Long Li*,
Lei Liu,
Caixia Qin

Study on the Rotor Spinning Technology of Cotton Stalk Bark Fibers/Cotton Fibers

DOI: 10.5604/01.3001.0012.5165

Xi'an Polytechnic University,
School of Textile & Materials,
Xi'an710048, China
* e-mail: lilong2188@126.com

Abstract
The length difference and low flexibility of cotton stalk bark fibers make fiber spinning difficult. In this work, cotton stalk bark fibers that were directly from degummed cotton stalk bark were wetted, carded and softened before sliver-marking, and then they were blended with cotton fibers for carding and spinning in various blending ratios. The results showed that a reasonable open roller speed was 6000 rpm for blending ratio 50/50, 7000 rpm for blending ratio 35/65, and 8000 rpm for blending ratio 20/80. The minimum yarn linear density was 60 tex for blending ratio 50/50, 50 tex for blending ratio 35/65, and 40 tex for blending ratio 20/80.

Key words: *cotton stalk bark fiber, cotton, blending, rotor spinning.*

Introduction

Natural fibers present important advantages such as low density, appropriate stiffness and mechanical properties as well as high disposability and renewability. Moreover they are recyclable and biodegradable. Ramie, flax, hemp and some other bast fibers have been used as textile materials. As agricultural waste, both cotton stalk and cotton stalk bark are usually used for paper-making, composites and as regenerated cellulose for rayon [1-3]. Cotton stalk bark fiber, obtained from cotton stalk bark through degumming, is a natural cellulose fiber. Natural cotton stalk bark fiber is technological fiber formed from a bundle of single cells [4]. It was reported in [5] that the quantity of textile fibers used for the Chinese textile industry was 41.3 million tons in the year 2010, which will reach 51.5 million tons in 2015. Among the industrial sectors, the cotton & chemical fibre textile industry made the greatest contribution, and its proportion always accounted for more than 50% [6]. Developing new textile fiber resources is very important to the textile industry. As a natural cellulose fiber, cotton stalk bark fibers exhibit low flexibility and poor cohesive force, which makes their spinning difficulty.

As far as economics is concerned, open-end spinning does not need a roving and winding machine. Nowadays, according to the end uses desired, rotor yarn can be spun from different types of fiber. The yarn produced is more uniform, fuller, aerated and regular in strength [7]. In this work, cotton stalk bark fibers were blended with cotton fibers to analyse cotton stalk bark fiber spinning performance on a rotor spinning frame, and the minimum yarn linear density (tex) and yarn properties of various blending ratios were investigated.

Experimental

Materials

Cotton stalk bark fibers were obtained through degummming cotton stalk bark [8, 9]. Cotton stalk bark fiber is a technological fiber in which many single cell fibers are bonded together. Moreover cotton stalk bark fiber length has a serious difference. The single cotton stalk bark fiber length was tested using a ruler. Through testing 1000 fibers at random sampling, it was shown that the maximum natural length was 289.5 mm, and minimum natural length 46.1 mm. In consequence, cotton stalk bark fibers were carded in order to remove the coarse fibers in cotton stalk bark fibers and to improve cotton stalk bark fiber textile use [10]. Cotton stalk bark fibers were firstly wetted by water in fine spray, and were then stored for 12 h so as to allow the water to soak into them. Then the wetted fibers were firstly carded on a roller carding machine, and then the carded fibers were carded again on a flat carding machine. For roller carding, the cylinder-worker gauge was 0.8 mm, and the cylinder-doffer gauge 0.6 mm. For flat carding, the cylinder-flat gauge was 0.03 mm, and the cylinder-doffer gauge 0.02 mm. Through the above carding, it was shown that the maximum length was 53.8 mm, and minimum length 12.6 mm. The mean length of carded cotton stalk bark fiber was 33 mm, and the fiber linear density 18 dtex.

The mean fiber length was 25.4 mm, and the fiber linear density 1.5 dtex for cotton fibers in this work.

The flexibility of cotton stalk bark fibers is poorer than that of cotton fibers. Thus it is difficult for the spinning of only cotton stalk bark fibers.

Carded cotton stalk bark fibers were softened to improve their flexibility. The softening of the fibers was carried out using Vaseline latex, consisting of Vaseline, peregal O, span-80, penetrating agent, and water, where Vaseline 5 g/l, peregal O 5 g/l, span-80 20 ml/l, and penetrating agent 1 ml/l were added into water and mixed by a blender for 1 h. Then Vaseline latex was formed.

Based on the total weight of the fibers, spraying evenly Vaseline latex 5% by weight onto carded cotton stalk bark fibers, and then covering them using plastic film for 5 h so that the latex penetrated into the fibers. The softened fibers were used for blending with cotton fibers.

Rotor spinning route

The softened cotton stalk bark fibers were used for rotor spinning. The rotor spinning route of cotton stalk bark fibers/ cotton fibers is shown below:

Cotton stalk bark fibers / Cotton fibers — Carding — Drawing (1) — Drawing (2) — Rotor spinning

It was found that sliver forming was difficult on the carding machine when the blending ratio of cotton stalk bark fibers was over 50 percent. Three blending ratios for cotton stalk bark fibers/cotton fibers were selected, i.e. 50/50, 35/65, and 20/80, in this work. Because cotton stalk bark fibers have bigger thickness and lower flexibility, it was found that more cotton stalk bark fibers were removed by flat bars on a flat carding machine. Therefore the carding of cotton stalk bark fibers/cotton fibers was carried out on a roller carding machine, where the distance of the worker-cylinder was 0.36 mm, stripper-cylinder 0.50 mm, worker-stripper 0.50 mm, and cylinder-doffer 0.30 mm. The cylinder speed was 100 rpm. The drawing was finished using a three-roller drawing frame. The draft multiple for drawing (1) and drawing (2) was 4.5, and the distance of the roller-roller was 3 8mm. The sliver weight after drawing(2) was 1.92 ktex, 1.98 ktex and 2.02 ktex for blending ratios 50/50, 35/65 and 20/80, respectively. Spinning was carried out on an RFRS 30 Type rotor spinning machine (Zhengjiang Rifa Textile Machinery Co. China). The rotor diameter was 50 mm, the rotor speed 40000 rpm, and the metallic tooth shape of the open roller was OK40. The yarn breakage number during spinning was used for evaluation of spinability. It was established in this work that the spinability was poor when the yarn breakage number was more than 10 per hour for the rotor spinning unit, which showed "×" in the following Tables, and "√"showed that the yarn breakage number was less than 10 per hour under the selected conditions.

Testing of yarn properties

The yarn breaking force was determined on a YG061F tensile tester, with a test length of 250 mm, extension rate of 250 mm/min and pretension of 0.5 cN/tex.

Hairiness was tested at a testing speed of 30 m/min on a YG173 hair tester. The hairiness value (dimensionless index), the accumulated length of fiber extended yarn-stem for 1 cm length yarn, was used as an evaluation value. All tests were performed in a standard atmosphere of 20 ± 2 °C and 65 ± 2% RH.

Table 1. *Results of blending ratio 50/50.* ***Note:*** *"x" – meaning of this put here as well "√" – meaning of this put here as well.*

No.	Yarn linear density, tex	Twist factor (α_{tex})	Yarn speed, m/min	Drafting multiple	Sliver feed speed, m/min	Yarn breakage, number/h	Spinability
1	90	500	75.9	41.8	1.82	∞	×
2	90	700	54.2	41.8	1.3	∞	×
3	90	900	42.1	41.8	1.01	4	√
4	80	900	39.8	47.0	0.85	6	√
5	70	900	37.2	53.8	0.69	7	√
6	60	900	34.4	62.7	0.55	7	√
7	50	900	31.4	75.3	0.42	15	×
8	40	900	28.1	94.0	0.3	∞	×

Table 2. *Results of blending ratio 35/65.*

No.	Yarn linear density, tex	Twist factor	Yarn speed, m/min	Drafting multiple	Sliver feed speed, m/min	Yarn breakage, number/h	Spinability
1	60	500	62.0	64.7	0.96	∞	×
2	60	700	44.3	64.7	0.69	3	√
3	55	700	42.4	70.5	0.6	5	√
4	50	700	40.4	77.6	0.52	9	√
5	45	700	38.4	86.2	0.45	14	×

Table 3. *Results of blending ratio 20/80.*

No.	Yarn linear density, tex	Twist factor	Yarn speed, m/min	Drafting multiple	Sliver feed speed, m/min	Yarn breakage, number/h	Spinability
1	50	500	56.6	77.6	0.73	∞	×
2	50	600	47.1	77.6	0.61	9	√
3	45	600	44.7	86.2	0.52	9	√
4	40	600	42.1	97.0	0.43	10	√
5	35	600	39.4	110.9	0.36	∞	×

Results and discussion

Spinning of various blending ratios

The rotor parameters and spinablity of various blending ratios are shown in ***Tables 1, 2*** and ***3***. For the same yarn linear density, it is shown that yarn breakage decreases when the yarn speed and sliver feed speed decrease and the yarn twist factor rises. Because the yarn speed and sliver feed speed increase, the spinning speed rises, and the poor cohesive force of cotton stalk bark fibers leads to high yarn breakage during spinning. The high yarn twist factor increases fiber cohesion in the yarn, and yarn breakage decreases during spinning. However, increasing the yarn twist factor will lead to high yarn stress, which lowers the yarn strength.

Through actual spinning, it was established that a reasonable open roller speed was 6000 rpm for blending ratio 50/50, 7000 rpm for blending ratio 35/65, and 8000 rpm for blending ratio 20/80, and the minimum yarn linear density was 60 tex for blending ratio 50/50, 50 tex for blending ratio 35/65, and 40 tex for blending ratio 20/80.

For blending ratio 50/50, spinning could not be done when the twist factor was less than 900 and the yarn linear density was 50 tex or 40 tex. For blending ratio 35/65, spinning could not be done when the twist factor was less than 700 and the yarn linear density was 45 tex. For blending ratio 20/80, spinning could not be done when the twist factor was less than 600 and the yarn linear density was 35 tex. When the yarn linear density (tex) decreases, the fiber number of the yarn cross-section decreases. A higher cotton stalk bark fiber blending ratio seriously increases yarn breakage because of the poor fiber cohesive force. Consequently the blend ratio of cotton stalk bark fiber influences its spinability.

Table 4. Spinning parameters.

Blending ratio	Minimum yarn linear density, tex	Twist factor (α_{tex})	Yarn speed, m/min	Drafting multiple	Sliver feed speed m/min
50/50	60	900	34.4	62.7	0.55
35/65	50	700	40.4	77.6	0.52
20/80	40	600	42.1	97.0	0.43

Table 5. Yarn properties.

No.	Blending ratio	Yarn linear density, tex	Twist factor (α_{tex})	Breaking force, cN	Tenacity, cN/tex	Hairiness value	Elongation at break, %
1	50/50	90	900	417.6	4.6	5.3	3.7
2	50/50	75	900	342.0	4.6	5	3.5
3	50/50	60	900	259.5	4.3	4.8	3.4
4	35/65	80	700	405.8	5.1	4.9	4.5
5	35/65	65	700	316.3	4.9	4.5	4.2
6	35/65	50	700	260.0	5.2	5.2	4.1
7	20/80	70	600	434.6	6.2	4.7	4.9
8	20/80	55	600	319.0	5.8	4.2	4.6
9	20/80	40	600	244.4	6.1	5.1	4.4

Reasonable spinning parameters for various blending ratios of cotton stalk bark fibers and cotton fibers are listed in ***Table 4***.

Yarn properties of various blending ratios

For various blending ratios, yarn properties are shown in ***Table 5***. It is shown that the hairiness value of the yarns is not significantly related to the blending ratio and yarn linear density. Hasani et al [11] concluded that the opening roller speed does not seem to exert a substantial influence on the hairiness of spun yarn. The yarn hairiness value, the accumulated length of the fiber extended yarn-stem for 1cm length yarn, has a little change. The breaking force of the yarn rises as the yarn linear density increases.

Conclusions

The blending ratio of cotton stalk bark fibers influences the minimum yarn linear density and sinability. With an increase in the cotton stalk bark fiber content, the spinning twist factor will increases in order to obtain the yarn. A reasonable open roller speed was 6000 rpm for blending ratio 50/50, 7000 rpm for blending ratio 35/65, and 8000 rpm for blending ratio 20/80. The minimum yarn linear density is 60 tex for blending ratio50/50, 50 tex for blending ratio 35/65, and 40b tex for blending ratio 20/80. The yarn tenacity value increases with a decrease in cotton stalk bark fiber content. The yarn tenacity value has little change for the same blending ratio when the yarn linear density changes. The hairiness value of the yarn is not directly related to the yarn linear density and blending ratio.

Acknowledgements

We are grateful for the support of this work by the Education Ministry of China (Project No. 208140), Science and Technology Department of Shaaxi Province (Project No. 2008K06-10), Special Foundation Item of the Key Academic Subjects Development of Shaanxi Province.

References

1. Akdeniz C R , Acaroglu M, Hepbasli A. Cotton stalk as a potential energy source. *Energy Source* 2004; 26 : 65-75.
2. Fahmy Y. and Ibrahim H. Cotton stalks as a fibrous source for fine paper and rayon: Part II: Dissolving pulp for viscose rayon. *Cellulose Chemistry and Technology* 1979; 1 :385-390.
3. Li G, Yu Y, Zhao Z, Li J. Properties study of cotton stalk fiber/gypsum composite. *Cement and Concrete Research* 2003; 33: 43-46.
4. Reddy N. and Yang Y. Properties and potential applications of natural cellulose fibers from the bark of cotton stalks. *Bioresource Technology* 2009; 100:3563-3569.
5. Use of recycled textile. http://www.gesep.com/News/Show_2_294908.html
6. Zhang J, Liu Y, Cheng L. Structural Changes and Growth Factors of China's Textile Industry: 1997-2012. *FIBRES & TEXTILES in Eastern Europe* 2018; 26, 2(128): 20-25. DOI: 10.5604/01.3001.0011.5734.
7. Ildephonse N, Jun W. Optimum Selection of the Opening Roller and Navel for Rotor Spun Silk/Cashmere Blended Yarn. *FIBRES & TEXTILES in Eastern Europe* 2010; 18 (5): 35-38.
8. Li L, Sheng G Z, Zhang S J, and Sun J L. Preparation and properties of cotton stalk bark fiber. *Journal of Materials Sciences and Engineering with Advanced Technology* 2011; 4: 57-68.
9. Li L, Zhao L. Nature Cellulose Fibre Extracted from Different Cotton Stalk Sections by Degumming. *FIBRES & TEXTILES in Eastern Europe* 2015; 23, 6(114): 37-40. DOI: 10.5604/12303666.1167415.
10. Li L, Zhang S J, and Sun J L. CN Patent 201110218140.2, 2011.
11. Hasani H, Tabatabaei S A. Optimizing Spinning Variables to Reduce the Hairiness of Rotor Yarns Produced from Waste Fibres Collected from the Ginning Process. *FIBRES & TEXTILES in Eastern Europe* 2011; 19, 3(86): 21-25.

Received 12.09.2017 Reviewed 26.02.2018