



Air Jet Spinning of Polyester-Viscose blend Part II: Mechanical Response

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Abstract: The present work embodies the influence of fibre type and blend proportion on mechanical behaviour of air jet single and twin spun yarns. It is observed that Abrasion resistance or fatigue behaviour of the yarn is very much responsive to plying process and presence of increased polyester content. Decrease in breaking load is higher with polyester majority yarn while the fall in elongation increases with the addition of viscose component while examining load cycling behaviour. Tensile properties of the twin spun yarn improves markedly in comparison to single air jet spun yarn.

Keywords: Fatigue, tenacity, breaking extension, load cycling, air jet spun, twin spun yarn

I. Introduction

Ring spinning possesses limitations in terms of productivity, spindle speed, traveller speed, total draft, and yarn package weight and additional processing costs like costs for the roving and winding process. Presence of spinning triangle is also one of the unavoidable reasons for yarn hairiness and one of the sources for weak places in the yarns. Spinning tension could create additional limitations for thermo plastic fibres producing melt spots in the yarn. The spinning principle of Murata Jet Spinner has been explained in the earlier communication¹. Air-jet spinning works on the principle of false twisting/wrapping that produces so-called ‘fasciated yarns’ due to the fact that the wrappers are not continuous^{2,3,4}. Air-jet spun yarn consists of a core of parallel fibres wrapped by surface fibres or binding fibres. The objective of Murata Twin Spinner aims at producing two folded yarns through a short-cut process. In this machine, the width of cots and bottom rollers are increased to accommodate drafting of two slivers simultaneously, without touching each other. The sliver guides are provided in drafting zones to avoid intermingling of the two strands during drafting³. The drafted strands are passed through air-jets separately and are given false twist. Finally, the two strands are brought together and wound in parallel onto a single package, which will be used as a precursor package for a two-for-one twister to produce folded yarn. A number of researchers⁵⁻⁸ have carried out work on air jet spinning with emphasis on influence of process variables but no critical work has been done so far in the chosen theme.

II Materials and method

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

Table 1: Fibre properties

Fibre	Origin	S.L. (mm)	Denier	Tenacity (gpd)	Elongation (%)
PET	RPL	51	1.0	6.2	16.4
Viscose	GRASIM	51	1.5	1.95	11.3

Two finisher slivers from third draw frame passage were then spun in Murata Twin Spinner MTS 881 at a delivery speed of 202 metres per minute. The twin spun yarn from MTS machine was twisted in ‘S’ direction on a VJ TFO using twist insertion rate of 15000 rpm and 17.3 twists per inch.

The various machines, hank and processing conditions used are:

Machines	Draft/* Hank	Atmospheric condition (relative humidity)
Truzschler Blow Room with chute feed arrangement		70-80%; Antistatic 0.16%;
Truzschler DK740 Card	draft 100, * sliver hank 0.184	65%
Draw frame sequence	LR DO/6 LR DO/6 LR DO/6	9.0(100% PET), 8.89 (PV blend) 9.0(100% PET), 8.89 (PV blend) 8.0 (100% PET), 7.64 (PV blend)
Air Jet Spinning : MTS 881 Twin spinner	Total Draft 184.3, MDR 30.21, feed and take up ratio 0.98, Nozzle Pressure 1st : 2.5kg/sq cm, 2nd: 4.0 kg/sq cm, condenser 2 mm Delivery speed 202 m/min	45-50%
Veejay Lakshmi Two-for-One Twister	15000 rpm, tpi 17.3	

Abrasion resistance was measured for both single and plied (twin spun) specimens where the yarn is clamped at one end and passed via polished pegs with yarn to yarn contact and finally tensioned at other end with known weight. The peg board was moved up and down at standard speed to create yarn to yarn abrasion and the number of abrasion cycles required to break the yarn was recorded from a counter. Tensile properties like breaking load, breaking extension, initial modulus were obtained using an Instron Tensile Tester model 4301 with 500 mm specimen length, cross head speed of 150 mm/minute and full scale load of 10N. The corresponding tenacity were obtained by dividing breaking load with tex value of each specimen. In each case, average values of tenacity, breaking extension and initial modulus of the specimens were obtained from 40 readings. For load cycling behaviour of single air jet yarn, minimum load was chosen above yield point of yarn and the specimen was conditioned for 20 cycles these minimum and maximum load for each blend. After completion of load cycling, breaking load and extension were evaluated for each sample. From average values fall in breaking extension (%) were calculated.

III Results and discussion

The fatigue or abrasion and other tensile responses have been shown from table 2 to table 4 .

TABLE 2: Tensile properties of air jet spun yarn Two ply twin spun (TFO CONE)

Material	Linear Density		Mean breaking Load, cN	Breaking extension%	Tenacity, cN/tex	Initial modulus, cN/tex	Abrasion cycles to break
	Tex	Ne					
2/80 P:V (100:0)	14.92	39.58	406.2	8.92	27.22 (+91.8)	214.30	292
2/76 P:V (70:30)	15.49	38.12	338.5	10.24	21.85 (+54.3)	207.68	193
2/76 P:V (55:45)	14.94	39.63	293.2	10.37	19.62 (+39.7)	206.07	138

(Figures in parentheses indicates percent improvement in strength after plying)

TABLE 3: Tensile Properties of air jet twin spun yarn (single yarn from MTS cheese)

Material	Linear Density		Mean breaking Load, cN	Breaking extension%	Tenacity, cN/tex	Initial modulus, cN/tex	Abrasion cycles to break
	Tex	Ne					
80 P:V (100:0)	7.49	78.86	106.3	13.89	14.19	214.30	18
76 P:V (70:30)	7.52	76.04	106.5	14.77	14.16	207.68	15
76 P:V (55:45)	7.51	78.06	105.5	15.02	14.04	206.07	14

Fatigue behaviour

The fatigue behaviour is likely to be governed by the following factors; nature of wrapping, number of wrapping fibres, the nature of wrapper fibres and the type of fibres which are employed in producing the air jet spun yarn. Table 2 and 3 indicate that addition of polyester component brings about a considerable improvement in the fatigue behaviour of both jet spun and two-ply twin spun yarn. In polyester majority yarns, low denier polyester component has low bending rigidity and is able to generate more number of wrapper fibres. In addition, there will be presence of more core fibres in the structure due to their lower area of curvature which lead to producing better reinforced and more compact structure. The wrapper fibres restrict the freedom of core fibres. The net effect is that the frictional grip increases with the increase in wrapper fibres. However in single jet yarns, the surface fibres are ruptured at comparatively lower number of abrasion cycles and quickly respond to fatigue failure by causing rapid exposure of the unprotected core. This leads to early failure of the single jet spun yarn. In the plied structure, the core fibres are also subjected to helical arrangement around each other and thus a transverse pressure develops along their contact region. The surface fibres too get twisted in the opposite direction (S), gradually ensures tightness and eventually helps in reinforcing the structure of the plied yarn.

Tenacity

Tenacity increases with the inclusion of polyester in the blend (Table3). Evaluation of plied yarn also depicts same behaviour and here increment in tenacity is mainly contributed by the high tenacity polyester fibre as has been evidenced for single yarn. Also the plied yarns show a considerable improvement in tenacity over single jet

yarns, the gain increases with increase in polyester content. In plied yarn the cohesion and strength depends no longer up on fibre migration and twist but merely on the wrapping of a strand consisting of a parallel arrangement of fibres around each other facilitating better exploitation of fibre properties.

The gain in tenacity of plied yarn may be attributed to the pressure developed along the contact region owing to helical arrangement of core fibres around each other when subjected to straining. The reinforcing effect of surface fibres and the mutual support offered by the helically wrapped core fibres become more effective for polyester majority yarn in maximising its strength.

Breaking Extension

The decrease in breaking elongation in case of polyester rich blend and polyester majority yarn may be ascribed to better reinforcement and more compactness of the yarn structure due to presence of low denier polyester fibre of higher flexibility. It is expected that polyester fibre, owing to its higher fineness, will respond better to surface wrapping mechanism during false twisting and will also generate more number of wrappers in unit length of the structure. With further increase of low denier polyester component, the number of fibres in both the wrapped and core portion of the yarn also increases. As a result, the frictional grip between the fibres both in wrapped portion as well a score portion increases and results in a better reinforced structure. During tensile loading, the fibres of such a reinforced structure will respond better to load rather than elongation. In other words, fibre breakage phenomenon will be more predominant than fibre slippage in the failure mechanism of yarn and hence lower extension is associated with polyester rich blended jet spun yarn.

Yarn Modulus

It is observed that single jet spun yarns polyester rich blends are associated with much higher modulus. This is because the yarn structure is now more rigid and well reinforced on account of presence of more number of wrapper fibres and intensive wrapping. Moreover higher modulus of polyester fibre also plays a major role in increasing the modulus of polyester-rich blended yarn. A yarn with higher modulus indicates its inextensibility and higher resistance to abrasion. The low yarn modulus with higher proportion of viscose component also accounts for its lower rigidity.

Load Cycling Behaviour

All single jet spun yarns depict similar behaviour when subjected to mechanical conditioning by loading them for definite number of cycles around yield point and another point nearer to breaking point. The fall in breaking load, in general is higher with polyester majority yarn while the fall in elongation increases with the addition of

Table 4 : Load cycling behaviour of Air Jet Single yarn

Count & Blend	Breaking load, cN	Elongation, mm	Breaking Load after cycling	Breaking elongation (after cycling)	Fall in load (%)	Fall in elongation (%)
80 P:V (100:0)	106.3	6.60	99.8	6.18	6.11	6.33
76 P:V (70:30)	106.5	7.93	97.1	6.86	8.82	13.49
76 P:V (55:45)	105.5	9.82	95.2	8.66	9.76	11.82

Fig 1: Influence of repeated load cycling on breaking load of single yarn

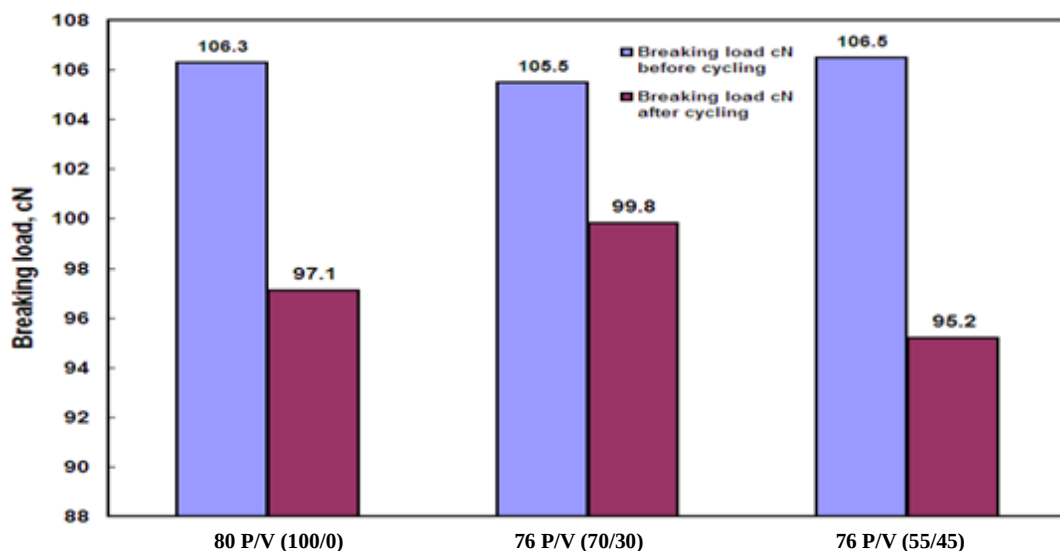
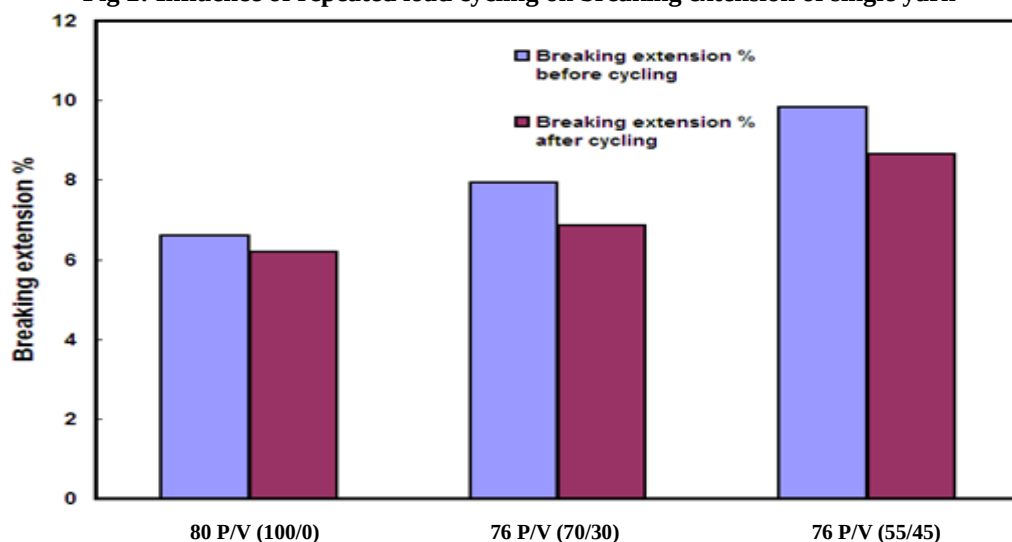


Fig 2: Influence of repeated load cycling on breaking extension of single yarn



viscose component in the blend (Table 4). It may be therefore surmised that addition of finer denier polyester in the blend results in better surface wrapping and formation of highly reinforced structure. This, in turn, imparts this yarn better endurance when subjected to cyclic loading. For polyester majority yarn, due to low denier, number of fibres in yarn cross section increases. Hence proportion of fibres in core and surface of the yarn increases. But proportion of surface wrapper fibres increases more in comparison to core, giving the structure a fair amount of rigidness. During load cycling, core fibre slippage takes place along with loosening of wrappers, contributing greater percentage of fall in breaking load. Thus the structure will respond better to loading rather than elongation. Viscose fibres do have lesser amount of elongation value in comparison to polyester fibres. Moreover as the number of low denier polyester fibres decrease in the blend; wrapping frequency becomes lower. Consequently the structure will respond better to elongation than loading. So percentage fall in elongation increases with the increased proportion of viscose component.

IV. Conclusions

1. Abrasion resistance or fatigue behaviour of the yarn improves markedly when plying occurs. With increased proportion of polyester content, abrasion resistance of the yarn increases.
2. Tenacity increases with the increase in the polyester content on the blend; whereas breaking elongation decreases with the increase in the polyester content.
3. Twin spun yarn shows a marked improvement in the tensile characteristics over that of single yarn.
4. Initial modulus increases with the increase in polyester content in the blend both in case of single and double yarn.
5. For load cycling behaviour, the decrease in breaking load is higher with polyester majority yarn while the fall in elongation increases with the addition of viscose component.
6. In significance testing, difference in mean breaking load in case of double yarn is significant while for single yarn difference is insignificant. Difference in mean breaking elongation of double yarn is significant except for polyester: viscose (70:30 and 55:45) yarns. For single yarn, difference in elongation is insignificant.

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