SAWTRI TECHNICAL REPORT

NO 390

A Comparison of Open-End and Ring Spinning of Cotton

Part III: The Effects of Mercerisation on Single Yarn Friction, Knitting Performance and Fabric Properties

by

L. Hunter and S. Smuts

SOUTH AFRICAN
WOOL AND TEXTILE RESEARCH
INSTITUTE OF THE CSIR

P.O. BOX 1124
PORT ELIZABETH
REPUBLIC OF SOUTH AFRICA

ISBN 0 7988 1236 2

A COMPARISON OF OPEN-END AND RING SPINNING OF COTTON

PART III: THE EFFECTS OF MERCERISATION ON SINGLE YARN FRICTION, KNITTING PERFORMANCE AND FABRIC PROPERTIES

by L. HUNTER and S. SMUTS

ABSTRACT

A range of 25 tex ring- and rotor-spun single yarns, unmercerised and mercerised in either caustic soda or liquid ammonia, was knitted into an interlock structure and the knitting performance of the yarns as well as the properties of the resulting fabric were compared. In general, the ring yarns performed better than the rotor yarns, with the unmercerised yarns better than the mercerised yarns.

INTRODUCTION

In two previous reports[1, 2] the properties of 25 tex yarns, spun on rotor and ring frames, from various cultivars, were compared both before and after mercerisation in either caustic soda or liquid ammonia. This report is concerned with the yarn frictional properties, which were not covered in the earlier studies, the knitting performance of the yarns and the physical properties of the resulting fabrics.

It is not proposed to review the vast literature on rotor (open-end) yarns since this present study is aimed at establishing and comparing the effects of mercerisation on ring and rotor yarn properties, a subject which, as yet, appears to have received little, if any, attention. Where relevant, reference will be made in the text to the findings of other workers.

EXPERIMENTAL

Details of the cultivars and yarns have been given in two earlier reports[1, 2]. It was decided to introduce two further cotton lots (from two bales of Rhodesian Albar 72B) which, together with the Delmac used in the earlier studies (as a control), were processed into 25 tex yarns. The fibre and yarn details of these additional cottons are given in Tables I and II. These latter yarns were not mercerised and were processed in the identical manner to the previous yarns. The rotor yarns were spun on a Rieter MO/5 machine (45 000 r/min rotor speed; 6 000 r/min opening roller speed). The fibre and yarns tests were carried out as before[1, 2].

Most of the yarns covered in the earlier studies together with the additional yarns were waxed with paraffin wax at various levels (within the range 0,1 to

TABLE I

FIBRE PROPERTIES OF ADDITIONAL COTTON LOTS

Code	Cotton	2,5% Span Length (mm)	Uniformity Ratio (%)	Bundle Test 3,2 mm (1/8″) Gauge		Maturity Ratio	Micronaire	Fibre Linear Density (mtex)
				Tenacity (cN/tex)	Extension (%)			
H	Delmac	32,0	47	32,5	4,8	0,99	3,9	156
I	Albar (72 B)	27,2	48	23,3	7,0	0,88	4,0	167
J	Albar (72 B)	28,2	48	22,5	8,0	0,96	4,4	178

TABLE II

YARN PROPERTIES OF THE ADDITIONAL COTTON LOTS

Cotton	Linear Density (tex)		Twist (Turns/m)		Hairiness (Hairs/m)		Breaking Strength				Tenacity (cN/tex)		Extension (%)		Irregularity CV (%)		Thin Places per 1 000 m		Thick Places per 1 000 m		Neps per 1 000 m	
							Mean (cN)		CV (%)													
	Ring	Rotor	Ring	Rotor	Ring	Rotor	Ring	Rotor	Ring	Rotor	Ring	Rotor	Ring	Rotor	Ring	Rotor	Ring	Rotor	Ring	Rotor	Ring	Rotor
Delmac	24,7	24,4	756	913	16,5	6,2	467	328	6,3	7,3	18,9	13,3	6,6	8,9	14,3	14,0	0	1	36	3	161	430
Albar (72 B)	24,5	24,0	763	947	19,7	7,6	390	271	8,8	9,0	15,9	11,3	6,3	8,1	15,1	16,7	1	15	70	2	204	501
Albar (72 B)	24,6	24,6	758	946	22,5	4,9	349	260	7,4	8,5	14,2	10,6	6,0	9,6	15,8	15,6	1	30	117	6	310	750

3 μg/cm) and their frictional properties (yarn-to-metal) measured on a SAWTRI yarn friction tester. The results of some of these tests are given in Table III.

Waxed and unwaxed yarns were knitted on an 18 gauge Mellor Bromley 8RD double jersey machine equipped with IRO trip-tape positive feed units. An interlock structure was knitted. This experiment was divided into two separate parts; in the one the yarn knitting performance was assessed by knitting the yarns at relatively high tightness factors (MTF's 17,5 and 18, respectively) while in the other the yarns were knitted at a standard tightness (MTF = 15,2; SCSL = 1,31 cm) so as to compare the physical properties of the fabrics knitted from the various yarns.

The results of the knitting trials are given in Table IV.

The fabrics knitted to a standard tightness were finished in the following way:

Scouring

5 g/ℓ soda ash
0,5 g/ℓ ®Nonidet P40
100°C for 90 minutes
One rinse at 35°C and one rinse at room temperature.

Bleaching

2,8 mℓ/ℓ H_2O_2 (50%)
2,0 g/ℓ ®Prestogen PC
0,6 g/ℓ sodium hydroxide 98,99%.

Fabrics were entered at 40°C after which the temperature was increased to 95°C and held for 90 minutes followed by a rinse at 35°C and another rinse at room temperature.

The fabrics were treated with 0,5 g/ℓ sodium dithionite at 60°C for 20 minutes followed by two cold rinses. The fabrics were finally decatised (Steam: 6 minutes; Exhaust: 6 minutes).

After finishing, the fabrics were allowed to condition at 20°C and 65% RH and then tested for various physical properties. The test methods were generally the same as those published in an earlier report[3] except that the wash tests were performed according to the AATCC wash test (135-IIIB, 5 cycles) and the sewability was measured on an L & M Sewability tester at a threshold level of 500 gf[4]. Table V gives the averages of the different cultivars, the individual results having been omitted because of the large number involved.

RESULTS AND DISCUSSION

YARN FRICTIONAL PROPERTIES

The range of yarn-to-metal friction results, prior to and after waxing, are given in Table III for all the different yarns. It was found that, in general, the yarns

TABLE III

YARN FRICTIONAL PROPERTIES (FRICTION IN cN)*

CULTIVAR	UNTREATED							CAUSTIC SODA MERCERISED					AMMONIA MERCERISED			
	RING YARN		ROTOR YARN FROM					RING YARN		ROTOR YARN FROM			RING YARN		ROTOR YARN FROM	
			OE Machine No. 1		OE Machine No. 2		OE Machine No. 3			OE Machine No. 1	OE Machine No. 2				OE Machine No. 2	
	U	W	U**	W	U**	W	U**	U	W	W	U	W	U	W	U	W
Deltapine BSG	32-40	12-16 (0,8-1,3)	32-38		36-38	12-14 (0,6-0,8)	36-38	37	10-14 (0,7-0,9)	–	36-38	12-14 (0,7-1,6)	32-38	14-20 (0,1-1,5)	33-36	14-18 (1,1-1,7)
68/4/21	32-40	12-14 (0,8-1,0)	34-38		–	–	–	36-41	10-14 (0,7-0,8)	10-14 (0,9-1,5)	–	–	–	–	–	–
Deltapine 5826	34-38	12-16 (0,6-1,1)	34-38		34-40	10-18 (0,6-0,9)	–	31-40	12-16 (0,6-1,1)	–	35-37	12-14 (1,3-1,4)	–	12-14 (0,9-1,1)	34-39	10-16 (0,6-1,6)
Deltapine RSA	26-32	10-14 (0,6-0,9)	28-36		34-36	10-12 (0,6-1,0)	34-38	35-40	10-14 (0,6-0,9)	10-12 (0,6-1,5)	35-36	10-12 (0,9-1,2)	25-35	12-14 (0,6-0,7)	32-34	10-16 (0,4-0,8)
Albar	30-36	12-14 (0,4-0,7)	30-36		32-40	10-14 (0,5-1,2)	–	35-39	12-14 (0,6-1,0)	–	35-36	10-12 (0,7-0,9)	33-35	12-16 (0,7-1,5)	33-37	10-14 (0,5-0,9)
Acala	32-36	12-14 (0,7-0,8)	–		32-38	12-14 (0,6-0,8)	–	32-39	10-16 (0,9-1,2)	–	37-40	12-14 (0,8-1,2)	33-40	12-16 (0,6-1,1)	32-36	14-20 (1,1-2,1)
Delmac	34-38	12-14 (0,4-0,6)	32-36		28-38	10-14 (0,5-0,9)	34-38	39-41	12-14 (0,9-1,3)	10-14 (0,9-1,3)	33-37	10-16 (1,6-2,0)	34-37	12-16 (0,8-1,2)	31-36	12-16 (0,6-1,2)
Delmac (2nd lot)	32-36	10-14	32-36	10-16	–	–	–	–	–	–	–	–	–	–	–	–
Albar (72B)	30-34	10-16	34-38	10-12	–	–	–	–	–	–	–	–	–	–	–	–
Albar (72B)	30-36	10-14	34-40	10-16	–	–	–	–	–	–	–	–	–	–	–	–
Overall Range	26-38	10-16	28-40	10-16	28-40	10-18	34-38	31-41	10-16	10-14	33-40	10-16	25-40	12-20	31-39	10-20
Approx. Average	34	13	35	12	35	13	36	37	13	12	36	12	34	14	34	14

* : Amount of wax applied ($\mu g/cm$) given in parenthesis
U : Unwaxed
W : Waxed
** : Measured on rotor parallel sided packages, the frictional force drops by about 5 cN when the yarn is wound from OE onto 9° 15′ cones used for all other yarns.

responded in a similar manner to waxing and a typical friction vs amount of wax applied curve is illustrated in Fig 1.

From Table III it can be seen that, provided the yarns have been waxed to the optimum frictional levels (approximately 1 μg/cm), there was little difference between the rotor and ring yarns or between the unmercerised and mercerised yarns. After waxing, therefore, the yarn-to-metal frictional properties of the different yarns can be regarded as the same for all practical purposes. Prior to waxing, the frictional force (tension) developed by the rotor yarns was slightly higher than that developed by the ring yarns *when the rotor* yarns *were tested off the parallel-sided rotor packages.* Rewinding these yarns into 9° 15′ cones, the same as that used for the ring yarns, reduced the frictional force (yarn tension) by about 5 cN on average which suggested that the actual yarn-to-metal friction of the *unwaxed rotor* yarns was possibly slightly *lower* than that of the unwaxed *ring* yarns. This is regarded to be of little practical consequence, however, since in any case it would be necessary for the yarns to be *waxed* if satisfactory knitting performance is to be obtained. The need for rewaxing does of course depend upon the severity of the knitting

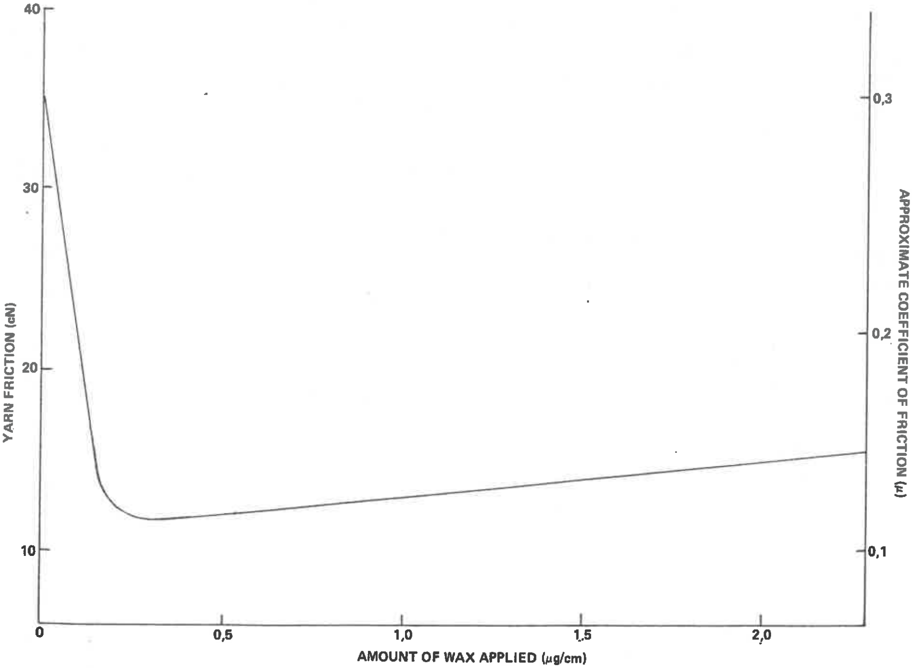

FIGURE 1

Typical Curve of Yarn Friction vs Amount of Wax applied for the various Cotton Yarns

conditions since there will be occasions where satisfactory knitting performance is possible without waxing.

From Table III it is apparent that, in the case of the *unwaxed* yarns, caustic soda mercerisation appeared to increase the yarn-to-metal friction slightly while ammonia mercerisation did not have a consistent effect on the yarn friction.

KNITTING PERFORMANCE

The knitting performance results are given in Table IV. These trials were carried out at very high tightness factors (i.e. under very severe knitting conditions) and are considered to give a measure of the *relative* abilities of the different yarns to withstand knitting stresses and strains. Such trials do not give a measure of the yarn breakages during knitting (i.e. holes) caused by knots and slubs. It is important to bear this in mind, since under commercial knitting conditions (and assuming reasonable tightnesses, the use of positive feed, optimum machine settings and machines which are in good order) many of the yarn breakages which occur during knitting (i.e. holes) are due to relatively infrequent events, such as knots and slubs. The ranking of the yarns under such conditions could, therefore, be quite different to that obtained under the knitting conditions employed here.

From Table IV it can be seen that waxing significantly reduced the number of yarn breakages during knitting whereas mercerisation *increased* the number of yarn breakages significantly, particularly the ammonia mercerisation process, probably due to its effect on the *yarn extension* at break. The *rotor* yarns generally performed much worse than the *ring* yarns.

It can, therefore, be concluded that, as far as their ability to withstand knitting stresses and strains is concerned, ring yarns should perform better than rotor yarns and unmercerised yarns better than mercerised yarn. It must be emphasized, however, that rotor yarns generally contain far fewer knots and slubs than ring yarns and this could result in their knitting performance being superior to that of ring yarns when knitting is carried out at *commercial* tightnesses and under conditions of minimum tension. In fact, this has been reported in the literature[5-7] although in one publication[8] it is claimed that rotor yarns could not be so successfully used in knitting as in weaving because of yarn cleanness, bending stiffness and modulus, surface structure, coefficient of friction, etc. Tension control, waxing and a reduction of twist and stiffness apparently greatly improved the knitting performance[8]. Nevertheless, from the results of the present study it would appear as though the ability of the yarns to withstand knitting stresses and strains is reduced by mercerisation, with the ring yarns being superior to the rotor yarns in this respect.

Waxing of yarns greatly improved their knitting performance which is in line with previous findings. The Delmac cotton yarns generally performed best.

A multiple regression analysis was carried out on the log results with number of yarn breakages (holes) during knitting as Y and with yarn linear density (tex) as X_1, yarn breaking strength (cN) as X_2, yarn extension at break (%) as X_3 and yarn-to-metal friction (cN) as X_4.

TABLE IV

NUMBER OF YARN BREAKAGES PER 1 000 REVOLUTIONS (MTF = 17,5*; INTERLOCK STRUCTURE; 4 FEEDERS EMPLOYED)

Code	CULTIVAR	UNTREATED							CAUSTIC SODA					LIQUID AMMONIA			
		RING YARN		ROTOR YARN FROM					RING YARN		ROTOR YARN FROM			RING YARN		ROTOR YARN FROM	
				OE MACHINE 1		OE MACHINE 2		OE Machine 3			OE Machine 1	OE MACHINE 2				OE MACHINE 1	
		U	W	U	W	U	W	U	U	W	W	U	W	U	W	U	W
A	Deltapine 58/26/BSG	783 (8705)	3 (880)	3 127 (13207)	–	12 293	268	13 000	3 575	88 (2433)	–	13 000	2525	8992	113	13 000	3515
B	68/4/21	1569	1	2 142 (10995)	–	–	–	–	4 047	100 (3348)	373	–	–	–	–	–	–
C	Deltapine 5826	1109	0 (845)	1 345 (6570)	–	10 798	138 (5175)	–	7 298	88	–	13 000	2062	6054	325	13 000	2563
D	Deltapine RSA	145	0	911	–	7 236	95 (2903)	5 174	1 180	20 (1820)	523	13 000	2540	2888	63 (4753)	13 000	1060
E	Albar	627	0	2 924 (14 081)	–	10 388	325	–	6 196	33 (1713)	–	13 000	1680	6514	68	13 000	3275
F	Acala	121	38 (318)	–	–	4 435	10 (1938)	–	3 766	10 (2025)	–	13 000	588	4804	18 (6648)	13 000	448
G	Delmac	28	0	315 (2 025)	–	1 651	3 (863)	1 988	2 851	– (3440)	198 (4688)	12 740	570	1051	18 (5427)	11 114	338
H	Delmac (2nd trial)	68 (1915)	10	1 144 (3225)	3 (432)	–	–	–	–	–	–	–	–	–	–	–	–
J	Albar (72B)	330 (3223)	20	2 918 (11 027)	132 (1633)	–	–	–	–	–	–	–	–	–	–	–	–
I	Albar (72B)	224 (4455)	0	1 771	153	–	–	–	–	–	–	–	–	–	–	–	–

U = Unwaxed
W = Waxed
*Results in parenthesis were obtained at an MTF of 18

The results of the analysis are given below:

MTF = 17,5:

$Y = 7{,}83 \times 10^{15} X_2^{-6{,}3} X_3^{-3{,}5} X_4^{4{,}06}$ . . . . (1)

$t = \quad 8{,}4 \quad 6{,}6 \quad 12{,}1$

$n = 99; \; r = 0{,}849$

MTF = 18:

$Y = 1{,}19 \times 10^{10} X_2^{-2{,}54} X_3^{-2{,}24} X_4^{1{,}38}$ . . . . (2)

$t = \quad 3{,}6 \quad 3{,}8 \quad 4{,}7$

$n = 30; \; r = 0{,}764$

In both cases the small variations in yarn linear density (X_1) had no significant effect on the number of yarn breakages, whereas an increase in yarn breaking strength (X_2) and yarn extension at break (X_3) and a decrease in yarn-to-metal friction (X_4) caused a decrease in the number of yarn breakages. This is in agreement with previous findings. In both the above equations, the yarn-to-metal friction accounted for about 60% of the observed correlation, with yarn breaking strength the next most significant variable. It is, therefore, clear that efficient lubrication (waxing) is probably the most effective means of improving knitting performance. It is also clear that the deterioration in knitting performance, resulting from yarn mercerisation, can probably be explained by the *decrease* in the *yarn extension* at break caused by the mercerisation processes. The resulting increase in yarn breaking strength appeared to be insufficient to compensate for the decrease in yarn extension at break.

The results obtained at the two different tightness factors correlated reasonably well ($r = 0{,}768$; $n = 29$).

FABRIC PROPERTIES

Comparison of rotor and ring yarns

The bursting strength of the fabrics knitted from the rotor yarns was about 20% lower than that of the fabrics knitted from the ring yarns. The fabrics knitted from rotor yarns were stiffer, had higher drape coefficients, poorer resistance to bagging, greater air permeability, lower mass per unit area values and lower k_3 but higher k_2 values than the fabrics knitted from ring yarns (see Table V). It must be emphasized, however, that the yarns from the OE machine No. 2, on which these comparisons are based, only had approximately 11% more twist than the ring yarns. It is to be expected that as the difference in twist is increased so the difference in fabric properties will change, notably the fabric stiffness, more in favour of the ring yarns.

Comparison of Rotor Machines

Where comparisons were possible it appeared that the rotor yarns from OE machine No. 1 (results omitted for the sake of simplicity) gave fabrics with a

TABLE V

AVERAGE VALUES* ILLUSTRATING THE EFFECTS OF MERCERISATION AND WASHING ON CERTAIN FABRIC PROPERTIES (MTF = 15,2)

		MASS PER UNIT AREA (g/m²)	THICKNESS (mm at a pressure of 0,5 kPa)	DRAPE COEFFICIENT (%)	AIR PERMEABILITY (ml/s/cm²)	BAGGING (IR %)	BURSTING STRENGTH (kN/m²)	ABRASION RESISTANCE (% mass loss after 10⁴ cycles)	PILLING	MONSANTO CREASE RECOVERY ANGLE (in degrees)	WASHING SHRINKAGE (%)			WALES/cm	COURSES/cm	DIMENSIONAL CONSTANTS			BENDING LENGTH (cm)			FLEXURAL RIGIDITY (mN. mm)			SEWABILITY (% at 500g threshold)
											LENGTH	WIDTH	AREA			k_3	k_2	k_1	Wale Direction	Course Direction	Mean	Wale Direction	Course Direction	Mean	
BEFORE WASHING																									
UNTREATED																									
Rotor Yarns	Mean	347	1,24	49,7	16,2	40,7	1153	1,49	2,6	195	8,9	-1,9	6,9	12,8	17,3	8,4	22,7	190	2,13	1,29	1,71	33,3	7,3	20,3	89
	CV	2,8	4,5	9,8	12,8	5,1	11,4	6,8	30,5	3,9	7,4	38,0	14,7	1,4	1,5	1,4	1,5		6,9	3,7	5,1	22,1	12,7	19,6	9,0
Ring Yarns	Mean	361	1,21	42,4	14,3	47,4	1456	1,36	1,7	228	10,9	-4,2	6,7	13,4	16,5	8,8	21,7	191	1,87	1,22	1,54	24,0	6,5	15,3	54
	CV	4,4	3,1	13,2	15,6	3,0	13,5	13,9	6,4	3,4	8,9	51,0	23,5	2,2	1,2	2,2	1,2		10,8	8,4	8,7	36,0	30,8	33,4	56,1
CAUSTIC SODA MERCERISED																									
Rotor Yarns	Mean	332	1,16	42,5	34,3	48,1	1112	1,70	1,5	207	11,4	-2,0	9,2	13,1	16,2	8,6	21,3	183	1,86	1,14	1,50	21,2	4,8	13,1	37
	CV	3,4	2,4	13,3	11,3	3,8	12,9	12,2	14,1	2,0	18,3	51,4	30,0	2,1	2,0	2,3	2,0		9,7	5,5	7,6	24,6	16,3	22,3	75,3
Ring Yarns	Mean	347	1,20	35,3	28,5	49,9	1450	1,60	1,5	223	11,3	-3,7	7,5	13,6	15,8	8,9	20,7	184	1,64	1,08	1,36	15,4	4,2	9,8	42
	CV	4,6	3,8	10,6	19,8	10,6	8,8	16,4	7,2	3,5	12,4	47,4	26,2	3,9	1,7	3,8	1,9		10,3	4,1	7,7	37,5	17,9	33,2	58,7
AMMONIA MERCERISED																									
Rotor Yarns	Mean	344	1,22	50,0	19,5	40,9	1183	2,0	2,0	222	8,2	-1,4	6,9	13,0	17,4	8,5	22,8	194	2,07	1,31	1,69	31,0	7,7	19,3	38
	CV	2,3	3,0	12,2	5,3	15,8	13,2	15,7	42,5	2,4	24,3	193	21,5	2,7	2,6	2,7	2,5		11,9	8,3	10,4	37,4	25,1	34,7	73,7
Ring Yarns	Mean	351	1,14	48,8	17,4	43,4	1507	1,52	2,1	213	9,8	-2,5	7,3	13,6	16,5	8,9	21,6	192	1,99	1,25	1,62	28,2	6,8	17,6	32
	CV	5,9	3,8	16,9	14,9	7,6	10,8	13,5	29,6	6,2	25,2	29,1	31,6	1,3	3,2	1,3	3,5		11,2	8,2	9,5	34,8	30,8	33,0	24,5
AFTER WASHING																									
UNTREATED																									
Rotor Yarns	Mean	362	1,29	58,2	13,5	37,7	1144		4,1	199				12,4	18,6	8,1	24,4	198	2,34	1,42	1,88	46,1	10,2	28,2	88
	CV	2,0	3,8	10,2	12,1	8,8	11,0		15,2	3,1				2,7	1,3	2,6	1,3		7,4	5,8	6,9	23,2	18,3	22,2	10,0
Ring Yarns	Mean	388	1,30	55,9	10,8	43,8	1483		4,4	199				12,7	18,3	8,3	24,0	200	2,35	1,37	1,86	50,6	9,8	30,2	89
	CV	3,9	2,5	13,8	16,6	5,8	11,7		29,2	8,2				2,2	1,8	2,1	1,7		9,1	6,7	8,2	27,2	23,5	26,2	6,6
CAUSTIC SODA MERCERISED																									
Rotor Yarns	Mean	361	1,27	46,9	26,6	42,7	1110		2,8	205				12,7	18,0	8,3	23,6	196	1,95	1,24	1,60	27,0	6,8	14,3	76
	CV	3,1	3,9	11,3	13,2	8,1	10,1		27,5	2,9				1,3	1,5	1,3	1,5		11,8	4,2	8,7	33,2	13,5	53,8	29,8
Ring Yarns	Mean	368	1,29	46,8	22,9	43,6	1406		3,1	211				12,7	17,5	8,3	23,0	192	1,98	1,21	1,60	28,7	6,5	17,6	90
	CV	6,0	4,9	10,9	22,9	5,9	9,5		38,1	4,4				1,6	1,3	1,6	1,3		9,8	5,7	8,0	30,2	21,7	28,5	6,0
AMMONIA MERCERISED																									
Rotor Yarns	Mean	367	1,28	57,1	16,0	35,5	1170		2,9	213				12,7	18,5	8,3	24,2	202	2,34	1,44	1,89	46,6	10,8	28,7	90
	CV	2,5	2,4	5,0	8,3	16,9	10,9		35,4	3,5				1,9	2,9	1,9	2,9		6,2	5,0	5,4	18,2	14,5	16,7	2,8
Ring Yarns	Mean	375	1,25	53,3	14,3	43,1	1511		3,6	204				13,3	18,4	8,7	24,1	209	2,24	1,33	1,78	42,6	8,7	25,7	84
	CV	5,1	3,0	11,4	16,1	3,7	8,5		6,3	3,8				2,3	2,0	2,3	2,0		10,1	6,7	8,8	32,5	24,3	31,0	12,5

*Each result represents the average of about 7 different cottons bursting strength on average 4% higher than that of the fabrics knitted from rotor yarns spun on OE machine No. 2 (the results of this machine are given in Table V). This difference can probably be ascribed to the higher (17,5%) twist inserted by the former machine[1]. Prior to washing, the difference in bursting strength was only really evident for the fabrics knitted from the caustic soda mercerised yarns but after washing all the fabrics showed this trend. For the untreated yarns, prior to washing, there was not a consistent difference between the two rotor yarn lots in spite of the fact that the yarns themselves originally differed significantly in strength.

The difference in twist between the two groups of rotor yarns was not reflected in the fabric drape or stiffness values in the way expected since the average drape of the fabrics knitted from the higher twist yarns was 4,8% (absolute) lower than that of the fabrics knitted from the lower twist yarns (results omitted).

The yarns spun on OE machine No. 1 produced fabrics with a resistance to bagging which was 2,3% (absolute) higher than that of yarns spun on OE machine No. 2 (i.e. which had the lower twist). Furthermore, little difference of any consequence was observed between fabrics knitted from these two groups of yarns, as far as resistance to abrasion, air permeability and k_3 were concerned.

On average, the higher twist rotor yarns, resulted in a better pill rating (0,6 units) compared to the lower twist yarns and also in slightly higher k_2 (and therefore k_1) values. Prior to washing, the fabrics knitted from the higher twist rotor yarns had a considerably better sewing performance (sewability) than that of the fabrics knitted from the lower twist rotor yarns. Caustic soda mercerisation of the yarns or washing of the fabrics removed this difference, however.

Effect of Yarn Mercerisation

Mercerisation of the yarns generally increased the pilling propensity of the fabrics, caustic soda more so than ammonia. Fabrics from the ring yarns had superior abrasion resistance, with the yarn mercerisation generally reducing the abrasion resistance of the fabrics slightly. Fabrics knitted from mercerised yarns showed slightly greater area shrinkage during washing than those knitted from unmercerised yarn.

Mercerisation of the yarns improved the sewability of the fabrics although this effect disappeared after washing.

Caustic soda mercerisation of the yarn reduced the fabric mass per unit area, the fabric thickness, fabric stiffness, bursting strength, resistance to abrasion, resistance to pilling and k_2 and k_1 but increased the resistance to bagging, the Monsanto crease recovery angle, k_3 and air permeability. Generally the effects were small, however.

Ammonia mercerisation of the yarns decreased the fabric mass per unit area and resistance to pilling but increased the air permeability, bursting strength (by less than 5%), k_2 and k_1. Once again the effects were small, however.

Prior to washing, the fabrics knitted from ammonia mercerised yarns had greater mass per unit area values, drape coefficients, stiffness values, bursting strength, resistance to pilling and k_1 values and lower air permeability, resistance to bagging values and washing shrinkage than the fabrics knitted from caustic soda mercerised yarns. Similar trends also existed after the fabrics had been washed.

GENERAL

Some of the fabric properties were also compared before bleaching (i.e. after scouring) and after bleaching (results not shown). In general, bleaching reduced the fabric mass per unit area, thickness, drape coefficient, stiffness and k_2 but increased the air permeability, bursting strength, abrasion resistance, resistance to pilling and k_3. On average, the Delmac cotton produced fabrics which had the lowest drape coefficient and the highest bursting strength. The Monsanto crease recovery angles varied between about 190 and 230 degrees with little difference between the rotor and ring yarns.

Washing generally caused the fabrics to increase in width (by about 2,5% on average) and to shrink in length (by about 10% on average). The average area shrinkage was about 7,5%. The effect of the wash test (washing) was to increase

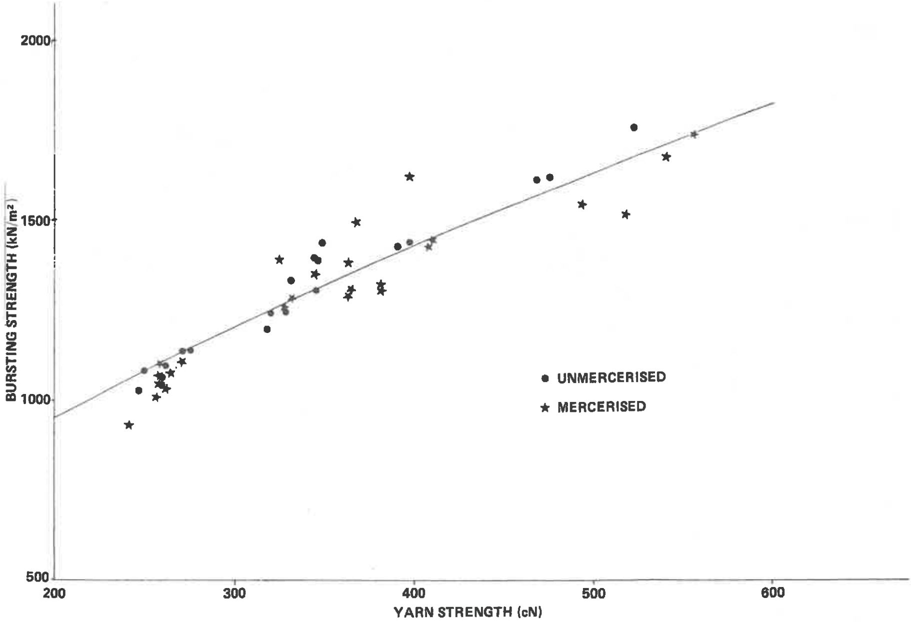

FIGURE 2

Fabric Bursting Strength prior to Washing vs Yarn Strength

fabric mass per unit area, thickness, stiffness, drape coefficient, resistance to pilling, k_2 and k_1 while it reduced the air permeability, resistance to bagging, crease recovery angle and k_3.

After washing, the dimensional constants of the fabrics were approximately as follows:

k_1 : 200
k_2 : 24
k_3 : 8,3

The k_2 and k_1 values for the fabrics knitted from the caustic soda mercerised yarns, however, were generally lower than the above. Prior to washing (i.e. after finishing), the approximate values were as follows:

k_1 : 189
k_2 : 21,8
k_3 : 8,7

Once again the k_2 and k_1 values for the caustic soda mercerised yarns were lower than those for the others.

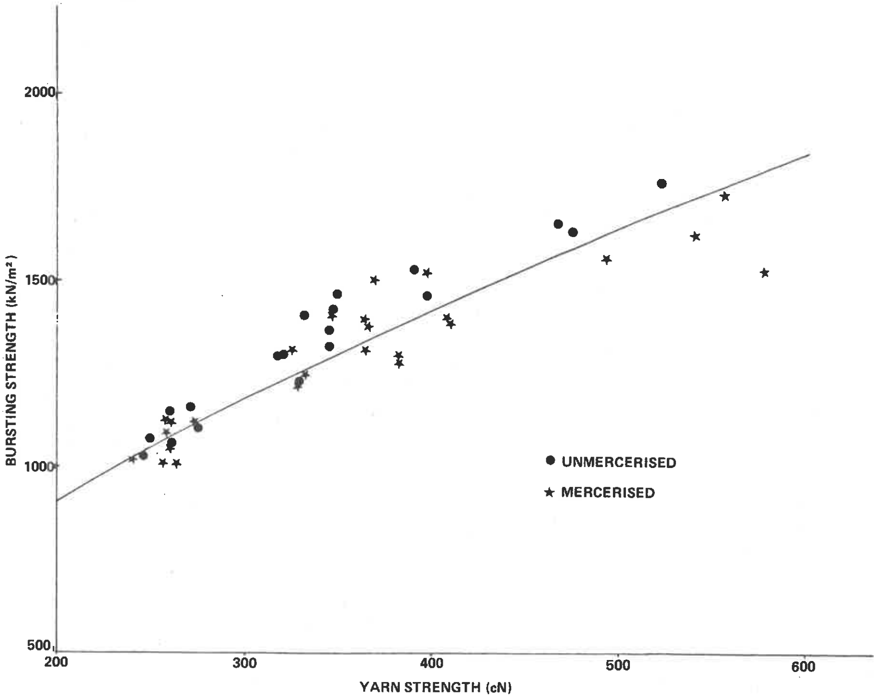

FIGURE 3

Fabric Bursting Strength after Washing vs Yarn Strength

The above values can be used in practice as a guide to the dimensional properties of interlock fabrics after finishing and after washing, respectively.

In general, the bursting strength of the fabrics reflected the strength of the yarns, with the Delmac cotton the strongest, as was the case for the yarns.

Multiple regression analysis, carried out on the log results, of bursting strength (Y) vs yarn linear density (X_1), yarn breaking strength (X_2) and fabric mass per unit area (X_3) yielded the following regression equations.

Fabrics prior to washing

$$Y = 1{,}44\, X_2^{0{,}64}\, X_3^{0{,}52} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$n = 46;\ r = 0{,}960$

Fabrics after washing

$$Y = 0{,}95\, X_2^{0{,}59}\, X_3^{0{,}64} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

$n = 47;\ r = 0{,}964$

From the above results it is clear that, in both cases, the fabric bursting strength was highly correlated with the yarn breaking strength (X_2 in cN) and fabric mass per unit area (X_3 in g/m^2). In both cases, yarn breaking strength explained about 95% of the observed correlation while fabric mass per unit area only explained about 5%. Clearly, yarn breaking strength greatly affects bursting strength, with the possible proviso that the changes in yarn strength are brought about by chemical treatments or by fibre properties and not by changes in yarn *twist*. In the above analysis the results of the rotor and ring yarns (mercerised and unmercerised) were all grouped together.

The effect of yarn strength on fabric bursting strength is illustrated in Figs 2 and 3 for the fabrics before and after washing, respectively. The corresponding regression curves have been superimposed (assuming a fabric mass per unit area of 375 g/m^2 for the fabrics after washing and 350 g/m^2 prior to washing).

SUMMARY AND CONCLUSIONS

A comparison has been made of the frictional properties, before and after waxing, and knitting performance of 25 tex rotor and ring spun *single* yarns, unmercerised and mercerised with either caustic soda or liquid ammonia. The yarns were spun from different cultivars grown in Southern Africa and were knitted into an interlock structure on an 18 gauge double jersey machine. The physical properties of the fabrics knitted, to a commercial tightness factor, from the various yarns were also compared.

Although differences in yarn frictional properties were observed prior to waxing, after waxing to the optimum levels, little difference of any practical consequence existed between the various yarns covered in this study. If anything, the yarn-to-metal friction of the unwaxed rotor yarns was slightly lower than that of the unwaxed ring yarns.

The relative ability of the various yarns to withstand high knitting stresses and strains was compared by knitting the yarns into an interlock structure at high machine tightness factors. It was found that under such conditions, the ring yarns performed better than the rotor yarns, with the unmercerised yarns performing better than the mercerised yarns. The observed differences in knitting performance could be explained to a large extent in terms of differences in the yarn friction, breaking strength and extension at break. It should be emphasized, however, that under *commercial knitting conditions* the yarns may be ranked differently since in such cases, yarn breakages during knitting (i.e. holes) are often caused by relatively infrequent faults such as knots and slubs. It is generally accepted that rotor yarns are superior to ring yarns in this respect.

The fabrics knitted from the rotor yarns were stiffer, had higher drape coefficients, poorer resistance to bagging, greater air permeability, lower mass per unit area values, lower bursting strength and lower k_3 but higher k_2 values than the fabrics knitted from ring yarns.

Mercerisation of the yarns generally increased the fabric pilling propensity, caustic soda more so than ammonia. Prior to washing, the fabrics knitted from mercerised yarns had better sewability than those knitted from unmercerised yarns. Relative to the unmercerised yarns, caustic soda mercerisation of the yarns reduced the fabric mass per unit area, thickness, stiffness, bursting strength, resistance to abrasion, resistance to pilling and k_2 and k_1 but increased the resistance to bagging, the Monsanto crease recovery angle, k_3 and air permeability. These effects, however, were generally small.

Ammonia mercerisation of the yarns decreased the fabric mass per unit area and resistance to pilling but increased the air permeability, bursting strength (by less than 5%) and k_2 and k_1. Once again the effects were small.

Prior to washing, the fabrics knitted from ammonia mercerised yarns had greater mass per unit area values, drape coefficients, stiffness values, bursting strength, resistance to pilling and k_1 values and lower air permeability, resistance to bagging values and washing shrinkage than the fabrics knitted from caustic soda mercerised yarns. Similar trends also existed after the fabrics had been washed.

Fabric bleaching was found to reduce the fabric mass per unit area, thickness, drape coefficient, stiffness and k_2, but increased the air permeability, bursting strength, abrasion resistance, resistance to pilling, and k_3.

The bursting strength of the fabrics was found to be highly correlated with the yarn breaking strength.

After five home laundry washes the following average values were obtained for the dimensional constants of the fabrics:

k_1 : 200
k_2 : 24
k_3 : 8,3

The k values for the fabrics knitted from the caustic soda mercerised yarns were generally lower than the above while the rotor and ring yarns appeared to give similar k_1 values. The fabrics knitted from the rotor yarns had slightly higher k_2 and slightly lower k_3 values than the fabrics knitted from the ring yarns.

ACKNOWLEDGEMENTS

The authors are indebted to staff members in the Departments of Cotton Processing, Knitting, Finishing, Textile Physics and Statistics for their contribution to this study.

Permission by the Rhodesian Cotton Promotion Council to publish these results is also gratefully acknowledged.

THE USE OF PROPRIETARY NAMES

The registered trade marks used in this publication are the property of the following companies:

®Nonidet – Shell Chemicals Ltd

®Prestogen – BASF

The fact that chemicals with proprietary names have been mentioned in this report does not in any way signify that SAWTRI recommends them or that there are not substitutes which are of equal or even better value.

REFERENCES

1. Hunter, L., Aldrich, De V. and Andrews, G., A Comparison of Open-End and Ring Spinning of Cotton, Part I: The Physical Properties of 25 tex Yarns Spun from Different Cottons Grown in Southern Africa, *SAWTRI Techn. Rep.* No. 328 (Nov, 1976).
2. Hunter, L. and Andrews, G., A Comparison of Open-End and Ring Spinning of Cotton, Part II: The Effects of Caustic Soda and Liquid Ammonia Mercerisation on Yarn Tensile Properties, *SAWTRI Techn. Rep.* No. 367 (August, 1977).
3. Smuts, S. and Hunter, L., Studies of Some Wool/Acrylic Woven Fabrics, Part I: Untreated Plain and 2/2 Twill Weave Fabrics from Wool Blended with Regular Acrylic, *SAWTRI Techn. Rep.* No. 305 (June, 1976).
4. Cawood, M. P. and Hunter, L., The Effect of Certain Yarn and Fabric Structural Variables on Some of the Physical Properties of Double Jersey Textured Polyester Fabrics, Part I: Yarn Bulk Properties, Machine Tightness Factor and Run-in-Ratio, *SAWTRI Techn. Rep.* No. 388 (January, 1978).
5. McKenna, F. P., Open-End Spinning: The Yarn Spinning Viewpoint, *Modern Textiles,* **56**, 60 (Sept., 1975).
6. Anon, The Most Important Features of open-end-spun Yarns, *Kettenwirk-Praxis,* **4/74**, 15 (1974).
7. Shaw, H. V., Open-End-Spun yarns and Their Processing Performance – Fabric Characteristics, *The Yarn Revolution, (Textile Inst. Conference – Harrogate),* 1 (May, 1976).
8. Konishi, T., New Methods and Trends in the Development of Open-End Spun Yarns, *Text. Month,* 63 (Sept., 1975).

Published by
The South African Wool and Textile Research Institute,
P.O. Box 1124, Port Elizabeth, South Africa,
and printed in the Republic of South Africa
by Nasionale Koerante Beperk, P.O. Box 525, Port Elizabeth

ISBN 0 7988 1236 2