance of a SDDA2122PH pneumatic cradle equipped with the new retaining bar was discussed. It is shown that by using the new retaining bar, the pressure of the cradle is larger and more stable, which is beneficial for improving the comprehensive qualities of spun yarn.

Then the acting mechanism of three kinds of top pin: a common top pin without a press bar, a top pin with front pressure bar, and a top pin with back pressure bar were presented with respect to yarn qualities, and JC 18.2 tex, JC60/T40 18.4 tex and T 18.4 tex yarns were spun on an EJM128K spinning frame equipped with different top pins. It is shown that for cotton yarn, it is beneficial for reducing yarn hairiness to use a top pin with pressure bar. For cotton blended yarns, it is beneficial for improving yarn strength to use a top pin with pressure bar. For pure chemical fibre yarn, the usage of a top pin with pressure bar is beneficial for improving yarn strength and evenness, but not for yarn hairiness and yarn thin and thick places.

Acknowledgements

This work was supported by the National Natural Science Foundation of P. R. China under Grant 11102072, the Natural Science Foundation of Jiangsu Province under Grant BK20151359, the Prospective industry-university-research project of Jiangsu Province BY2015019-10, Henan collaborative innovation of the textile and clothing industry (hnfz14002), and the Prospective industry-university-research project of Guangdong Province 2013B090600038.

References

1. China Textile Engineering Institute. Reports on advances in Textile science and technology. Science and Technology of China Press, 2014.
2. Liu XJ, Su XZ, Wu TT. Effects of the Horizontal offset of the Ring Spinning Triangle on Yarn. *Fibres and Textiles in Eastern Europe* 2013; 21, 1(97): 35-40.
3. Jie JF, Xu BG, Tao XM, Hua T. Theoretical Study of Spinning Triangle with Its Application in a Modified Ring Spinning System. *Textile Research Journal* 2010; 80, 14: 1456-1464.
4. Liu XJ, Su XZ. Research on spun yarn qualities in a modified ring-spinning system using airflow-twisting device. *Journal of the Textile Institute* 2013; 104, 11: 1258-1267.
5. Cheng KPS, Yu C. A study of compact spun yarns. *Textile Research Journal* 2003; 73, 4: 345-349.
6. Liu XJ, Liu WL, Zhang H, Su XZ. Research on pneumatic compact spun yarn quality. *Journal of the Textile Institute* 2015; 106, 4: 431-442.
7. Dou HP, Liu SR. Trajectories of fibers and analysis of yarn quality for compact spinning with pneumatic groove [J]. *Journal of the Textile Institute* 2011; 102, 8: 713-718.
8. Liu XJ, Xie CP, Su XZ, Mei H. Numerical Studies on a Three-dimensional Flow Field in Four-Roller Compact Spinning with a Guiding Device. *Fibres and Textile in Eastern Europe* 2013, 21, 6(102): 50-57
9. Zou ZY, Zhu YD, Hua ZH, Wang Y, Chen LD. Studies of Flexible Fiber Trajectory and Its Pneumatic Condensing Mechanism in Compact Spinning with Lattice Apron. *Textile Research Journal* 2010; 80, 8: 712-719.
10. Beceren Y, Nergis BU. Comparison of the effects of cotton yarns produced by new, modified and conventional spinning systems on yarn and knitted fabric performance. *Textile Research Journal* 2008; 78, 4: 297-303.
11. Xu BJ, Ma J. Radial Distribution of Fibres in Compact-Spun Flax-Cotton Blended Yarns. *Fibres and Textiles in Eastern Europe* 2010, 18, 1(78): 24-27.



Received 03.07.2015

Reviewed 21.09.2015