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Studies on the Dref III Spinning System

Part IV: The Spinning of Cotton and Polyester/Cotton Stretch Yarns

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STUDIES ON THE DREF III SPINNING SYSTEM PART IV: THE SPINNING OF COTTON AND POLYESTER/ COTTON STRETCH YARNS

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ABSTRACT

Cotton and polyester/cotton yarns containing an elastomeric core were spun on the Dref III spinning system. Among other things, yarn linear density, twist level and production speed were varied and equivalent yarns were spun without an elastomeric core for purposes of comparison. Yarn tenacity was found to increase with increasing twist levels, the elastic yarns having a slightly lower tenacity than the corresponding control yarns. The irregularity of the cotton yarns was higher than that of the polyester/cotton yarns, but both were similar to their equivalent ring-spun counterparts in this respect.

INTRODUCTION

Stretch fabrics, both woven and knitted, have an important share of the market. Stretch is mainly achieved by using yarns with an elastomeric component, the latter usually consisting of rubber or man-made elastomeric fibres[1-3]. Several conventional methods are available for incorporating an elastic component into a yarn, these mostly involving several processing steps[4]. Core spun yarns, containing an elastomeric core, can be spun directly on a ring spinning machine equipped with special take off and guide elements to extend and guide the elastic core, the core being introduced through the front rollers of the drafting system. Other methods involve combining a non-elastic yarn with an elastic filament to produce an elastic yarn with the required stretch and other characteristics. For example, the components can be assembly-wound on a suitable winder, the elastic filament being positively fed and pre-stretched, and subsequently uptwisted on a ring twister. Alternatively, the positively fed and pre-stretched elastic filament can be fed directly into the ring twister together with the non-elastic yarn thereby eliminating the separate assembly-winding operations. For this process, two-for-one twisters are frequently used instead of ring-twisters.

The Dref III friction spinning system also provides a method for combining staple fibres and elastic filament in one process, the filament being placed in the yarn core[5-8]. It is claimed that this system allows a high degree of covering of the filament by the staple sheath and that yarns can be produced at higher production rates and with fewer processing steps than with the conventional processes.

On the Dref III spinning machine, two streams of fibres are fed independently into the spinning zone between the perforated spinning drums. The sheath fibres are fed through an opening drum system and fly vertically onto the spinning drums. The fibres forming the core of the yarn are fed through a conventional apron drafting system situated at one end of the spinning drums. The elastic filament is delivered by a positively driven feeding device in a prestretched state to the nip between the front rollers. The amount of stretch can be changed by changing the size of a pulley. The yarn is then wound onto a package in the fully stretched state and can thus contract, but not stretch elastically when initially wound off the bobbin. If the yarns are steam-set after spinning, most of the stretch can only be regained after the finishing of the fabric and in such cases the fabrics should be made looser than usual to allow the elastic yarn a certain amount of freedom to contract during finishing.

Research information on the production and properties of stretch (elastic) yarns produced on the Dref III appears to be very limited and it was therefore decided to undertake a study in this regard. For the purpose of this study, some 40 and 60 tex cotton and polyester/cotton stretch yarns were spun on the Dref III spinning system and their physical and stretch properties compared.

EXPERIMENTAL

Processing Details

As raw material a middling cotton and a 38 mm 1,7 dtex polyester staple fibre were used. A 156 dtex continuous elastomeric filament thread (®Lycra) was used as a core component. The cotton and polyester were processed from the bale through a conventional blowroom, card and drawframe line (2 passages) into a 2,5 ktex sliver. Yarns of 40 tex and 60 tex were spun using cotton for the sheath (except for yarn No. 7 where 3 cotton and 1 polyester slivers were used) and either cotton (for the 100% cotton yarns) or polyester (for the polyester/cotton yarns) in the core. The 40 tex yarns were spun using a 40 dtex polyester filament core (textured) for better spinning performance. The elastomeric filament was delivered at a specific stretch ratio (1:3,6 in most cases) through a positively driven elastomer unwinding device to the front rollers of the core drafting system and thus incorporated into the fibre assembly. For puposes of comparison, 60 tex cotton and polyester/cotton yarns were also spun without an elastomeric core. Further yarn processing details are given in Table I. Prior to testing, the yarns were steam set, small quantities of unsteamed yarn having been kept aside for the testing of the yarn elastic properties since the steam setting would temporarily remove the elasticity.

Yarn Tests

Single thread breaking strength and extension were measured on an

TABLE I
PROCESSING DETAILS

YARN No.		Yarn Linear Density (tex)	TWIST LEVEL			Core to Sheath Ratio	Spinning Speed (m/min)	Elastic Filament Stretch Ratio	Code
			Low	Medium	High				
1	COTTON YARNS	40		×		80/20	150	3,6	2.)
2		40		×		0/1	150	3,6	
3		60	×			70/30	200	3,6	
4		60		×		70/30	200	3,6	
5		60			×	70/30	200	3,6	
6		60		×		70/30	200	—	1.)
7	POLYESTER/COTTON YARNS	40		×		0/1	150	3,6	2.)3.)
8		60	×			70/30	200	3,6	
9		60		×		70/30	200	3,6	
10		60			×	70/30	200	3,6	
11		60		×		70/30	200	—	1.)
12		60		×		70/30	250	3,6	
13		60		×		70/30	300	3,6	
14		60		×		70/30	200	2,0	

1.) Control yarn, no elastic filament in core.
2.) 40 dtex Polyester filament in core.
3.) 3 × Polyester, 1 × Cotton sliver in sheath.

Uster automatic strength tester (constant rate of load). Yarn irregularity and frequencies of imperfections were measured on the Uster range of equipment, using standard settings and following standard procedures. Hairiness was measured on a Shirley Yarn Hairiness meter at the standard distance of 3 mm.

In order to gain some more information on the yarn elastic properties, stretch and relaxation cycles were simulated on an Instron Tensile Tester. Since elastic yarns on the Dref III stystem are produced at the maximum elongation (i.e. the yarn on the bobbin can initially only contract but not stretch elastically) and also because the elasticity of the Dref yarns is not as high as that of yarns produced by combining elastic filament and non-stretch yarns on a twister, conventional testing methods[9] had to be modified to suit the purposes of this study. The yarn was positioned between the clamps of the tester and a pre-tentioning force of 0,1 N was applied for 60 s (i.e. the fully stretched state). The clamps were then closed at a distance of 200 mm . Thereafter the yarn was relaxed by a downward movement of the upper clamp at a crosshead speed of 100 mm/min. When a distance of 140 mm was reached the head was stopped and five continuous stretch and relaxation cycles were carried out at the above-mentioned crosshead speed, the stretch and relaxation limits being 200 and 140 mm, respectively. The first and fifth cycles were recorded (chart drive speed 200 mm/min.). At the maximum extension of the fifth cycle the crosshead was stopped for 30 s in order to measure the stress decay (i.e. the loss of tension due to relaxation) in the yarn in the stretched state. The test was completed at the end of the fifth cycle. Five tests were carried out for each yarn. In addition, one test was carried out on the elastic filament thread alone, not using the pretension force, but inserting the filament into the clamps at the proper stretch ratio (1:3,6) at a clamp distance of 200 mm .

The yarn tension at the maximum elongation of the first and fifth cycle as well as the stress decay after the fifth cycle were recorded for each test and the values obtained on the five specimens were averaged.

All tests were carried out at 20°C and 65% RH.

RESULTS AND DISCUSSION

YARN PHYSICAL PROPERTIES

Yarn physical properties are given in Table II.

Tenacity

The tenacity of the 60 tex yarns generally increased with increasing twist level as shown in Fig. 1, the effect being more pronounced for the polyester/cotton yarns than for the cotton yarns. The control yarns (No 6 and 11) had higher tenacities than the corresponding elastic yarns (Nos. 3,4,5,8,9,10), due to

TABLE II

YARN PHYSICAL PROPERTIES

Yarn No.	LINEAR DENSITY			BREAKING		Tena-city (cN/tex)	Exten-sion (%)	CV (%)	Irregu-larity (CV %)	Thin Places per 1000 m	Thick Places per 1000 m	Neps per 1000 m	HAIRINESS	
	Nomi-nal (tex)	Mean (tex)	CV (%)	Mean (cN)	CV (%)								Mean (Hairs/m)	CV (%)
1	40	39,5	1,6	274	13	6,9	4,8	14,1	19,3	301	450	554	22	4
2	40	39,6	0,6	376	8	9,5	8,8	13,5	14,7	11	13	854	32	4
3	60	59,0	0,8	480	13	8,1	5,7	12,2	15,0	12	44	183	57	2
4	60	59,7	2,0	548	11	9,2	6,2	10,6	15,5	20	55	186	52	5
5	60	60,3	2,0	559	9	10,2	6,2	9,7	16,2	11	76	216	44	3
6	60	60,4	1,6	614	10	10,2	5,5	12,0	15,8	9	44	206	46	1
7	40	39,1	0,7	467	11	11,9	13,4	11,8	15,1	11	23	820	48	3
8	60	61,4	1,1	408	62	6,7	19,5	114,5	13,4	21	9	237	57	2
9	60	60,7	0,7	731	35	12,0	8,0	34,2	13,0	0	5	232	54	4
10	60	61,5	1.1	866	15	14,1	9,3	14,1	12,8	1	6	160	52	3
11	60	61,1	0,8	1123	8	18,4	10,4	5,9	12,8	2	6	198	44	17
12	60	60,2	0,7	881	12	14,6	9,4	10,3	13,0	0	4	230	52	4
13	60	59,4	0,8	852	14	14,3	9,4	10,6	13,7	1	16	324	63	5
14	60	59,3	1,0	919	8	15,5	10,5	6,1	11,6	6	2	108	41	2

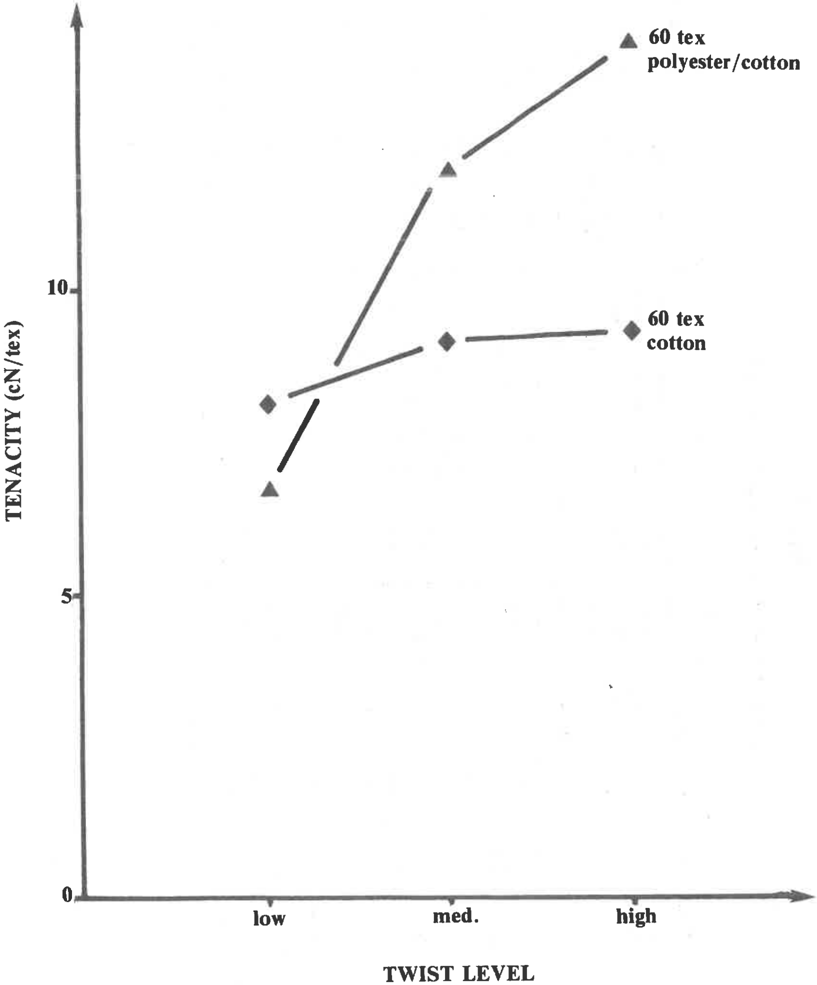

Fig. 1 – Yarn Tenacity

the fact that the elastic filament contributes to the yarn linear density but not to the breaking strength to any appreciable extent. With the 40 tex yarns the polyester/cotton yarn (No. 7) also had a higher tenacity than the cotton yarn (No. 2), both containing the polyester filament in the core in addition to the elastomer.

A slight increase in tenacity with increasing yarn production speed was found for the 60 tex polyester/cotton yarns, the friction ratio being kept constant (yarns Nos. 9, 12, 13). The variation (CV) of the tenacity values was very high in the case of a lower twist yarn (No. 8). It is likely that the yarn tended to slide apart during the tensile testing with the result that, in some cases, the strength of the elastic filament was being tested. This is also reflected in the CV values for the breaking strength (CV = 62%) and extension (CV = 115%).

Extension

The extension results showed no significant trends with changes in yarn twist and production speed. A significant difference was found between the polyester/cotton and the cotton yarns, the polyester/cotton yarns having some 80% higher extension values than the cotton yarns. The high values for the extension and its CV of yarn No. 8 (60 tex polyester/cotton, low twist) were attributed to a too low twist which in certain cases resulted in a sliding apart of the staple component, the elastic filament subsequently determining the extension and breaking strength for these yarns.

No significant difference was found between the stretch yarns and the control yarns because the yarns were tested in a stretched state, the stretch having been fixed by the steaming process.

Irregularity and Imperfections

No significant effect of the different yarn parameters on yarn irregularity and imperfections was found. The polyester/cotton yarns were generally more regular than the cotton yarns.

Compared to the Uster statistics[10] for ring spun yarns the irregularity and imperfection values of the yarns produced corresponded to the 50% experience values.

Hairiness

As illustrated in Fig. 2, yarn hairiness decreased with increasing twist level for the 60 tex cotton and polyester/cotton yarns, the hairiness being slightly higher for the polyester/cotton yarns. The hairiness of the control yarns was slightly higher than that of the elastic yarns. No other trends could be established.

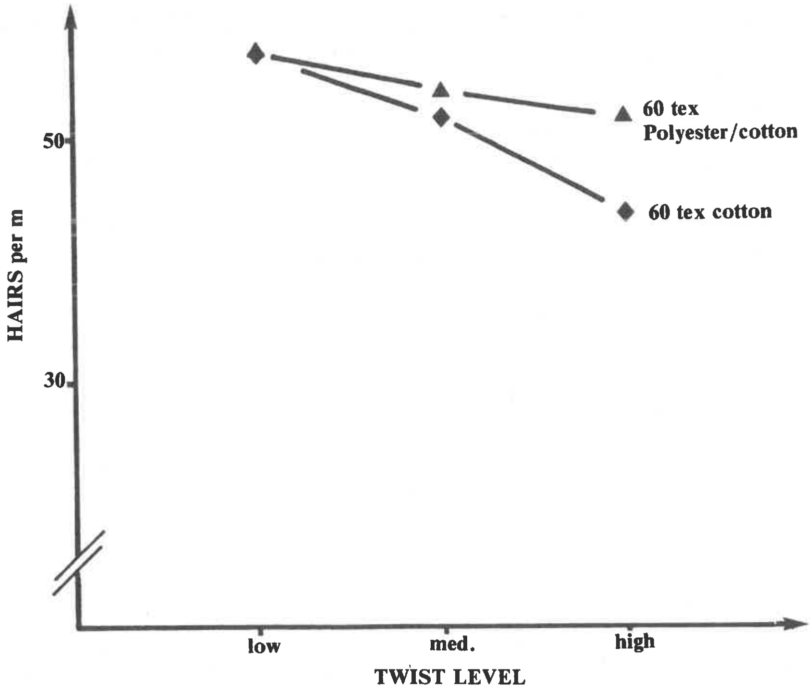

Fig. 2 – Yarn Hairiness

ELASTIC PROPERTIES

Fig. 3 shows an example of the force/extension curves during the first and fifth extension/relaxation cycle. The elastic properties were recorded in terms of stress decay and maximum force during the first and fifth stretch/relaxation cycle for all elastic yarns and for the elastic filament and the results are given in Table III. The stress decay of the elastic filament by itself was 28 mN. For the elastic yarns the stress decay was equal to or lower than this value, a lower value indicating that the binding forces of the fibres on the filament restricted relaxation. The average stress decay for the cotton yarns was slightly higher than that for the polyester/cotton yarns spun under the same conditions. This indicates that the polyester had a higher cohesion to the elastic filament thereby restricting relaxation. When the elastomeric filament was tested by itself the maximum force at the first cycle was slightly higher than that at the fifth

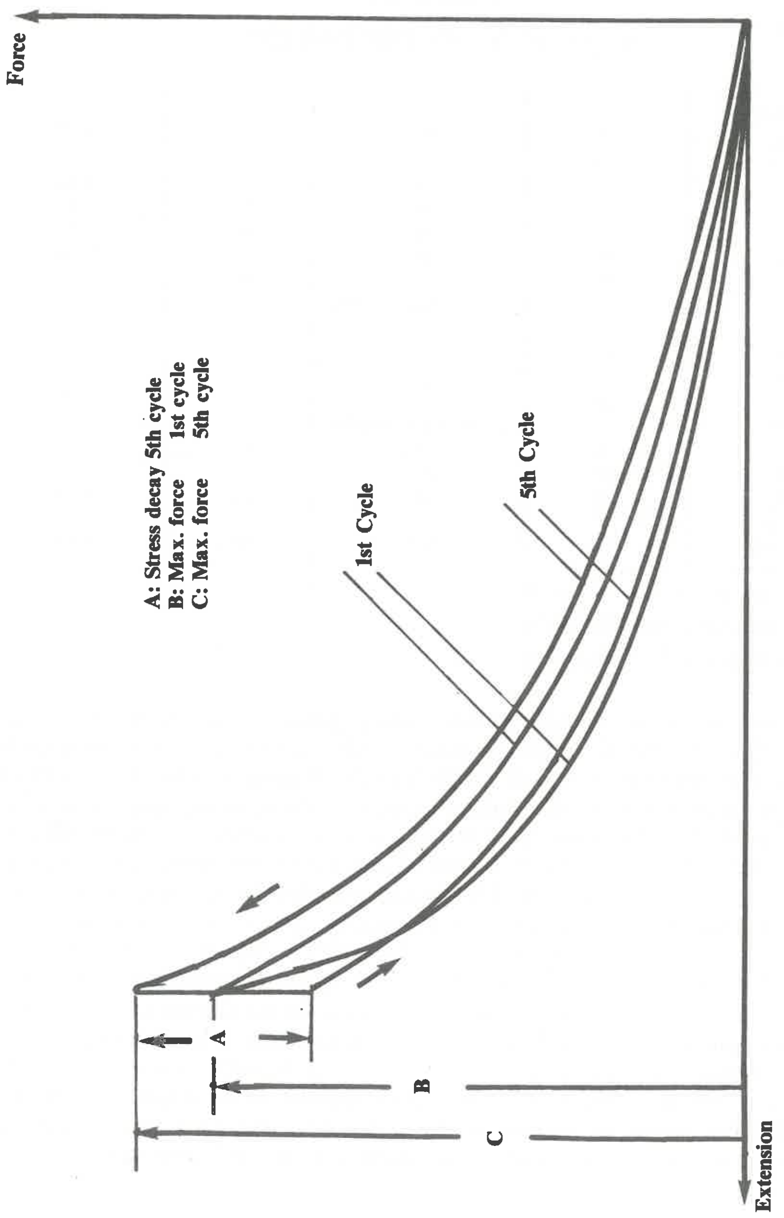

Fig. 3 – Example for force-extension curves of stretch yarns

TABLE III
ELASTIC YARN PROPERTIES

YARN NO.	A	B	C	C/B
1	23	133	138	1,04
2	25	135	138	1,02
3	23	129	136	1,05
4	28	139	152	1,09
5	28	128	146	1,14
6		CONTROL YARN		
7	17	120	124	1,03
8	17	124	127	1,02
9	22	128	134	1,05
10	20	117	127	1,09
11		CONTROL YARN		
12	28	136	150	1,10
13	26	127	141	1,11
14	22	126	132	1,10
Lycra Filament	28	212	198	0,93

A: Stress decay at 5th cycle (mN)
B: Maximum force at 1st cycle (mN)
C: Maximum force at 5th cycle (mN)

cycle, indicating that relaxation was taking place during each cycle. This, however, did not apply to the elastic yarns. In all cases, the maximum force at the first cycle was lower than that at the fifth cycle. It appears, that the sheath and core staple fibres inhibited the elastic recovery of the filament and that after the five extension and relaxation cycles the fibres were loosened around the filament thereby improving the recovery forces of the latter and hence the maximum force during the cycle concerned. This is supported by the fact that the maximum force during the stretch/relaxation cycles was far lower for the yarns than what they were for the elastic filament itself. It would be expected, however, after a certain number of stretch relaxation cycles when a maximum freedom of movement for the elastic filament is reached, that the maximum force during the individual cycles would decrease due to a relaxation of the elastomer.

The quotient of the maximum force during the fifth cycle and during the first cycle (C/B) provides a measure of the amount of loosening taking place during the five cycles. In the case of the elastic filament by itself this ratio was < 1 because of the relaxation of the filament. For all the other yarns this ratio was > 1 which indicates that the tension in the elastic filament was retained by the wrapper fibres during the first cycle and also — to a lesser extent — during the fifth cycle.

SUMMARY AND CONCLUSIONS

A study was carried out on the spinning of cotton and polyester/cotton stretch yarns on the Dref III system. Processing parameters were varied in terms of spinning drum speed (i.e. twist level), yarn linear density and yarn production speed and yarns were spun without an elastic core for purposes of comparison. The yarn physical and elastomeric properties were determined and compared. Yarn tenacity was found to increase with increasing twist levels, with the tenacity of the polyester/cotton yarns generally higher than that of the cotton yarns. The tenacity of the control yarns (no elastic core) was higher than that of the elastic arns. The extension of the control yarns was similar to that of the elastomeric yarns, this being explained by the fact that the yarns were steam set in their extended state and also tested in this extended state. The polyester/cotton yarns had considerably higher extension values than the cotton yarns. Yarn irregularity and the number of imperfections were approximately average according to Uster statistics for conventional cotton and polyester/cotton ring spun yarns. Yarn production speed did not have a very large effect on yarn physical properties.

Elastic properties were determined on the unsteamed yarns and it was found after a certain number of extension/relaxation cycles that the contraction forces in the yarn improved due to a loosening of the yarn structure. At similar extensions, the contraction forces were found to be considerably higher for the elastomeric filament on its own than for the elastic yarn which indicates that the cohesion between the fibres and the elastomeric filament prevented a proper relaxation (contraction) of the latter.

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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.

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