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The Influence of Elimination of Roving Frame on Ring Spun Cotton Yarn Characteristics

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Abstract

Generally, ring spun yarns are manufactured from roving which is produced by roving frame. In this paper, an experiment has been done producing ring spun cotton yarn directly from finisher drawn sliver eliminating the roving frame. Total 3 types of yarn with the various linear density of 8 Ne, 10 Ne & 12 Ne were produced using a roving frame and without using a roving frame. In the next step, physical and mechanical properties of those yarns including unevenness, imperfections, hairiness & tenacity were investigated. The result showed that ring spun cotton yarns produced from sliver exhibited inferior physical and mechanical properties compared with samples from the conventional ring spinning system.

Keywords

Roving Frame, Linear Density, Physical and Mechanical Properties, Ring Spun Yarn, Cotton Yarn

1. Introduction

Nowadays, spinning industry is conscious about cost optimization which has diverted the industry policy from mass production to mass customization. So, it is necessary to invent modern production technique for superior yarn quality [1]. Yarn manufacturing is a long and difficult technological process that is thus expensive. Newspinning systems tend to curtail this process by combining machines in processing line or by eliminating some of the machines (Idzik [2]). The final scutcher is removed during the preliminary fiber processing step and the number of machines is decreased from several to a few. Currently, just 3 to 4 machines open and clean fiber prior to being constructed to transfer loose fiber mass from a container in a processing line with a carding machine. There are options that connect the carding machine directly to the drawing frame.

In fact, producing yarns directly from the sliver, there is nothing new in this concept. This concept has been around for well over a century. According to documents, a guy called Day patented a continuous technique in 1836 that amounted to producing yarn directly from sliver. Since then, various single-process techniques for generating high-quality yarns have been created [3]. Cotton yarns made straight from sliver have long been a dream of spinners all over the world [4]. Many countries' researchers, as well as numerous industrial makers, have done this on occasion. The majority of the time, the advancements were set aside either the quality of yarn was not up to par or the procedure was not feasible or cost-effective. However, after World War II, there has been a resurgence in this thought and Japan has produced the first true practical use of this method for the yarn spinning. Specifically, super high draft spinning is an invention perfected by the O-M spinning machine firm in Osaka, Japan, around seven years ago. It essentially comprises two Casablanca systems working together [5]. Other than, the deletion of all roving frames result in cost savings, the process of spinning yarns directly from drawn sliver offers significant theoretical benefits such as floor space, power, maintenance, depreciation, work in progress inventory to consider [6]. Finisher drawn sliver denotes the most uniform strand in terms of quality (for both short-term and long-term variation) in the factory [5]. The roving frame doubles the short-term variation and indicates a change in drafting direction [8]. In reality, multiple recent pieces of research have demonstrated that while drafting is done in a similar direction, there is lower chance of generating variation. Although there were various pieces of research on the manufacturing process of ring spun yarn from roving, a few were performed on the effect of simplex machine's absence on the yarn properties. In this study, an attempt has been made to produce ring spun cotton yarn directly from finisher drawn sliver. Therefore, the influence of the elimination of roving frame on yarn characteristics such as unevenness, imperfections, hairiness, tenacity was investigated & then compared to the traditional ring spun yarn which is usually made from roving mentioned in **Table 1**.

Table 1. Manufacturing process of ring spun yarn from traditional process & modified process.

Traditional Process	Modified process
Blow room	Blow room
Carding	Carding
Breaker draw frame	Breaker draw frame
Finisher draw frame	Finisher draw frame
Roving frame/Simplex machine	Ring frame
Ring frame	

2. Materials & Methods

2.1. Materials

In this study, a mixture of Brazil 1-1/8”, USA, Chad 1-5/32” and organic cotton fiber with the mean fineness of 4.49 micronairevalue, 2.5% span length of 29.28 mm and tenacity of 29.32 g per tex were used to produce finisher drawn sliver of 70 grains per yard & roving of 0.7 Ne. The HVI (High Volume Instrument) & AFIS (Advanced Fiber Information System) test report of fibers is shown in Table 2 & Table 3.

2.2. Methods

2.2.1. Preparation of Card Sliver

At first cotton fibers were processed through the Trutzschler blow room section thus producing 550 g per meter card mat. Card mat was then processed through a Rieter C-70 carding machine and 80 grains per yard card sliver was produced. Card sliver properties are given in Table 4.

2.2.2. Preparation of Drawn Sliver

A breaker draw frame [SB-D-30] was used to convert that card sliver into breaker drawn sliver of 70 grains per yard. Similarly, a finisher draw frame

Table 2. Raw cotton properties (HVI).

Raw Cotton	SCI	Micronaire	Length (mm)	Strength (g/tex)	Elongation (%)
Brazil 1-1/8”	121	4.17	27.63	29.4	6.3
USA	120	4.42	29.56	28.7	6.5
CHAD 1-5/32”	124	4.53	29.67	28.2	5.9
Organic	135	4.84	30.27	31.0	8.0

Table 3. Raw cotton properties (AFIS).

Raw Cotton	Neps (cnt/g)	Scn (cnt/g)	SFC (w)	SFC (n)	IFC (%)
Brazil 1-1/8”	321	20	9.1	25.5	9.2
USA	464	19	10.9	28.5	8.7
CHAD 1-5/32”	235	20	6.2	19.3	9.7
Organic	105	17	8.3	23.9	7.6

Table 4. Card sliver properties.

Sample	U%	CV_m%
1	2.52	3.19
2	2.48	3.12
3	2.50	3.18
Mean	2.50	3.16

[RSB-D-45] was used to produce finisher drawn sliver of 70 grains per yard. Drawn sliver properties are shown in Table 5 & Table 6.

2.2.3. Preparation of Roving

A roving frame [Model: F-39] was used to produce roving of 0.7 Ne. Flyer rpm was 1100, TPI set 1.05. Cotton roving properties are shown in Table 7. In summary, the production details of roving preparation from raw materials are shown in Table 8.

2.2.4. Production of Yarn Using Roving

Finally 0.7 Ne roving was fed through the Ring Frame [Model: LR-6] machine and three yarns of linear densities of 8 Ne (TPI: 16.52), 10 Ne (TPI: 18.34) & 12 Ne (TPI: 19.41), with 12,000 spindle speed, ring spun yarns were produced shown in Figure 1. Lakshmi ring frame is one of the market leaders nowadays for its quality production. Therefore this model of ring frame was employed to manufacture the mentioned yarn.

2.2.5. Production of Yarn Using the Sliver

70 grains per yard finisher drawn sliver was fed directly through the same ring frame machine which was used to manufacture yarn from roving and 8, 10 & 12 Ne ring spun yarns were produced again with the same machine parameter (Figure 2).

To comply with the criteria and obtain more accurate findings from future

Table 5. Breaker drawn sliver properties.

Sample	U%	CV_m%
1	2.69	3.37
2	2.67	3.33
3	2.61	3.26
Mean	2.65	3.32

Table 6. Finisher drawn sliver properties.

Sample	U%	CV_m%
1	2.07	2.61
2	1.99	2.48
3	2.04	2.52
Mean	2.03	2.53

Table 7. Cotton roving properties.

Sample	U%	CV_m%
1	3.90	4.89
2	3.82	4.79
3	3.83	4.79
Mean	3.85	4.82

Table 8. Production details for preparation of roving from raw materials.

Machine/Process	Model	Delivery material	Speed
Blow Room	Trutzschler	550 gram per meter card mat	-
Carding	Rieter C-70	80 grains per yard card sliver	200 m/min
Breaker Draw Frame	Rieter SB-D-30	70 grains per yard drawn sliver	700 m/min (doubling 8)
Finisher Draw Frame	Rieter SB-D-45	70 grains per yard drawn sliver	700 m/min (doubling 8)
Simplex	Toyoda F-39	0.7 Ne roving (TPI-1.05)	900 rpm (Flyer speed)

Figure 1. Ring frame producing yarn from roving.

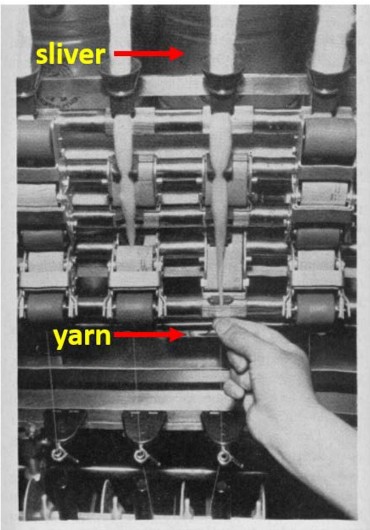

Figure 2. Ring frame producing yarn directly from sliver [5].

testing, all yarn samples were conditioned for at least 24 hours at 20˚C ± 2˚C and 65% ± 4% relative humidity (RH) according to ISO 139. Uster Tester 3 was used to assess the yarn unevenness, CV_m%, imperfections and hairiness. For thick place, thin place and neps, the default settings of imperfection for ring spun yarns were +50%, −50%, and +200%, respectively.

3. Results & Discussion

Investigation into the potential of directly feeding a ring frame machine with the drawn sliver and removing the roving frame in the technological process having already been carried out at the Faculty of Material Technologies and Textile Design's Department of Spinning Technology and Yarn Construction. Quality parameters were found in the yarn that was obtained significantly comparable to those produced by a standard spinning method.

3.1. Unevenness

Unevenness is defined as the variation in weight per unit length of yarn or the variation in thickness of the yarn. Uster uses a capacitive approach to measure yarn unevenness [8]. Yarn unevenness is measured in U% and coefficient of variation of unevenness is measured in CV_m%, CV_m3m% and CV_m10m% by the Uster Tester. It can be observed from **Table 9** that the influence of roving frame on ring spun cotton yarn unevenness is significant. Ring spun yarns produced without roving frame have higher unevenness values than yarns produced using theroving frame. As high draft is required to produce yarn directly from the sliver, this unevenness causes. There is a limit to how much tension may be conveyed to floating fibers with apron rollers via grabbed fibers before the tension becomes extremely critical and surpasses the ideal quantity of movement force per drew fiber [9]. In a Casablanca system, measuring the drafting force, Audivert [10] showed that there was a restriction in break draft beyond which the drafting force grew quickly and significantly and yarn unevenness also increased (**Figure 3**).

Table 9. Ring spun cotton yarn properties.

Count	System	Unevenness (%)	Imperfections/km	Hairiness	RKM (cN/tex)
8 Ne	Using roving frame	7.76	20	7.1	25.39
	Without roving frame	8.65	35	7.5	24.96
10 Ne	Using roving frame	8.52	28	6.6	24.15
	Without roving frame	9.00	39	7.0	23.84
12 Ne	Using roving frame	9.07	35	6.1	23.36
	Without roving frame	9.93	50	6.4	22.16

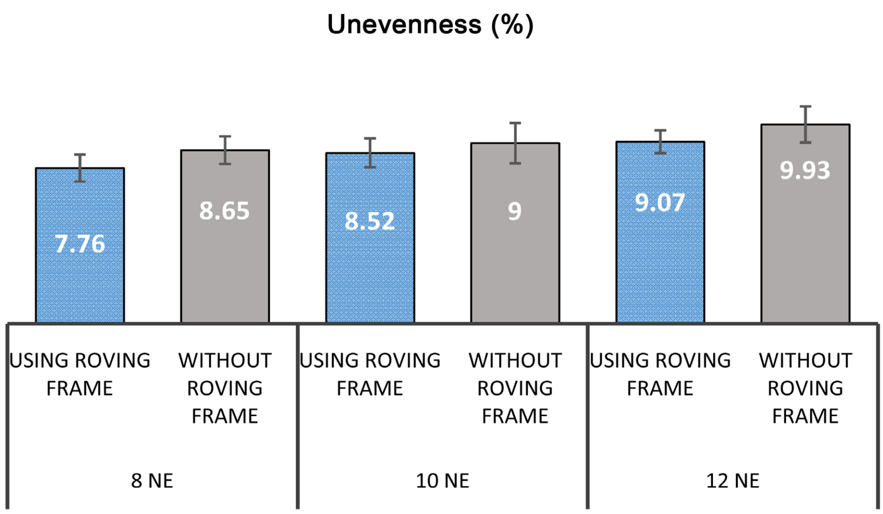

Figure 3. Influence of roving frame on Unevenness (%).

3.2. Imperfections

The Imperfection Index (IPI) of spun yarn means the thin places, thick places and neps in the yarn. IPI describes to the total number of thin places (−50%), thick places (+50%) and neps (+200%) present per km of yarn [11] [12]. Imperfections in ring-spun yarn have a negative impact on fabric qualities. Yarns with more imperfections will perform poorly in future processes, have a poorer aesthetic grade and have a lower strength in the end product [13].

The influence of roving frame on the IPI of the yarn is described in **Figure 4**. Based on the figure, it is clear that roving frame has a great impact on the IPI of spun yarn. Imperfection index is higher in case of yarns produced directly from the sliver. The drafting force has an impact on yarn quality in conjunction with other variables like yam count and the condenser. When compared to the amount of fibers controlled by the apron rollers, the quantity close to the front roller drops. Slower-moving fibers will better manage a floating fiber. Thus if the draft surpasses a threshold value, yarn imperfections rise [14].

3.3. Hairiness

The yarn hairiness is caused by the fiber protrusion from the surface of the yarn. The amount of loose fibers projecting from the center of yarn towards the outer surface usually defines yarn hairiness. Its determination is crucial because it affects the after spinning operation and parameters of the end product. Because the variables that influence yarn hairiness, are linked, the results depend on the manufacturing circumstances [15]. Yarns produced directly from sliver show more hairy fibers. The high draft on the fiber strand reduces the fiber controlling on the yarn and can't entrap the fibres and incorporate them into the center of yarn [16] (**Figure 5**).

3.4. Yarn Tenacity

The strength of yarn per unit linear density is known as tenacity. This tenacity is

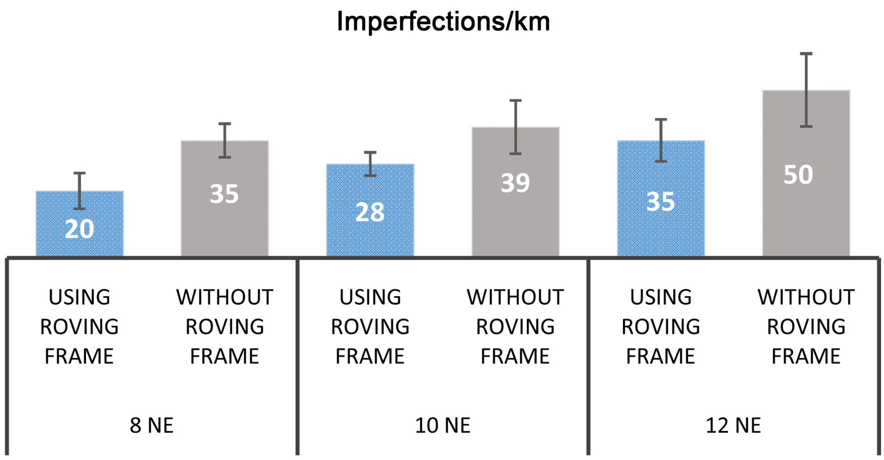

Figure 4. Influence of roving frame on IPI.

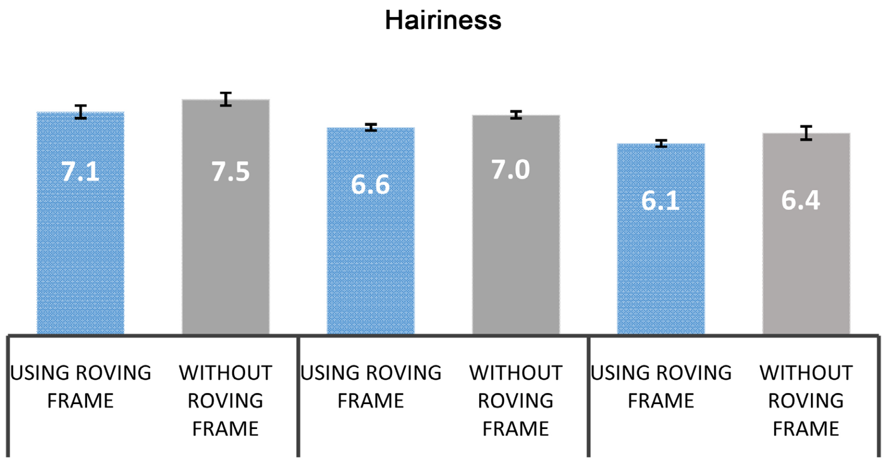

Figure 5. Influence of roving frame on Hairiness.

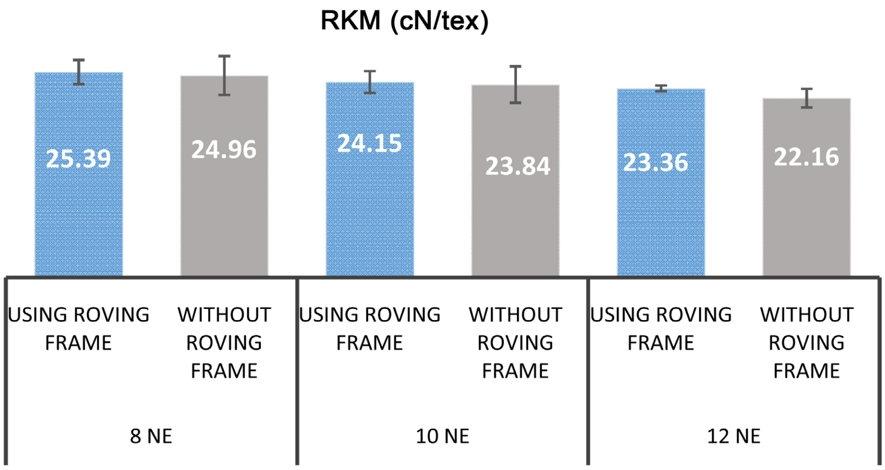

Figure 6. Influence of roving frame on RKM.

a crucial parameter for determining the quality of yarn. The amount of yarn breakages throughout the spinning, weaving, and knitting processes is heavily influenced by the strength of the yarn [17]. The high draft in ring frame increases yarn tenacity which could be due to a decrease in fiber content, an increase in number of hooks and yarn diameter, a reduction in packing density. In the preceding example, the influence of migration parameters is minimal. With the increase in the main draft, the mean fiber position grows little, while root mean square deviation increases at first, then declines. Hence the yarn tenacity overall decreases with the increase in the draft [18] (**Figure 6**).

4. Conclusion

In summary, we see that yarn irregularity increases while producing yarn without using the roving frame. For example, unevenness value increased from 7.76% to 8.65% for 8 Ne. Similarly, U% increased from 8.52 to 9.00 for 10 Ne and 9.07 to 9.93 for 12 Ne. As high draft is required to produce yarn directly from the sliver, this irregularity causes. Moreover, more thin places, thick places & neps are also noticed in the produced yarn. Yarn hairiness also increased. For instance, hairiness increased from 7.1 to 7.5 for 8 Ne. Moreover, with the elimination of roving frame and greater assignments in the spinning, there are significant labor cost savings. Hence research can be carried out in the future on the influence of simplex machine's absence on production cost of ring spun yarn.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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