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Effect of spinning conditions on mechanical and performance characteristics of cotton ring- and compact-spun yarns

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The effect of spinning conditions on the structural, mechanical and low -stress response of cotton ring- and compact-spun yarns has been studied. Spinning conditions include spinning draft, twist factor, yarn tex and spindle speed. Generally, the compact- spun yarns display higher mean migration intensity and lower values of mean fibre position, helix angle and helix diameter. It is also observed that the yarn structures produced under various spinning conditions yield different performance characteristics and the differences are quite meaningful; however, using appropriate twist factor and varying spindle speed, one can successfully spun yarns with less hairiness, better abrasion resistance, and quite sufficient structural integrity and compressional energy. An optimal spinning draft is required if the optimum level of structural integrity, compressional energy, compressional resilience and abrasion resistance of a yarn needs to be achieved for a specific end-use. The behaviour of compact-spun yarns is noticeably better in respect of tensile strength, work of rupture, abrasion resistance, hairiness and mass irregularity.

Keywords: Abrasion resistance, Compressional energy, Compact-spun yarn, Cotton, Ring-spun yarn, Structural integrity

1 Introduction

The mechanical characteristics of staple yarns are decisively influenced by the yarn structure characterized by the arrangement of individual fibres in yarn cross-section. The yarn structure can be modified by changing physical and technological parameters of the spinning process. Many yarn characteristics such as tenacity, breaking elongation, appearance and uniformity depend on fibre distribution along the yarn cross-section. Hence, numerous studies have been carried out on yarn structure and related properties[1-3]. In contrast to the availability of vast amount of literature on fibre arrangement in ring-, rotor- and jet-spun yarns[4-7], relatively little attention has been given to the structural features of compact-spun yarns. Most of the studies on compact-spun yarns have been focused on the application of compact spinning to short-to-medium cottons and are concerned with the properties of yarns produced by different systems[8-11]. There are occasional references to the fibre arrangement in compact yarns[12,13], but none has so far addressed the question of the extent to which the spinning parameters influence structural features and quality characteristics. This paper highlights the structural and characteristic variations in cotton ring- and compact-spun yarns caused by spinning draft, twist factor and twisting speed. Besides, the performance characteristics of these yarns are also examined.

2 Materials and Methods

2.1 Preparation of Yarn Samples

The yarns used for the study were made from J-34 cotton (2.5% span length, 26.8mm; fineness, 1.8dtex; tenacity, 26.7 g/tex; and breaking extension, 6.5%) on ring and compact spinning machines with different twist factors ranging from 33.56 to 38.36. Lap was made on Lakshmi Rieters' blow room line and carded on Texmaco Howa card. The conversion to combed sliver was carried out by using Rieters' sliver lapper LE2/4a, Rieters' ribbon lapper LE4/7a and Rieters' comber E 7/4. The stock from the combing unit was drawn twice on a Lakshmi Rieters' draw frame DO/2S and converted into 2.5 Ne rove using an O K K fly frame, which was used to produce 14.7 tex yarn on Rieters' G 5/1 ring frame using conventional and rotorcraft compact spinning mode (RoCoS)[14]. The spindle speed and spinning draft were changed, while other production parameters were kept constant. Six sets of 29.5 tex yarns were also spun at two different speeds with three twist factors.

2.2 Test Methods

Prior to processing, 0.5% of cotton fibres dyed in red colour was added to the grey fibres during mixing

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and the lot was spun into yarns in a normal way. The yarns were then immersed in methyl salicylate having the same refractive index as the fibres so that the dyed fibres could be readily observed through an image analyzer. The yarn structural parameters, namely mean fibre position, mean migration intensity, helix angle and helix diameter, were measured using a Lieca Q 500 MC, image analyzer. Eighty observations with both ends shown on the screen were made for each yarn sample. Tensile properties of all the yarns were measured on an Instron using 500mm test specimen and 200mm/min cross-head speed. The mean yarn tenacity and breaking extension were averaged from 50 observations for each yarn sample. Zweigles hairiness meter (Model G 565) was used to record yarn hairiness and an uster evenness tester to assess mass irregularity of the yarns. Abrasion resistance of yarns was determined by CSI abrasion tester according to ASTM D3885-99; the number of abrasion cycles required to rupture the specimen was noted. The structural integrity was determined on Instron tensile tester using 200 mm gauge length and 20mm/min cross-head speed. The upper limit was fixed at 2% strain and twenty cycles were fixed on the Instron universal tester. The yarn performance was assessed in terms of percentage decay using the following expression:

$$\% \text{ Decay} = [(A_1 - A_{20})/A_1] \times 100$$

where A_1 and A_{20} are the areas under the curves for first and twentieth cycles. The yarns were tested for compressional energy on the Instron universal tester according to the method described by Basu and Chellamani[15]. A parallel array of yarn was compressed between two parallel compression plates to a pressure of 2.5 g/m^2 with the anvil and foot diameters of 120mm and 40mm respectively. The initial separation between the plates was kept as 10mm and cross-head speed as 0.5 mm/min. The compressional resiliency was calculated by expressing unloading curve area as percentage of loading curve. Twenty observations were made for each yarn sample.

3 Results and Discussion

3.1 Structural Features

The relationships between structural characteristics and spinning conditions of the ring- and compact-spun yarns are shown in Figs 1-2. The results show

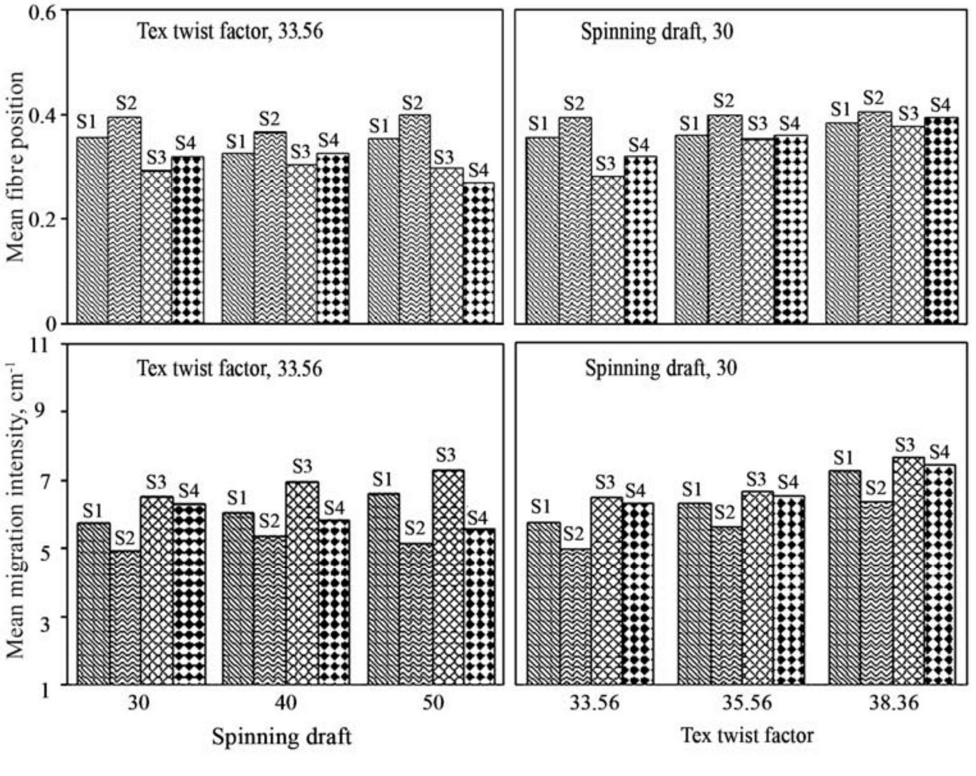


Fig.1—Variation in mean fibre position and mean migration intensity with spinning parameters [S1–compact yarn, 250 rps; S2–ring yarn, 250 rps; S3–compact yarn, 291.66 rps, and S4–ring yarn, 291.66rps]

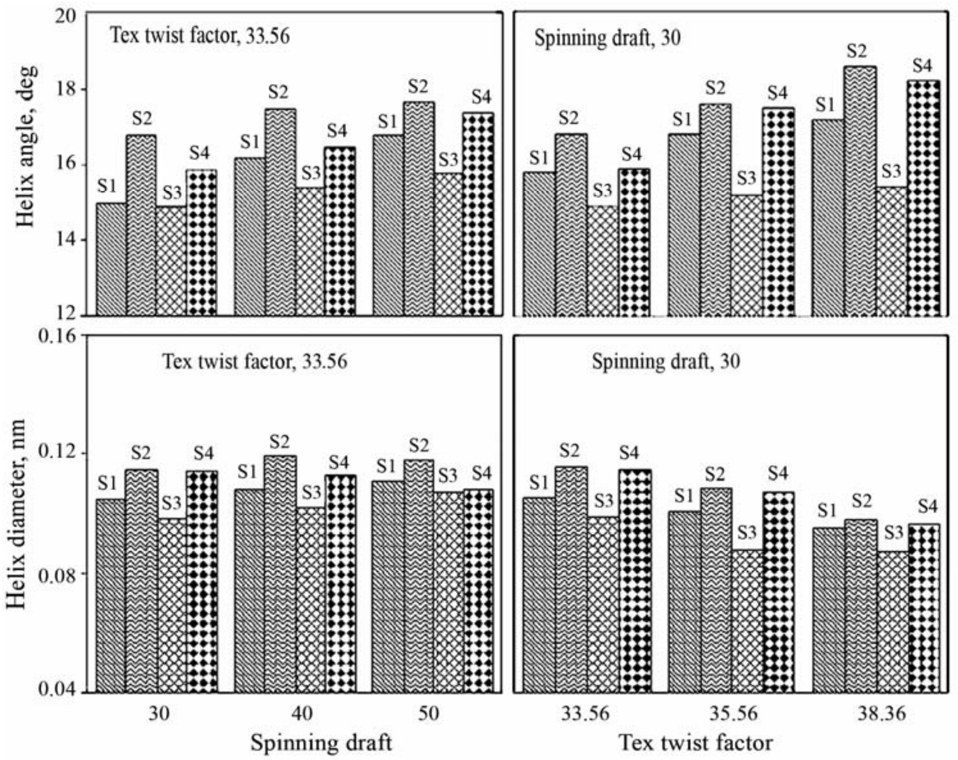


Fig.2—Variation in helix angle and diameter with spinning parameters [S1–compact yarn, 250 rps; S2–ring yarn, 250 rps; S3–compact yarn, 291.66 rps, and S4–ring yarn, 291.66rps]

Table 1 — ANOVA test results

Process parameter	F-ratio									
	Tenacity	Breaking extension	Work of rupture	Unevenness	Packing density	Abrasion resistance	Hairiness	Structural Integrity	Compressional energy	Compressional resiliency
Spinning mode	924.1 (34.1)	400.0 (34.1)	424.8 (34.1)	81.6 (21.2)	98.0 (34.1)	69.2 (21.2)	864.7 (34.1)	261.5 (34.1)	3249.0 (98.4)	182.6 (34.1)
Spinning draft	216.0 (34.1)	324.0 (34.1)	198.8 (34.1)	160.0 (21.2)	84.5 (34.1)	24.0 (21.2)	529.0 (34.1)	56.6 (34.1)	4225.0 (98.4)	104.1 (34.1)
Twist factor	100.1 (34.1)	171.9 (34.1)	336.3 (34.1)	106.1 (21.2)	69.4 (34.1)	174.0 (21.2)	93.3 (34.1)	63.8 (34.1)	739.6 (98.4)	581.8 (34.1)
Spindle speed	118.8 (34.1)	25.0 (34.1)	115.1 (34.1)	91.2 (21.2)	38.0 (34.1)	14.2 (21.2)	121.0 (34.1)	42.3 (34.1)	961.0 (98.4)	73.0 (34.1)

Figures in parentheses indicate table values.

that the different spinning systems deliver yarns with distinct structural features, and their variance depends on the spinning conditions used. In general, compact-spun yarns have lower mean fibre position, higher mean migration intensity, and smaller helix angle and helix diameter. Mean migration intensity increases with the increase in twist factor and spindle speed. An increase in spindle speed causes a regular decrease in mean fibre position and helix diameter; the latter further reduces with the increase in twist factor. For both types of yarn structures, helix angle increases with twist factor and decreases with spindle speed. No specific relationship between structural parameters and spinning draft for ring- and compact-spun yarns has been observed; however, yarns spun with a large spinning draft exhibit larger values of mean fibre position, mean migration intensity, helix angle and helix diameter.

3.2 Tensile Properties

The influence of four experimental factors, viz. spinning mode, twist factor, level of spinning draft and twisting speed, on the yarn characteristics was assessed for significance using ANOVA analysis (Table 1); the confidence level used was 99%. Table 2 shows the results of tensile test. The differences between tenacity

Table 2 — Effect of spinning conditions on tenacity, breaking elongation and work of rupture of ring- and compact-spun yarns
[Yarn linear density, 14.7 tex]

Yarn type	Spinning draft	Tex twist factor	Tenacity, mN/tex		Breaking elongation, %		Work of rupture$\times 10^{-3}$, g/den	
			250[a]	291.66[a]	250[a]	291.66[a]	250[a]	291.66[a]
Compact	30	33.56	158.9	161.8	5.6	5.3	50.4	48.5
Compact	30	35.96	169.7	182.4	5.9	5.4	56.7	54.7
Compact	30	38.36	181.4	189.3	6.4	6.0	65.7	64.3
Compact	40	33.56	176.5	178.5	6.4	6.1	64.0	61.6
Compact	40	35.96	186.3	189.3	6.7	6.5	70.7	69.6
Compact	40	38.36	192.2	194.2	7.1	6.9	77.3	75.9
Compact	50	33.56	168.7	176.5	5.8	5.3	55.4	53.5
Compact	50	35.96	177.5	178.5	6.3	6.1	63.3	61.1
Compact	50	38.36	186.3	188.3	6.8	6.4	71.7	68.2
Ring	30	33.56	140.2	143.2	4.5	4.3	35.7	34.8
Ring	30	35.96	154.0	157.9	4.9	4.6	42.7	41.1
Ring	30	38.36	166.7	174.6	5.2	5.0	49.1	49.4
Ring	40	33.56	152.0	155.9	5.1	4.8	43.9	42.4
Ring	40	35.96	162.8	166.7	5.6	5.4	51.6	51.0
Ring	40	38.36	175.5	179.5	6.2	6.0	61.6	61.0
Ring	50	33.56	141.2	145.1	4.8	4.6	38.4	37.8
Ring	50	35.96	162.8	167.7	5.3	5.0	48.8	46.6
Ring	50	38.36	172.6	174.6	5.8	5.6	56.7	55.3

[a] Spindle speed, rps.

indices for ring- and compact-spun yarns are significant at 99% confidence level, and in all cases, compact-spun yarns have substantially higher values than those of conventional ring-spun yarns. These results obviously indicate that the compact spinning leads to better integration of fibres, resulting in effective and better utilization of fibre characteristics in these yarns. Besides, improved fibre binding caused by lateral condensation of fibres by pneumatic forces also contributes to the higher tenacity. With spinning draft, tenacity exhibits distinct trends. In general, the tenacity of all yarns initially increases with spinning draft and then drops at increasing draft of 50. The increase in yarn tenacity at low spinning drafts is expected to be due to the reduction in mean fibre position and improved equivalent migration frequency. Indeed, mean fibre positions in ring- and compact-spun yarns reduce from 0.3568 and 0.3958 to 0.3286 and 0.3680 respectively with the increase in spinning draft from 30 to 40. Increasing the spindle speed from 233.33 rps to 266.66 rps has a strong influence on yarn tenacity, which can further be enhanced by increasing tex twist factor. This coincides with the change in yarn packing density at the higher twist factor. The packing density of 14.7 tex compact yarns spun at 250 rps with 33.56 and 38.36 twist factors are 0.44 and 0.47 respectively.

Analysis of variance results of the breaking elongation (Table 1) show that the differences in breaking elongation of normal ring- and compact-spun yarns are statistically significant at 99% confidence level and that the breaking elongation of compact yarn is generally higher than that of normal ring-spun yarn for all experimental combinations. The significant improvement in yarn breaking elongation for the compact- spun yarns is due to the fact that the fibres are better integrated and uniformly arranged[16] to effectively contribute to yarn breaking elongation. Differences become apparent in breaking elongation values of yarns differing in twist. The yarns spun with 38.56 twist factor are considerably more extensible than the yarns twisted with 33.36 twist factor. This implies that the helical arrangement of fibres influences yarn elongation. On the other hand, a remarkable dependence of the breaking elongation on spindle speed can be seen in Table 2. As is generally known, higher spindle speed produces less extensible yarns obviously due to increased spinning tension, causing the removal of original curliness of fibres in the yarn structure.

The data for work of rupture for different cotton yarns in respect of spinning draft, twist factor and spindle speed are presented in Table 2. Expectedly, compact spinning produces yarns of remarkably higher work of rupture. In regards to twist factor, work of rupture reflects a similar trend as yarn tenacity and breaking elongation. However, if spindle speed is increased from 250 rps to 291.66 rps, the work of rupture shows a noticeable decrease, regardless of the spinning mode. Spinning draft is also a very important parameter, which correlates well to the spun yarn properties. Table 2 reveals that when yarn is spun at a given spindle speed, work of rupture is best according to the medium spinning draft of about 40, clearly indicating an optimum spinning draft for compact spinning to obtain the best yarn quality.

3.3 Mass Irregularity and Imperfections

Analysis of variance performed on the yarn evenness and imperfections such as thin places (-50%), thick places (+50%), and neps(+200%) reveals that for all experimental conditions, the differences between the mass irregularity values of ring- and compact-spun yarns are statistically significant at 99% confidence level; the evenness of conventional ring-spun yarns is not as good as that of the compact yarns (Table 3). This result is quite surprising because yarn regularity is largely governed by the average number of fibres in yarn cross-section. Since the number of fibres in yarn cross-section should remain the same for a given fibre and yarn linear density, the better regularity of the compact- spun yarns is the expected consequence of the improved integration of fibres at twisting triangle and reduction in fibre loss from the yarn body. When a comparison of the evenness test data of the yarns produced with different spinning drafts is made, the mass irregularity and imperfection indices of the yarns spun using higher spinning draft is appreciably higher due to increased drafting wave[17]. It is also worth noting that evenness of both types of yarns deteriorates significantly with increasing twist factor, most likely due to obstruction in fibre movement at the nip of front roller. Moreover, yarns with better uniformity could be produced using lower spindle speed. Analysis of variance results verify that the effect of twist factor and spindle speed on the number of imperfections is significant.

3.4 Performance Characteristics

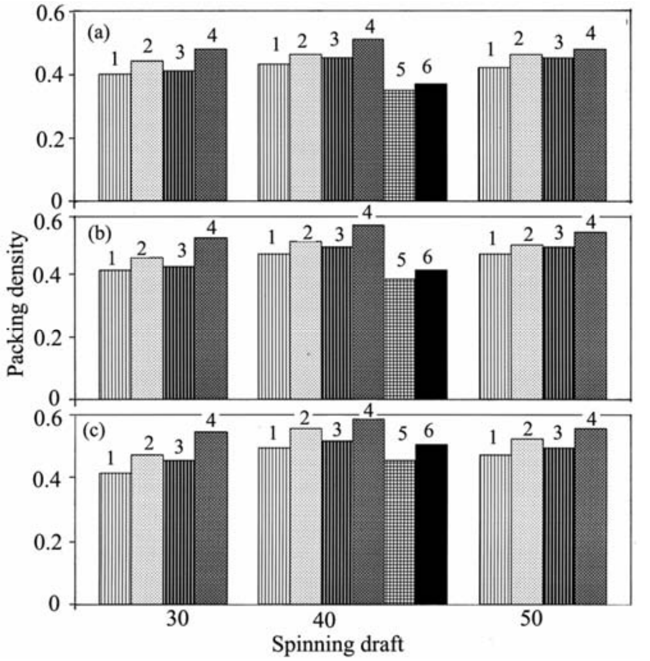
3.4.1 Packing Density

Figure 3 shows the packing density of various yarns. The fact that different systems deliver different yarn diameters also holds true for this investigation. Generally, compact-spun yarns possess higher packing density than the ring-spun yarns, and its

Table 3 — Effect of spinning conditions on unevenness and imperfections of ring- and compact-spun yarns
[Yarn linear density, 14.7 tex]

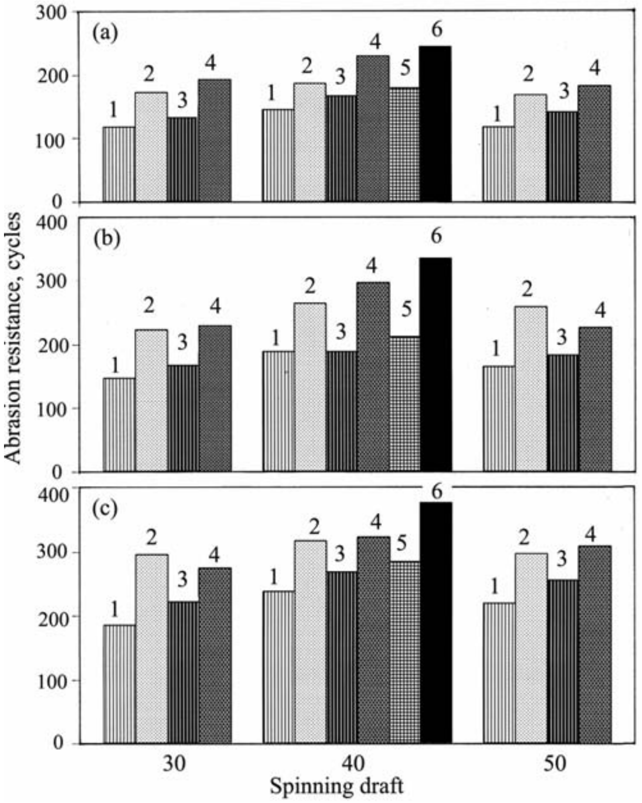
Yarn type	Spinning draft	Tex twist factor	U%		Imperfections/1000 m							
			250[a]	291.66[a]	250[a]				291.66[a]			
					Thick places (+50%)	Thin places (-50%)	Neps (+200%)	Total	Thick places (+50%)	Thin places (-50%)	Neps (+200%)	Total
Compact	30	33.56	9.6	9.9	23	2	54	79	34	0	66	100
Compact	30	35.96	9.9	10.5	32	0	65	97	34	1	91	125
Compact	30	38.36	10.3	11.3	42	0	103	145	44	0	107	151
Compact	40	33.56	10.5	11.2	32	1	71	104	36	0	77	113
Compact	40	35.96	11.0	11.9	37	2	75	114	47	1	86	134
Compact	40	38.36	11.5	12.6	48	3	106	157	57	10	110	177
Compact	50	33.56	10.8	11.3	34	4	87	125	42	10	98	150
Compact	50	35.96	11.2	11.5	46	13	102	161	51	12	114	177
Compact	50	38.36	11.8	12.6	57	19	109	185	63	19	123	205
Ring	30	33.56	10.4	10.7	35	2	69	106	39	0	75	114
Ring	30	35.96	10.9	11.3	52	1	100	153	55	1	112	168
Ring	30	38.36	11.2	12.2	65	6	115	186	63	11	126	200
Ring	40	33.56	11.3	12.3	44	0	83	127	52	0	104	156
Ring	40	35.96	11.6	12.5	59	2	115	176	71	3	120	194
Ring	40	38.36	12.4	12.8	77	4	122	203	87	7	132	226
Ring	50	33.56	11.5	12.5	49	7	103	159	59	13	122	194
Ring	50	35.96	12.1	12.8	68	18	128	197	75	18	133	209
Ring	50	38.36	12.7	13.0	82	26	139	247	98	30	146	274

[a] Spindle speed, rps.



1–14.7 tex ring-spun, 250 rps spindle speed ;	2–14.7 tex compact-spun, 250 rps spindle speed
3–14.7 tex ring-spun, 291.66 rps spindle speed ;	4–14.7 tex compact-spun, 291.66 rps spindle speed
5–29.5 tex ring-spun, 291.66 rps spindle speed ;	6–29.5 tex compact-spun, 291.66 rps spindle speed

Fig. 3—Variation in packing density of ring- and compact-spun yarns with spinning parameters [tex twist factor: (a) 33.56; (b) 35.96; and (c) 38.36]



1–14.7 tex ring-spun, 250 rps spindle speed ;	2–14.7 tex compact-spun, 250 rps spindle speed
3–14.7 tex ring-spun, 291.66 rps spindle speed ;	4–14.7 tex compact-spun, 291.66 rps spindle speed
5–29.5 tex ring-spun, 291.66 rps spindle speed ;	6–29.5 tex compact-spun, 291.66 rps spindle speed

Fig. 4—Variation in abrasion resistance of ring- and compact-spun yarns with spinning parameters [tex twist factor: (a) 33.56; (b) 35.96; and (c) 38.36]

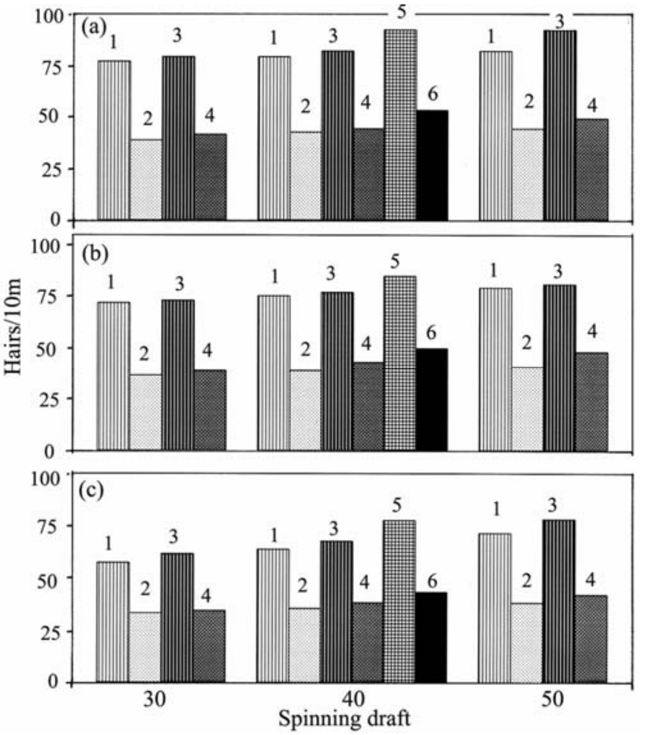
variance depends on the experimental conditions used. The higher packing density of the compact-spun yarns could be the result of the narrow ribbon width fed to the spinning triangle, causing the spinning triangle to virtually disappear. As a result, all fibres from the drafted ribbon are collected and fully integrated in the yarn body. For both types of yarn structures, the packing density increases significantly with the increase in spindle speed due to regular straightening and enhanced migration of fibres, which, in turn, improves packing coefficient. The impact of yarn linear density is along the expected lines, a higher linear density results in a lower packing density. On increase in spinning draft, the packing density first increases significantly and then decreases. This is because of a reduction in the width of fibre band in the drafting zone at lower spinning drafts, which produces a compact yarn with smaller diameter. However, at 50 spinning draft, the fibres are in less compact form due to the increased ribbon width. Consequently, there is less hindrance to fibre migration, and the twisting angle is also more obtuse[18], which influence the average values of yarn diameter and packing coefficient. High twist factor causes high packing coefficient in the yarn according to the data given in Fig. 3. Yarns spun with 33.56 twist factor have the least packing density, and there are meaningful differences between 33.56 twist factor and the other twist factors for packing density.

3.4.2 Abrasion Resistance

Figure 4 shows the results of abrasion test. When compared with conventional ring-spun yarns, compact-spun yarns have significantly higher abrasion resistance. In compact spinning, the minimization of the spinning triangle enables almost all fibres to be incorporated into the yarn structure. Besides, the uniform pretension of the majority of fibres enables more synchronic breakage of the majority of fibres, which contributes to higher abrasion resistance. When one looks on the association of abrasion resistance with spinning draft, there seems to be a significant relationship for the yarns at various spinning drafts. For all the yarns, the abrasion resistance initially increases with spinning draft and then drops at an increasing spinning draft of 50. The increase in abrasion resistance at low spinning draft is associated with the enhanced fibre cohesion caused by reduction in mean fibre position[19]. The mean fibre positions are found to be 0.3614 and 0.3441 for 14.7 tex compact-spun yarns made with 30 and 40 spinning drafts with 35.96 twist factor at 250 rps spindle speed. Increasing twist factor from 33.56 to 38.36 has a strong positive influence on yarn abrasion resistance, which can be further enhanced by raising spindle speed. Also, as yarn linear density increases, abrasion resistance increases, regardless of spinning parameters used.

3.4.3 Hairiness

The variation in hairiness of cotton ring- and compact-spun yarns with varying twist factor, spindle speed and spinning draft is shown in Fig. 5. In general, compact-spun yarns are consistently less hairy than the ring-spun yarns produced under identical processing conditions. For both these yarns, there is a marked reduction in hairiness as the yarn linear density decreases. Increasing spinning draft causes a continuous increase in hairiness on account of the increased release of floating fibres[20]. Both spindle speed and twist factor have a marked influence on hairiness. Hairiness increases linearly when spindle speed increases and, at the same time, when twist factor decreases. The increase can be attributed to the aforementioned factors.

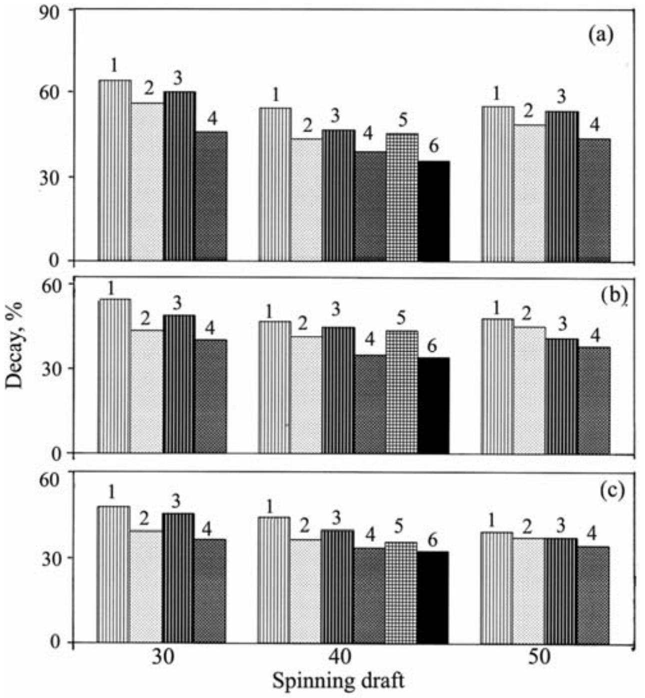


1–14.7 tex ring-spun, 250 rps spindle speed	;	2–14.7 tex compact-spun, 250 rps spindle speed
3–14.7 tex ring-spun, 291.66 rps spindle speed	;	4–14.7 tex compact-spun, 291.66 rps spindle speed
5–29.5 tex ring-spun, 291.66 rps spindle speed	;	6–29.5 tex compact-spun, 291.66 rps spindle speed

Fig. 5—Variation in hairiness of ring- and compact-spun yarns with spinning parameters [tex twist factor: (a) 33.56; (b) 35.96; and (c) 38.36]

3.4.4 Structural Integrity

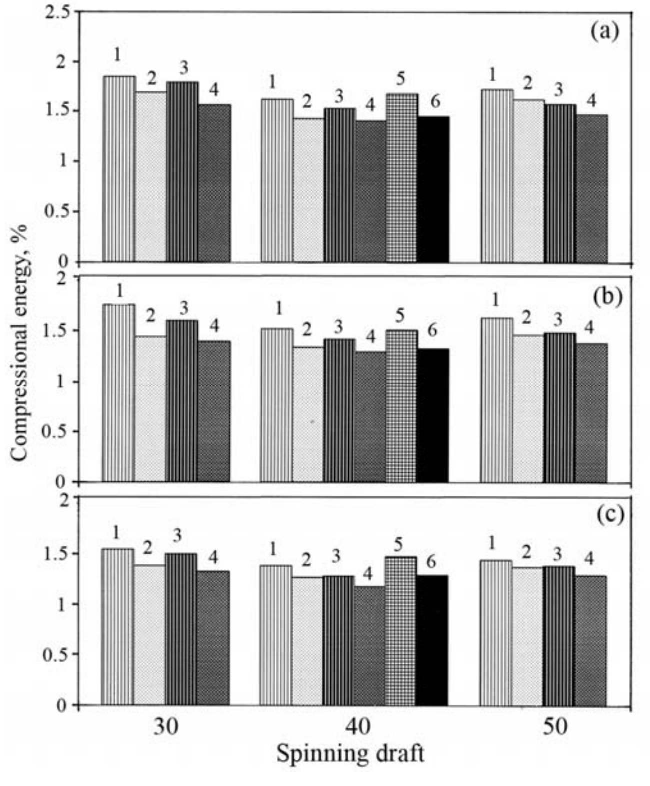
The decay behaviour of textile materials can be used to characterize their structural integrity. Figure 6 illustrates the effects of different processing factors on the structural integrity of ring- and compact-spun yarns. As expected, the yarn results show a highly significant effect of the spinning process on structural integrity. Invariably, the compact-spun yarns exhibit progressively better structural integrity than the



1–14.7 tex ring-spun, 250 rps spindle speed	;	2–14.7 tex compact-spun, 250 rps spindle speed
3–14.7 tex ring-spun, 291.66 rps spindle speed	;	4–14.7 tex compact-spun, 291.66 rps spindle speed
5–29.5 tex ring-spun, 291.66 rps spindle speed	;	6–29.5 tex compact-spun, 291.66 rps spindle speed

Fig. 6—Variation in per cent decay of ring- and compact-spun yarns with spinning parameters [tex twist factor: (a) 33.56; (b) 35.96; and (c) 38.36]

conventional ring-spun yarns, irrespective of the processing parameters used. The superior structural integrity is believed to result from increased compactness of the yarn structural matrix as a consequence of the incorporation of fibres into yarn structure, which, in turn, causes the fibres to cohere, leading to increased yarn strength. The twist factor is important for yarn structural integrity. In general, as the twist factor increases from 33.56 to 38.36, structural integrity also improves regardless of yarn type and spindle speed, indicating that the higher yarn twist impairs the reduction in structural integrity. Change in spindle speed also noticeably improves structural integrity, and a higher spindle speed is preferable. On the other hand, 14.7 tex yarns experience a greater decay than the 29.5 tex yarns for all experimental combinations. However, characteristic decay tends to be longer in yarns produced with very high spinning drafts, as expected.

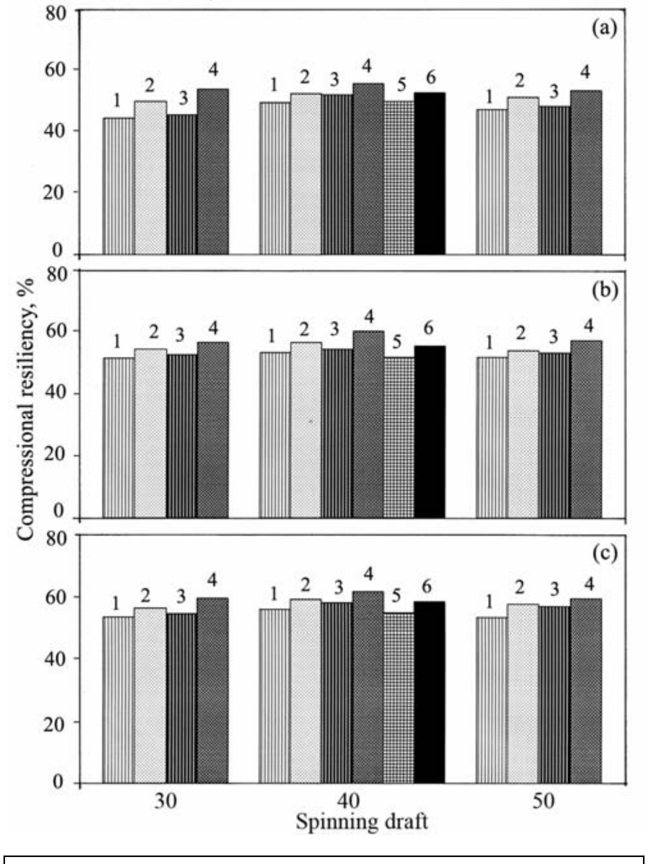


1–14.7 tex ring-spun, 250 rps spindle speed	;	2–14.7 tex compact-spun, 250 rps spindle speed
3–14.7 tex ring-spun, 291.66 rps spindle speed	;	4–14.7 tex compact-spun, 291.66 rps spindle speed
5–29.5 tex ring-spun, 291.66 rps spindle speed	;	6–29.5 tex compact-spun, 291.66 rps spindle speed

Fig. 7—Variation in compressional energy of ring- and compact-spun yarns with spinning parameters [tex twist factor: (a) 33.56; (b) 35.96; and (c) 38.36]

3.4.5 *Compressional Energy*

Figure 7 shows the mean values of compressional energy for various yarn structures. The compressional energy of ring-spun yarns varies between 1.28% and 1.85%, depending upon the spinning conditions used. In the case of compact-spun yarns, it varies from 1.17% to 1.69% and 1.29% to 1.46% for the 14.7 tex and 29.5 tex yarns respectively, indicating that compressional energy alters with different spinning modes. A higher difference between compressional energy of the compact and conventional yarns produced on Rieter's ring frame is believed to be the outcome of the greater fibre consolidation brought out by the drafting system used on the former. When the spinning draft increases from 30 to 40, the subsequent result is a decrease in compressional energy; the latter, however, increases as the spinning draft is



1–14.7 tex ring-spun, 250 rps spindle speed	;	2–14.7 tex compact-spun, 250 rps spindle speed
3–14.7 tex ring-spun, 291.66 rps spindle speed	;	4–14.7 tex compact-spun, 291.66 rps spindle speed
5–29.5 tex ring-spun, 291.66 rps spindle speed	;	6–29.5 tex compact-spun, 291.66 rps spindle speed

Fig. 8—Variation in compressional resiliency of ring- and compact-spun yarns with spinning parameters [tex twist factor: (a) 33.56; (b) 35.96; and (c) 38.36]

further increased to 50. The larger yarn diameter produced with high spinning drafts contributes greatly to the compressional energy of these yarns. On the other hand, the compressional energy of both types of yarns tends to increase with the increase in yarn linear density. The analysis of variance demonstrates that the changes in compressional energy caused by alteration in spinning mode are significantly influenced by the twist factor and spindle speed at a 99% confidence level. This is particularly evident for the yarns produced with higher twist factor and spindle speed.

3.4.6 Compressional Resiliency

The influence of spinning conditions on compressional resiliency of different yarns is shown in Fig. 8. Invariably, the compact-spun yarns display relatively higher compressional resiliency compared to the ring-spun yarns. The analysis of variance of these yarns suggests that there are significant differences in compressional resiliency between the ring- and the compact-spun yarns. Increase in compressional resiliency of compact-spun yarns agrees with the common view that compact spinning enhances inter-fibre cohesion through fibre consolidation, which ultimately leads to increased compressional resiliency. Although no specific relationship between spinning draft and compressional resiliency either for compact or for ring-spun yarns is observed, the compressional resiliency reduces as the yarn linear density increases. The statistical analysis of data indicates that twist factor and spindle speed have a marked effect on the compressional resiliency of compact-spun yarns with F-ratios of 581.8 and 73.0 respectively. This is particularly evident for the yarns produced with higher spindle speed. A high spindle speed obviously leads to better randomization and regular straightening of fibres that would produce less bulky structure, resulting in higher compressional resiliency.

4 Conclusions

4.1 Generally, compact- spun yarns display higher mean migration intensity and lower values of mean fibre position, helix angle and helix diameter. As spindle speed increases, each of mean fibre position, helix angle and helix diameter also tends to decrease and mean migration intensity tends to increase. Increasing twist factor increases mean migration intensity and helix angle but has no effect on mean fibre position. There is no specific relationship between structural features and spinning conditions either for ring- or for compact-spun yarns. Future studies with wide range of spinning drafts and cottons should further clarify the effects of draft levels on fibre arrangement.

4.2 Compact spinning contributes to the production of good quality yarns with significantly reduced hairiness, lesser mass irregularity and improved mechanical and abrasion characteristics. Both spinning draft and twist factor have a marked influence on tensile properties. With increasing spinning draft, the tenacity, breaking elongation, work of rupture and abrasion resistance improve initially but drop thereafter as the spinning draft is further increased beyond a particular limit. Higher twist factor also considerably enhances these characteristics. The enhancement in properties with higher twist factor is less marked in yarns produced at higher spindle speed.

4.3 Regularity characteristics such as evenness, thick places and neps get much better when spinning draft reduces and, at the same time, when twist factor goes down. Low spindle speed also has a favorable impact on yarn regularity and imperfections. Moreover, compact spinning better satisfies the spinners' expectations in terms of yarn regularity. Fibre packing density is of major importance in yarn abrasion. The compact-spun yarn structures exhibit a higher packing density and therefore give a higher abrasion resistance. High spindle speed and twist factor offer significant advantages in respect of abrasion resistance; the latter, however, reduces steadily with decrease in yarn linear density.

4.4 Spun yarns provide the opportunity to manipulate their low-stress response by selecting the process and spinning parameters. Yarn structural integrity and compressional resiliency increase with increasing twist factor and spindle speed. The compressional energy of the yarns decreases with increasing yarn twists and spindle speed. As the yarn linear density increases, the structural integrity and compressional energy increase significantly, but compressional resiliency decreases. Additionally, an optimal spinning draft is required if the optimum level of structural integirity, compressional energy, compressional resiliency and abrasion resistance of a yarn need to be achieved for a specific end use situation. Moreover, use of compact spinning contributes to the production of good quality yarns with better structural integrity, lower com-pressional energy and higher compressional resiliency.

4.5 There is relatively less hairiness in compact-spun yarns, and it can be further reduced by the application of low spindle speed. High twist factor and small spinning draft lead to a marked reduction in hairiness. However, the reduction is less marked in coarse yarns.

References

1 Hearle J W S & Gupta B S, *Text Res J*, 35(1965) 788.
2 Balasubramanian N, *Text Res J*, 40(1970) 129.
3 Ford J E, *J Text Inst*, 49(1958) T608.
4 Dyson E, *J Text Inst*, 65(1974) 215.
5 Pillay K P R, Viswanathan N & Parthasarthy M S , *Text Res J*, 45(1975) 366.
6 Punj S K, Debnath S & Ishtiaque S M, *Indian J Fibre Text Res*, 23(1998)229.
7 Ishtiaque S M & Khare S K, *Text Asia*, 24(1993)36.
8 Cheng K P S & Yu C, *Text Res J*, 73(2003) 345.
9 Karifa M & Ethridge M D, *Text Res J*, 76(2006) 388.
10 Das J R, Ishtiaque S M & Alagirusamy R, *Indian J Fibre Text Res*, 27(2002)362.
11 Goktepe F, Yilmaz D & Goktepe O, *Text Res J*, 76(2006) 226.
12 Basal G & Oxenham W, *Text Res J*, 76(2006) 567.
13 Ganeshan S & Ramakrishnan G, *Indian J Fibre Text Res*, 31(2006)381.
14 Imstiaque S M, Salhotra K R & Kumar A, *Asian Text*, 12(2003)74.
15 Basu A & Chellamani K P, *Indian J Fibre Text Res*, 25(2000)163.
16 Artzt P, *Int Text Bull*, 49(1)(2003) 40.
17 Cavaney B &Foster G A R , *J Text Inst*, 52(1961) 50.
18 Balasubramanian N, *Text Res J*, 40(1970) 129.
19 Baldua R K, *Structure and properties of cotton ring- and compact-spun yarns in relation to some process parameters*, M Tech thesis, The Technological Institute of Textile & Sciences, Bhiwani, 2008.
20 Tyagi G K & Dhamija S, *Indian J Fibre Text Res*, 23(1998)13.