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Effect of annealing on MJS yarn characteristics

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The response of polyester/viscose MJS yarns to annealing under relaxed condition has been studied. It is observed that the annealing significantly increases the breaking extension and abrasion resistance but adversely affects the tenacity and initial modulus of yarn. The flexural rigidity of yarn considerably decreases whereas the elastic recovery increases on annealing. The variation in properties on annealing is more conspicuous in the yarns produced with higher proportion of polyester fibre and lower first jet pressure.

Keywords: Annealing, Air-jet spinning, Breaking extension, Flexural rigidity, Elastic recovery, Polyester/viscose yarn, Tenacity

1 Introduction

Among the modern high-production technologies, air-jet spinning has some advantages over others, especially for the production of fine polyester blended yarns. In the past few years, a number of publications have dealt with many aspects of this technology. Though the earlier studies mainly dealt with the effect of fibre and process variables on yarn properties[1-5], the recent ones aim at exploring the possibilities of increasing productivity by optimization of jet design[6,7]. However, doubts over the future potential of this technology still continue due to the higher bending rigidity of air-jet yarns. The structure of air-jet yarn suggests that annealing would bring down the bending rigidity of this yarn. Though a number of studies have been made on the influence of annealing of yarn and textile materials[8-10], there is little information in this regard on air-jet yarns[11]. This paper discusses the changes in the mechanical properties of polyester/viscose MJS yarns on annealing under relaxed condition.

2 Materials and Methods

2.1 Preparation of Yarn Samples

Two sets of yarns of 11.5 tex and 29.5 tex were spun from blends of polyester and viscose rayon fibres on Murata air-jet spinner at different first jet pressures. The specifications of polyester and viscose fibres used are given in Table 1. Laps made on a Lakshmi Rieters' blow room were carded on a semi high production MMC card. The card slivers were drawn on Lakshmi Rieters' DO/2S drawframe. Three passages of drawing were given to all the samples. The linear density of finisher sliver was adjusted to 3.2 ktex. The finisher slivers were spun on Murata air-jet spinner 802 MJS. Second jet pressure of 3.5 kg/cm^2, spinning speed of 200 m/min and feed ratio of 0.97 were kept constant.

2.2 Annealing Treatment

All the yarns were annealed by dry heating at 160° C for 5 min in a laboratory curing-setting chamber under relaxed condition. Skeins of 300-400m were prepared on a wrap reel and laced at 5 points. The

Table 1—Properties of polyester and viscose rayon fibres before and after annealing

Fibre	Length	Linear density	Before annealing		After annealing	
	mm	dtex	Tenacity cN/tex	Breaking extension, %	Tenacity cN/tex	Breaking extension, %
Polyester	51	1.66	49.12	29.52	46.56	36.34
Viscose	51	1.66	19.31	18.20	18.61	21.6[illegible]

lacings were kept completely loose so as not to hinder the relaxation process in yarn during shrinkage. The skeins were then hung loosely in curing-setting chamber for annealing.

2.3 Measurement of Yarn Characteristics

All the yarns were tested for tensile properties on Instron tensile tester (model 4411) using 50 cm test specimen and 20 cm/min extension rate. The mean tenacity, breaking extension and initial modulus were averaged from 100 observations for each yarn sample. The flexural rigidity and elastic recovery were measured on weighted ring yarn stiffness tester by the ring loop method. A ring of known circumference (L) was deflected under a constant load (M) and the position of each loop was observed before loading, after loading and after unloading. The observations were termed as R_1, R_2 and R_3. The yarn deflections D_1 and D_2 i.e. $(R_2 - R_1)$ and $(R_2 - R_3)$ were tabulated and the respective values of Z i.e. (D_1/L) were read from the supplied table. These values were then used to calculate the corresponding values of flexural rigidity (ML^2/Z) and elastic recovery (D_2/D_1).

Resistance to abrasion was assessed by using Custom scientific abrasion tester. Skeins were prepared on wrap reel and then from each skein, 2.54 cm wide and 23 cm long specimens were cut. The yarns were then kept in contact with a reciprocating abradant under a load of 500 g and the number of rubs needed to break the specimen was taken as a measure of abrasion resistance.

Thermal shrinkage was measured according to BSI method. The skeins were conditioned and hung from a hook at the top of a measuring scale so that the inside of the top of the skein coincided with the zero of the measuring scale. Lengths of the skeins before (l_1) and after (l_2) annealing treatment were measured and the yarn thermal shrinkage was calculated using the following expression:

$$\text{Thermal shrinkage } (\%) = (l_1 - l_2) \times 100 / l_1$$

3 Results and Discussion

3.1 Tensile Properties

Annealing of yarn in relaxed condition leads to the following changes: (i) the polyester wrapper fibres undergo stress relaxation. The transverse pressure and the resultant binding induced by them decreases, leading to drop in inter-fibre cohesion of core fibres, (ii) the polyester fibres in the core shrink slightly, and (iii) the tenacity of polyester fibres decreases and breaking extension increases as shown in Table 1.

Table 2 and Figs 1-3 show the tensile properties of polyester/viscose MJS yarns before and after annealing under relaxed condition. The results show a decrease in breaking tenacity (4.2-13.8 %), a large increase in yarn breaking extension (12.1-26.4 %) and a very large decrease in initial modulus (33.6-46.3 %) of yarn. These changes may be attributed to the relaxation of wrapping fibres, decrease in fibre tenacity and increase in breaking extension due to

Table 2—Effect of annealing on the tensile properties of polyester/viscose jet-spun yarns

Yarn composition (P/V)	Linear density tex	First jet pressure kg/cm^2	Before annealing			After annealing			Change in tenacity of parent yarn %	Change in bkg extn of parent yarn %	Change in initial modulus of parent yarn %
			Tenacity cN/tex	Breaking extension %	Initial modulus cN/tex	Tenacity cN/tex	Breaking extension %	Initial modulus cN/tex			
48/52	11.5	2.0	16.66	14.97	101.51	15.30	16.99	65.52	−8.16	+13.49	−35.45
		2.5	17.12	15.27	112.53	16.07	17.17	74.20	−6.13	+12.44	−34.06
		3.0	17.69	15.66	118.46	16.95	17.56	78.62	−4.18	+12.13	−33.63
80/20	11.5	2.0	19.68	16.15	120.04	17.12	19.30	70.81	−13.01	+19.50	−41.01
		2.5	20.17	16.70	130.56	17.97	19.83	80.34	−10.91	+18.74	−38.46
		3.0	20.65	17.42	133.72	18.85	20.55	85.15	−8.71	+17.96	−36.32
48/52	29.5	2.0	15.34	13.17	130.58	13.88	15.96	75.16	−9.51	+21.18	−42.44
		2.5	15.76	13.66	139.50	14.60	16.51	82.02	−7.36	+20.86	−41.20
		3.0	16.55	14.14	148.02	15.64	19.94	85.53	−5.49	+20.50	−40.19
80/20	29.5	2.0	18.69	15.01	146.51	16.11	18.97	78.63	−13.80	+26.38	−46.33
		2.5	19.29	15.63	153.54	17.09	19.54	85.43	−11.40	+25.01	−44.35
		3.0	19.78	16.05	156.63	17.91	19.89	90.81	−9.45	+23.92	−42.02

P—Polyester and V—Viscose

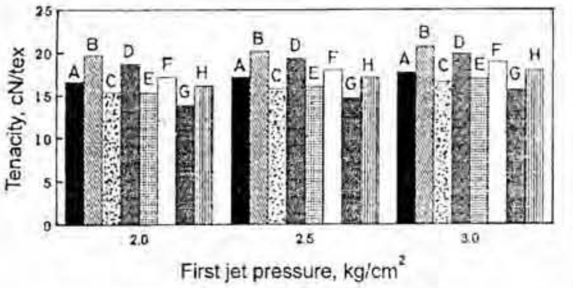

Fig. 1—Influence of annealing on tenacity of MJS yarns [**Grey: A**—11.5 tex, 48:52 P/V; **B**—11.5 tex, 80:20 P/V; **C**—29.5 tex, 48:52 P/V; **D**—29.5 tex, 80:20 P/V; and **Annealed: E**—11.5 tex, 48:52 P/V; **F**—11.5 tex, 80:20 P/V; **G**—29.5 tex, 48:52 P/V; **H**—29.5 tex, 80:20 P/V]

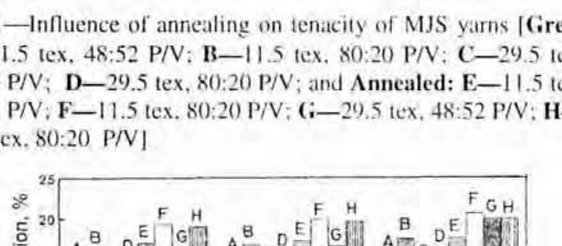

Fig. 2—Influence of annealing on breaking extension of MJS yarns [**Grey: A**—11.5 tex, 48:52 P/V; **B**—11.5 tex, 80:20 P/V; **C**—29.5 tex, 48:52 P/V; **D**—29.5 tex, 80:20 P/V; and **Annealed: E**—11.5 tex, 48:52 P/V; **F**—11.5 tex, 80:20 P/V; **G**—29.5 tex, 48:52 P/V; **H**—29.5 tex, 80:20 P/V]

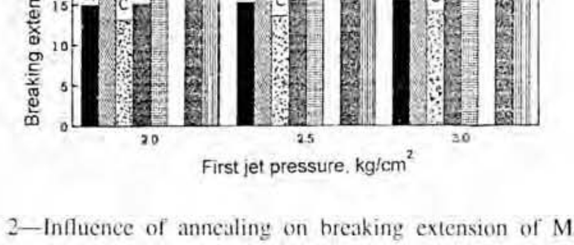

Fig. 3—Influence of annealing on initial modulus of MJS yarns [**Grey: A**—11.5 tex, 48:52 P/V; **B**—11.5 tex, 80:20 P/V; **C**—29.5 tex, 48:52 P/V; **D**—29.5 tex, 80:20 P/V; and **Annealed: E**—11.5 tex, 48:52 P/V; **F**—11.5 tex, 80:20 P/V; **G**—29.5 tex, 48:52 P/V; **H**—29.5 tex, 80:20 P/V]

annealing. The strength loss due to annealing is greater for 29.5 tex yarn as compared to 11.5 tex yarn. The decrease in strength and modulus increases with increase in polyester content due to the stress relaxation of greater percentage of polyester wrapper fibres.

Table 2 also shows that the initial modulus of polyester/viscose MJS yarns decreases after annealing. This may be attributed to the decrease in inter-fibre cohesion of core fibres. Similarly, the yarns spun with higher polyester content experience a greater decrease in initial modulus after annealing due to greater decrease in inter-fibre cohesion of core fibres. However, the magnitude of reduction is somewhat lower with higher first jet pressure. This is due to greater restriction on the core fibres due to greater number of wrapper fibres with higher first jet pressure.

3.2 Thermal Shrinkage

Table 3 shows that the coarse yarns undergo greater thermal shrinkage on annealing. It increases further with the increase in the proportion of polyester fibre. This behaviour can be ascribed to shrinkage of thermoplastic polyester fibre and stress relaxation of wrapper fibres. Due to lower percentage of wrapper fibres in coarser yarns, the restriction imparted by wrapper fibres on core fibres is lower and thus the shrinkage is greater. The first jet pressure also has some effects on the thermal shrinkage of MJS yarns; higher first jet pressure results in higher shrinkage (Fig. 4).

3.3 Flexural Rigidity

Table 3 shows that on annealing, the flexural rigidity decreases by 8.38-18.56 %. This may be attributed to loosening of yarn core, allowing easier inter-fibre sliding during bending. The yarns spun at higher first jet pressure have higher flexural rigidity (Fig. 5). On annealing, these yarns show a lesser decrease in rigidity. These results suggest that a higher first jet pressure results in lesser drop in restriction on the movement of core fibres due to compact nature of yarn because of the higher incidence of wrapper fibres. The decrease in flexural rigidity increases with higher polyester content due to its thermoplastic nature. Further, the decrease is higher for coarse yarns due to their lower compactness because of the lower percentage of wrappers.

3.4 Abrasion Resistance

Table 3 and Fig. 6 show that the abrasion resistance for an annealed MJS yarn is always higher than that for corresponding untreated yarn. The higher abrasion resistance of yarn after annealing may be attributed to the opening up of yarn structure, leading to greater fibre mobility in the yarn body. The minimum increase in abrasion resistance on annealing corresponds to the yarn spun with highest first jet pressure of 3.0 kg/cm^2. This is expected as the gain in fibre mobility would be lower for the more compact yarn produced at a higher pressure. Increase in

Table 3—Effect of annealing on flexural rigidity, elastic recovery, abrasion resistance and residual shrinkage of polyester/viscose jet-spun yarns

Yarn composition (P/V)	Linear density tex	First jet pressure kg/cm^2	Before annealing			After annealing			Reduction in flexural rigidity of parent yarn, %	Thermal shrinkage %
			Flexural rigidity ×10^3 gcm^2	Elastic recovery %	Abrasion resistance cycles	Flexural rigidity ×10^3 gcm^2	Elastic recovery %	Abrasion resistance cycles		
48/52	11.5	2.0	6.58	50.50	582	5.86	55.16	768	10.94	7.42
		2.5	6.66	52.68	650	6.02	57.32	848	9.60	7.01
		3.0	6.80	53.84	736	6.23	58.38	954	8.38	6.63
80/20	11.5	2.0	7.29	60.15	829	6.36	68.03	1055	12.75	8.53
		2.5	7.37	62.51	914	6.60	70.51	1182	10.44	8.16
		3.0	7.58	66.66	1064	6.85	72.89	1372	9.63	7.76
48/52	29.5	2.0	8.11	31.13	1390	6.89	34.95	2052	15.04	9.56
		2.5	8.57	32.85	1460	7.47	36.68	2160	12.83	9.02
		3.0	8.84	35.33	1484	7.85	43.32	2207	11.19	8.64
80/20	29.5	2.0	9.22	44.96	1618	7.51	51.89	2408	18.56	10.43
		2.5	9.70	47.76	1706	8.15	54.56	2530	15.97	9.80
		3.0	10.42	49.95	1872	8.99	56.47	2796	13.72	9.31

P—Polyester and V—Viscose

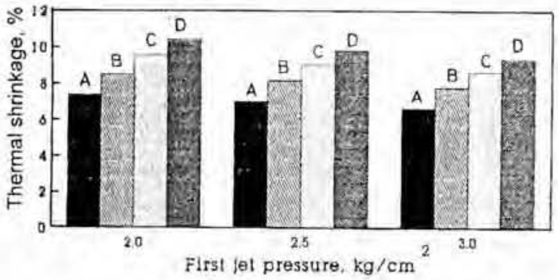

Fig. 4—Thermal shrinkage of MJS yarns [A—11.5 tex, 48:52 P/V; B—11.5 tex, 80:20 P/V; C—29.5 tex, 48:52 P/V; and D—29.5 tex, 80:20 P/V]

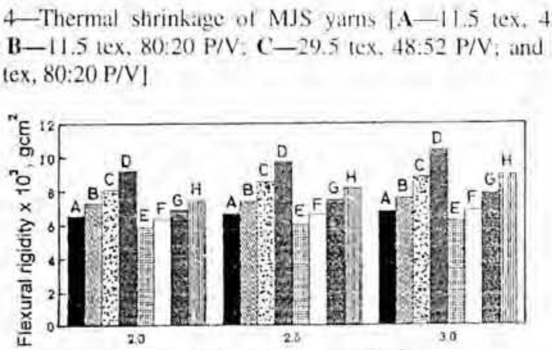

Fig. 5—Influence of annealing on flexural rigidity of MJS yarns [**Grey: A**—11.5 tex, 48:52 P/V; **B**—11.5 tex, 80:20 P/V; **C**—29.5 tex, 48:52 P/V; **D**—29.5 tex, 80:20 P/V; and **Annealed: E**—11.5 tex, 48:52 P/V; **F**—11.5 tex, 80:20 P/V; **G**—29.5 tex, 48:52 P/V; **H**—29.5 tex, 80:20 P/V]

polyester content results in greater increase in the abrasion resistance due to higher stress relaxation in polyester wrapper fibres and thus greater fibre mobility. The increase in abrasion resistance is greater for coarse yarn, irrespective of the blend ratio, again due to greater gain in mobility in less compact coarse yarn.

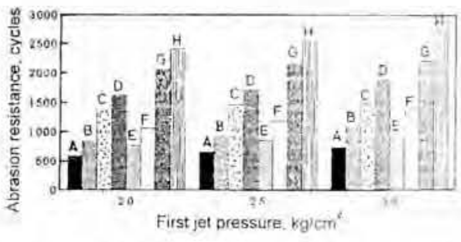

Fig. 6—Influence of annealing on abrasion resistance of MJS yarns [**Grey: A**—11.5 tex, 48:52 P/V; **B**—11.5 tex, 80:20 P/V; **C**—29.5 tex, 48:52 P/V; **D**—29.5 tex, 80:20 P/V; and **Annealed: E**—11.5 tex, 48:52 P/V; **F**—11.5 tex, 80:20 P/V; **G**—29.5 tex, 48:52 P/V; **H**—29.5 tex, 80:20 P/V]

3.5 Elastic Recovery

Annealing considerably influences the recovery behaviour of polyester/viscose MJS yarns. Table 3 shows that the elastic recovery increases after annealing. It also increases with the increase in polyester content. Such a behaviour expectedly occurs due to the stress relaxation in the thermoplastic polyester fibre, leading to loosening up of yarn. This is supported by the increase in breaking extension on annealing. However, as expected, the increase in elastic recovery is less marked in compact yarns produced with high first jet pressure (Fig. 7). This

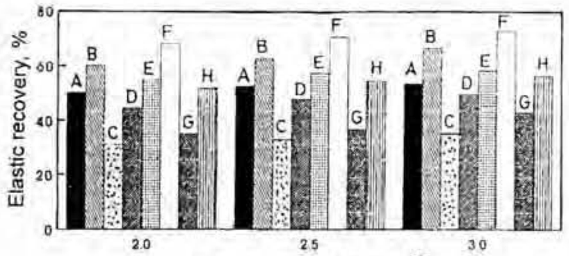

Fig. 7—Influence of annealing on elastic recovery of MJS yarns [**Grey: A**—11.5 tex, 48:52 P/V; **B**—11.5 tex, 80:20 P/V; **C**—29.5 tex, 48:52 P/V; **D**—29.5 tex, 80:20 P/V; and **Annealed: E**—11.5 tex, 48:52 P/V; **F**—11.5 tex, 80:20 P/V; **G**—29.5 tex, 48:52 P/V; **H**—29.5 tex, 80:20 P/V]

confirms the earlier hypothesis that the higher incidence of wrapper fibres associated with the high first jet pressure restricts the longitudinal shrinkage of core components and thereby reduce its magnitude.

4 Conclusions

Annealing of polyester/viscose MJS yarns under relaxed condition increases the breaking extension, abrasion resistance and elastic recovery and decreases flexural rigidity. Tenacity and initial modulus, however, considerably decrease. The level of change in these yarn characteristics is higher for coarse yarns, higher polyester content and lower first jet pressure.

References

1 Grosberg P, Oxenham W & Miao M, *J Text Inst*, 78 (1987) 189.
2 Lawrence C A & Baqui M A, *Text Res J*, 61 (1991) 123.
3 Puttachaiyong S & Oxenham W, *Text Asia*, 23 (1992) 52.
4 How Y L, Cheng K P S & Wong S K, *Text Asia*, 23 (1992) 80.
5 Kaushik R C D, Salhotra K R & Tyagi G K, *Indian J Fibre Text Res*, 17 (1992) 219.
6 Oxenham W & Basu A, *Text Res J*, 63 (1993) 674.
7 Artz P, Steinbach (FG) G & Zeigler F H (K), *Melliand Textilber*, E5 (1995) 2.
8 Tyagi G K, Malik A P & Lal A, *Indian J Text Res*, 12 (1987) 40.
9 Sukigara X T S, Postle R & Dhingra R C, *Text Res J*, 57 (1987) 601.
10 Daspal D, *Influence of slack and tension annealing on properties of air-jet, ring and rotor-spun polyester yarns*, M Tech thesis, Indian Institute of Technology, New Delhi, 1991, 31.
11 Tyagi G K, Kaushik R C D & Salhotra K R, *Indian J Fibre Text Res*, 23 (1998) 105.