SAWTRI TECHNICAL REPORT

NO 477

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by

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WOOL AND TEXTILE RESEARCH
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P.O. BOX 1124
PORT ELIZABETH
REPUBLIC OF SOUTH AFRICA

ISBN 0 7988 1955 3

A COMPARISON OF SOME COMMERCIAL SELF-TWIST (STT) AND RING-SPUN WOOL YARN PROPERTIES

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ABSTRACT

The physical properties of commercial lots of two-ply ring-spun and Repco self-twist twisted (STT) weaving yarns, spun from similar wools, have been compared. It was found that the STT yarns generally had higher irregularity (including thick and thin places) and extension values than, but similar strength and CV of strength values to, those of the ring-spun yarns. The frequencies of weak places, as measured on a Shirley Constant Tension winding tester for the STT and ring-spun yarns differed very significantly, however, with the ring-spun yarns on average giving 0,07 breaks per 1 000 m, the STT yarns spun on a Repco Mk I machine giving 2,10 breaks per 1 000 m and the STT yarns spun on the Repco Mk II machine giving 3,87 breaks per 1 000 m . All the breaks in the constant tension winding test occurred at a thin place of relatively high twist. For the STT yarns, the breaks during the constant tension winding test generally followed a Poisson distribution.

INTRODUCTION

It is generally stated that self-twist twisted (STT) wool yarns made to suitable twist and other specifications have equivalent tenacity[1-5] and weavability, higher extension[1-4] and marginally higher irregularity[1-4,6], compared to the corresponding conventional two-ply ring-spun yarns[1-4]. The marginally higher irregularity of STT yarns has been ascribed[1,7] to the cyclic changes in twist and apparently is not reflected in the fabric appearance[7]. It appears, however, that the tenacity of STT wool yarns approaches that of conventional weaving yarns only at optimum twist[3-8]. It has also been reported[8] that the weaving performance of STT yarns is as good as, if not better than, that of ring-spun yarns except if self-twist (ST) levels are high or if both self-twist and added twist (up-twist) levels are high.

It has also been reported[11] that STT yarns have more thin places but fewer thick places than ring-spun yarns and that the CV of strength of STT yarns is similar to that of conventional two-ply ring-spun yarns[6,12].

In spite of the widely reported similarity of properly constructed STT yarns and two-ply ring-spun yarns in terms of physical properties and weaving performance, a mill with a large Repco installation approached SAWTRI because of problems they were experiencing with the weaving performance of certain all-wool STT yarns. What was particularly disconcerting was the fact that routine laboratory quality control tests did not reflect the differences in weaving performance neither between ring and STT yarns nor between different lots of STT yarns. In an attempt to throw some light on this anomaly and to find a better laboratory measure of weaving performance, a selection of ring-spun and self-twist twisted yarns (from both Repco Mk I and Mk II machines, the spinning speed being 220 m/min on both machines) produced from similar wool lots and with similar linear densities and used in similar woven constructions were obtained from the firm and subjected to wide-ranging tests at SAWTRI. It must be emphasized that the yarns were drawn from commercial production lots and were therefore not necessarily spun from the *identical* raw material.

EXPERIMENTAL

A selection of R50 tex/2 all-wool yarns (see Table I) was subjected to standard physical tests, the results of which are given in Table II.

Yarn breaking strength was determined on an Uster automatic yarn breaking strength tester (constant rate of loading), with at least 200 tests, spread over 10 cones, being carried out per yarn lot. Yarn irregularity was measured on the Uster range of equipment, a total of about 2 000 metres of yarn being tested per yarn lot. Once again the tests were carried out on different cones. Yarn hairiness was measured on a Shirley tester at a distance of 3 mm and the yarn 'Count Strength Product' (CSP) was measured on 80 x 1,37 m skeins using a Heal skein-strength tester.

In addition to the above-mentioned tests, two full packages from each yarn lot, were subjected to a Shirley Constant Tension winding test. To expedite the test, all the yarns were tested at one tension, viz. 211 cN (421 cN load) and the results expressed as the number of breaks per 1 000 m (B.S. Handbook II: 1974, Section 3, page 44). In a number of cases, the linear density (tex) of the yarn in the vicinity of a rupture was determined by cutting off short lengths of the yarn adjacent to the point of rupture and measuring their mass and length. The results of these tests are given in Tables III and IV.

RESULTS AND DISCUSSION

From Table I it is apparent that the yarns were well-matched from the point of view of the raw material used and the yarn twist levels were in line with the recommended values. Table II in the main confirms the trends reported by other workers, viz. STT yarns have similar tenacity, and higher extension and irregularity than similar two-ply ring-spun yarns. Furthermore, the STT yarns generally contained more thin and thick places and also had a marginally greater CV of breaking strength than the ring-spun yarns.

Taking an overall view of the results, it appears that the Mk I and Mk II yarns were very similar in their physical properties and these test results do not reflect the reported differences in weaving performance. In summarising, it appears that the results of the standard laboratory physical tests given in

TABLE I

FIBRE DETAILS AND YARN TWIST LEVELS

Yarn Lot	Mean Fibre Length (mm)	Fibre Diameter (μm)	Singles Twist* (turns/m)	Plying Twist* (turns/m)
RING-SPUN				
30674	74,4	22,6	536	520
30919	72,4	22,2	536	520
31764	72,7	21,8	536	520
31274	73,4	21,8	536	520
31282	72,8	21,6	536	520
30859	75,2	21,6	536	520
Repco Mk I			Self-Twist* (ST) (turns per half-cycle)	Uptwist* (STT) (turns/m)
51195	70,6	21,7	26	489
51199	72,4	22,2	26	489
51208	72,4	22,2	26	489
51225	75,7	21,8	26	489
51227	72,1	22,0	26	489
Repco Mk II				
51047	71,1	21,7	27	504
51104	68,2	21,5	28	536
51120	68,2	22,0	26	489
51124	68,2	21,5	26	489
51250	73,4	21,8	26	489
51316	73,4	21,8	26	489
51317	77,3	22,0	26	489
51331	77,3	22,0	26	489

*Nominal values

TABLE II
YARN PHYSICAL PROPERTIES

Yarn Linear Density		Breaking Strength		Tenacity	Extension		Irregularity CV (%)	Thin Places per 1000 m	Thick Places per 1000 m	Neps per 1 000 m	Hairness	
Mean (Rtex/2)	CV (%)	Mean (cN)	CV (%)	(cN/tex)	CV (%)	(%)					Mean (Hairs/m)	CV (%)
Ring-Spun												
51,9	1,5	333	9	6,4	14,9	23	14,6	2	1	7	39	6
51,1	1,9	406	8	7,9	24,4	20	14,6	4	2	7	43	9
51,4	1,3	367	10	7,1	21,3	23	14,3	1	3	8	35	14
54,9	1,0	399	9	7,3	21,6	20	12,6	—	—	—	22	10
52,8	5,1	400	9	7,6	23,6	21	13,5	2	3	5	45	24
51,2	5,0	393	8	7,7	22,6	22	13,0	—	—	—	44	12
52,2	2,6	383	9	7,3	21,4	21	13,8	2	2	7	38	12
Repco Mk I												
50,9	1,3	387	10	7,6	28,1	19	15,6	10	16	2	39	7
52,1	2,7	358	10	6,9	24,4	22	15,9	12	17	4	40	6
50,4	2,5	382	10	7,6	26,7	20	15,9	13	9	2	38	9
50,9	2,6	380	10	7,5	26,6	23	15,7	12	9	2	36	7
51,9	2,8	380	9	7,3	26,2	21	15,9	9	10	6	37	7
51,2	2,4	377	10	7,4	26,4		15,9	11	12	3	38	8
Repco Mk II												
49,9	1,8	388	10	7,8	27,7	21	15,0	9	6	3	23	7
49,6	2,0	392	12	7,9	28,9	23	15,0	9	7	2	25	10
49,4	1,8	356	10	7,2	24,5	24	15,5	10	6	2	28	10
48,4	2,0	358	11	7,4	22,4	27	15,4	10	7	4	37	14
48,2	1,5	371	10	7,7	24,9	24	16,7	22	25	18	21	10
50,3	6,3	380	10	7,5	23,2	27	15,8	13	23	5	23	11
51,8	4,7	408	11	7,9	25,7	24	15,0	5	8	2	29	10
48,5	3,3	384	9	7,9	26,9	21	15,5	9	12	4	29	8
49,5	2,9	380	10	7,7	25,5	24	15,5	11	12	5	27	10

TABLE III

SHIRLEY CONSTANT TENSION WINDING TEST RESULTS FOR RING-SPUN YARNS

Yarn Details	Yarn Linear Density (Rtex/2)		Length of Yarn Tested (m)	Number of Yarn Breaks	Yarn Breaks per 1 000 m
	Mean	at Point of Rupture			
RING-SPUN					
Navy 31741 Cone 1		47,3	10 238	1	0,1
Navy 〃 Cone 2		30,7	10 049	1	0,1
Mean	51,9		10 144	1	0,1
Light Grey 30674 Cone 1		51,6	10 425	1	0,1
Light Grey 〃 Cone 2			10 052	0	0
Mean	51,1		10 239	1	0,05
Charcoal 30919 Cone 1		31,8	10 338	2	0,2
Charcoal 〃 Cone 2		28,4	10 656	1	0,1
Mean	51,4		10 497	2	0,14
Dark Green 31282 Cone 1		—	10 064	1	0,1
Dark Green 〃 Cone 2		—	10 224	0	0,0
Mean	54,9		10 144	0,5	0,05
Light Green 30859 Cone 1		—	10 076	0	0,0
Light Green 〃 Cone 2		—	10 064	1	0,1
Mean	52,8		10 070	0,5	0,05
Light Blue 31274 Cone 1		—	10 008	0	0
Light Blue 〃 Cone 2		—	9 913	0	0
Mean	51,2		9 961	0	0
OVERALL MEAN (RING YARNS)	52,2	38,0	122 107*	8*	0,07

*Total

TABLE IV

SHIRLEY CONSTANT TENSION WINDING TEST RESULTS FOR STT YARNS

Yarn Details	Yarn Linear Density (Rtex/2)		Length of Yarn Tested (m)	No. of Yarn Breaks	Yarn Breaks per 1 000 m	Distri-bution
	Mean	at Point of Rupture				
REPCO Mk I						
Light Grey 51195 Cone 1		38,2	8 967	24	2,7	Poisson
Light Grey 〃 Cone 2		37,5	6 647	13	2,0	Poisson
Mean	50,9		7 807	19	2,4	
Brown 51199 Cone 1		36,6	10 065	32	3,2	Poisson
Brown 〃 Cone 2		35,6	10 121	27	2,7	Poisson
Mean	52,1		10 093	30	3,0	
Grey/Green 51208 Cone 1		38,6	10 330	6	0,58	Poisson
Grey/Green 〃 Cone 2		36,6	10 047	6	0,60	Poisson
Mean	50,4		10 190	6	0,6	
Grey/Mink 51225 Cone 1		26,3	10 424	24	2,3	Poisson
Grey/Mink 〃 Cone 2		29,9	10 101	23	2,3	Poisson
Mean	50,9		10 263	24	2,3	
Khaki 51227 Cone 1		36,5	10 228	24	2,3	Not Poisson
Khaki 〃 Cone 2		27,9	10 432	29	2,8	Poisson
Mean	51,9		10 330	27	2,6	
OVERALL MEAN (Mk I)	51,2	34,4	97 362*	208*	2,1	
REPCO Mk II						
Light Grey 51120 Cone 1			9 320	15	1,6	Not Poisson
Light Grey 〃 Cone 2			14 032	23	1,6	Poisson
Mean	49,9		11 676	19	1,6	
Light Grey 51104 Cone 1		26,6	8 325	33	4,0	Poisson
Light Grey 〃 Cone 2		30,6	12 707	10	0,8	Poisson
Mean	49,6		10 516	22	2,0	
Navy 51124 Cone 1			17 931	74	4,1	Not Poisson
Navy 〃 Cone 2		29,8	12 999	77	5,9	Poisson
Mean	49,4		15 465	76	4,9	
Charcoal 51047 Cone 1			18 920	70	3,7	Poisson
Charcoal 〃 Cone 2			18 993	137	7,2	Poisson
Charcoal 〃 Cone 3			19 093	134	7,0	Not Poisson
Mean	48,4		19 002	114	6,0	

TABLE IV (Contd.)

Yarn Details	Yarn Linear Density (Rtex/2)		Length of Yarn Tested (m)	No. of Yarn Breaks	Yarn Breaks per 1 000 m	Distri-bution
	Mean	at Point of Rupture				
Undyed 51250 Cone 1		32,7	10 067	28	2,8	Poisson
Undyed 〃 Cone 2		36,8	10 414	12	0,96	Poisson
Mean	48,2	)	10 241	0	1,9	
Light Mole 51316 Cone 1		23,4	10 021	128	12,8	Poisson
Light Mole 〃 Cone 2		29,6	10 180	15	1,5	Poisson
Mean	50,3	25,5	10 101	72	7,1	
Light Fawn 51317 Cone 1		36,6	10 103	11	1,1	Poisson
Light Fawn 〃 Cone 2		34,8	10 125	11	1,1	Poisson
Light Fawn 〃 Cone 3		33,4	10 038	14	1,4	Poisson
Mean	51,8	34,9	10 088	12	1,2	
Light Camel 51331 Cone 1		27,8	10 332	52	5,0	Poisson
Light Camel 〃 Cone 2		25,9	10 178	22	2,2	Poisson
Mean	48,5	26,9	10 255	37	3,6	
OVERALL MEAN (Mk II)	49,5	30,7	223 778*	866*	3,87	

*Total

Table II do not differentiate in a clear-cut manner between the yarn lots in such a way that it bears any relationship with weaving efficiencies reportedly obtained in the mill, the ring yarns having been found to perform best in this respect, followed by the Mk I STT yarns. This largely confirmed the mill's experience with their own quality control tests.

The Shirley constant tension winding test (Tables III and IV) presented a very different picture to that presented by the results in Table II. The ring-spun yarns exhibited far fewer breaks during the test (on average 0,07 breaks per 1 000 m) than the Mk I yarns (2,1 breaks per 1 000 m) which in turn averaged fewer breaks than the Mk II yarns (3,87 breaks per 1 000 m). This is also the order in which the mill ranked the general weaving performance of these yarns. Clearly, although the average breaking strengths of the ring-spun, Mk I and Mk II yarns were similar there was a significant difference in the occurrence of weak places. Moreover, the Mk II yarn results also tended to be the most variable, both within and between lots, which was in accordance with the experience of the mill. In certain cases, different cones within a specific Mk II lot varied so much in their constant tension winding test results that, statistically, they could not be considered as originating from the same population. Whether this signifies that "poor" yarns are being produced consistently at certain spinning heads (positions) or by certain machines or whether a spinning head or machine at times produces "poor" yarn needs to be ascertained.

The yarn linear density results, corresponding to the point of rupture (Table IV), clearly show that the STT yarns broke at a *thin* place. In fact, of the some 350 breaks examined all but one occurred at a point where the yarn was considerably thinner than average. The breaks generally were clean (i.e. sharp) indicating that the thin places were also highly twisted; this is in line with the known trend for twist to run into thin places.

The intervals at which yarn breakages occurred during the Shirley constant tension winding test were recorded and the distribution of yarn break intervals checked. It was found that, in the majority of cases, by far, the yarn breaks conformed to a Poisson distribution when assessed on the distribution of breaks per 100 m . This means that the standard deviation of a result equals its square root. Clearly, too few breaks occurred for the ring-spun yarns to determine the type of distribution.

SUMMARY AND CONCLUSIONS

A mill which produces and weaves large quantities of all-wool ring-spun and self-twist twisted (STT) yarns found that differences in weaving performance, either between ring-spun and STT yarns or within STT yarn lots, were not reflected in their standard quality control checks, involving twist, irregularity, linear density, strength and extension. SAWTRI was therefore approached to investigate this anomaly.

Tests were carried out on six ring-spun two-ply weaving yarns, five STT yarns spun (at 220 m/min) on Repco Mk I machines and eight STT yarns spun (also at 220 m/min) on Repco Mk II machines. All the yarns were from the mill's normal production and were spun from similar wool lots ($\simeq$ 22 μm, 70 mm), which, except for one, had been top dyed. Recommended twist levels were used throughout.

It was found that, as a group, the STT yarns generally had higher irregularity (including thin and thick places) and extension than the ring-spun yarns but the two sets of yarns were similar as far as breaking strength and CV of breaking strength were concerned. The STT yarns produced on the two different models of Repco machines, viz. Mk I and Mk II, were very similar as far as these yarn properties were concerned. This, therefore, confirmed the mill's experience, namely that the standard laboratory tests did not reflect the differences in weaving performance since they had found that their ring-spun yarns generally had the best weaving performance followed by the STT yarns produced on the Repco Mk I machines.

Since it was suspected that there might be differences between the yarns as far as the incidence of weak places was concerned, it was decided to test the yarns on a Shirley Constant Tension winding tester. About 440 000 m of yarn were tested in this manner and it was found that the ring-spun yarns exhibited the fewest breaks, viz. 0,07 breaks per 1 000 m (8 breaks in 122000 m), followed by the STT yarns produced on the Repco Mk I machine, viz. 2,1 breaks per 1 000 m (208 breaks in 97 000 m), with the STT yarns produced on the Repco Mk II machine giving 3,87 breaks per 1 000 m (866 breaks in 223 800 m). These differences were highly significant and ranked the yarns in the same order as their reported weaving performances. In practice the constant winding test may therefore be a better guide to weaving performance than other routine quality control tests, although it is rather time consuming. What is very important though, is that the winding test showed that there were significant differences in the frequencies of weak places in the yarns, which had not been reflected by other standard tests. Of the some 350 constant tension winding test breaks examined, all but one had occurred at a thin place (of relatively high twist) in the yarn. The average linear density at the place of break for the STT yarns was about 33 tex compared with the average yarn linear density of the yarn which was 50 tex. The distribution of breaks for the STT yarns was found to be Poisson in the majority of cases. Too few breaks were recorded for the ring-spun yarns to allow the frequency distribution of the breaks to be determined.

ACKNOWLEDGEMENTS

The authors wish to thank Mrs M. E. Hill, Mrs M. Kritzinger, Mrs W. Leeuwner and Miss S. Verrie for technical assistance.

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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 1955 3