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Structure and Properties of Lycra-Viscose Ring- and Air-Jet Spun Core Yarns

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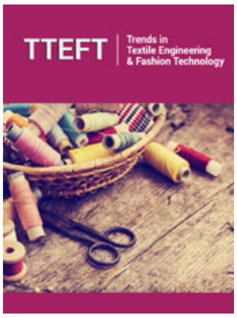

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Abstract

The structure and properties of lycra-viscose core-spun yarns made on ring- and air-jet spinning machines in relation to ribbon width, filament position and spinning speed have been studied. Under all experimental conditions, the air-jet spun core yarns are weaker, less extensible, hairier and have poor abrasion resistance than the conventional core yarns; however, the positioning of filament on the roving has a decisive effect on core yarn quality. The core yarns produced with centered adjustment of lycra filament, in general, display substantially higher strength and breaking extension, less bulk, less hairiness, and poor abrasion resistance and regularity and more imperfections regardless of the yarn structure. Furthermore, fine air-jet core yarns exhibit smaller helix diameter, more wrapper fibres and wraps/cm and larger helix angle than the coarse core yarns. Increase in spinning speed results in higher incidence of wrapper fibres; however, both wraps/cm and helix angle increase initially and decrease thereafter with increasing spinning speed.

Keywords: Air-jet spinning; Core-spun yarn; Lycra filament; Ribbon width; Wrapper fibres

Introduction

Cotton wrapped, filament-core spun yarns have been produced for many years [1-5], but incomplete core coverage and unsatisfactory strip resistance are major factors limiting potential uses. Sawhney et al. [6] reported several modifications of the conventional core-yarn ring spinning system and, more recently, a novel tandem core-yarn spinning system with air jets and friction drums [7]. Furthermore, Tyagi et al. [8] studied the influence of jet spinning parameters on sheath resistance and other related properties of polyester-viscose jet spun yarns. Dhouib et al. [9] studied the impact of elastane ratio on mechanical properties of cotton wrapped elastane-core spun yarns. The yarns containing elastomers are frequently required by textile fabric producers for manufacturing elastic textile products and accessories. Important market segments for elastomeric yarns include hosiery, swimwear, sportswear, underwear, and lace, as well as fashionable clothing. The most common methods of producing elastic yarns are hollow spindle technique, entangling, twisting, and core spinning on a modified ring frame, and rotor, friction, and air-jet spinning. These processes are characterized by different yarn properties, structures, and yarn count ranges. This study aims at analyzing the effects of core positioning, ribbon width and spinning speed on the structure and properties of lycra-viscose ring- and air-jet spun core yarns.

Experimental Section

Materials

Two sets of elastomeric core yarns of 19.6 and 29.5tex were spun from viscose staple of 51mm and 1.66dtex and Dupont lycra filament of 63dtex on air-jet spinning machine. The specifications of viscose staple and lycra filament used in the study are given in Table 1. Lap of viscose fibre was prepared on Lakshmi Reiter's blow room line and carded on MMC card. The conversion to drawn silver was carried out using Lakshmi Rieters' draw frame DO/2S. Three draw frame passages were given to the card sliver to produce a finisher sliver of 3 ktex. The drawn sliver was spun into yarns on Murata air jet spinner 802MJS. The lycra filament, placed on a modified creel, was guided to the nip of the front roller with a filament pretension of 45.9 grains and positioned accurately at center and then at the edge of the drafted ribbon of fibres, and finally spun into yarns. The process parameters used to produce these yarns are given in Table 2.

Table 1: Specifications of lycra filament and viscose staple fiber.

Fibre/Filament	Length mm	Linear Density dtex	Tenacity cN/tex	Breaking Elongation %
Viscose	51	1.66	19.42	18.7
Lycra	51	63.18	13.24	716

Table 2: Spinning parameters for lycra-viscose MJS core yarns. [NP1,2.5kg/cm^2; NP2, 3kg/cm^2; Feed ratio,0.98 and Distance between front nozzle and nip of front roller,39.5mm].

Yarn Ref. No.	Yarn tex	Fibre Composition (lycra:viscose)	Ribbon Width mm	Filament Position	Spinning Speed m/min
S11	19.6	0.602083	4	Core	150/170/190
S12	19.6	0.602083	4	Side	150/170/190
S13	19.6	0.602083	6	Core	150/170/190
S14	19.6	0.602083	6	Side	150/170/190
S15	19.6	0.069444	0	Nil	150
S16	29.5	0.438194	4	Core	150/170/190
S17	29.5	0.438194	4	Side	150/170/190
S18	29.5	0.438194	6	Core	150/170/190
S19	29.5	0.438194	6	Side	150/170/190
S20	29.5	0.069444	0	Nil	150

Test methods

Prior to processing, 0.8% of viscose fibres dyed with red colour were added to the grey fibres during mixing 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, wrapper fibres, wraps/m, helix angle and helix diameter were then measured for sheath fibres using a Leica Q 500 M C image analyzer. Eighty yarns with both ends shown on the screen were observed for each yarn sample. The yarns were also tested for different properties as per ASTM standards, such as tenacity and breaking extension (Instron), mass irregularity and imperfections (Uster evenness tester), abrasion resistance (Universal wear tester) and hairiness (Zweigles 565 hairiness meter).

Result and Discussion

Yarn structural parameters

Wrapper fibres: The experimental results for the structural parameters are given in Table 3. The results show that wrapper fibres are sensitive to the yarn spinning technique, and they are fewer for core-spun yarns because core spinning does not provide adequate fibre control as compared to staple spinning. The influence of filament position on wrapper fibre formation is critical, as the data reveal that the positioning of filament at the edge of the fibre ribbon produces a very significant reduction in formation of wrapper fibres. The ribbon width is another important factor influencing wrapper fibres. As is evident from Table 3, the core-yarns spun with larger ribbon width show higher incidence of wrapper fibres. The increase in wrapper fibres arises due to an increase in the number of edge fibres, which later become wrapper after being separated from the main strand by the yarn ballooning action. Amongst air-jet spun yarns, the incidence of wrapper fibres is apparently high for 19.6tex yarns then for 29.5 tex yarns, which further increases with the increase in spinning speed.

Wraps/m: Table 3 shows the wraps/m with respect to different spinning parameters. It is observed that as the yarn linear density decreases from 29.5 to 19.6tex, there is a noticeable increase in wraps/m, as expected. In comparison with 100% viscose yarn, core yarns exhibit fewer wrapper fibres possibly due to increased balloon tension resulting from the higher retraction power of elastomeric component, which, in turn, disturbs the ballooning action and leads to generation of wild fibres. While the positioning of lycra filament at the edge of the ribbon produces a yarn with fewer wraps/m, the use of a larger ribbon width can enhance wraps/m. On increasing spinning speed, the wraps/m initially increases but reduces thereafter as the spinning speed is raised to 190m/min. The air flow at the nip of the front roller at higher speed causes the fibres to move away from the fibre bundle, resulting in longer and even wrappings. However, a further increase in spinning speed is obtained by the filament bouncing tendency to move to the original position, which, in turn, results in uneven wrapping and consequently decreased wraps/m.

Helix diameter and Helix angle: Changes both in yarn linear density and filament position can affect helix diameter and helix angle, although 100%viscose staple yarn is generally bulkier than air-jet spun core yarns (Table 3). When spinning speed is increased from 150m/min to 170m/min, the helix diameter of air -jet core yarns reduces considerably but starts to increase at 190m/min spinning speed. The initial reduction in helix diameter arises due to more uniform, even, and tight wrappings of wrapper fibres, which later becomes more irregular at high spinning speeds. The helix diameter of all the yarns produced with 6mm ribbon width, however, is much larger than the yarns produced with 4mm ribbon width. For all experimental combinations, the helix angle maintains a relationship that coincides with wraps/m.

Table 3: Effect of spinning speed, ribbon width and filament position on structural parameters of lycra-viscose air-jet spun core yarns. [NP1,2.5kg/cm^2; NP2,3kg/cm^2; Feed ratio,0.98 and Distance between first nozzle and the nip of front roller,39.5mm].

Yarn Ref. No.	Wrapper Fibres/m			Wraps/cm			Helix Diameter, mm			Helix Angle, deg		
	150[a]	170[a]	190[a]	150[a]	170[a]	190[a]	150[a]	170[a]	190[a]	150[a]	170[a]	190[a]
S1	9	10	13	12	14	13	0.138	0.13	0.145	39	43	40
S2	7	9	12	11	13	12	0.148	0.144	0.144	38	39	41
S3	11	14	16	14	16	15	0.123	0.121	0.141	42	44	41
S4	9	12	14	12	14	13	0.131	0.124	0.125	41	43	41
S5	11	11	11	13	13	13	0.138	0.138	0.138	44	44	44
S6	5	6	10	8	11	9	0.208	0.198	0.217	38	39	39
S7	4	5	8	7	10	8	0.212	0.203	0.209	38	39	38
S8	8	11	13	10	13	11	0.18	0.173	0.184	40	45	42
S9	6	10	12	9	11	10	0.184	0.183	0.185	40	42	40
S10	7	7	7	9	9	9	0.204	0.204	0.204	41	41	41

[a] Spinning speed, m/min

Tensile properties: Table 4 shows that the air-jet spun core yarns, whether produced with lycra filament positioned at the edge or at the center of the ribbon, are weaker than the conventional core yarns; however, the contribution of the wrap material to the overall yarn tenacity is minimal in both methods. The lower tenacity of air-jet core yarn can be attributed to its unique structure. For both types of yarn structures, the core spun yarn with lycra filament core shows significantly lower tenacity than that of the 100% viscose staple yarn. This may be explained by an assumption that the core spinning perhaps does not have good fibre control compared to staple spinning. If one compares the two core-spun yarns, the one spun with centered adjustment on the roving has markedly higher tenacity than that of the core yarn produced with core at the edge of the roving. Surprisingly, however, the tenacity of air-jet spun core yarns first increases significantly and then drops with increasing spinning speed. This is because of the increase in the incidence of wrapper fibres with increasing spinning speed from 150m/min to 170m/min, which produces a compact structural matrix on account of increased radial pressure on core fibres. However, at 190m/min spinning speed, the fibres are less compact due to increased yarn unevenness. Consequently, there is less radial pressure on core fibres, which affects the average value of packing density and yarn tenacity. On the other hand, a consistent decrease in core yarn tenacity with increase in ribbon width could be related to the large reduction in load bearing core fibres [10]. Regarding yarn linear density, yarn tenacity shows opposite trends for ring- and air-jet spun core yarns. In the case of ring-spun yarns, the tenacity is lower than usual for finer yarns. However, for air-jet spun yarns, the tenacity is higher for 19.5tex yarns, and it decreases as the yarn linear density increases to 29.5tex. Invariably, ring- and air-jet spun core yarns exhibit higher breaking extension than that of 100% viscose staple yarn. However, air-jet spun core yarns are less extensible than their ring-spun counterparts. On the other hand, the breaking extension of air-jet core yarn spun with centered filament position is much higher as compared to the core yarn spun with filament positioned at the edge of the roving. Both yarn linear density and ribbon width play a significant role in influencing breaking extension. As can be seen from Table 3, the breaking extension is appreciably low in coarse core yarns and it decreases further with increase in ribbon width, which may probably arise from high wrapper to core-fibre ratio that makes the yarn insufficient to sustain tensile loading, leading to a decrease breaking extension. Change in spinning speed also has a marked impact on yarn breaking extension and the core yarns spun with a higher spinning speed have much higher breaking extension.

Bulk: Table 4 compares the diameters of lycra-viscose ring- and air-jet spun core yarns. Generally, air-jet spun core yarns possess less bulk than their ring-spun counterparts and its variance depends on the experimental conditions used. The lesser bulk of air-jet spun core yarns would be the result of higher incidence of wrapper fibres and wraps/m, causing the structural matrix to become more compact. On the other hand, lycra-viscose core yarns, whether produced on ring- or air jet spinner, are bulkier than 100% viscose staple yarn owing to the poor fibre control exercised during core yarn spinning. Amongst the air-jet spun core yarns, the yarn spun with centrally positioned filament has less bulk than that of the core yarn produced with the filament at the edge of the ribbon. The impact of yarn linear density is along the expected lines, a higher linear density results in a higher bulk. On increase in spinning speed, the bulk of air-jet spun core yarns first reduces significantly and then increases. This is because of higher fibre cohesion attained at higher spinning speed on account of presence of more wrapper fibres and hence a compact yarn. However, at 190m/min spinning speed, uneven and irregular wrappings are formed, which, in turn, exert less radial pressure on the core fibres and consequently a larger yarn diameter. Furthermore, the average yarn bulk reduces significantly with the increase in ribbon width.

Abrasion resistance: Table 4 depicts the number of rubs required to rupture lycra-viscose ring- and air-jet spun core yarns. Invariably, core-spun yarns exhibit higher abrasion resistance than 100% viscose staple yarn regardless of the spinning system used. This is quite understandable and is the result of high abrasion resistance of the lycra filament present in the core yarn. Amongst air-jet spun core yarns, the one spun with filament positioned at the edge of the ribbon displays much higher abrasion resistance than that spun with filament positioned at the center; the presence of high abrasion resistant filament at the surface reduces the intensity of abrading action. Increasing spinning speed from 150m/min to 170m/min enhance abrasion resistance of air-jet spun core yarns due to increased incidence of wrapper fibres. However, a further increase in spinning speed no longer favours an increase in abrasion resistance on account of decreased packing density. Moreover, the abrasion resistance increases with increase both in yarn linear density and ribbon width.

Table 4: Effect of spinning speed, ribbon width and filament position on tenacity, breaking extension, diameter, and abrasion resistance of lycra-viscose ring- and air-jet spun core yarns. [NP1,2.5kg/cm^2; NP2,3kg/cm^2; Feed ratio,0.98 and Distance between first nozzle and the nip of front roller,39.5mm].

Yarn Ref. No.	Tenacity, g/tex				Breaking Extension, %				Diameter, mm				Abrasion Resistance, Cycles			
	Ring Yarn	Air-Jet Yarn			Ring Yarn	Air- Jet Yarn			Ring Yarn	Air-Jet Yarn			Ring Yarn	Air-Jet Yarn		
		150[a]	170[a]	190[a]		150[a]	170[a]	190[a]		150[a]	170[a]	190[a]		150[a]	170[a]	190[a]
S1	11.5	10	10.4	10.2	11.2	9.3	9.5	9.9	0.168	0.158	0.15	0.162	305	223	258	234
S2	11.2	9.5	9.8	9.2	11	9.1	9.2	9.6	0.17	0.167	0.163	0.169	340	236	269	253
S3	11.5	8.8	9.4	8.9	11.2	8.8	9.4	9.5	0.168	0.145	0.139	0.158	305	256	287	266
S4	11.2	8.6	9.3	7.9	11	8.2	9.1	9.3	0.17	0.147	0.146	0.15	340	290	293	276
S5	14.2	11	10.9	10.9	12.2	7.9	7.9	7.9	0.164	0.157	0.157	0.157	78	53	53	53
S6	12.9	9.8	10.1	9.7	12.9	8.4	8.9	9	0.228	0.226	0.217	0.218	376	241	301	278
S7	12.7	8.9	9.2	9	12.7	8.2	8.7	8.8	0.235	0.23	0.222	0.226	419	320	339	300
S8	12.9	9.1	9.3	8.8	12.9	8	8.5	8.8	0.228	0.203	0.189	0.202	376	295	363	350
S9	12.7	8.6	9.1	8	12.7	6.8	7.3	7.6	0.235	0.205	0.202	0.2	419	359	390	371
S10	15	10	10.1	10.1	12.8	6.8	6.8	6.8	0.226	0.219	0.219	0.219	88	67	67	67

[a] Spinning speed, m/min.

Hairiness: Table 5 shows the hairiness of different yarns. Under all experimental conditions, the hairiness of core-spun yarns is generally higher than 100% viscose staple yarn. This is an expected consequence of poor fibre control exercised in core spinning as compared to staple spinning control. However, the core-spun yarn with centered adjustment of the filament core has much less hairiness than that of the core-spun yarn produced with the core at the edge of the ribbon. On the other hand, the hairiness of air-jet spun core yarns tends to increase with an increase in spinning speed and ribbon width owing to an increase in the number of floating fibre [11]. If one compares ring- and air-jet spun core yarns, the hairiness of the former is lower. Variation in hairiness, however, is greater for the air-jet spun yarns than for the ring-spun yarns. Hairiness increases with increasing yarn linear density for both ring- and air-jet spun yarns.

Unevenness and imperfections: Table 5 shows that uster values (U%) and imperfection figures for core-spun yarns are generally much less than that for 100% viscose staple yarn. Although thin places (-50%) per 1000-meter length of the 100% viscose staple yarn are considerably higher than that of the core-spun yarns, the other IPI values are very close to those for the three types of yarns produced on the air-jet spinner. This suggests that the core-spun yarn spinning process does not adversely affect yarn evenness and imperfections.

Table 5: Effect of spinning speed, ribbon width and filament position on hairiness, unevenness, and imperfections of lycra-viscose ring- and air-jet spun core yarns. [NP1,2.5kg/cm^2; NP2,3kg/cm^2; Feed ratio,0.98 and Distance between first nozzle and the nip of front roller,39.5mm].

Yarn Ref. No	Hairs/10m				Unevenness, U%				Imperfections/1000m											
	Ring Yarn	Air-Jet Yarn			Ring Yarn	Air-Jet Yarn			Ring Yarn			Air-Jet Yarn								
									Thin Places (-50%)	Thick Places (+50%)	Neps (+200%)	Thin Places, (-50%)			Thick Places, (+50%)			Neps, (+200%)		
		150[a]	170[a]	190[a]		150[a]	170[a]	190[a]				150[a]	170[a]	190[a]	150[a]	170[a]	190[a]	150[a]	170[a]	190[a]
S1	62	51	82	94	10.7	13	12	12	2	6	34	76	42	42	74	48	50	72	26	36

S2	65	70	90	108	11.1	13	12	11	16	18	42	62	36	52	56	90	78	72	114	165
S3	62	104	156	200	10.7	13	12	12	2	16	34	52	68	28	44	76	78	40	46	42
S4	65	108	180	202	11.1	13	13	12	16	18	42	68	40	36	66	50	60	40	30	56
S5	47	59	59	59	11.7	13	13	13	14	38	40	120	120	120	38	38	38	40	40	40
S6	64	83	104	116	9.5	13	12	12	0	12	12	8	86	24	26	156	42	12	88	8
S7	68	126	132	176	10.1	12	11	11	14	26	38	2	4	28	18	28	88	16	34	102
S8	64	210	232	242	9.5	13	12	12	0	12	12	10	42	36	130	66	58	40	16	24
S9	68	282	313	234	10.1	11	11	11	14	26	38	2	6	4	30	26	20	20	26	22
S10	50	53	53	53	11.5	13	13	13	8	30	50	44	44	44	50	50	50	44	44	44

[a] Spinning speed, m/min

Conclusion

Yarn linear density, ribbon width, spinning speed and filament position play important roles in influencing structural characteristics of air-jet spun core yarns. Invariably, fine air-jet spun core yarns exhibit smaller helix diameter, more wrapper fibres and wraps/cm and larger helix angle than the coarse core yarns. An increase in spinning speed, under all circumstances, results in higher incidence of wrapper fibres; however, both wraps/cm and helix angle increase initially and decrease thereafter with increasing spinning speed. Positioning of filament at the center leads to marked increment in wrapper fibres and wraps/cm but reduces helix diameter. Core yarns spun with larger ribbon width, on the other hand, show larger helix diameter, smaller helix angle and more wrapper fibres and wraps/cm.

Under all experimental conditions, the air-jet spun core yarns are weaker, less extensible, and hairier and have poor abrasion resistance than the conventional core yarns; however, the positioning of filament on the roving has a decisive effect on core yarn quality. The core yarns produced with centered adjustment of lycra filament, in general, display substantially higher strength and breaking extension, less bulk, less hairiness, and poor abrasion resistance and regularity and more imperfections regardless of the yarn structure.

High spinning speed is necessary for air-jet spinning if adequate wrapper fibres are to be produced, and the optimum, in practice, depends on many factors such as filament position, ribbon width and yarn linear density. Optimum speed is about 170m/min. The ribbon width is also important. Too small ribbon width results in inadequate wrapper fibres to produce a sufficiently strong yarn; and too large a ribbon leads to a higher incidence of wrapper fibres which has a deleterious effect on yarn regularity and hairiness. Although thin places of 100% viscose staple yarn are considerably higher than those for the core-spun yarns, the other IPI values are very similar for the three types of yarns produced on air-jet spinner, suggesting that core-spun yarn spinning process does not adversely affect yarn evenness and imperfections.

Conflict of Interest

The authors declare no conflict of interest.

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