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Compact Roving for Improved Quality of Ring Spunyarn

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Abstract
This article is concerned with the development of a compact system suitable for producing compact roving. The objective is to reduce twist and improve the performance of roving in the subsequent processes. Combed compact cotton yarn with a linear density of 9.84tex was spun from compact and conventional roving. In order to conclude that compactness had been formed in roving, two special tests, namely the minimum twist of cohesion and roving cohesion strength were determined. Yarns produced from conventional and compact roving were compared for their strength, evenness and hairiness. The results show that there was an improvement in the strength and hairiness of the compact yarns produced from compact roving when compared to conventional yarns.

Key words: *compact roving, suction pressure, pneumatic compact, slot size, profile tube, double compacting, ring spun yarn.*

Introduction

Many developments have occurred in ringframe design such as higher speeds, anti-wedge rings, umbrella creel, and autodoffing arrangements. Ringframe is a chief form of spinning a wide range of counts, and in relation to the above developments an important landmark is the modification of the spinning triangle, which represents the most central part of the ring spinning system. In compact spinning, the spinning triangle is almost eliminated and most of the fibres are incorporated into the yarn structure under the same tension. This leads to a significant reduction in yarn hairiness and an improvement in tenacity and abrasion resistance. Compact yarns ensure complete utilisation of fibres and a saving in sizing cost. As a consequence of this, various types of compacting system have been introduced.

The first compact spinning system to be commercialised was by the Rieter Corporation and is called Com4 spinning. Suessen (the Elite) and Zinser (the Air-Com-Tex 700) have also introduced compact spinning. Rocos, in two versions, has also been developed for making compact yarns, but the method that followed is quite different from the pneumatic method. Pneumatic compact technology is claimed to offer superior quality and better raw material utilisation. Although the properties of compact yarns have been compared with those of conventional yarns, there is no study available concerning the compacting of roving. Since coarser cotton yarns are made in a roving frame with high twist for technical textiles and blankets, it will be of interest to attempt to make compact roving by air suction. According to a study conducted by SITRA, roving contributes to 15% of yarn irregularity and thus any development in roving irregularity will improve yarn quality. Also considerable importance has been given to roving quality by many research workers. Hearle and Merchant [1] derived a formula for obtaining the optimum twist which is in substantial agreement with the findings of other research workers. Smith and Grosberg [2] determined the strength of slivers of relatively low twist. Moreover there are prospects of reducing the twist in the roving frame as a result of compactness. Another advantage of compacting the roving is that the working of the roving will improve by means of a reduction in end breaks. A break in roving will lead to a catastrophic break in the ring frame. By compacting the roving, the end breaks can be reduced not only in roving but also in the ring frame. The Rieters Pavena system should be mentioned here as it dealt with the production of dyed bonded roving and subsequent production of yarns in a ring frame. This system did not become successful due to difficulty in drying the roving. Attempts were made to wet the roving prior to spinning for getting a compact yarn. But this was also found to be unsuccessful owing to the corrosion problem in the ringframe.

Roving gains strength because of the twist, whereas this creates a helical form of fibres and reduction in orientation of fibres towards the axis of the fibre. Improving cohesion in the speed frame improves yarn strength. By a reduction of twist, it is possible to get more parallelisation of fibres, which can be achieved by compacting fibres in the roving stage without increasing the twist.

Most of the work on compactness relates to compacting yarn in the final process on the ring frame. No attempt has been made to compact the roving structure to enable fibre cohesion and evenness. The compact system used in the ring frame reduces the spinning triangle and almost all fibres are incorporated into the yarn structure. Similarly in the roving 'the roving triangle' is also formed, which leads to more hairiness on the surface of roving, causing irregular alignment of fibres. Many researchers have described the technical principles of compact spinning and the more organised structure, without peripheral fibres and with a better twist distribution. The compact yarn shows higher strength, reduced hairiness, and improved evenness.

Higher tenacity yarns are obtained from high strength rovings produced with high twist due to less spreading of fibres in the drafting zone. Akshay Kumar [3] et al. concludes that the speed frame is a crucial process which decides the final quality of yarn. The negative effect of the preceding spinning machine can be overcome by proper selection of parameters at the speed frame. The compactness obtained in the spinning stage contributes only to the already formed structure in the yarn.

Barella [4] et al. in 1965 investigated the cohesion phenomena in rovings and yarns. Basu and Chellamani [5] et al. did work on the influence of fibre length and denier on the properties of polyester ring and air jet spun yarns. Dash, Ishtiaque and Alagirusamy [6] carried out work on compact yarn properties and the processibility of compact yarns. Cheng and Yu [7] found that finer yarn had given better results when compared to coarser yarns during compact spinning.

Nikolic [8] et al. did work on the compact spinning of cotton and blended yarns. Mohamed [9] et al. investigated the impact of new spinning technologies on Egyptian cottons. Sevda Atlas [10] et al. did a comparison of pneumatic compact systems and mechanical compact systems. Ganesan [11] et al. studied the fibre migration in compact yarns.

Bojun Xu.jian Ma [12] studied the radial distribution of fibres in compact spun flax cotton blended yarns. Tyagi [13] et al. investigated the effect of spinning conditions on the mechanical and performance characteristics of ring and compact yarns. Magesh Kumar [14] et al. optimised the process parameters in Eli-twist yarns.

Mohammed Furquan Khurshi [15] et al. did a comparative analysis of cotton yarn properties spun by pneumatic compact spinning. Alsid Ahmed Almetwally [16] et al. compared the physical properties of compact yarns spun from different pneumatic compact systems.

Packing density is a very important parameter of yarn as it determines its bulkiness, warmth, feel, moisture and dyeing characteristics. Ganesan [17] et al. states that the increase in strength of compact yarn can be attributed to factors such as higher packing density and better integration of fibres to the yarn body. Hussain [18] states that packing density is greatly influenced by the raw material as well as by yarn manufacturing techniques and spinning variables. Packing density depends on the twist and fibre alignment. Yarn diameter greatly affects the packing, with an decrease in diameter representing a decrease in the inter fibre distance and vice versa. Gokarneshan [19] et al. did work on the inter fibre cohesion phenomenon of various kinds of yarns. Musa Kilic [20] et al. compared the packing densities of yarns spun by ring, compact and vortex spinning systems.

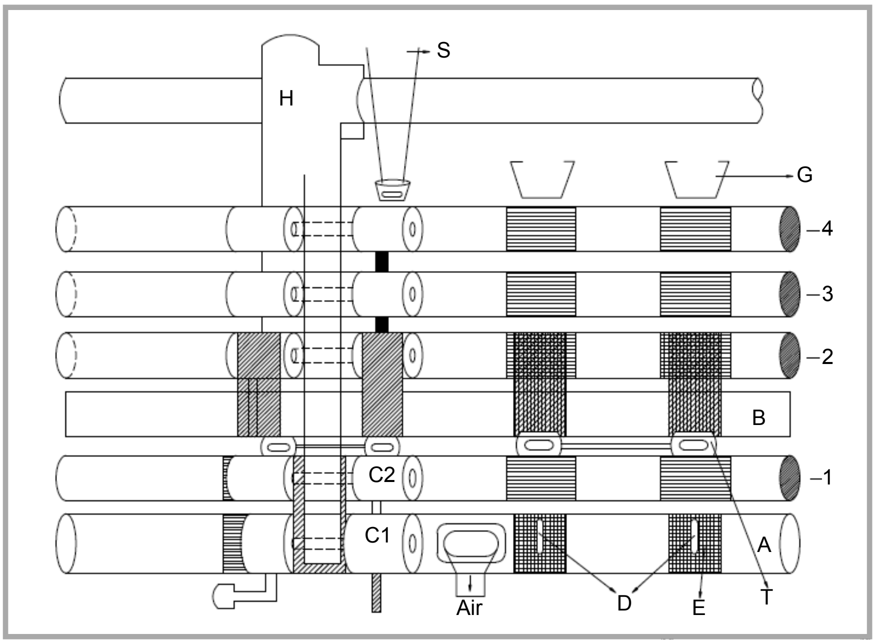

Figure 1. *Pneumatic roving compact system: 1) front bottom roller. 2) IInd bottom roller. 3) IIIrd bottom roller. 4) back bottom roller. A) profile tube. B) nose bar; compact unit with C1) compact front top roller and C2) compact small top roller. D) suction slot. E) lattice rerforated apron.*

The purpose of the study was to produce compact roving following the principle of compacting yarn in a ring frame and to compare the yarns using conventional and compact roving in the ring frame. The main goal of mills today is to achieve improved yarn quality that will lead to better performance in the subsequent processes. Therefore an investigation was conducted to compare the quality of yarns made from conventional and compact rovings to justify whether the quality parameters demonstrated a significant improvement or not for the development of the compacting system in a roving frame.

Experimental design

Material

Cotton mixing is conducted with MCU 5 cotton and DCH 32 cotton in the ratio of 60:40, respectively, and conditioned for 24 hours at a relative humidity of 60%.

Details of the cotton used are shown in ***Table 1***.

The technological parameters used in the production of yarn with a linear density of 9.84 tex are given in ***Table 2*** (see page 26).

Working principle of roving pneumatic compact system

The compact unit of roving was fixed on a LF1400 LMW Simplex machine as shown in (***Figure 1***). The front drafting unit has an air-permeable lattice apron [E] running over a profile tube. The profile tube [A] is used for suction by means of a compressor, which creates negative pressure, and there is a slot [D] tilted in the direction of fibre movement for each roving position. After the fibres leave

Table 1. *Details of cotton used in the process.*

Cotton used	MCU 5 cotton	DCH 32 cotton
25% span length, mm	30	32
50% span length, mm	15	16
Micronaire value	3.4	3
Bundle strength, g/tex	24.5	24
Uniformity ratio%	49	48

Table 1a. *Origin of Cotton used.*

1	MCU 5	TAMIL NADU	INDIA
2	DCH 32	KARNATAKA	INDIA

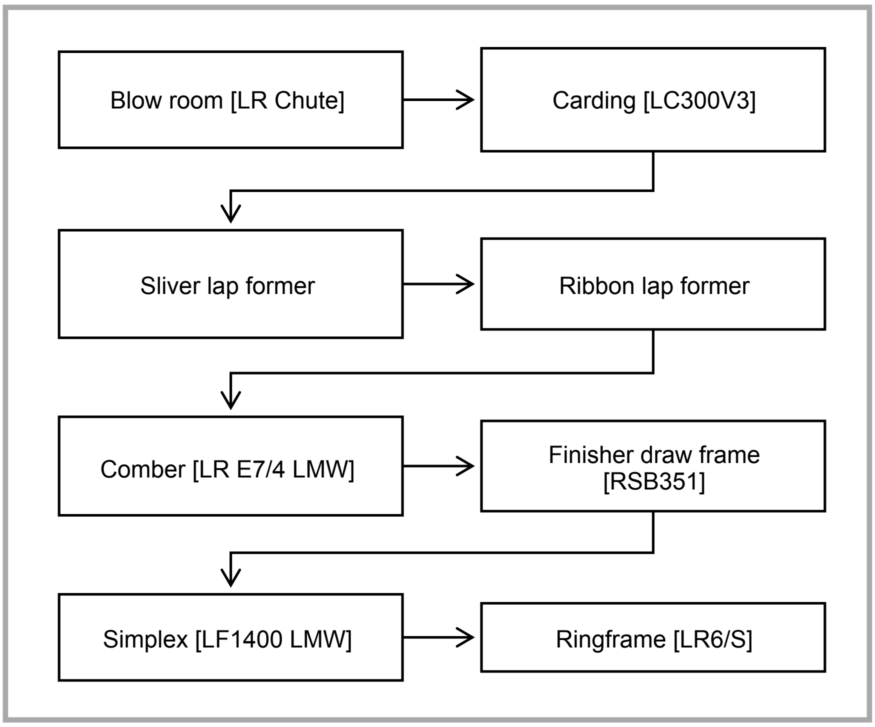

Figure 2. *Flow chart for processing sequence.*

the front roller nip line, they are guided by means of the lattice aprons over the openings of the suction slots, where they move sideways and are condensed and compacted due to the suction of air flow. The openings of the suction slots [D] are at an inclined position, at an angle of 85 degrees to the direction of fibre flow. This generates a transverse force on the fibre band during the passage over the slot and causes the fibre band to rotate around its own axis. The perforated apron carries the fibres attached to it up to the delivery nip line. The delivery roller [C1] has a bigger diameter than the driven front top roller [C2], which generates tension in the longitudinal direction during the condensing process. The tension ensures the straightening of curved fibres.

Method of processing

The entire work of processing the samples was carried out in a standard spinning mill with latest machineries, as shown in the flow chart (***Figure 2***).

The mixed cotton is processed in the blow room, which has 3 beating points with MBO, MONOCYLINDER, UNIMIX and ERM. The processed cotton is chute fed to cards having a doffer speed of 110 m/min and delivery sliver of 4.216 ktex linear density. The sliver is passed through sliver lap and ribbon lap machines, and the lap is processed in the comber at a speed of 180 nips/min and delivery sliver of 4.216 ktex linear density. The combed sliver is fed into the finisher draw frame with a speed of 350 mpm and delivery sliver of 3858 tex linear density. The draw frame sliver is passed to the simplex frame at a speed of 750 rpm to produce roving with a linear density of 393.66 tex.The roving is then processed through the compacting unit to produce compact roving. Roving without compact [conventional] is produced in the same machine simultaneously side by side for comparison purposes. The roving is spun into yarn with a linear density of 9.84 tex in the ring frame with or without the compacting system as per the requirement.

Preparation of yarn samples

Compact and conventional rovings of a linear density of 393.66 tex were prepared under identical conditions using a LR 1400 simplex machine where a special pneumatic compact system had been fitted. Four types of samples of yarns were produced as shown below (***Figure 3***).

Types of yarn samples

A Ring compact yarn is produced by compacting in the ring frame

B Roving compact yarn is produced by compacting on the simplex machine.

C Double compact yarn is produced by compacting both in the ring frame and on the simplex machine

Table 2. *Technological parameters of m/cs used.*

Quality Parameters	Units	Roving	Yarn
Linear density	tex	393.66	9.84
Spindle speed	rpm	750	18750
Drafting system	–	LF1400LMW	P3
Twist	tpm	60.98	1167
Total draft	–	9.8	40

Roving pneumatic compacting system

Table 2a. *Details of Instruments used.*

Sl. No.	Properties	Instruments used	Producer	Country of origin
1.	Evenness	Uster Tester 5	Uster Technologies AG	SWITZERLAND
2.	Tensile strength	Uster Tensorapid	Uster Technologies AG	SWITZERLAND
3.	Hairiness	Zweigle Hairiness tester	Uster Technologies AG	SWITZERLAND
4.	Friction	Lawson Hemphill friction meter	Lawson Hemphill	USA
5	Abrasion Resistance	MAG SITRA	Mag Solvics (p) Ltd	INDIA

Table 3. *Roving properties, * Significant at 1% level.*

	Properties	Compact	Conventional
1.	Evenness, u %	3.98±0.06*	4.58±0.16
2.	Roving cohesion strength, cN/tex	1.40±0.26*	1.06±0.24
3.	Packing Density	0.221±0.017*	0.186±0.011
4	Wicking test, mm	11*	20.4
5.	Minimum Twist of Cohesion value, %	60±0.26*	69.33±0.25

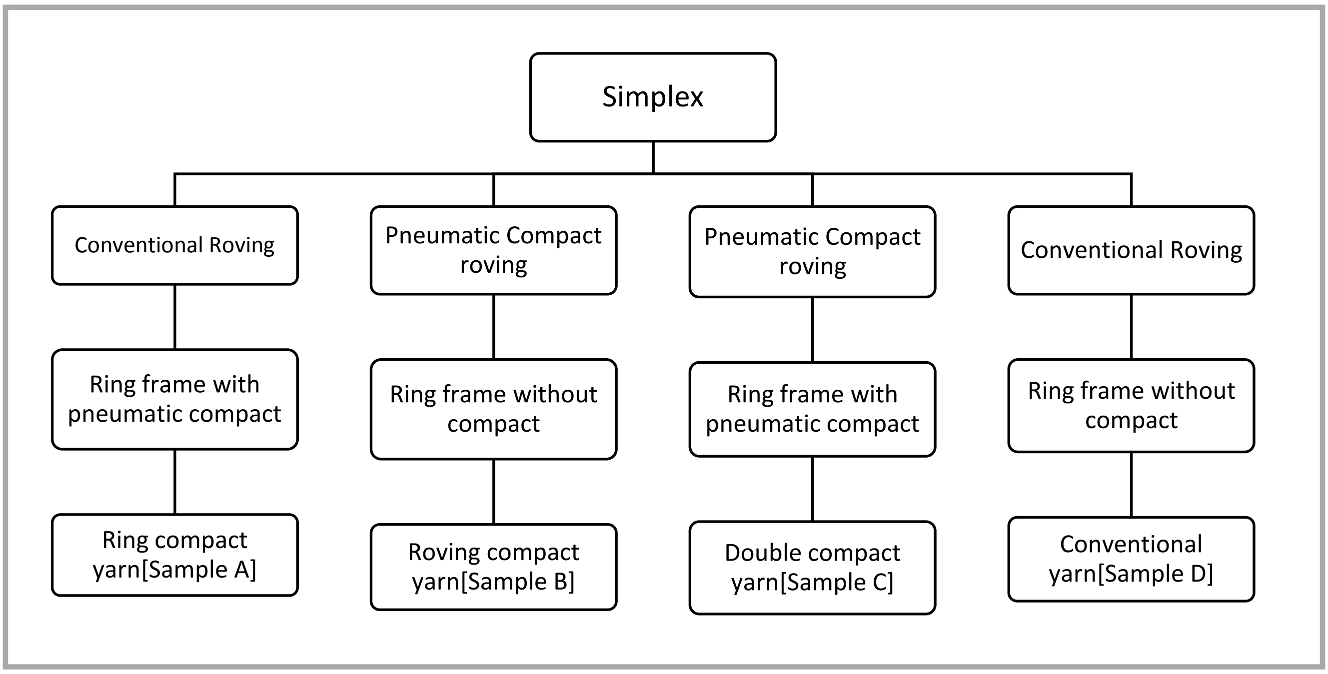

Figure 3. *Flow chart for preparation of samples.*

D Conventional yarn is produced without compacting either in the ringframe or on the simplex machine

Testing and evaluation

All tests were carried out at Rh 65 ± 2%, and 27 ± 2°C.

Yarn evenness imperfections and hairiness properties were tested using an Uster tester 5, and yarn tenacity and elongation by an Uster Tensorapid. Wicking tests were performed as stipulated by the DIN 53924 test method. Yarn hairiness and S3 values were determined using a Zweigle hairiness tester. The friction coefficient was estimated using a Lawson Hemphill and the abrasion resistance by a Mag Sitra yarn abrasion tester. The inter fibre cohesion of compact and non-compact rovings was found using the minimum twist of cohesion values determined by the methods followed by Barella [4]. The packing densities were calculated by measuring the diameter of roving and yarns using a projection microscope and by applying the following formula, where "d" is the yarn diameter in mm.
Packing density = (tex count / 380πd).

The mean of ten tests was taken to determine the values.

The flexural rigidity of yarns was determined using the Carlenes' loop method [21].

Results and discussion

[A] Roving analysis

The compact and conventional rovings were analysed for differences in their properties. The compact roving was found to be better than conventional roving in all the properties compared, as shown in the ***Table 3***, and statistically significant at a 1% level.

Evenness
Compact roving shows better evenness. Compact yarns show 3.98U% whereas in conventional roving it is 4.58U%, being a significant difference in the value, attributed to the better alignment of all fibres towards the axis of the yarn by pneumatic suction. Loose fibres are held back inside due to the rolling action of the roving upon the inclined slot in the profile tube.

Roving cohesion strength
Table 3 shows that compact roving of 393.66 tex shows a cohesion strength value of 1.4 cN/tex, while for conventional roving it is 1.06 cN/tex, which shows an increase of 25% in cohesion.

The relation between roving compactness and the twist multiplier is important in improving the quality of roving. The tenacity of roving increases with an increase in the twist multiplier. However, this characteristic of roving does not always lead to the expected increase in yarn strength. The yarn tenacity increases to a maximum value and then decreases as the roving TM increases. But in the case of compact roving, cohesion is obtained due to the parallelisation of fibres and a higher number of fibres in the cross section, improving the roving strength. TM can be reduced in roving to get the same strength by using compact roving. A high drafting force is required to draft the high strength roving produced by high twist. But in the case of compact roving, the effect of the helical nature of fibres is reduced, and thus a lesser drafting force is required. Hence the irregularity produced in high twist roving is reduced when compact roving is used. The fibres are packed well because of pneumatic compacting, and therefore there is more cohesion between fibres, contributing more strength and elongation.

Packing coefficient
The manifestation of higher packing density is an indication of compactness. The result indicates that there is a decrease in diameter to the extent of 8.2%. The packing density of 393.6 6tex compact roving is 0.221, which is higher than that of conventional roving, which is 0.186, representing a significant difference in the packing densities of compact and conventional roving.

Minimum twist of cohesion
Compact roving shows a value of 60% MTC, whereas for conventional roving

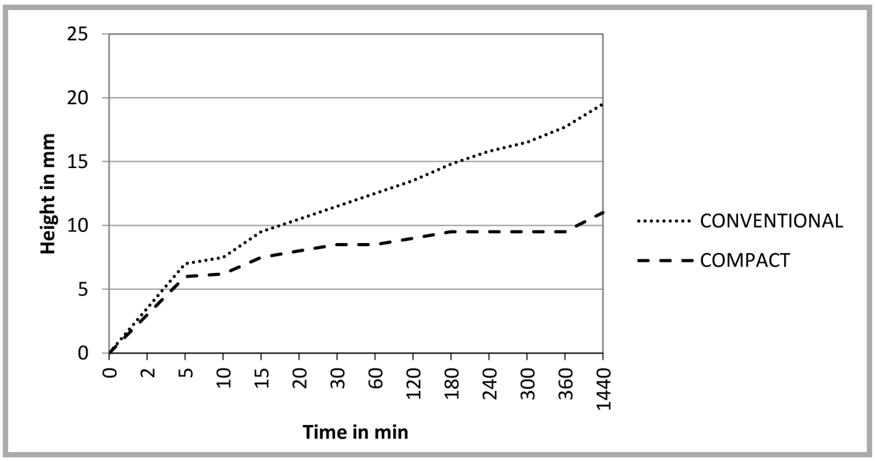

***Figure 4.** Wickability of conventional and compact roving.*

it is 69.33%. The result shows that the cohesion has improved the compactness of roving by more than 14%,which is a significant difference in the value, indicating adequate cohesion in compact roving. The lower MTC value indicates higher compactness.

Wickability of roving

The wickability of compact and conventional roving is compared in ***Figure 4***.

The wicking effect shows that compact rovings have better compactness when compared to conventional roving. There is a significant difference in the wicking distance. After 24 hours of wicking, the conventional roving had reached a distance of 19.5 mm, while compact roving was able to wick only 11mm.The lower the value of the wicking height, the better the compactness.

[B] Yarn analysis

The properties of the four yarn samples are shown in ***Table 4.*** Conventional yarn (D) is compared with pneumatic compact ring yarn (A), and pneumatic compact roving yarn (B) with double compact yarn (C) for their differences in properties.

The properties were statistically analysed and it was found that ring compact yarn and roving compact yarns are more or less equal in their properties and that there was no significant difference, whereas double compact yarns are better in all properties when compared to other yarns. The breaking strength, RKM, S3 value and wicking height of roving compact yarns are not statistically significant when compared to ring compact yarns.

Statistical Analysis

A test of significance [t-test] was used to find out the differences between samples at the 5% and 1% levels. A two tailed test was performed to estimate the p value for any differences between samples.

Yarn evenness

The experimental results of different types of compact yarns are shown in ***Table 4***. As per the statistical analysis shown in ***Tables 5 & 6***, the effect of compact roving yarns are significant when compared with conventional yarns.

The compact yarns show better evenness when compared to conventional yarns.

A&B (***Table 5***) – The roving compact yarn shows 11.31U% and ring compact yarn – 11U%, which clearly indicates that compact roving yarn has improved uniformity, closer to that of ring compact yarn.

B&C (***Table 5***) – The double compact, introduced both at the roving stage and ring frame stage, has improved yarn evenness, reduced imperfections and more strength and elongation when compared to yarns with compaction only in the roving frame.

A&C (***Table 5***) – The double compact both at the roving and ring frame stage has improved U% compared to yarns with compaction only at the ring frame stage.

A&D (***Table 6***) – Ring compact – [A] has better evenness when compared with conventional roving yarns – [D].

B&D (***Table 6***) – Roving compact yarns (B) have better evenness when compared with conventional yarns. The effect of compacting at the roving stage is increased packing density. The number of fibres is higher in the cross section and also more aligned due to pneumatic compacting. Hence there is an increase in evenness.

C&D (***Table 6***) – Double compact yarns [C] are still better in evenness when compared with conventional and other single compact yarns. This shows that residual fibres are still more compacted to the increase in evenness.

Imperfections

The compact roving yarn has reduced imperfections since loose fibres are bound inside the roving and thus reduces the chances of getting entangled with surfaces of contact. Moreover hairiness is reduced in compact roving due to better fibre alignment in roving formation. In ring spinning, by over-twisting of outer fibres in the spinning triangles, some percentage of fibres break, which does not occur in compact roving. Due to the positive condensation, the width of the fibre stream is reduced after drafting and almost all fibres are incorporated into the roving body.

In the compact roving process, fibres in the roving twist gradually in a parallel state and interlace perfectly. These factors not only greatly reduce roving hairiness but also improve yarn evenness, making the appearance of yarns cleaner and closer to ring compact yarns without compact roving. Double compact yarns [C] have the least total imperfections of 133/1000 m when compared to A, B & D type yarns.

Breaking strength

A higher number of fibres in the cross section and parallelisation of fibres contributed more strength. Hence the tenacity or RKM values show an increasing trend for compact yarns.

A&B – It is seen from the ***Table 4*** that strength and rkm values are more or less equal and that there is no significant difference, which clearly indicates that compacting in roving has improved strength because of the edge fibres being gripped in the process.

Double compact yarn [C] has the highest strength of 233 cN and RKM of 22.16 when compared to the A, B & D types of yarns.

Breaking extension

It is seen that the elongation of compact roving increased when compared to ring compact yarns. Double compact yarns exhibit better elongation.

Table 4. Yarn properties – 9.84 tex, 100% cotton yarn, A-ring compact yarn, B-roving compact yarn, C-double compact yarn; D-conventional yarn.

SL.NO	PROPERTIES	UNIT	A	B	C	D
1.	Evenness	Uster U%	11.01±0.12	11.31±0.11	10.28±0.13	12.47±±0.14
2.	Imperfections /1000 M	Uster IPI	152±8.83	188±2.97	133±±4.15	706±9.92
3.	Hairiness	Uster H	2.89±0.17	3.49±0.12	2.09±0.08	4.64±0.15
4.	Breaking strength	cN	206±2.6	205±2.2	223±3.2	165±5.2
5.	RKM/tenacity	cN/tex	20.93±0.27	21.17±0.28	22.16±0.26	16.77±0.24
6.	Elongation	%	4.77±0.17	4.30±0.16	5.07±0.15	3.54±0.18
7.	S3 Value (ZWEIGLE)		51±12.8	57±12.7	42±13.55	106±11.1
8.	Flexural rigidity	$g.cm^2 * 10^{-3}$	1.31±0.008	1.29±0.007	1.36±0.01	1.21±0.01
9.	Frictional coefficient		0.25±0.008	0.26±0.008	0.24±0.005	0.28±0.014
10.	Abrasion resistance	cycles	145±3.64	140±2.23	155±1.67	133±2.3
11.	MTC Value	%	40±0.37	43.58±0.47	32.88±0.38	45.41±0.38
12.	Wicking height	mm	106.8±3.48	109.2±4.13	93±2	117.2±1.51

*Table 5. Statistical analysis of compact yarns; (*P<0.05, NS-not significant and p>0.05, ** P<0.01)*

SL. NO	PROPERTIES	A&B		B&C		C&A	
		t	sig	t	sig	t	sig
1.	Evenness, u%	4.26	0.00001**	20.20	0.00001**	12.73	0.00001**
2.	Imperfections, IPI	7.57	0.00003*	21.09	0.00001**	3.81	0.002*
3.	HAIRINESS, H	24.01	0.00001**	40.40	0.00001**	78.26	0.00001**
4.	Breaking strength, cN	1.42	0.096*NS	10.79	0.00001**	13.15	0.00001**
5.	RKM, cN/tex	1.35	0.106*NS	10.02	0.00001**	9.81	0.00001**
6.	Elongation, %	16.02	0.00001**	3.20	0.006*	17.98	0.00001**
7.	S3VALUE (ZWEIGLE)	0.68	0.255*NS	2.69	0.1374*	2.05	0.03714*
8.	Flexural rigidity, $g.cm^2*10^{-3}$	3.28	0.0055*	6.19	0.00013*	8.23	0.000018*
9.	Frictional coefficient	1.88	0.0477*	4.91	0.00058*	2.68	0,01389*
10.	Abrasion resistance, cycles	6.32	0.00031*	12.48	0.00001**	5.29	0.00036*
11.	MTC Value	1.77	0.04683*	8.94	0.00001**	2.17	0.02113*
12.	Wicking height, mm	0.779	0.229066 NS*	6.19	0.00031*	6.02	0.000157*

*Table 6. Statistical analysis of compact and conventional yarn; (*P<0.05 and ** P<0.01)*

SL. NO	PROPERTIES	A&D		B&D		C&D	
		t	sig	t	sig	t	sig
1.	Evenness, u%	15.26	0.00001**	13.33	0.00001**	29.10	0.00001**
2.	Imperfections, IPI	81.62	0.00001**	97.84	0.00001**	104.22	0.00001**
3.	HAIRINESS, H	78.39	0.00001**	56.11	0.00001**	180.31	0.00001**
4.	Breaking strength, cN	45.60	0.00001**	27.20	0.00001**	45.13	0.00001**
5.	RKM, cN/tex	31.58	0.00001**	21.89	0.00001**	29.21	0.00001**
6.	Elongation, %	31.14	0.00001**	19.75	0.00001**	32.80	0.00001**
7.	S3VALUE (ZWEIGLE)	6.09	0.00014*	5.62	0.00024*	7.18	0.00047*
8.	Flexural rigidity, $g.cm^2*10^{-3}$	15.17	0.0001**	12.03	0.00001**	21.23	0.00001**
9.	Frictional coefficient	3.93	0.00125*	2.62	0.1518*	5.93	0.000173*
10.	Abrasion resistance, cycles	5.39	0.00032*	6.13	0.00014*	3.77	0.01202*
11.	MTC Value	5.94	0.00001**	3.49	0.00128*	13.89	0.00001**
12.	Wicking height, mm	4.807	0.000671*	3.192	0.006379*	16.94	0.00001**

The significant improvement in yarn breaking elongation for the compact spun yarns is due to the fact that fibres are better integrated and uniformly arranged to effectively contribute to yarn breaking elongation. The breaking extension of a spun yarn is basically related not only to the fibre extension but also the way in which the fibres are arranged in its body. Roving compact spun yarns are characterised by better fibre integration and a uniform fibre arrangement, which is due to the reduction in the roving triangle and spinning triangle in the compact spinning, which reduces the differential path of fibre in the yarn, and hence the fibre follows a smaller helical path in the roving compact yarn than conventional ring yarn. Double compact yarn shows 40% more extension when compared to conventional yarn.

Hairiness

The Uster Hairiness value, H, of ring compact yarn is 2.89, whereas for roving compact yarn it is 3.89. Although roving compact yarn is slightly more than ring compact yarn, it has reduced hairiness when compared to conventional yarn with 4.64. This clearly demonstrates the effect of compacting in roving in reducing hairiness.

The S3 value indicates that there is no significant difference in the hairiness value of ring and roving compact yarns.

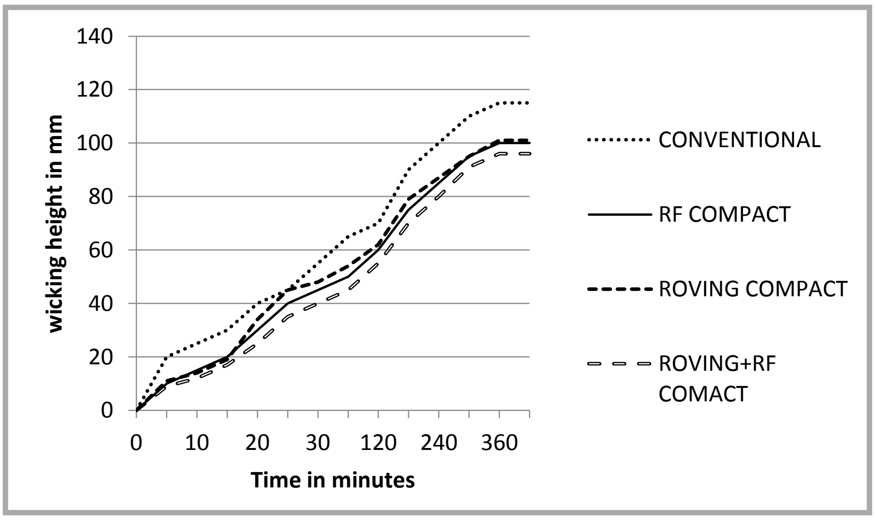

Figure 5. *Wicking phenomena of compact and conventional yarns.*

Double compact yarns exhibit lesser hairiness when compared to single compact yarns. Due to the pneumatic suction arrangement, the compact yarns pull all short fibres towards the axis of the yarn, thus preventing the short fibres form protruding outwards. Hence there is a reduction in hairiness.

Wickability of yarn

The wicking effect of compact and conventional yarn is shown in ***Figure 5***.

- Roving compact yarns show slightly higher wicking height of 109.2 mm when compared to ring compact yarn. This shows that the effect of compacting at the roving stage improved the roving compactness.
- Double compact yarns exhibit better compactness by having a wicking height of only 93 mm as compared to conventional and other single compact at the ring frame or roving stage.
- Due to lesser compactness conventional yarns have more wicking height when compared to compact yarns.

Flexural rigidity

Flexural rigidity is closely related to the freedom of fibre movement during bending. An increase in inter fibre cohesion as a result of higher compactness, increased packing density, a higher number of fibres in the yarn cross section and higher radial pressure restrict the freedom of fibre movement, thus leading to higher flexural rigidity.

The flexural rigidity of ring compact yarns is 1.31 $g.cm^2*10^{-3}$, whereas for roving compact yarns it is 1.29 $g.cm^2*10^{-3}$. This shows that there is an improvement in flexural rigidity when compacting at the roving stage. Double compact yarns both at roving and ring frame stages exhibit a higher flexural rigidity of 1.36 $g.cm^2*10^{-3}$. All the compact yarns show a marked difference in flexural rigidity when compared to conventional yarns. The values are statistically significant.

Minimum twist of cohesion

MTC is defined as the minimum number of twists required to cause cohesion between the fibres so as to be held in the yarn structure.

The yarns produced from compact rovings were analysed for MTC values. They were compared with conventional yarns and it was found that there was an increase in the cohesion value by 10-30% over conventional roving yarns. The increased cohesion is due to the increase in packing density of compact roving.

The compact yarns showed an improvement in cohesion as shown below:

- Conventional yarns < roving compact < ring frame compact < double compact (45.41%<43.58%<40%<32.88%). The lower the value of MTC, the better the performance in terms of compactness.
- Roving compact yarn shows better cohesion when compared to conventional yarns. Double compact yarns have the lowest MTC value, indicating better inter fibre cohesion.

Packing density

The packing coefficient of double compact yarn shows a higher packing density of 0.61, whereas for ringframe compact yarn it is 0.57, which clearly defines the effect of compactness due to roving compaction. Conventional yarn has a packing coefficient of 0.50 only. Statistical tests show higher significant values.

Friction coefficient

The friction coefficient of double compact yarn is lower when compared to ring compact and roving compact yarns. This explains the effect of compact roving on friction. Double compact yarn is 0.24, while for ring compact it is 0.25 and for roving compact – 0.26, which is due to the lower area of contact of compact yarns with the surface. The values are found to be statistically significant.

Abrasion resistance

The abrasion resistance of double compact yarns shows a significant difference with conventional and single compact yarns. Double compact yarns can withstand 155 cycles, as compared to the 133 cycles of conventional yarns. Ring compact yarns withstand 145 cycles and roving compact yarns – 140 cycles. The improvement in abrasion resistance in double compact is mainly due to the effect of compactness in roving.

Conclusions

Analysis of the results obtained within the comparative research into the quality properties of conventional and compact ring frame yarns produced from conventional and compact roving led to the following conclusions.

Although compact yarns produced from conventional roving are found to be less hairy and stronger than conventional yarns, compact yarns produced from compact roving show outstanding performance.

Since there is a significant improvement in the characteristics of compact yarns, it can be taken that the compaction of roving represents a promising technology for future spun yarn production. Compact roving has the potential of producing superior quality yarns which can be used by industries profitably.

The following advantages are possible with compact roving yarns.

1) Compacting roving produces less fly in simplex
2) The compacting of roving reduces hairiness and increases strength and

elongation when compared to conventional yarn.
3) There is a significant reduction in the yarn friction coefficient value, an increase in abrasion resistance, and higher flexural rigidity values.
4) Increase in the evenness of yarn.
5) Compact roving can be used to produce lower counts, such as 590.5 tex to 147.62tex, for the production of various technical textiles like blankets, tarpaulins, canvas, tents, and mountaineering suits.
6) Less expensive raw material can be used to produce good quality yarn.

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