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Structural and characteristic variations in viscose ring- and air-jet spun yarns as a consequence of draw frame speed and its preparatory process

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The influence of high draw frame speed and its preparatory on the structure and properties of viscose ring- and air-jet spun yarns has been studied. The data indicate insignificant differences in the tensile and regularity characteristics of the yarns produced with different card drafts and the yarns made with high draw frame speed display higher strength, higher breaking extension and better regularity than the yarns made with lower draw frame speed. Furthermore, a lower second nozzle pressure is needed to reduce rigidity of air-jet yarns to acceptable limits. When compared with ring-spun yarns, air-jet yarns have significantly smaller helix angle, but display higher packing density. Of the various process variables, card draft and second nozzle pressure markedly affect mean fibre extent, helix angle and packing density, whereas draw frame speed affects each of the parameters studied in a non-distinguishable manner.

Keywords: Air jet spinning, Card draft, Ring-spun yarn, Second nozzle pressure, Wrapper fibres

1 Introduction

Structural characteristics constitute an important quality criterion in air-jet spun yarns and strongly influence performance properties. Variations in structure of air-jet spun yarns are due to such factors as fibre properties, nozzle design and process parameters. The important process parameters that affect the properties of air-jet spun yarns are main draft, inter jet distance, injector and twisting jet pressures and production speed[1]. Various authors[2-6] have investigated the influence of these process variables on characteristic variations in air-jet spun yarns using different fibres and yarn linear densities, There are also studies on the influence of draw frame speed and its preparatory process on sliver orientation and ring yarn properties[7,8].However, information on this aspect for air- jet spun yarns is scanty and needs corroboration. The key of forming yarn for this technology is to produce sufficient leading end free edge fibres and form a twist difference between the egde fibres and the core ones. In order to increase the number of wrappers, the degree of fibre parallelization in drawn sliver is quite critical in practical spinning process. Besides, the fibre configuration in feed card sliver can affect fibre behaviour during draw frame passage and then affect fibre lay out at draw frame sliver and, consequently yarn structure and properties. Uematsu[9] shows that differences in spinning conditions could account for the different classifications. However, no publication regarding contribution of preparation processes to air-jet spun yarn quality is available so far. As air-jet spun yarns become more refined and diverse, the information with regard to combined influence of system variables and preparation process needs further corroboration and systematic investigation. This study investigates the structural and characteristic variations in viscose air-jet spun yarns as a consequence of card draft, draw frame speed and second nozzle pressure.

2 Materials and Methods

2.1 Preparation of Yarn Samples

Two sets of yarns of 17.3 and 24.6 tex were spun from viscose staple (length, 51mm; fineness, 1.66 dtex; tenacity, 19.8 g/tex; and breaking extension, 23.7%) on ring- and air- jet spinning machines with different second nozzle pressures ranging from 3.5 kg/cm^2 to 4.5 kg/cm^2. Lap was made on Lakshmi Rieters' blow room line and carded on MMC card with 80, 100 and 120 card drafts. The conversion to drawn sliver was carried out by using Trutzschlers' draw frame TD 03, the linear density of finished sliver being adjusted to 3.5 and 4.9 kex. Two drawing passages were given to carded sliver using three breaker draw frame speeds, viz. 300, 500 and 700m/min. The drawn

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slivers were spun into yarns on Murata air-jet spinner 802 MJS. The process parameters used to produce these yarns are given in Table 1. For ring yarns, the drawn slivers were converted into 1.2 and 1.7 Ne roves using an O K K fly frame, which were used to produce 17.3 and 24.6 tex yarns on Rieters' G 5/1 ring frame using a spindle speed of 15000 rpm.

2.2 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 fibes so that the dyed fibres could be readily observed through an image analyzer. The yarn structural parameters, namely mean fibre extent, wrapper fibres, wraps/m and helix angle were then measured for sheath fibres using a Leica Q 500 MC 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 A S T M standards, such as tenacity and breaking extension (Instron), mass irregularity and imperfections (Uster evenness tester) and flexural rigidity by ring loop method[10] (Shirley weighted ring yarn stiffness tester).

3 Results and Discussion

3.1 Yarn Structural Parameters

3.1.1 Mean Fibre Extent

The experimental results for the structural parameters are given in Table 2. The results show that mean fibre extent is sensitive to the spinning system, and it is very high for air-jet spun yarns as majority of fibres in air- jet yarn lie almost parallel to the yarn axis at the yarn core. The influence of card draft on the mean fibre extent is critical, as these data reveal that the higher card draft produces very significant reduction in mean fibre extent on account of an increase in curved fibre ends and decrease in coefficient of relative fibre parallelization in card sliver. Ishtiaque *et al.*[7] reported an initial increase in coefficient of relative fibre parallelization followed by a decrease with the increase in card draft. This reduction in mean fibre extent, however, depends on the breaker draw frame speed and yarn linear density. When breaker draw frame speed is increased from 300 m/min to 500 m/min, the mean fibre extent of air-jet spun yarns improves considerably but starts to reduce at 700m/min of draw frame speed. The initial increase in mean fibre extent arises due to more uniform and regular wrapping of wrapper fibres, which later becomes more irregular at high draw frame speeds. The ring-spun yarns, on the other hand, display a consistent increase in mean fibre extent with increase in breaker draw frame speed. Amongst air-jet spun yarns, the values of mean fibre extent are apparently smaller for 17.3 tex yarns then for 24.6 tex yarn, which further decrease with the increase in second nozzle pressure.

Table 1 — Spinning parameters for air-jet spun yarns

Yarn ref. no.	Linear density tex	Card draft	Draw frame speed, m/min	Second nozzle pressure, kg/cm^2
S1	17.3	80	300	3.5/4/4.5
S2	17.3	80	500	3.5/4/4.5
S3	17.3	80	700	3.5/4/4.5
S4	17.3	100	300	3.5/4/4.5
S5	17.3	100	500	3.5/4/4.5
S6	17.3	100	700	3.5/4/4.5
S7	17.3	120	300	3.5/4/4.5
S8	17.3	120	500	3.5/4/4.5
S9	17.3	120	700	3.5/4/4.5
S10	24.6	80	300	3.5/4/4.5
S11	24.6	80	500	3.5/4/4.5
S12	24.6	80	700	3.5/4/4.5
S13	24.6	100	300	3.5/4/4.5
S14	24.6	100	500	3.5/4/4.5
S15	24.6	100	700	3.5/4/4.5
S16	24.6	120	300	3.5/4/4.5
S17	24.6	120	500	3.5/4/4.5
S18	24.6	120	700	3.5/4/4.5

3.1.2 Wraps/cm

Table 2 shows the wraps/cm with respect to different spinning parameters. It is observed that as the yarn linear density is decreased from 24.6 tex to 17.3 tex, there is a noticeable increase in wraps/cm, as expected. The wraps/cm, however, depict no specific trend with an increasein card draft but, in general, showsw an initial increase followed by a decrease with increase in breaker draw frame speed. Second nozzle pressure seems to markedly influence wraps/cm. For all experimental combinations, an increase in wraps/cm with the increase in second nozzle pressure has been observed.

3.1.3 Wrapper Fibres

Table 2 shows that fine yarns exhibit considerably more wrapper fibres as compared to the coarse yarns. An obvious reason is the fine sliver fed for fine yarns, leading to higher incidence of edge fibres, which would undoubtly govern the formation of wrapper fibres. The wrapper fibres do not show any particular trend with card draft but increase noticeably when second nozzle pressure increases. On increasing the breaker draw frame speed, the wrapper fibres initially increase but reduce thereafter as the breaker draw frame speed is raised to 700m/min. An initial increase in draw frame speed would enhance fibre parallelization with reduced surface cohesion and thus leads to higher incidence of edge fibres, which later become wrappers. However, a further increase in breaker draw frame speed is obtained by the increased sliver compactness, which, in turn, obstructs the formation of edge fibres and consequently lower incidence of wrapper fibres.

3.1.4 Helix Angle

Invariably, the helix angle appears to be smaller for the air-jet spun yarns and it substantially increases as card draft is increased from 80 to 120 (Table 2). Obviously, this increase in helix angle could be caused by the decrease in coefficient of relative fibre parallelization and increase in proportion of curved fibre ends and hooked fibres[11]. In regard to breaker draw frame speed, the helix angle shows a distinct trends for ring- and air-jet spun yarns. In the case of ring yarns, helix angle is smaller, as expected, for higher breaker draw frame speeds. However, for air-jet spun yarns, the helix angle initially decreases with the increase in breaker draw frame speed from 300 m/min to 500m/min and then significantly increases with further increase in breaker draw frame speed to 700m/min. The helix angle of all the yarns spun with 3.5 kg/cm^2 second nozzle pressure, however, is much smaller than the yarns produced with 4.5 kg/cm^2 pressure.

3.2 Tensile Properties

The influence of five experimental factors, viz, yarn linear density, card draft, breaker draw frame speed, second nozzle pressure and spinning mode, on the yarn properties was assessed with the help of ANOVA analysis (Table 3), the confidence level used was 99%. Table 4 shows the results of tensile test. As

Table 2 — Effect of draw frame speed and its preparatory process on structural parameters of viscose ring- and air-jet spun yarns

Yarn ref. no.	Mean fibre extent, mm				Wraps/cm			Wrapper fibres/m			Helix angle, deg			
	Ring yarn	Air-jet yarn			3.5^a	4^a	4.5^a	3.5^a	4^a	4.5^a	Ring yarn	Air-jet yarn		
		3.5^a	4^a	4.5^a								3.5^a	4^a	4.5^a
S1	32.2	36.1	35.6	35.0	13	14	16	10	13	16	17	12	11	9
S2	33.1	37.2	36.5	35.7	14	16	17	11	16	22	15	11	9	8
S3	33.8	35.5	34.9	34.2	11	13	14	9	13	15	14	12	10	9
S4	30.1	33.3	32.6	31.8	15	18	18	9	13	16	19	16	14	12
S5	31.5	36.6	36.0	35.3	12	14	16	12	17	23	17	14	12	12
S6	32.2	34.4	33.9	33.3	14	15	16	11	13	16	17	15	13	14
S7	28.8	32.8	32.3	31.3	12	13	14	13	16	19	22	18	17	16
S8	29.9	33.5	32.7	32.0	15	16	18	14	18	23	20	16	14	13
S9	30.6	32.5	31.9	31.2	13	15	16	11	14	15	19	17	15	13
S10	30.6	36.6	36.4	35.9	11	12	13	6	10	14	19	9	9	8
S11	31.1	40.6	40.9	40.2	12	13	14	7	11	16	16	8	7	7
S12	31.9	38.3	37.8	37.2	9	11	13	6	9	11	15	9	8	8
S13	28.1	36.6	36.0	35.3	13	13	15	5	9	12	21	13	12	12
S14	29.0	37.1	36.6	36.0	10	12	12	8	11	13	19	11	9	8
S15	29.8	36.4	36.2	35.5	10	12	14	6	7	8	17	12	10	10
S16	25.6	34.4	33.9	33.5	10	11	14	5	8	12	24	15	15	13
S17	26.2	35.5	35.2	34.1	12	13	15	7	12	14	23	13	13	10
S18	27.2	34.3	34.0	33.7	11	13	14	5	8	9	22	14	12	12

^{a} Second nozzle pressure, kg/cm^2.

Table 3 — ANOVA test results

Process parameter	Yarn characteristics					
	Tenacity	Breaking extension	Packing fraction	Flexural rigidity	Unevenness	Imperfections
Yarn linear density	s	s	s	s	s	s
Card draft	s	s	s	s	s	s
Draw frame speed	s	s	s	s	s	s
Second nozzle pressure	s	s	s	s	s	s
Spinning mode	s	s	s	s	s	s

s-Significant at 99% confidence level.

expected, ring-spun yarns are noticeably stronger than the equivalent air-jet spun yarns and the strength difference depends upon the processing parameters used. For both types of yarns, the tenacity decreases steadily as the card draft is increased from 80 to 120. The influence of breaker draw frame speed on ring-spun yarn tenacity is along the expected lines, a higher breaker draw frame speed results in higher tenacity due to decrease in total number of hooks as well as hooks extent in the yarn, reduction in yarn diameter and increase in mean fibre extent and packing density[7]. Surprisingly, however, the tenacity of air-jet spun yarns first increases significantly and then drops with increasing breaker draw frame speed. This is because of the increase in the incidence of wrapper fibres with increasing breaker draw frame speed from 300 m/min to 500 m/min, which produces a compact structural matrix on account of increased radial pressure on the core fibres. However, at 700 m/min breaker draw frame speed, the fibres are in less compact form due to the decreased number of wrapper fibres and increased yarn unevenness. Consequently, there is less radial pressure on the core fibres, which affects the average values of packing coefficient and yarn tenacity. Increasing second nozzle pressure enhances the tenacity of air-jet spun yarns due to increase in transverse forces. Since there is no effective migration of the core fibres, the transverse forces necessary for the inter-fibre cohesion required to sustain external loading are provided by the wrapper fibres wound on the surface of the core fibres. These transverse forces would depend on the number of wrapper fibres and wrapped-in length[12]. Moreover, the tenacity indices of air-jet spun yarns are considerably lower for 24.6 tex yarns than for 17.3 tex yarns made under identical processing conditions.

The breaking extension of viscose ring-spun yarns varies between 11.4 % and 14% depending upon the processing parameters used. In the case of air-jet spun yarns, the breaking extension varies from 7 % to 10.8 %. For both types of yarn structures, the breaking extension decreases significantly with increase in card draft due to reduced fibre extent, which, in turn, reduces packing coefficient. The impact of breaker draw frame speed is opposite to that on yarn tenacity. Both yarn linear density and second nozzle pressure play a significant role in influencing breaking extension of air-jet spun yarns. As can be seen from Table 4, the breaking extension is appreciably low in coarse yarns and it decreases with the increase in second nozzle pressure due to greater compactness owing to the increased transverse forces[12].

Table 4 — Effect of draw frame speed and its preparatory process on tenacity, breaking extension, packing fraction and flexural rigidity of viscose ring- and air-jet spun yarns

Yarn ref. no.	Tenacity, mN/tex				Breaking extension, %				Packing fraction				Flexural rigidity × 10^{-3} g.cm^2			
	Ring yarn	Air-jet yarn			Ring yarn	Air-jet yarn			Ring yarn	Air-jet yarn			Ring yarn	Air-jet yarn		
		3.5[a]	4[a]	4.5[a]		3.5[a]	4[a]	4.5[a]		3.5[a]	4[a]	4.5[a]		3.5[a]	4[a]	4.5[a]
S1	151.0	123.6	128.5	134.3	12.7	10.7	10.2	9.6	0.393	0.521	0.536	0.552	2.80	4.89	5.34	5.89
S2	152.0	125.5	131.4	137.4	12.5	10.5	9.9	9.3	0.410	0.537	0.553	0.569	2.88	5.12	5.67	6.22
S3	154.1	124.5	127.5	132.4	12.3	10.8	10.3	9.8	0.415	0.518	0.533	0.548	2.95	4.75	5.20	5.65
S4	148.1	111.8	115.7	119.6	12.4	10.2	9.8	9.4	0.372	0.503	0.517	0.521	2.75	4.22	4.57	4.92
S5	150.0	113.7	120.6	125.5	12.0	9.9.	9.4	8.9	0.392	0.522	0.537	0.552	2.78	4.63	5.08	5.53
S6	151.7	112.8	114.7	117.7	11.8	10.3	9.9	9.6	0.398	0.513	0.527	0.540	2.85	4.25	4.60	4.85
S7	144.2	105.9	108.8	111.8	12.0	9.5	9.2	8.9	0.356	0.459	0.472	0.485	2.50	3.77	4.02	4.27
S8	146.1	107.9	112.8	116.7	11.7	9.3	9.0	8.6	0.362	0.470	0.483	0.497	2.66	4.23	4.48	4.85
S9	147.1	104.8	106.9	109.8	11.4	9.7	9.5	9.2	0.374	0.461	0.473	0.485	2.70	3.98	4.24	4.51
S10	164.8	102.0	106.9	110.8	14.0	8.5	8.1	7.6	0.371	0.458	0.472	0.487	3.20	5.88	6.43	6.99
S11	165.7	104.9	109.8	114.7	13.9	8.2	7.7	7.5	0.389	0.469	0.484	0.499	3.40	5.98	6.63	7.28
S12	167.7	103.0	105.9	109.8	13.7	8.6	8.3	8.0	0.403	0.453	0.467	0.481	3.66	5.73	6.38	6.93
S13	158.9	95.1	98.1	101.0	13.4	8.1	7.8	7.5	0.356	0.446	0.459	0.472	2.99	5.22	5.72	6.16
S14	160.8	98.1	102.0	105.9	13.1	7.9	7.5	7.1	0.363	0.463	0.477	0.491	3.11	5.73	6.28	6.83
S15	162.8	95.2	98.2	100.0	12.9	8.2	7.9	7.7	0.379	0.441	0.454	0.466	3.33	5.15	5.60	5.95
S16	154.0	84.3	86.3	88.2	12.6	7.6	7.4	7.2	0.333	0.406	0.418	0.430	2.86	4.88	5.23	5.58
S17	155.9	86.3	88.2	91.2	12.3	7.5	7.3	7.0	0.347	0.428	0.440	0.453	2.90	5.43	5.78	6.12
S18	157.9	85.3	86.3	91.2	12.0	7.8	7.7	7.6	0.361	0.410	0.421	0.432	3.24	4.71	4.97	5.22

[a] Second nozzle pressure, kg/cm^2.

3.3 Packing Density

Table 4 shows the packing densities of various ring- and air-jet spun yarns. The fact that different spinning systems deliver different yarn diameters also holds true for this investigation. Generally air-jet spun yarns possess higher packing density than the ring-spun yarns, and its variance depends on the experimental conditions used. The higher packing density of the air-jet spun yarns would be the result of the higher incidence of wrapper fibres and wraps/mm, causing the structural matrix to become more compact. For both types of yarn structures, the packing density decreases significantly with the increase in card draft due to decrease in coefficient of relative fibre parallelization and increased proportion of curved fibre ends and hooked fibres[9], which, in turn, reduce 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 breaker draw frame speed, the packing density of air-jet spun yarns first increases significantly and then decrease. This is because of high degree of fibre parallelization with low fibre cohesion attained at lower draw frame speed, which produce more wrapper fibres and hence a compact yarn. However, at 700m/min speed, the fibres in sliver are in more compact form on account of the increased centrifugal force arising from higher coiler speed. Consequently, less wrapper fibres are formed, resulting in a less compact yarn with larger diameter. High second nozzle pressures cause high fibre packing coefficient in the yarn according to the data given in Table 4. Yarns spun with 3.5 kg/cm^2 second jet pressure have the least packing density, and there are meaningful differences between 3.5 kg/cm^2 second jet pressure and the other second nozzle pressures for packing density.

3.4 Flexural Rigidity

As can be observed from Table 4, the flexural rigidity is considerably higher for air-jet spun yarns and it increases with increasing yarn linear density. The higher flexural rigidity of air-jet spun yarns has been related to its unique structure by several workers. Increasing card draft markedly reduces the flexural rigidity regardless of yarn structure. The lower flexural rigidity results due to lower packing coefficient associated with decreased coefficient of relative fibre parallelization and increased proportion of curved ends and hooked fibres.[13] In regard to breaker draw frame speed, the flexural rigidity reflects distinct trends for ring- and air-jet spun yarns. In the case of ring yarns, flexural rigidity is higher as usual for higher breaker draw frame speeds. However, for air-jet spun yarns, the flexural rigidity initially increases with breaker draw frame speed and then reduces at breaker draw frame speed of 700m/min. The initial increase in flexural rigidity with increasing breaker draw frame speed is associated with the increased incidence of wrapper fibres, which makes the yarn more compact and restricts the freedom of fibre movement during bending. However, a further increase in breaker draw frame speed is observed by the decreased number of wrapper fibres. Consequently, there is less hindrance to the relative movement of fibres during bending. The second nozzle pressure is another prime factor in controlling yarn rigidity. The second nozzle pressure therefore needs to be chosen carefully because high second nozzle pressure increases the wrapper fibres which could elevate the problem.

3.5 Mass Irregularity and Imperfections

Invariably, air-jet spun yarns are more even than their ring-spun counterparts (Table 5). The use of higher card draft results in higher yarn unevenness which indicates that card draft contributes directly to mass irregularity. Increasing card draft from 80 to 120 significantly increases the thickness of the feed material, which, in turn, results in less penetration of wire points in the material and fewer points per fibe offered by taker- in . This reduces the opening of the fibre tuft and consequently increases the proportion of curved fibre ends in the sliver, resulting in increased yarn unevenness. Increasing second nozzle pressure markedly increases the unevenness of air-jet spun yarns regardless of the card draft. The higher unevenness results due to more irregular and tight wrappings of wrapper fibres associated with higher second nozzle pressure. Apart from the card draft and second nozzle pressure, the breaker draw frame speed also appears to influence yarn unevenness. For all air-jet spun yarns, the U% values tend to initially decrease with breaker draw frame speed and then increase at increasing breaker draw frame speed of 700m/min. Initial decrease in yarn unevenness results from the improvement in fibre extent with the increase in draw frame speed. However, the increase in U% with the increase in card draft from 100 to 120 may be attributed to the expected consequence of more irregular wrappings of wrapper fibres at the later stage, which, in turn, affects mass distribution in

Table 5 — Effect of draw frame speed and its preparatory process on unevenness and imperfections of viscose ring- and air-jet spun yarns

Yarn ref. no.	Unevenness, U%				Imperfections/125m															
	Ring yarn	Air-jet yarn			Ring yarn				Air-jet yarn											
		3.5[a]	4[a]	4.5[a]					3.5[a]				4[a]				4.5[a]			
					Thick places +50%	Thin places -50%	Neps + 200%	Total	Thick places +50%	Thin places - 50%	Neps +200%	Total	Thick places +50%	Thin places - 50%	Neps +200%	Total	Thick places +50%	Thin places-50%	Neps +200%	Total
S1	11.8	10.0	10.3	10.7	37	24	42	103	18	10	20	48	24	14	26	64	31	19	33	83
S2	11.7	9.7	101	10.6	35	22	41	98	16	7	18	41	21	9	23	53	27	13	29	69
S3	11.4	10.1	10.5	10.8	34	19	39	82	19	11	21	51	25	15	27	67	32	20	34	85
S4	12.4	11.4	11.8	12.0	39	25	46	110	21	12	23	56	26	15	28	69	32	21	34	87
S5	12.1	11.0	11.4	11.9	38	23	43	104	19	10	21	50	25	13	25	63	28	15	30	73
S6	12.4	11.5	11.9	12.2	36	21	41	98	23	13	25	61	27	16	30	73	33	21	36	90
S7	13.0	11.8	12.0	12.0	41	25	48	114	26	13	26	65	30	17	30	77	33	22	35	90
S8	12.4	11.5	11.9	12.1	38	24	45	107	23	12	24	59	28	16	27	71	32	20	32	84
S9	12.3	11.9	12.1	12.2	36	23	43	102	26	15	28	69	30	19	32	81	35	23	36	94
S10	11.6	9.4	9.6	9.8	35	22	38	95	15	8	18	41	20	11	23	54	26	15	29	70
S11	11.4	9.2	9.5	9.6	32	19	36	87	13	6	16	35	17	8	20	47	22	11	25	68
S12	11.1	9.5	9.8	10.1	31	18	35	84	16	9	19	44	21	12	24	57	27	16	29	72
S13	12.0	10.6	10.7	10.8	38	23	40	101	20	10	22	52	24	13	26	63	29	16	30	75
S14	11.8	10.0	10.3	10.6	35	21	38	94	18	9	20	47	23	11	23	57	28	13	27	68
S15	11.4	10.4	10.8	10.9	33	20	36	89	21	11	23	55	26	14	27	67	30	18	31	79
S16	12.6	11.1	11.6	11.8	40	24	43	107	25	12	24	61	29	13	28	70	31	15	32	78
S17	12.3	10.8	11.0	11.4	37	22	41	100	22	10	23	55	26	12	25	63	30	13	28	71
S18	12.0	11.4	11.7	11.9	34	20	39	93	24	13	25	62	29	16	28	73	33	20	33	86

[a] Second nozzle pressure, kg/cm^2.

strand length. In the case of ring-spun yarns, U% decreases consistently as the breaker draw frame speed is increased. Moreover, the U% values are appreciably lower for air-jet spun yarns than for ring-spun yarns.

The effects of yarn linear density and breaker draw frame speed on imperfections are similar to those on yarn unevenness (Table 5). Incidentally, no specific relationship between second nozzle pressure and imperfection indices has been observed, the latter, however, alter with card draft. As is evident from test results, the thick places and neps are less in yarns made with low card draft and increase as the card drafty is increased. Such an increase can again be attributed to the fore-mentioned factors.

4 Conclusion

4.1 Yarn linear density, card draft, draw frame speed and second nozzle pressure are prime factors in controlling structural characteristics of air-jet spun yarns. Invariably, fine air-jet spun yarns exhibit higher mean fibre extent, more wrapper fibres and wraps/mm and larger helix angle than the coarse yarns. Each of these structural parameters, except helix angle, increases initially and decreases thereafter with increasing breaker draw frame speed. High card draft leads to a marked increment in helix angle but reduces mean fibre extent. Yarns spun with higher second nozzle pressure, on the other hand, show lesser fibre extent, smaller helix angle, and more wrapper fibres and wraps/cm.

4.2 High card draft offers no significant advantage in air- jet spinning with regards to yarn quality. The yarns produced with a high card draft, in general, are substantially weaker, less extensible, less rigid, and have poor regularity and more imperfections regardless of the yarn structure. Nevertheless, air-jet spun yarns are relatively weaker, less extensible, more rigid, more uniform and have fewer neps and thick places than ring-spun yarns.

4.3 High draw frame speed is imperative for air-jet spinning if adequate wrapper fibres are to be produced, and the best one will, in practice, depend on many factors such as yarn linear density, card draft and second nozzle pressure. Optimum draw frame speed is about 500m/min, the lower is suitable for coarse yarns. In the case of ring-spun yarns, higher draw frame speed gives good regularity, high strength and rigidity with reduced breaking extension. The second nozzle pressure is also important. If it is too low, the wrapper fibres are inadequate to produce a sufficiently strong yarn; if it is too high, the higher incidence of wrapper fibres can have deleterious effect on yarn regularity and rigidity.

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