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Bulk and related properties of acrylic-cotton jet-spun yarns

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Jet-spun yarns produced with higher acrylic fibre content showed substantially higher bulk, abrasion resistance, flexural rigidity, tenacity and breaking extension than the yarns spun with higher cotton fibre content. Reasonably higher acrylic content is needed to enhance yarn bulk. Use of a narrow condenser and lower main draft reduces rigidity and yarn bulk.

Keywords: Acrylic-cotton yarn, Flexural rigidity, Jet-spun yarn, Main draft, Wrapper fibres

1 Introduction

Following the constant growth in demand for textiles, the need for the expansion of production capacities for spun yarns has drastically increased. In order to respond more quickly to market trends, spinners nowadays are resorting to modern spinning technologies. In the past few years, air-jet spinning has gained importance in comparison with all other spinning systems. Research in this field has considerably increased in recent years in many parts of the world with the sole objective of understanding the technological effects of fibre and machine variables on the properties of spun yarns[1-5]. Reports published so far show that air-jet spinning enjoys a distinct reputation as a major contributor to the production of fine yarns. However, the production of acceptable yarns from acrylic-cotton blends is a subject for constant concern in the spinning mills for the reasons of strength, yield, stiffness and process performance. Trials have been conducted at the Technological Institute of Textile & Sciences to attain this objective and the initial results of these trials have already been published[6]. In the present work, the influence of some variables on the bulk and related properties of acrylic-cotton MJS yarns have been studied and the results are reported here.

2 Materials and Methods

2.1 Preparation of Yarn Samples

Two sets of yarns of 19.6 and 29.5 tex were spun from two different blends of acrylic and cotton fibres on Murata air-jet spinner. The specifications of the fibres used are given in Table 1. For blending acrylic and cotton fibres, the cotton was first combed and then mixed with acrylic in the opening room. The preparatory sequence prior to spinning included carding in a MMC card and three passages of drawing in a Lakshmi Rieters' draw frame DO/2S. The linear density of drawn sliver was adjusted to 3.0 ktex. The spinning trials were carried out on a Murata air-jet spinner 802 MJS. The details of process parameters used to produce these yarns are given in Table 2.

2.2 Tests

The yarn tenacity and breaking elongation were determined on an Instron tensile tester using 500 mm test specimen and 200 mm/min extension rate. The mean yarn strength and extension were averaged from 50 observations for each yarn sample. Yarn hairiness and diameter, before and after steaming, were measured on a Projectina microscope and the residual shrinkage of yarns

Table 1—Specifications of acrylic and cotton fibres

Fibre	Length mm	Linear density dtex	Tenacity g/tex	Breaking extension %
Acrylic	38	1.66	23.18	30.5
Cotton	25.1*	1.66	20.70	5.0

*2.5% Span length

Table 2—Process parameters for jet-spun yarns

Yarn ref. no.	Yarn linear density, tex	Blend ratio (Acrylic/ Cotton)	Main draft	Ribbon width mm	Spinning speed m/min	NP1 kg/cm²	NP2 kg/cm²
S1	30	70:30	30.91	4	170	3.5	4.5
S2	30	70:30	35.77	4	170	3.5	4.5
S3	30	70:30	41.55	4	170	3.5	4.5
S4	30	70:30	41.55	5	170	3.5	4.5
S5	30	70:30	41.55	6	170	3.5	4.5
S6	30	30:70	30.91	4	170	3.5	4.5
S7	30	30:70	35.77	4	170	3.5	4.5
S8	30	30:70	41.55	4	170	3.5	4.5
S9	30	30:70	41.55	5	170	3.5	4.5
S10	30	30:70	41.55	6	170	3.5	4.5
S11	19.5	30:70	30.91	4	170	3.5	4.5
S12	19.5	30:70	35.77	4	170	3.5	4.5
S13	19.5	30:70	41.55	4	170	3.5	4.5
S14	19.5	30:70	41.55	5	170	3.5	4.5
S15	19.5	30:70	41.55	6	170	3.5	4.5

NP1—First nozzle pressure; and NP2—Second nozzle pressure

Table 3—Influence of blend ratio, yarn linear density, ribbon width and main draft on yarn characteristics

Yarn ref. no.	Bulk×10⁻⁴, cm³		Shrinkage %	Tenacity mN/tex	Breaking extension %	Abrasion resistance cycles	Flexural rigidity ×10³, g cm²	Hairs/m		
	Parent yarn	Steamed yarn						0-2 mm	2-4 mm	Total
S1	3.38	4.01	12.7	71.8	9.2	285	7.41	144	5	149
S2	3.31	3.90	12.4	72.5	10.3	293	7.52	158	5	163
S3	3.29	3.86	12.0	74.5	11.1	318	7.66	166	6	172
S4	3.25	3.80	11.7	76.4	11.9	336	7.73	175	7	182
S5	3.23	3.78	11.2	83.6	12.6	358	7.87	187	7	194
S6	3.28	3.72	7.8	53.5	6.4	207	6.92	164	5	169
S7	3.25	3.67	7.4	54.6	6.6	218	7.09	176	6	182
S8	3.22	3.65	7.1	56.3	7.5	230	7.23	189	7	196
S9	3.19	3.60	6.6	57.4	8.0	246	7.38	198	7	205
S10	3.17	3.56	6.3	58.6	8.4	259	7.51	206	8	214
S11	2.17	2.38	6.8	58.1	8.2	238	5.39	183	6	189
S12	2.15	2.35	6.3	62.2	8.5	255	5.57	195	6	201
S13	2.12	2.32	6.0	65.0	8.9	275	5.68	209	7	216
S14	2.10	2.29	5.8	70.6	9.3	282	5.87	221	8	229
S15	2.08	2.25	5.4	72.3	9.8	294	5.92	234	8	242

was estimated by the method mentioned in BSI handbook. Flat abrasion resistance was determined by Custom Scientific abrasion tester and the yarn flexural rigidity on a weighted ring yarn stiffness tester using the ring loop method.

3 Results and Discussion

3.1 Bulk

The yarn test results are given in Table 3. It may be seen that, in general, the most bulky yarns are those spun from the higher proportion of acrylic fibre, and this is exhibited in Fig. 1. The variability of surface wrapping fibres is the most important factor in determining yarn bulk. Fig. 1 shows that bulk reduces when both ribbon width and main draft are increased. Both these factors increase the wrapper fibres which exert more radial pressure on the core fibres, resulting in compact packing. In practice, spinners generally produce yarns with wide condenser and higher main draft since these give better tensile properties[5,6]. However, increasing these factors may adversely affect yarn rigidity which results in harsh handle in the fabrics. On the other hand, Yarn bulk increases considerably after steaming process and reflects

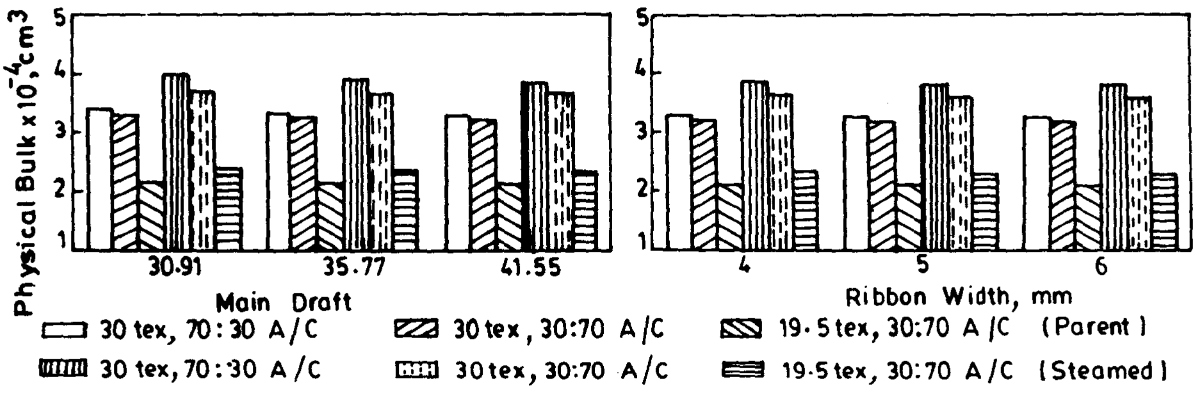

Fig. 1—Variation of physical bulk of parent and steamed acrylic-cotton jet-spun yarns

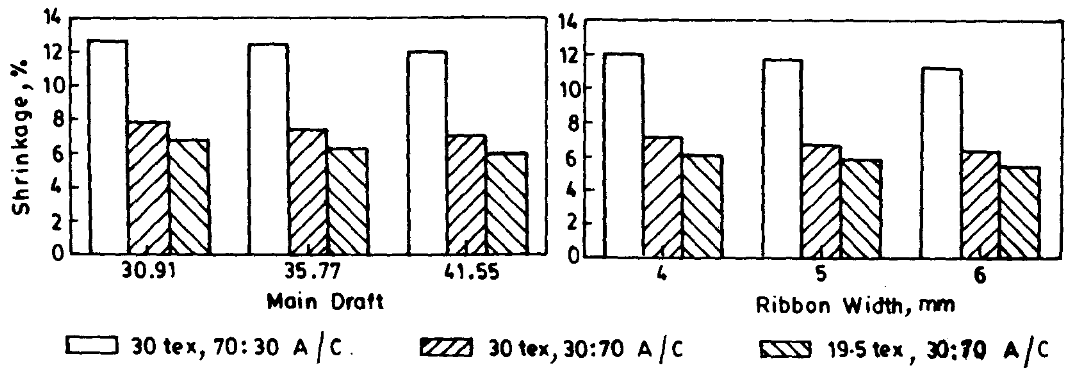

Fig. 2—Variation of residual shrinkage of parent acrylic-cotton jet-spun yarns

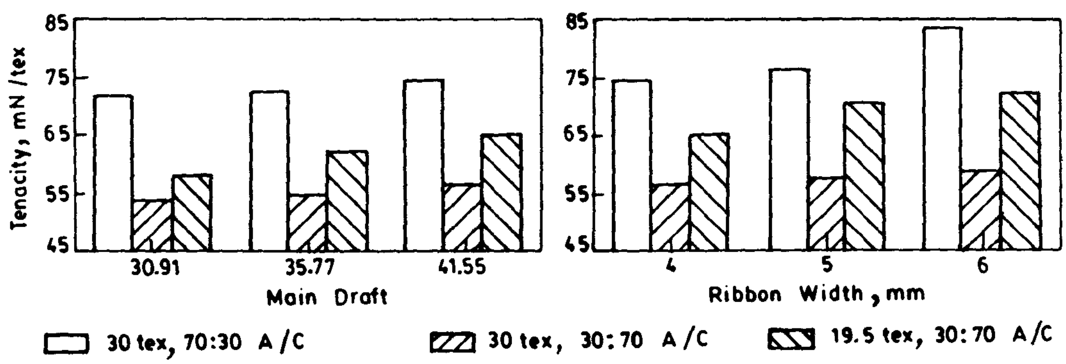

Fig. 3—Variation of tenacity of parent acrylic-cotton jet-spun yarns

the same tendency as the residual shrinkage shown in Fig. 2.

3.2 Relaxation Shrinkage

The results show an increase in the yarn relaxation shrinkage with increase in yarn linear density (Fig. 2). Blend ratio also has a profound influence on the relaxation shrinkage, the latter increases with increasing acrylic content due to higher shrinkage potential of this fibre. However, with the increase in main draft the relaxation shrinkage reduces significantly. The reduction occurs because contraction of surface wrapping fibres has a restrictive influence on the longitudinal shrinkage of core fibres. The use of wider condenser also reduces the relaxation shrinkage.

3.3 Tenacity and Breaking Extension

Figs 3 and 4 show that yarn spun from a higher proportion of acrylic fibre is stronger and more extensible than the yarn spun under otherwise

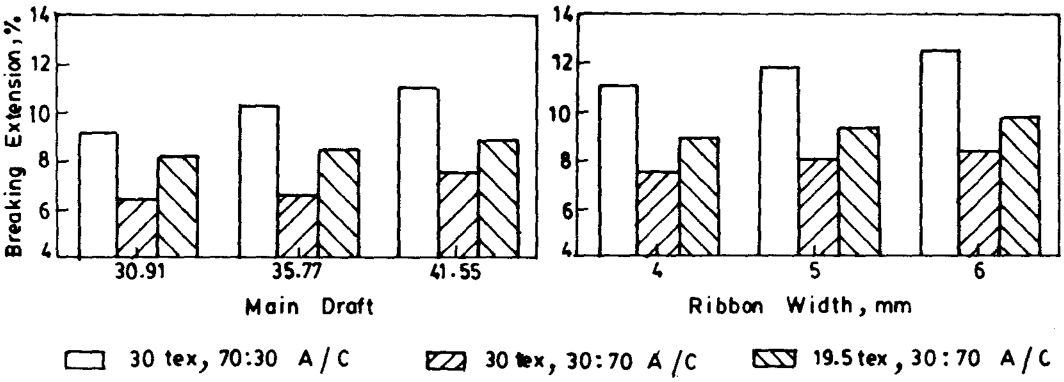

Fig. 4—Variation of breaking extension of parent acrylic-cotton jet-spun yarns

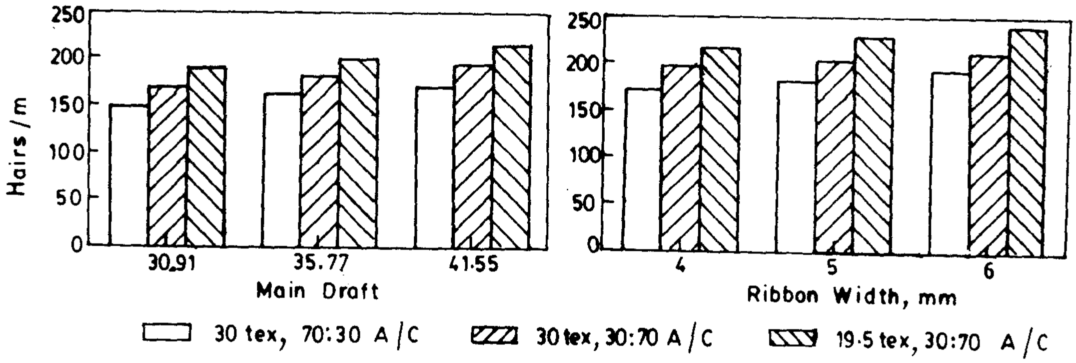

Fig. 5—Variation of hairs/m of parent acrylic-cotton jet-spun yarns

identical conditions but with a cotton-majority mix. This trend is the outcome of the higher tenacity, higher breaking extension and lower bending rigidity of acrylic fibre. Wider condenser results in higher values of tenacity and breaking extension. With wider condenser, the inter-fibre friction is reduced, which, in turn, results in longer wrappings. Increasing main draft improves these characteristics, which deteriorate when yarn linear density is increased.

3.4 Hairiness

The variation in hairiness with varying blend ratio, yarn linear density, ribbon width and main draft is shown in Fig. 5. Cotton-majority yarns are relatively more hairy than yarns having higher acrylic content. The higher flexural rigidity and short length of cotton fibre partly explain the high degree of hairiness as compared with acrylic. Increasing ribbon width causes a continuous increase in hairiness on account of the increased release of floating fibres. Both yarn linear density and main draft also have a marked influence on hairiness. Hairiness increases linearly when main draft increases and, at the same, when the yarn linear density decreases. The increase can be attributed to the forementioned factors.

3.5 Abrasion Resistance

Fig. 6 shows the influence of processing factors on abrasion resistance, with the lower values corresponding to yarns made from the higher proportion of cotton fibre and the higher values corresponding to yarns produced with acrylic-majority blends. The fact that widely differing cotton and acrylic fibres may produce different amount of wrapper fibres explain the observed trends. Higher main draft results in higher abrasion resistance. An obvious reason for the higher abrasion resistance is the increase in the number of wrapper fibres which shield the yarn core and thus increase the abrasion resistance. Increasing ribbon width further increases the abrasion resistance. However, the increase is less in yarns spun from higher proportion of cotton fibre.

3.6 Flexural Rigidity

The values of flexural rigidity of acrylic-cotton MJS yarns related to influencing variables are

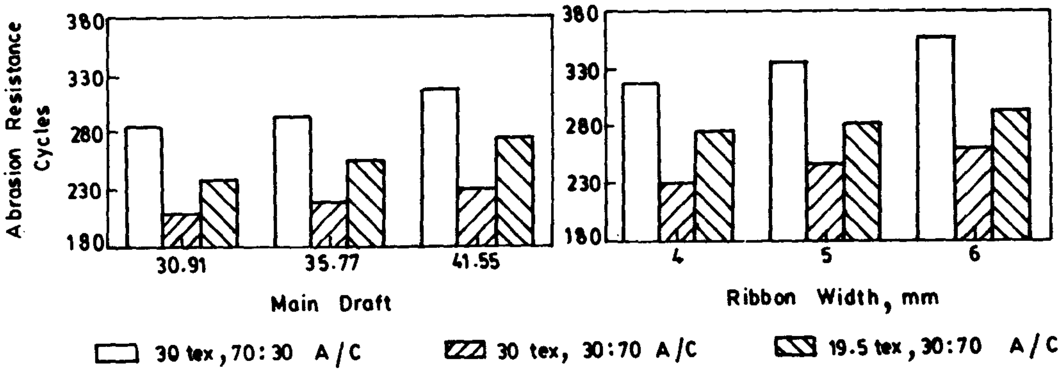

Fig. 6—Variation of abrasion resistance of parent acrylic-cotton jet-spun yarns

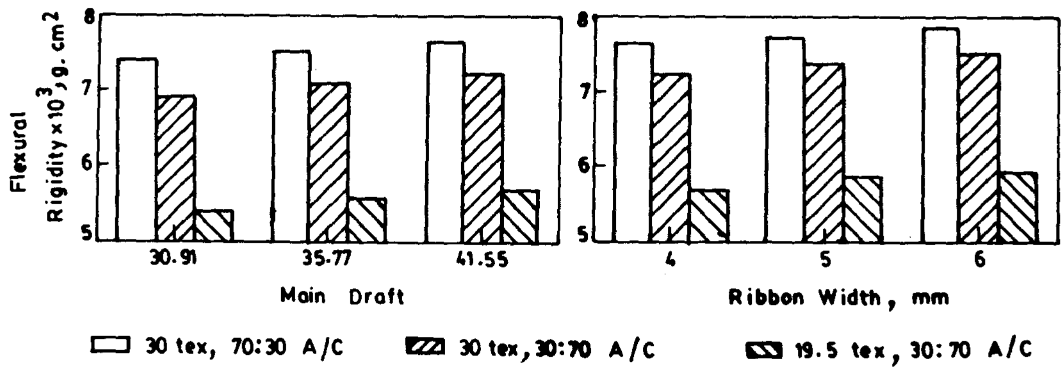

Fig. 7—Variation of flexural rigidity of parent acrylic-cotton jet-spun yarns

shown in Fig. 7. Expectedly, yarn rigidity significantly increases with increase in yarn linear density. Although acrylic fibre is less rigid than cotton fibre, the yarns spun from higher proportion of acrylic fibre exhibit higher flexural rigidity owing to higher incidence of wrapper fibres. With regard to the contribution of the bending rigidity of the constituent fibres to the incidence of wrapper fibres, Puttachaiyong and Oxenham[2] mentioned that wrapper fibres can be produced more easily from polyester fibres than cotton fibres of the same fineness owing to the lesser rigidity of the former. The use of narrower condenser reduces the flexural rigidity; the latter, however, increases with increase in main draft. The observed increase is probably due to the increase in the number of wrapper fibres, which impede the freedom of core fibres, resulting in higher flexural rigidity.

4 Conclusions

4.1 Reasonably higher acrylic content is needed to enhance yarn bulk. The use of higher main draft and wider condenser decreases yarn bulk. However, bulk increases considerably after steaming.

4.2 The relaxation shrinkage of acrylic-majority MJS yarns is higher than that of their cotton-majority counterparts. The shrinkage is highly dependent on the main draft and condenser size, and the yarns produced with relatively higher main draft and wider condenser show lower relaxation shrinkage.

4.3 MJS yarns with higher proportion of cotton content are substantially weaker, less extensible and yield lower abrasion resistance than the yarns spun with higher proportion of acrylic fibre. High main draft and wide condenser lead to a marked improvement in these characteristics.

4.4 70/30 acrylic/cotton yarns are more rigid than 30/70 acrylic/cotton yarns. A narrower condenser and lower main draft are needed to reduce rigidity.

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