



Air Jet Spinning of Polyester-Viscose Blend Part I: Physical Response

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Abstract: It is generally established that yarns contribute significantly to fabric and product performance. The present work embodies the influence of fibre type and blend proportion on mass evenness and yarn imperfections. It is seen after variance length curve analysis that drafting arrangement in air jet spinning system contributes towards generation of short and medium term irregularities but remains unresponsive for long term irregularity. Hairiness is also influenced by the proportion of polyester content in the blend. It is reduced with the concomitant increase in polyester in the blend and the subsequent plying process.

Keywords: Unevenness, air jet spinning, variance-length curve, index, hairiness, twin spun yarn

I. Introduction

Over decades and centuries, ring spinning became the foundation of spinning, accompanied by rotor spinning. Both technologies have their own fields of end-uses, and ring spinning has been boosted further with the development of compact spinning, resulting in much less yarn hairiness on account of reduced spinning triangle. However, ring spinning method has become the subject of great apprehension among the spinners over several decades due to its low throughput rate in spite of its ability of producing optimal yarn characteristics and ability in producing spun yarns of any fineness. The technological and mechanical restrictions towards escalating the throughput speed of classical ring spinning system has been eradicated in the fine count range by the air jet spinning technique which has ability to produce MJS or MTS yarns at much higher throughput rate.

The twin-jet Murata Jet Spinner is illustrated in Fig 1. Staple fibres are drafted using a roller drafting system with three or four pairs of rollers^{1,2}. The fibres are then threaded through the twin-jet assembly. The second jet N_2 has a higher twisting torque than the first jet N_1 . Immediately after leaving the front drafting rollers, the fibres in the core of the yarn are twisted in the twist direction of N_2 . The fibres on the edges of the drafted ribbon are twisted by the weaker force at jet N_1 and wrap around the core fibres in the opposite direction. Since the jet

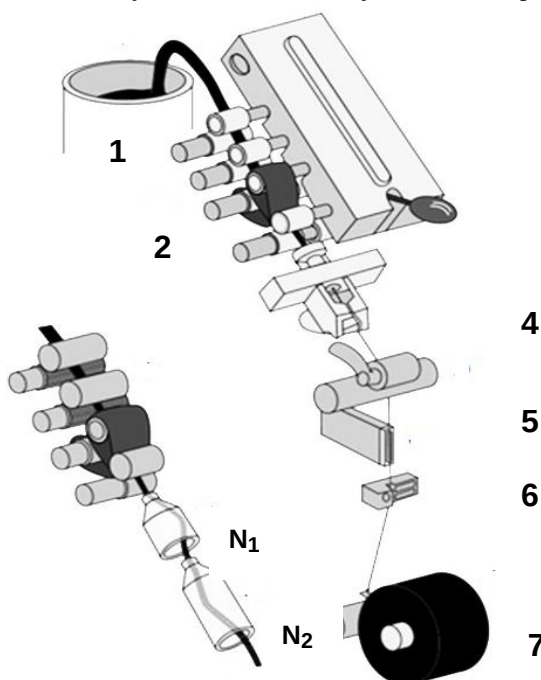


Fig 1: Air jet spinning system

- 1 = Sliver can,
- 2 = drafting arrangement,
- N_1 = first jet,
- N_2 = second jet,
- 3 = jet spun yarn,
- 4 = take off roller,
- 5 = yarn suction device,
- 6 = electronic yarn clearer,
- 7 = cross-wound package

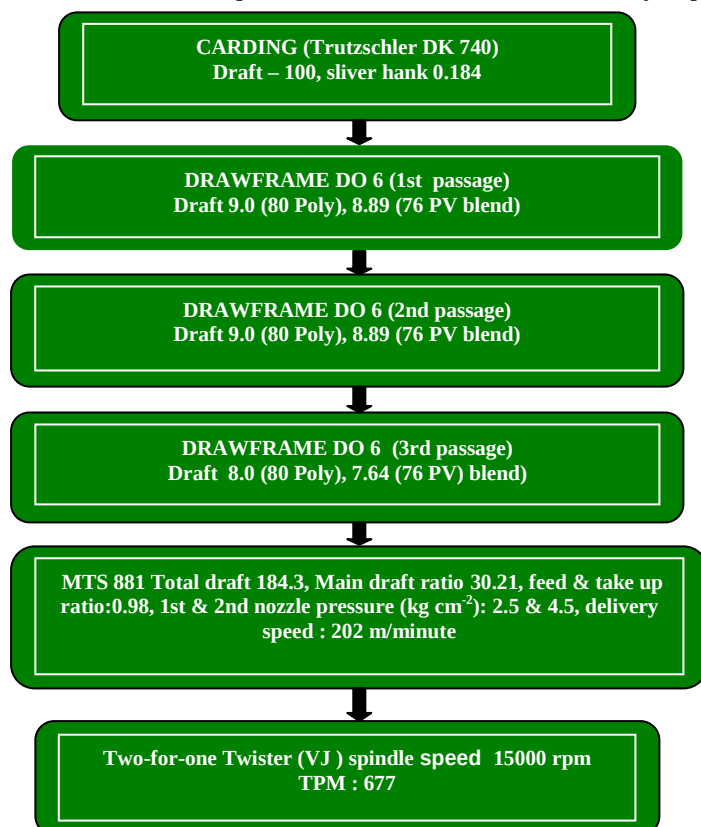
system is located between the front drafting rollers and the yarn delivery rollers, neither of which rotates around the axis of the yarn, the twist inserted by the jets is not real twist and after the yarn passes through the jet

system, the core fibres become twistless. The yarn strength is imparted by the wrapping of the edge fibres. Because of the small jet dimensions, very high rotational jet speeds are possible. Although twist efficiency is only 6–12% because of the twist resistance of the yarn, delivery speeds of up to 300mmmin^{-1} are possible. However, the yarn has a harsher handle. The system is only suitable for medium to fine yarn linear densities as the effectiveness of wrapping decreases with the yarn thickness. The rigid yarn core of parallel fibres makes the yarn stiffer than the ring and rotor yarns².

A number of researchers³⁻⁷ have carried out work on influence of machine and process variables on physical and mechanical characteristics of jet spun yarn but analysis of the evenness and faults at different length spectrum from variance length curve for jet spun yarns has remained unexplored.

II. Materials and methods

Polyester (1.0 d x 51 mm) and viscose (1.5d x 51 mm) were blended in Trutzschler blow room line with chute feed device and then processed⁸ in DK 740 card followed by 3 passages of draw frame LR DO 6 model.



The process flow and parameters in respective processes initiating from card are given in the adjacent diagram. Testing for mass evenness of the yarn samples was carried out following ASTM D1425 method on an Uster Tester 3 using a speed of 400 m/min for 5 minutes for yarn samples and 25 m/min for draw frame sliver for 1 minute. Simultaneous recording for yarn imperfections was also made from the equipment at sensitivity levels of -50% (thin place), +50% (thick place) and +200% (neps) respectively. The machine also produces recording of yarn hairiness for the produced samples as an index by recording total number of hairs per centimetre. Ten readings were taken for each sample and subsequently average values are considered.

III. Results and discussion

The mass evenness and other responses which includes CV% values representing short-, medium and long term variation have been shown from table 2 to table 7 and irregularity index as well as yarn imperfections as recorded by the Uster Evenness Tester has been summarised in the aforesaid tables.

Table 1 : Physical properties of air jet spun yarn : two ply yarn (TFO cone)

Sample type/blend ratio	Linear Density Ne tex		Um%	CV _m %	Index	Imperfections per km			Hairiness Index
						Thin	Thick	Neps	
2/80 P:V (100:0)	14.98	39.43	10.47	13.20	1.39	4	21	44	3.24
2/76 P:V (70:30)	15.53	38.02	11.38	14.38	1.50	12	12	53	3.38
2/76 P:V (55:45)	15.01	39.33	11.65	14.63	1.52	30	18	78	3.43

**Table 2 : Physical properties of air jet spun single yarn
(single yarn from MTS cheese)**

Sample no	Linear density Ne tex	Um%	CV _m %	Index	Imperfections per km			Hairiness Index
					Thin	Thick	Neps	
80 P:V (100:0)	7.49 78.86	10.74	13.89	1.36	10	14	49	3.79

76 P:V (70:30)	7.76 76.04	11.72	14.77	1.47	12	12	77	4.02
76 P:V (55:45)	7.51 78.66	11.96	15.02	1.52	30	18	83	4.15

Table 3: CV% values for weight of long length of single air jet yarn and corresponding length of finisher sliver

Cut length	Total draft from finisher sliver to yarn	CV% of 76 P/V (70/30) blend		CV% of 76 P/V (55/45) blend	
		Sliver	Yarn	Sliver	Yarn
Yarn 1.47 mt	184.3	-	3.80	-	4.00
Sliver 0.8 cm	184.3	2.90	-	3.26	-
Yarn 1.47 mt	184.3	-	3.30	-	3.60
Sliver 1.08 cm	184.3	2.90	-	3.26	-
Yarn 10 mt	184.3	-	2.00	-	2.00
Sliver 5.42 cm	184.3	2.50	-	2.80	-

Table 4 : Short and medium term variation of air jet yarn from B/L curve analysis

Material	Short Term Variation		Medium Term variation		Long Term Variation	
	Cut length	CV%	Cut length	CV%	Cut length	CV%
2/76 P:V (70:30)	8 mm	15.07	2 mt	3.3	10 mt	2.0
2/76 P:V (55:45)	8 mm	15.02	2 mt	3.6	10 mt	2.0

Table 5: Short and medium term variation of draw frame sliver from B/L curve analysis

Material	Short Term Variation		Medium Term variation	
	Cut length	CV%	Cut length	CV%
76 P/V 70/30 blend	8 mm	2.9	1 mt	0.85
76 P/V 55/45 blend	8 mm	3.26	1 mt	0.98

Table 6 : Short and medium term variation of air jet yarn from B/L curve analysis (TFO cone)

Material	Short Term Variation		Medium Term variation		Long Term Variation	
	Cut length	CV%	Cut length	CV%	Cut length	CV%
2/76 P/V 70/30 blend	8 mm	14.38	2 mt	3.65	10 mt	1.9
2/76 P/V 55/45 blend	8 mm	14.63	2 mt	4.10	10 mt	2.6

Yarn Evenness and Imperfections

From Tables 1 and 2, we observe the yarn irregularity (CVm%), index of irregularity and imperfections. If the yarns spun with different blend ratios are compared, it may be seen that unevenness registers a sharp increase with decrease in polyester proportion in the blend. Here evenness of polyester and poly rich blend improves along with irregularity index possibly due to smooth flow of drafted ribbon of fibres to the first nozzle after the emergence from the front roller and also the longer wrappings. Polyester-majority yarn spun on air jet system emerges as the most uniform yarn also on account of presence of higher number of fibres in the yarn cross section due to use of finer denier polyester fibre. Similar trend is observed specially with the frequency of thin places which increases steadily with inclusion of viscose in the blend. This trend is prevalent for both kinds of yarn, jet spun as well as two ply twin spun yarn. A steady increase in overall imperfections is also observed with increase in proportion of viscose in the blend. The outcome of this phase of experimentation is that polyester fibre responds better to air jet spinning system than viscose fibre from evenness point of view. Exactly similar

trend is observed with respect to frequency of total imperfections. It may therefore be surmised from present experiment that inclusion of higher proportion of fine denier polyester fibre results in improved mass evenness and reduced number of yarn imperfections in air jet spinning system.

Medium and long term variation

With regard to medium and long term variation in air jet yarn, it can be said that drafting arrangement in air jet spinning system contributes distinctly towards generation of short and medium term irregularities, being drafted from the equivalent length of finisher draw frame sliver (Table - 3). But no such effect can be seen for long term irregularity. Hence it may be surmised that drafting arrangement in air jet spinning system does not contribute for long term variation. From Tables 4,5 and 6, the short, medium and long term variation of draw frame finisher slivers and corresponding air jet yarns (single and double) at different cut lengths, analysed from B-L curves can be seen.

Hairiness

With regard to hairiness of jet spun and two ply yarns, it may be seen that hairiness increases with inclusion of viscose component but after a level again shows a marginal decrease with further addition of viscose component. In an air jet spun yarn, formation of hairs is influenced by the number of fibre ends in the yarn length, the number of edge fibres being separated from the main strand and the number of detached edge fibres that fail to be properly caught by the yarn. Due to improper separation of edge fibres and lack of favourable conditions to prevent formation of hairs, more entanglements result and thus ultimately form the hairs. Less number of core fibres results with the increase of wrapper fibres and have a significant impact on hairiness. The higher fineness, or in other words, low linear density of polyester fibre also plays an important role in increasing compactness of surface wrapper fibres in the structure and hence leads to reduced hairiness, arising out of better reinforcement of wrapper fibres. After plying, all the specimens demonstrate noticeable decrease in hairiness. When ply twist in 'S' direction is given, the individual strands rotate on their own axis causing 'Z' wrapped surface fibres to untwist and become loose initially. These surface fibres gradually acquire zero twist on further addition of ply twist will reverse the direction of twist of surface fibres which become eventually more taught and reinforced into the structure. This reinforcing effect consequently assists in reducing number of hairs in the two ply yarn.

IV. Conclusions

Increase in the proportion of polyester content corresponds to improvement in evenness characteristics of air jet yarn. Yarn $U_m\%$ and $CV_m\%$ improves with the increase in polyester content in the blend. It was seen from variance length curve analysis that drafting arrangement in air jet spinning system contributes towards generation of short and medium term irregularities. But no such effect can be seen for long term irregularity. Hairiness index decreases with the increase in the proportion of polyester content. After plying, all the specimens demonstrated distinct decrease in hairiness. In case of air jet single yarn, drafting arrangement in the air jet spinning machine contributes to generation of short and medium term irregularities but no contribution is observed in case of long term irregularities.

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