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Studies on the Dref III Spinning System
Part III : The spinning of 55/45 Polyester/Wool Yarns

by

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STUDIES ON THE DREF III SPINNING SYSTEM PART III : THE SPINNING OF 55/45 POLYESTER/WOOL YARNS

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ABSTRACT

Polyester/wool yarns were spun successfully on a Dref III friction spinning machine and a ring spinning machine, the Dref III machine providing considerably higher production rates than the ring spinning machine and also involving fewer processing steps than the latter. Yarns were spun to different linear densities, twist levels and at different spinning speeds. The Dref III spinning performance was favourable at relatively low speeds, with higher spinning speeds generally resulting in a deterioration of yarn physical properties. The best yarn tenacity results were obtained with the type of opening roller(10°) recommended for man-made fibres. The best yarn regularity, but lowest tenacity, was obtained when wool and polyester were blended on the drawframe (i.e. the core and sheath of the yarn containing the polyester/wool blend). The properties of the ring spun yarns were generally superior to those of the Dref yarns.

INTRODUCTION

The friction spinning system has increased in importance[1–3], particularly since ITMA 1983. Prior to ITMA 1983 the Dref II and Dref III machines represented the only friction spinning machines available on the market, but since then other manufacturers have also entered the field and one of these has started marketing a friction spinning machine[4, 5].

The Dref III spinning system has the advantage that blends of different fibres can be produced in such a way that the different fibre components can be positioned either in the sheath or core of the yarn, as desired. There is a further advantage associated with the system and that is that, if necessary, the different fibre components can be converted into slivers suitable for the Dref III by using the type of processing system and preparatory machinery suited to each of the fibre components, 'blending' of the fibres then taking place on the spinning machine.

At SAWTRI, research on the Dref III spinning system has, until now, concentrated mainly on polyester/cotton yarns, the machine having been designed for fine fibres of short and medium staple length. It was decided to investigate the possibilities of spinning wool or wool blends on the Dref III spinning system, using short, fine wool in blends with polyester.

In this study drawframe blending and spinning machine blending were compared. Different types of opening rollers (20° tooth angle for cotton and 10° tooth angle for man-made fibres) were also studied and the friction spun yarns were compared to ring spun yarns of the same linear density and fibre content, the fibres being prepared on the short staple system.

EXPERIMENTAL

Preliminary Trials

Initial trials on different types of wool showed that relatively low spinning speeds were required and that short and fine wools performed best. A short staple polyester type was selected since the Dref drafting systems for both core and sheath would not draft a long staple polyester fibre properly. It was decided to prepare the fibres on the short staple system, only the drawing of the wool top to the required sliver fineness for the subsequent processes being carried out on a worsted gillbox. Fibre breakage of the longer wool fibres on the drawframe and Dref III spinning machine was unavoidable because of restrictions regarding the maximum nip distance on the drafting system of these machines. Nevertheless, the processing performance was found to be good at relatively low spinning speeds. At higher spinning speeds the yarn tended to lose its strength and slide apart due to insufficient twist in the yarn, even at the highest spinning drum speeds.

Raw materials and processing details

A short fine wool top of 19,7 μm and a mean fibre length of 35,7 mm (Hauteur) and a 38 mm, 1,5 dtex semi-dull staple polyester (®Trevira type 120) were used. The polyester was processed into lap through a blowroom and the lap was then processed on a Platt card. The following processing steps involved a short staple drawframe and roving frame as illustrated in Fig 1.

Both 60 and 80 tex yarns, each at two twist levels, were produced on the ring and the Dref III spinning machines. For the Dref yarns, the spinning drum speed was chosen so as to obtain a low and a high friction ratio[6]. The friction ratio (dy) is defined as the ratio of spinning drum surface speed to yarn delivery speed and this ratio, together with the amount of slip occurring between the fibres and drums, determines the angle of the fibres in the yarn (i.e. the twist). Friction ratios of 2,8 : 1 and 4,8 : 1, representing low and high twist respectively for the yarns spun at 100 m/min, were selected. For the higher spinning speeds the spinning drum speeds were selected so as to have an intermediate friction ratio. All yarns were spun to the popular commercial blend of 55% polyester and 45% wool[7]. For the Dref III yarns the spinning speed, the type of opening rollers and the blending system were varied. For yarns A and C (Table I) the core contained 100% polyester and the sheath 100% wool, the core to sheath ratio being 55 : 45. In the case of yarn B, polyester/wool drawframe blended slivers were used, the core to sheath ratio

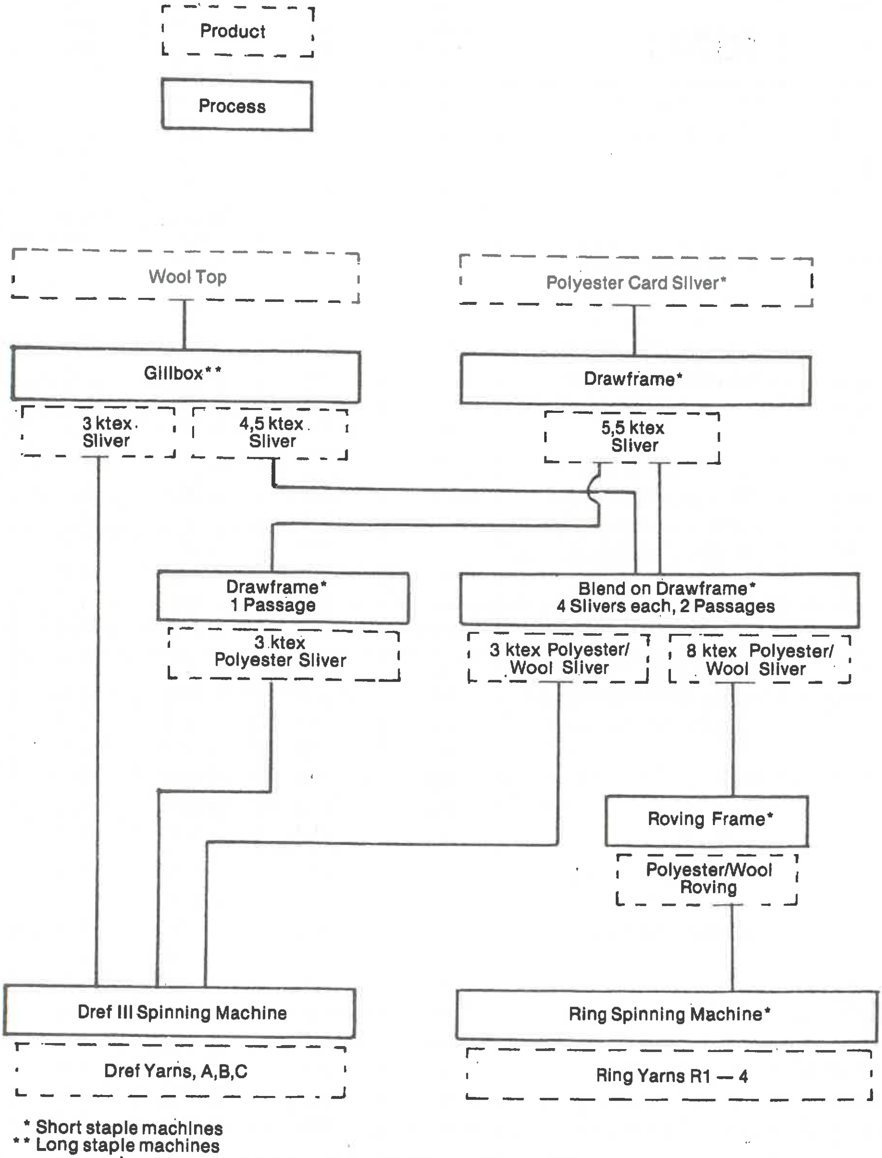

Fig 1 — Processing Sequences

YARN TENSILE PROPERTIES

The test results are given in Table II.

Tenacity

The tenacity of the ring yarns was generally higher than that of the Dref III yarns except that the tenacity of the high-twist 80 tex yarn spun at 100 m/min, was similar to that of the ring yarns. For the Dref III yarns, the tenacity was higher at the higher spinning drum speeds (i.e. twist level) and higher linear densities. This is in line with earlier findings on polyester/cotton[9]. For the Dref III, yarn tenacity decreased with an increase in yarn delivery speed (see Fig 3).

The tenacity of Yarn A (10° rollers) was higher than that of Yarn C (20° rollers) that of Yarn B being the lowest. The fact that Yarn B was the weakest can be attributed to the fact that its core, which largely determines the yarn tenacity, consisted of a blend of polyester and wool whereas the cores of yarns A and C consisted of 100% polyester.

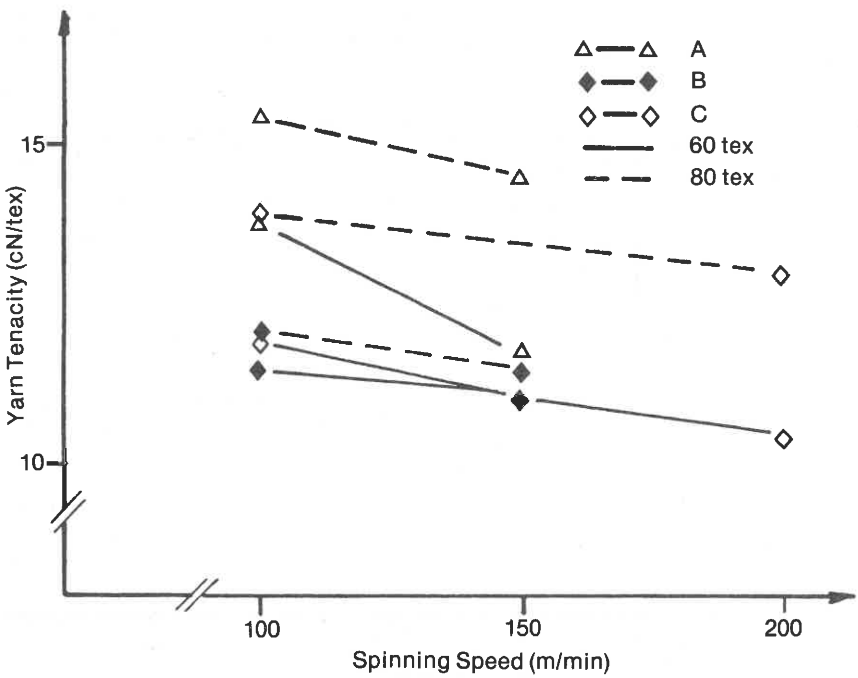

Fig 3 — Effect of Spinning Speed on Yarn Tenacity

Extension

The extension at break of both the Dref III and ring yarns increased with increasing yarn linear density and twist, with the extension of the ring yarns higher than that of the Dref III yarns. In an earlier study[10,11] on polyester/cotton it was found that the Dref III yarns had higher extension values than the ring and rotor yarns. In that study, however, very high spinning drum speeds (i.e. twist level) had been used. Yarn C (20° opening rollers) had higher extension values than yarns A and B (10° opening rollers), the values for yarn B (intimate blend of wool and polyester) being intermediate. For the Dref III yarns, extension decreased with an increase in spinning speed as illustrated in Fig 4.

YARN EVENNESS PROPERTIES

Irregularity

From Fig 5 it can be seen that the ring yarns were considerably more even than the Dref III yarns, the irregularity of the latter decreasing with increasing

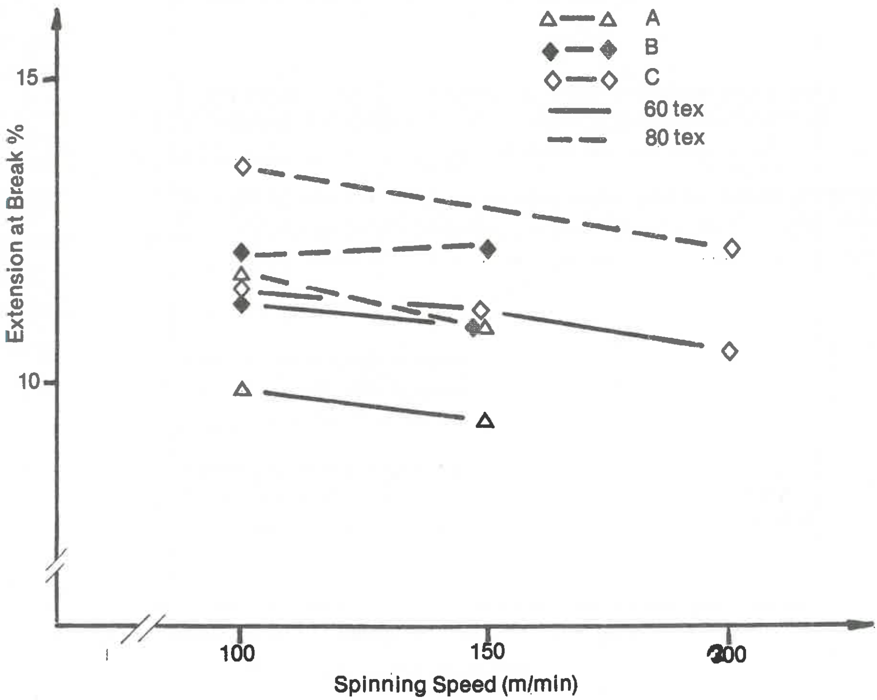

Fig 4 — Effect of Spinning Speed on Yarn Extension at Break

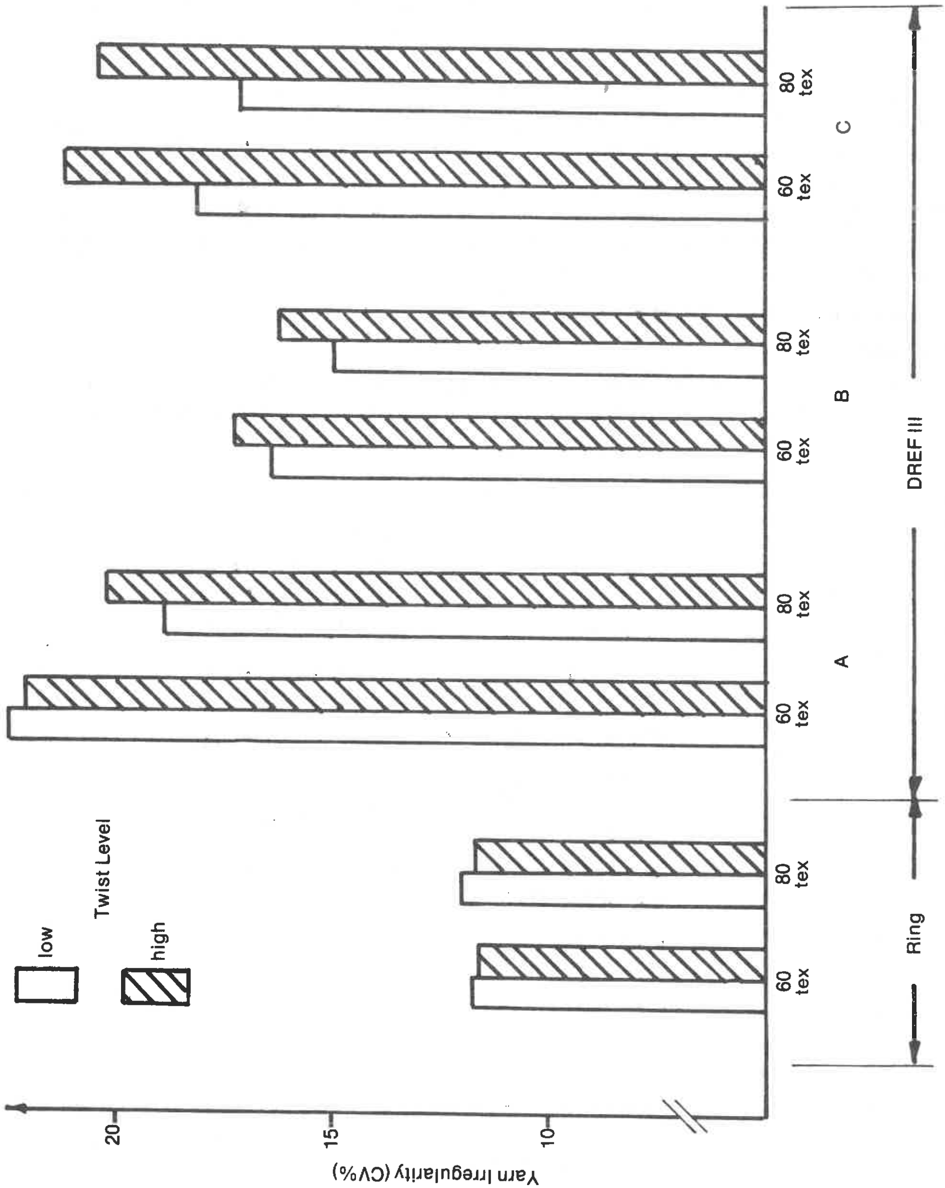

Fig 5 — Yarn Irregularity

yarn linear density. A similar trend was found in earlier studies on polyester/cotton yarns[10]. While twist level had little effect on the irregularity of the ring spun yarns, an increase in twist level generally increased the irregularity of the Dref III yarns. Those yarns containing the intimately blended fibres in both core and sheath (yarn B) were more even than the others, with yarn A (10° opening rollers) being the most irregular. Spinning speed had no consistent effect on irregularity.

Imperfections

In most cases yarn A (10° opening roller, polyester in core and wool in sheath) contained the most imperfections with Yarn B (10° opening rollers, intimately blended fibres) generally containing the fewest imperfections. This is in line with the irregularity results. The 80 tex yarns spun to the higher twist level, generally contained more imperfections than those spun to the lower twist level but this did not apply to the 60 tex yarns. Neither yarn linear density nor spinning speed had a consistent effect on the frequency of imperfections.

YARN HAIRINESS

When considering the hairiness results it must be remembered that the yarns had been rewound prior to testing and that rewinding generally increases hairiness slightly. The results show that the hairiness of the ring yarns was generally slightly lower than that of the Dref yarns, an increase in twist level resulting in a decrease in the hairiness of the Dref yarns. An increase in spinning speed generally increased the hairiness of the Dref yarns. The coarse yarns tended to be hairier than the finer yarns. Of the Dref yarns, yarn B (intimate blend in core and sheath) was the least hairy.

YARN STRUCTURAL PROPERTIES

Yarn structure was characterised in terms of diameter, twist angle and yarn flexural rigidity and the results are given in Table III.

Diameter and twist angle

A very high variation was found in the individual twist and diameter values obtained on each of the yarns probably due to the test method applied. The results of this part of the investigations therefore can only be regarded as indicative of broad trends and the tabulated results should be used with discretion, considering the large confidence limits. The Dref III yarns (B) consisting of an intimate blend of wool and polyester, had the largest diameters, followed by the ring yarns. The Dref yarns A and C had the lowest diameters. A higher twist level resulted in a lower diameter in all cases.

The twist angle, derived from the photographs, was the lowest for the ring spun yarns and, as expected, higher twist angles were generally associated with higher twist levels. The twist in the sheath of the Dref yarns was much higher than that in the sheath of the ring yarns. No other trends could be established due to the large variations in the test results.

TABLE III — STRUCTURAL YARN PROPERTIES

Yarn No.	Diameter (mm)	Confi-dence limit*	Twist-Angle (°)	Confi-dence limit*	Twist (turns/m)	Flexural Rigidity (10^{-9} Nm^2)	Confi-dence limit*
R1	0,38	0,05	30,8	7,4	499,3	6,7	1,5
R2	0,33	0,02	28,8	2,1	530,3	5,1	0,3
R3	0,45	0,03	23,2	2,6	303,2	5,0	0,7
R4	0,43	0,05	30,5	4,8	436,0	7,6	0,8
A1	0,38	0,06	31,1	3,6	509,3	23,0	6,6
A2	0,30	0,05	40,4	3,8	903,0	25,8	7,8
A3	0,44	0,04	33,3	5,9	475,2	36,6	8,4
A4	0,43	0,05	35,4	6,5	526,1	48,7	15,6
A5	0,32	0,05	32,4	3,5	631,3	20,4	6,4
A6	0,45	0,05	31,4	5,4	431,8	47,8	10,6
B1	0,42	0,07	31,8	1,3	469,9	21,2	3,4
B2	0,38	0,06	35,3	2,4	593,1	33,3	5,5
B3	0,48	0,03	34,9	2,5	462,6	45,7	9,3
B4	0,45	0,05	37,4	5,4	540,8	58,3	12,6
B5	0,44	0,05	33,4	4,9	477,0	18,4	2,9
B6	0,42	0,03	33,2	5,3	495,9	38,0	7,3
C1	0,32	0,03	34,3	5,8	678,6	24,2	3,7
C2	0,31	0,04	34,7	5,0	711,0	30,6	6,4
C3	0,41	0,07	38,4	6,5	615,3	32,6	7,5
C4	0,34	0,05	42,6	5,4	860,9	70,6	24,6
C5	0,34	0,06	33,9	5,1	629,1	18,0	5,0
C6	0,39	0,05	35,3	7,6	577,9	38,0	8,9
C7	0,32	0,03	33,2	4,5	650,9	24,5	6,7
C1.1	0,43	0,05	33,6	5,1	491,8	36,4	4,9
C1.2	0,41	0,07	38,4	6,5	615,3	32,6	7,5
C1.3	0,36	0,02	40,6	3,8	757,8	56,1	17,0
C1.4	0,37	0,05	37,6	6,2	662,5	50,6	10,7
C1.5	0,34	0,05	42,6	5,4	860,9	70,6	24,6
C1.6	0,35	0,06	41,3	5,8	799,0	87,3	10,3
C1.7	0,34	0,05	40,1	8,3	788,4	66,4	9,5
C1.8	0,37	0,04	44,3	5,1	839,5	86,9	16,4
C1.9	0,34	0,06	35,8	4,6	675,2	75,9	13,6
C1.10	0,35	0,07	40,4	6,8	774,0	70,8	20,4

*calculated at 95% significance level

In the case of yarn C (20° opening drums, 100% polyester in core, 100% wool in sheath), small quantities of 60 tex yarns were spun at a wide range of spinning drum speeds (constant yarn delivery speed) in order to establish the influence of spinning drum speed on yarn diameter, twist and flexural rigidity. The results for yarn diameter are plotted in Fig 6. In spite of the large variation in results, it can be seen that up to a spinning drum speed of about 3 000 rev/min, an increase in spinning drum speed resulted in a decrease in the yarn diameter, after which the values tended to level off. According to Fig 7, twist increased with increasing spinning drum speeds up to about 3 000 rev/min (representing a twist in the sheath of the yarn of about 800 turns/m), whereafter it levelled off. It therefore appears that an increase in spinning drum speed only increased the twist inserted into the yarn within certain limits. Above these limits ($\simeq$ 3 000 rev/min in this case) the frictional force between spinning drums and yarn were insufficient to overcome the yarn torsional resistance and increased slippage occurred.

Flexural rigidity

The flexural rigidity results are shown in Fig 8. It can be seen that the flexural rigidity of the ring yarns was far lower than that of the Dref III yarns. This was observed previously as well[9].

Twist and linear density had little effect on the flexural rigidity of the ring yarns. For the Dref III yarns, an increase in spinning drum speed caused a sharp increase in flexural rigidity, the 80 tex Dref yarns being stiffer than the 60 tex yarns. A higher delivery speed generally resulted in a lower flexural rigidity value although the friction ratio was kept constant. This was probably due to an increase of slippage occurring at higher spinning drum speeds which results in a lower twist level and therefore, lower flexural rigidity.

In Fig 9 the flexural rigidity values for one Dref yarn (C) have been plotted against a wide range of spinning drum speeds. It appears that, at relatively low spinning drum speeds, flexural rigidity increased with increasing spinning drum speed, after which it levelled off.

GENERAL DISCUSSION

It was found that for the Dref yarns an increase in measured yarn twist generally was associated with a decrease in yarn diameter, i.e. gave a more compact and rigid yarn (higher flexural rigidity). For the Dref yarns spun at widely different spinning drum speeds (C type), a regression analysis yielded the following equations:

$$\text{Diameter (mm)} = 89{,}74 \times \frac{1}{\text{Twist(turns/m)}} + 0{,}237$$

Regression coefficient R = 0,845

Significant at the 99% level.

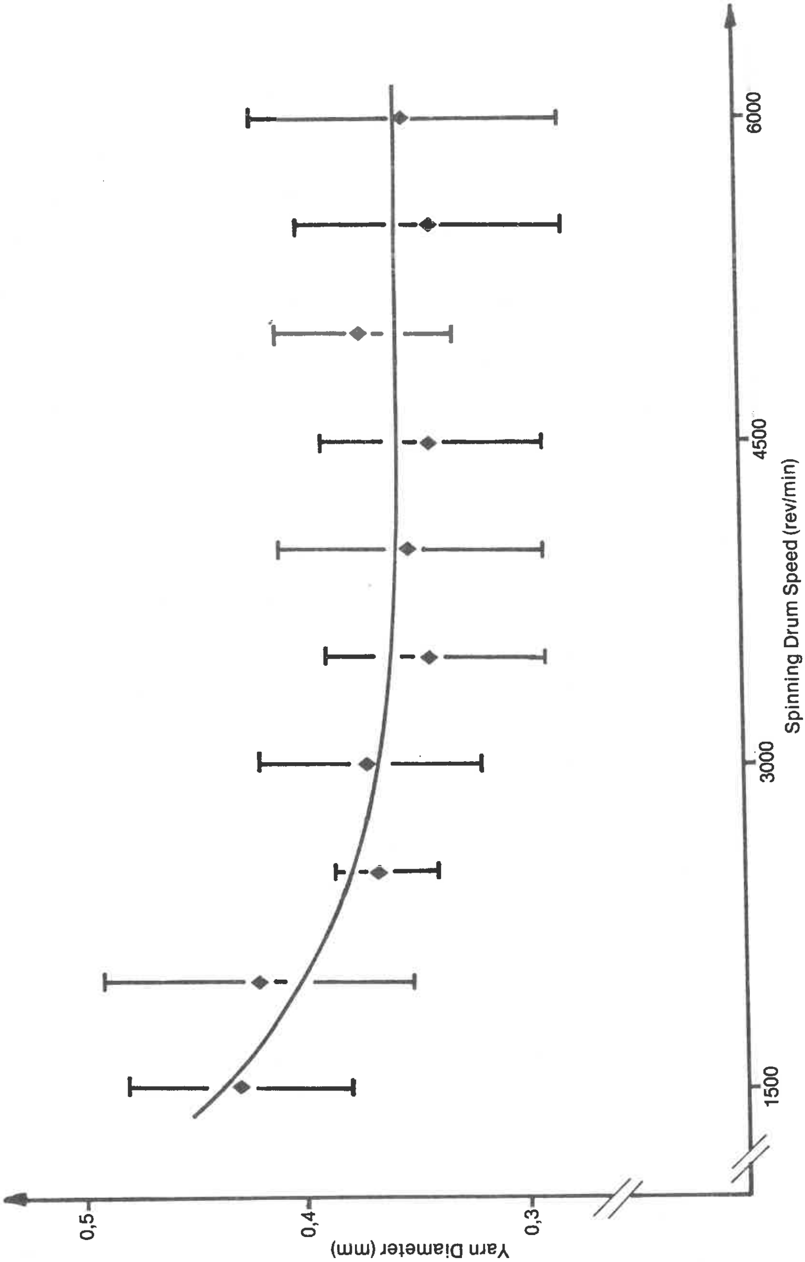

Fig 6 — Yarn Diameter vs Spinning Drum Speed

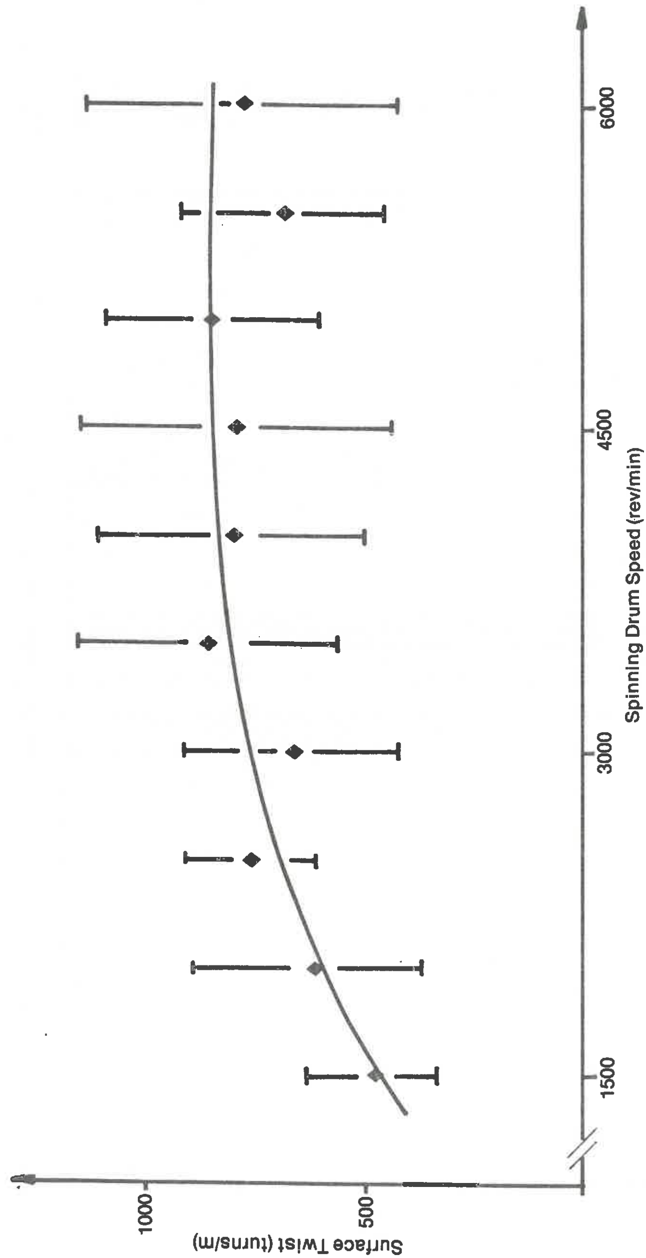

Fig 7 — Yarn Surface Twist vs Spinning Drum Speed

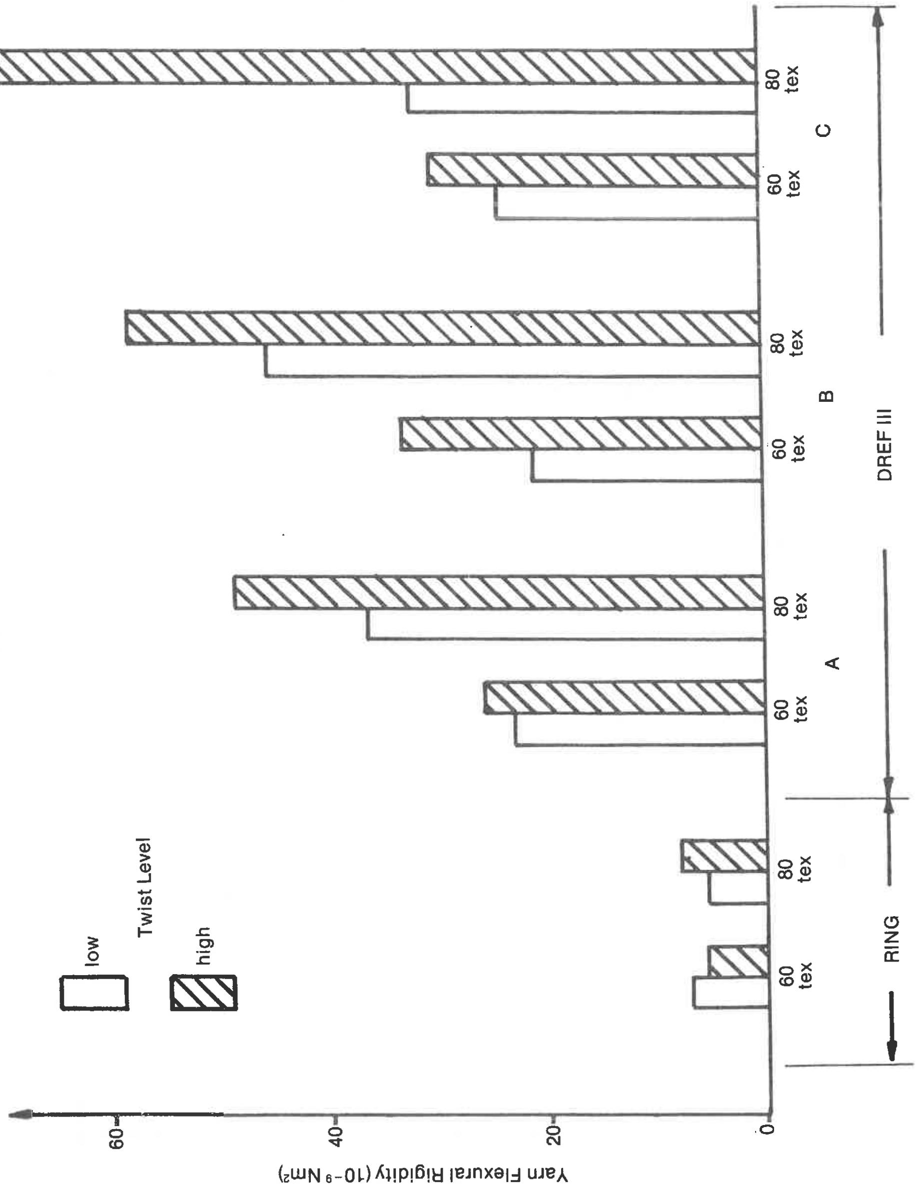

Fig 8 — Yarn Flexural Rigidity

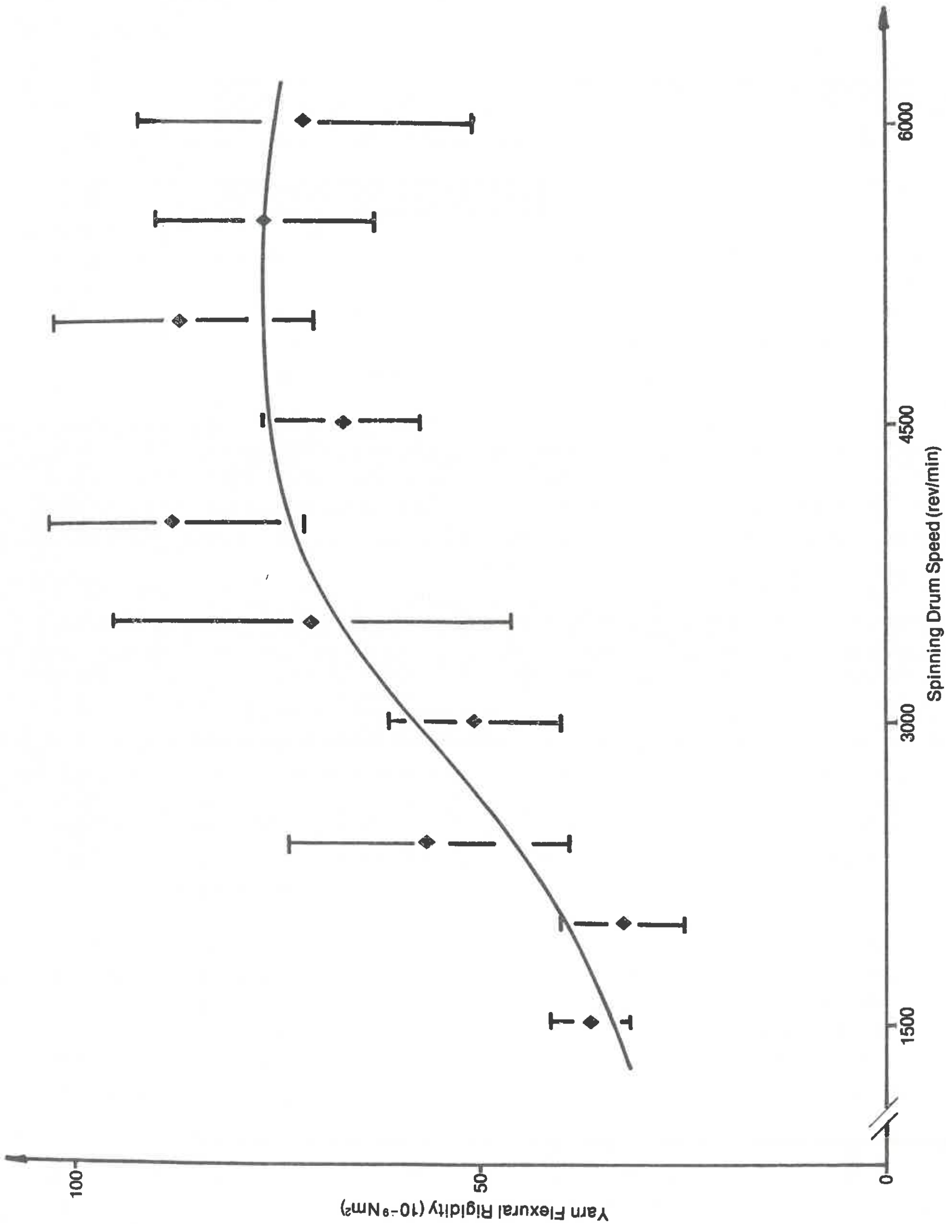

Fig 9 — Yarn Flexural Rigidity vs Spinning Drum Speed

Flexural rigidity (10^{-9} Nm^2) = 0,21 x Twist (turns/m) — 89,56.

Regression coefficient R = 0,794

Significant at the 99% level.

For the Dref yarns it appears that a higher yarn diameter was associated with a lower tenacity, an increase in twist was generally associated with a lower diameter and also with a higher tenacity. This may probably have been due to variations in the radial forces inside the yarn, a high radial force resulting in a lower diameter and a higher radial pressure on the yarn core. This would increase the fibre-to-fibre friction in the yarn core and consequently improve the yarn tenacity.

SUMMARY AND CONCLUSIONS

The Dref III spinning system was originally designed for the spinning of short and medium staple cotton and man-made fibres. This study was undertaken in order to investigate the possibilities of spinning polyester/wool blends on this system, preparation for spinning essentially taking place on the short staple system. Drawn top slivers of the required linear density were used as input material in the case of the wool.

Blends of 55/45 polyester/wool were spun into 60 and 80 tex yarns at two twist levels. Different types of opening rollers (Dref III) and different blending methods (either blending on the short staple drawframe or blending by introducing 100% wool sliver as sheath and 100% polyester slivers as core into the drafting systems of the spinning machine) were studied. The yarns were compared to ring spun yarns of the same linear density and fibre content.

The spinning performance of the Dref yarns was better at relatively low spinning speeds (≃ 100 m/min), than at higher speeds the latter generally resulting in a deterioration in yarn properties. Generally, the ring spun yarns were superior to the Dref yarns, being stronger and more even. For the Dref yarns, an increase in both twist and linear density, within the ranges studied, improved yarn physical properties considerably.

Of the Dref yarns, the yarns spun with the 10° opening rollers (recommended for use with man-made fibres) and having a core containing 100% polyester and a sheath containing 100% wool, had the highest tenacity. These yarns, however, were the most irregular. The yarns produced from intimate blended slivers in both core and sheath were the weakest but the most even. The higher tenacity of the yarn with the pure polyester core was attributed to the fact that it is the core which mainly determines the strength of the yarn, it containing the stronger polyester fibres.

Yarn structural properties were determined in terms of yarn flexural rigidity, twist angle and yarn diameter. The flexural rigidity of the Dref yarns increased with increasing twist level and yarn linear density. The flexural rigidity of the ring yarns did not change consistently with twist, and was considerably lower than that of the corresponding Dref yarns. It was also found that structural properties of the 60 tex polyester/wool yarn mainly changed when the spinning drum speed increased from 1 500 (lowest practicable spinning speed) to 3 500 rev/min, little further change taking place at higher spinning drum speeds. It was suggested that above a certain spinning drum speed slippage between the yarn and spinning drums increased considerably and frictional conditions became unstable.

It was concluded that polyester/wool yarns could be spun successfully on a Dref III spinning machine at considerably higher production rates than on a ring spinning machine and also involving fewer processing steps than the latter. Yarn properties of the Dref yarns were, however, not as good as ring yarn properties.

ACKNOWLEDGEMENTS

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THE USE OF PROPRIETARY NAMES

The names of proprietary products where they appear in this report are mentioned for information only. This does not imply that SAWTRI recommends them to the exclusion of other similar products.

REFERENCES

1. Brockmanns, K. J., *Int. Text. Bull., Yarn Formation,* **30** (2), 5 (1984).
2. Anon., *O.E. Rep.,* **7** (42), 14 (1983).
3. Anon., *O.E. Rep.,* **8** (44), 9 (1984).
4. Anon., *Text. Month,* **12,** 35 (1983).
5. Parker, A., Farnhill, W. M., and Clough, D. O., U.K. Patent GB 2094843B.
6. Lünenschloss, J. and Brockmanns, K. J., *Chemiefasern,* **38/85** (9), 570 (1983).
7. Lowe, J. *et al, Wira Rep.* No. 244, 11 (1974).
8. Peirce, F. T., *J. Text. Inst.,* **21,** T33 (1930).
9. Thierron, W., *SAWTRI Techn. Rep.* No. 546 (March, 1984).
10. Thierron, W. and Hunter, L. *SAWTRI Techn. Rep.* No. 530 (September 1983).
11. Thierron, W. and Hunter, L., *Melliand Textilber.,* **65** (4), 228 (1984).

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