SAWTRI TECHNICAL REPORT

NO 176

Properties of Some Fabrics from Wool/Nylon Core Spun Yarns

by

Miriam Shiloh, P. J. Kruger and R. I. Slinger

SOUTH AFRICAN WOOL AND TEXTILE RESEARCH INSTITUTE OF THE CSIR

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

ISBN 0 7988 0223 5

PROPERTIES OF SOME FABRICS FROM WOOL/NYLON CORE SPUN YARNS

*by MIRIAM SHILOH, P. J. KRUGER and R. I. SLINGER**

ABSTRACT

Mechanical properties of fabrics from wool and multi-filament nylon core yarns were measured and compared with other fabrics. The core yarns were made from textured and untextured nylon multi-filaments and in one case an additive was applied to increase fibre cohesion. Tensile strength, bending, wrinkling, and air permeability as well as the abrasion resistance of the fabrics before and after dyeing were measured and the effect of the different core yarns analysed.

KEY WORDS

Core-spun yarns, blends, wool, nylon, polyester, mechanical properties, strength efficiency, wrinkling, bending, dyeing, wear.

INTRODUCTION

In core-spun yarns the different properties of the inner and outer regions of the yarns may be exploited through the choice of different fibres to provide the required end use properties. Core-spun yarns consist of a central core surrounded by a sheath of staple fibres. They can be classified into elastic yarns, non-elastic yarns, and "exploded filament" yarns in which the staple fibres migrate into the core. Usually the core component is used to increase the strength or elasticity of the yarn, while the covering fibres serve to provide bulk, softness or some other desirable property. Fabrics can therefore be produced from such yarns to meet many different end use requirements through proper selection of the core and cover fibres and their assembly into a suitable fabric structure.

Core-spun yarns are manufactured by using a filament which is inserted into the staple fibre component during spinning. Spinning methods are described by Miller[1], Johnson[2, 3] and others, for a number of types of composite core yarns. Johnson[2] lists three objectives for core spinning:

(i) to support the yarn during spinning and weaving;
(ii) to make strong foundation weaves; and
(iii) to eliminate twisting or plying to a certain extent.

Accordingly, reduced production costs can be anticipated in addition to the high degree of diversified textile products which can be manufactured from core-spun yarns.

---

* Deceased

In most applications it is essential that the core remain permanently at the centre of the yarn. The staple fibres should enclose the core and cover it completely along the surface of the yarn. Satisfactory results can therefore only be obtained with the correct extensions and spinning procedures.

In a recent report Kruger[4] described core spinning of wool with a textured multi-filament nylon core. Similar procedures were used for preparing the yarns in the present study.

The use of core-spun yarns in woven fabrics seems to be most beneficial to obtaining light weight apparel fabrics with satisfactory mechanical properties. The limited production of such fabrics is, however, probably due to the poor abrasion resistance of the yarns on the loom resulting in poor weavability. Some problems involved in weaving textured core-spun yarns using different sizes and lubricants will be discussed by Robinson[5]. As far as is known woven fabrics from core-spun yarns presently on the market are limited mainly to high tenacity yarns in industrial fabrics[6].

The purpose of the present study was to attempt to produce apparel fabrics which would retain the better qualities of the wool and, with the added strength of nylon core filaments, could maintain durability in wear, reduce shrinkage and improve wrinkling performance in spite of their relatively light weight. It is feasible that the lower production costs of such fabrics could consequently justify their introduction to the market.

EXPERIMENTAL

Twenty denier (7 filaments) textured and untextured nylon multi-filaments were used as cores. The wool used was an untreated 64's top. The yarns were spun on a Rieter spinning frame with double apron drafting systems, as described elsewhere[4]. About 30% pre-extension was applied to the textured filament prior to spinning and about 5% to the untextured filament. The wool component was arranged so that the count was approximately 21 tex, with a twist of 680 t.p.m. The yarns were then doubled with a folding twist of 420 t.p.m. giving a resultant count of R42 tex/2. The percentage, by mass, of the wool component was 88%, and that of the cores, 12%. To increase cohesion of the wool fibres in the yarn some *Alon* (fumed Aluminium Oxide, by Cabot Corp., U.S.A.) was applied to the wool tops during drawing, and core yarns with textured filaments were spun. For the sake of comparison yarns of similar counts and twists were also prepared from 100% wool and from an intimate blend of 80% (by mass) wool and 20% Trevira Type 220 (Hoechst) polyester staple fibres. An intimate blended yarn of 88/12 wool and staple nylon was unfortunately not available for this study. Five different yarns were therefore prepared: wool with either textured or untextured cores, Alon-treated wool with a textured core, pure wool and finally a wool rich polyester blend. The properties of these yarns are summarized in Table I.

TABLE I

YARN PROPERTIES

Yarn	Count (tex)	Singles twist (t.p.m.)	Ply Twist (t.p.m.)	Breaking Strength		Extension at break (%)	Mean Fibre tenacity (gf/tex)	Yarn to Fibre Strength efficiency (%)
				gf	gf/tex			
100% wool	37,4	687	435	256	6,8	20,7	14,0	48,6
80/20 wool/polyester intimate blend	38,2	680	403	495	13,0	22,9	18,2	71,4
88/12 wool/untextured nylon core	44,0	672	439	412	9,4	23,0	16,5	57,0
88/12 wool/textured nylon core	43,9	694	393	429	9,8	25,4	16,4	59,8
88/12 wool/textured nylon with Alon added	43,9	689	400	450	10,3	28,7	16,4	62,8
Approximated 95% confidence limits	±3,0	±50	±10	±30	±0,7	±2,0	±2,0	–

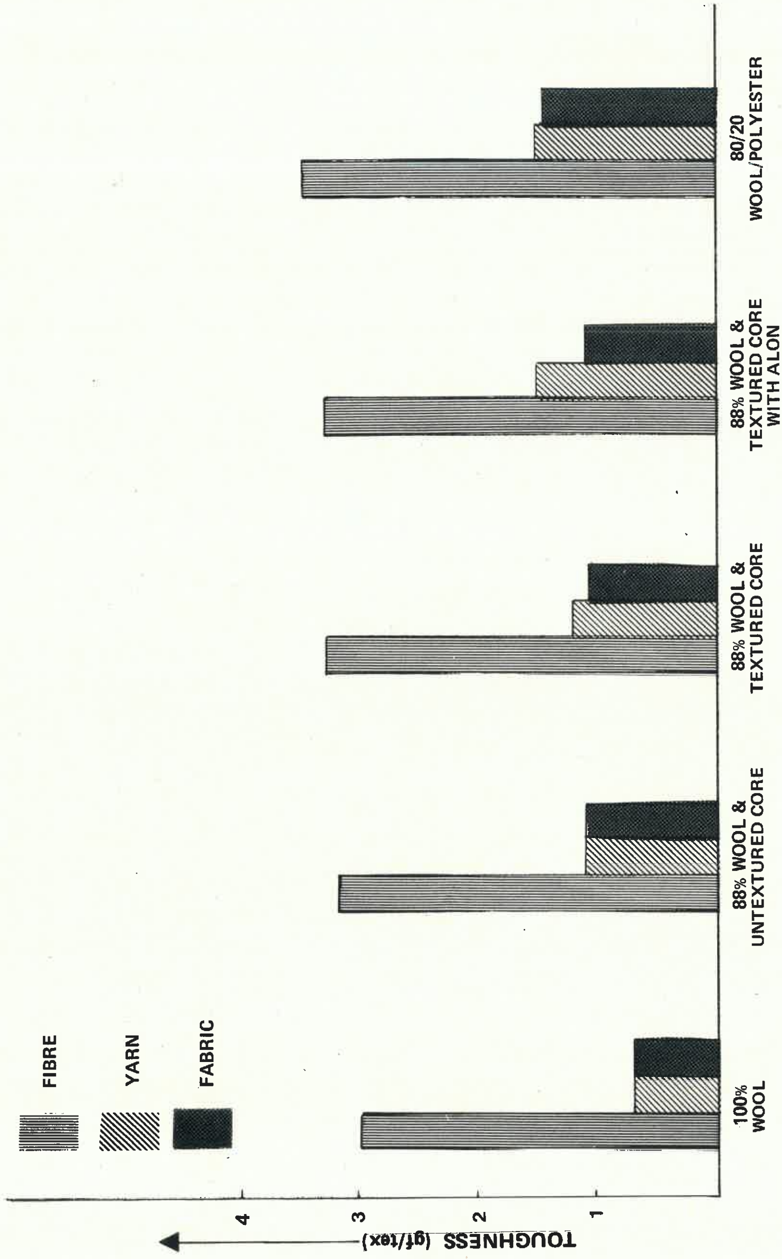

FIGURE 1

Toughness of Fibres, Yarns and Fabrics from Core Spun Yarns

Bending, Wrinkling and Shrinkage:

The resistance to bending and wrinkling of the fabrics was evaluated through a number of tests as summarized in Table III. The flexural rigidity (cantilever method) of all the fabrics was close to 90 mgf cm^2 per cm, with only the wool polyester being slightly stiffer than the pure wool. The flexural rigidities as determined by Owen's method (B) also did not differ much between fabrics, the wool/polyester again being the stiffest. The B values of the autoclave decatized fabrics were lower than those of the fabrics which were only decatized. When considering Owen's bending test to show a better correlation[11] with fabric handle and stiffness, the B results may be used to conclude that autoclave decatizing had effectively decreased the resistance to bending by the more adequate setting mechanism of the autoclave decatizing process. This trend, however, is not observed in the cantilever flexural rigidity results. The frictional couple (Mo) also decreased after autoclaving, as could be expected. In the case of the blend fabrics the frictional couples were higher than those of the pure wool, and they were the highest in the textured plus Alon fabric. It was not possible to analyse for residual Alon particles in the fabric in view of the very low amount applied (0,3%). Nevertheless, it seemed that whereas most of the particles from the outer surface of the yarns had been removed during finishing, a small amount of Alon particles remained entrapped in the textured core yarns and was responsible for the increase of the frictional couple.

When the bending tests were carried out, also after dyeing (Table V), it was found that the significant difference between the frictional couple of the textured-with-Alon fabric and the one without Alon was still present. When these two fabrics were dyed with a chrome dyestuff, the shade of the fabric from the textured-with-Alon yarns differed considerably from the other, due to the presence of the aluminium oxide particles. In addition to the fact that the Alon was not completely removed during finishing, it also contaminated the other fabric (which was finished simultaneously with it) as evidenced by the latter, displaying patches of colour, consistent with the shade of the former fabric.

The residual curvature (Mo/B) is considered to be correlated with fabric "liveliness"[11], and in this respect would be proportional to the rate of recovery from creasing. As the creasing and wrinkling tests were not carried out as a function of time, it was not possible to measure the rate of recovery in practice. If, however, Mo/B can be used as a means of measuring the recovery rate from wrinkling, it can be anticipated that the pure wool fabrics will be the most rapid and the core textured with Alon – the slowest, to shed their wrinkles and creases.

Crease recovery angles measured after creasing at 75% R.H. and 27°C did not provide any significant conclusions, except that it would appear as though the fabric composed of staple fibre yarns performs better than the fabrics made from core-spun yarns.

The area shrinkage after 48 min Cubex washing was improved considerably in the 80/20 blend, compared with the pure wool fabric, and the core yarn fabrics were intermediate between these two, their area shrinkages still being too high to

TABLE III

BENDING, SHRINKAGE AND WRINKLING

Fabric	Finishing	Flexural rigidity (mg cm^2 per cm)	Owen's Bending Test			Shirley Crease recovery angle at 75% R.H. (W + F)	% Area shrinkage (after 48 min washing)	Wrinkle Severity H x T (mm x 10^2)		
			Mo (mg cm per cm)	B (mg cm^2 per cm)	Mo/B (cm^{-1})			After washing	F.R.L. (27°C, 75% R.H.)	AKU (90°C, 10% R.H.)
100% wool	D	78,4	8,5	58,8	0,144	259	12,1	9,02	7,15	2,19
	K	83,1	8,3	49,4	0,172	274	9,3	7,84	3,41	2,17
80/20 wool/polyester intimate blend	D	100,1	17,3	70,1	0,247	270	2,6	1,03	2,39	2,28
	K	86,6	9,6	56,9	0,170	267	1,5	1,39	2,26	2,17
88/12 wool/untextured nylon core	D	82,8	16,7	54,1	0,310	250	7,4	11,89	4,26	1,93
	K	87,3	10,2	42,7	0,237	257	6,4	4,89	2,96	2,66
88/12 wool/textured nylon core	D	83,8	14,3	53,3	0,267	259	5,9	11,69	4,39	2,05
	K	89,6	11,7	46,5	0,250	252	3,0	1,05	2,83	2,26
88/12 wool/textured nylon core with Alon	D	93,8	23,3	59,1	0,396	248	5,4	8,12	5,45	2,17
	K	89,3	16,0	49,0	0,326	248	4,5	1,22	2,95	2,68
Approximated 95% confidence limits		±5,0	±1,0	±2,5	–	±12	±12	±1,0	±0,50	±0,50

D – decatized **K – Autoclave decatized**

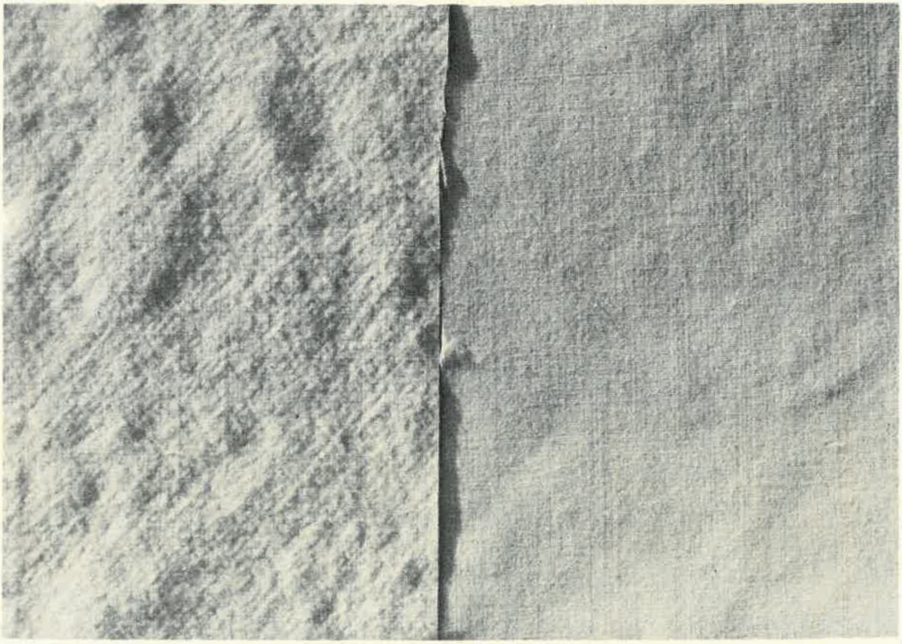

FIGURE 2

88/12 Wool and Textured Core Fabrics after two Washing Cycles

be considered as acceptable. The effect of autoclave decatizing was pronounced providing significant improvements to dimensional stability in all fabrics.

The wash-and-wear wrinkle severity index was also found to improve after autoclave decatizing, and the most outstanding difference was observed between the "D" and "K" finishing procedures in the wool and textured nylon core. The appearance of one of these fabrics after two Cubex washing cycles of 48 min and tumble drying is shown in Figure 2. It is clear that the autoclave decatizing brought about acceptable wash-and-wear performance in this fabric, whereas by the conventional finishing procedures its performance was very poor. A good correlation was obtained between the wash-and-wear results and the area shrinkage (at a 95% level of confidence), indicating that smooth drying properties can only be obtained when proper setting brings about good dimensional stability as well. The wool/polyester fabric showed the best smooth drying appearance, while the core yarn with untextured filament fabric was unsatisfactory even when autoclaved. It is possible that by either giving the wool tops a shrink resistant treatment or by a modified autoclaving procedure still better wash-and-wear properties could be obtained.

The FRL wrinkling test, in which the fabrics were creased at 75% R.H., again substantiated the better performance of the 80/20 wool/polyester blend fabric and the improvement due to autoclaving. The results are also well correlated with the area shrinkage (at the 99,9% level of confidence). In the AKU test in which the fabrics had been creased at 90°C, the results were quite different from the previous H x T results. Here no significant differences were found between the fabrics, the pure wool fabric not being inferior to the blends under hot wear conditions. It also seems possible that the creases in the blend fabrics are more durable than those of the wool fabric, providing a better crease retention on the one hand but retaining undesirable creases for longer periods on the other hand. This time dependence of wrinkle recovery will be studied in future tests. When the results of the wash-and-wear, high humidity (FRL) and high temperature (AKU) tests were analysed it was observed that the three test methods provided significantly independent sets of results. Wrinkling of the washed samples was most severe and the high temperature creasing the least. The autoclave decatizing brought about a significant improvement in the wrinkling performance, except in the high temperature creasing tests. Significant differences between the fabrics were only found for within each test procedure but not in the overall factorial analysis where the high temperature test results were more or less the same for all fabrics.

Properties of Dyed Samples:

The results of the spectro-reflectometer readings are presented in Table IV. It is apparent from this Table that the difference in shade between the fabrics from textured core-spun yarns and the pure wool was very slight, therefore indicating that the textured core was covered effectively by the wool fibres. It also appeared that the untextured core was not covered as effectively as the textured core, although the colour difference was small. As could be expected, the shade of the

TABLE IV

COLOUR MEASUREMENTS OF DYED SAMPLES

Fabric	Chromaticity Coordinates			ΔE
	x	y	Y	
100% wool	0,268	0,255	13,63	–
80/20 wool/polyester	0,269	0,261	17,04	1,19
88/12 untextured	0,255	0,262	16,09	0,98
88/12 textured	0,260	0,249	13,44	0,31
88/12 textured, Alon added	0,267	0,254	13,48	0,08

intimate blend differed most from that of the wool, due to the polyester fibres present on the surface of the fabric. Whether the deeper shade of the textured core yarns is also durable to washing and mechanical wear still needs further confirmation. The results of the tests carried out on the dyed samples are presented in Table V.

It can be seen that the air-permeability of the fabrics decreased after dyeing, particularly that of the pure wool where some shrinkage and surface felting occurred. When the samples were subjected to a 15 min abrasion test in the random pilling tester, no pilling or fluff could be observed on their surfaces and their loss in mass was only about 2%. Their air-permeability was affected, however, both the pure wool and the textured core fabrics showing an increase in air-permeability due to the removal of wool fibres from the fabric. The bending tests on the dyed samples show that the flexural rigidity (B) decreased after dyeing by about 10%. A similar decrease was indicated in the frictional couples of the fabrics from the core-spun yarns, while it did not decrease in the pure wool fabric. As mentioned above, the differences in the frictional couples between the textured and the textured-with-alon-added yarns were still present after dyeing and could only be attributed to the residual Alon particles which were present in the later fabric. The loss in breaking strength after a flex abrasion test of 500 cycles was found to be much smaller in the core yarn fabrics than in the pure wool. When the flex abrasion test was carried out up to the breaking point, it could be observed that the nylon core had improved the resistance to flex abrasion by a factor of 3 to 6. The untextured core was most resistant, while the Alon particles might have been responsible for some accelerated flexing wear in the textured core-spun fabric. The random pilling test of 15 min did not bring about a noticeable loss in mass, but it caused a pronounced change in the air-permeability as some of the wool fibres which had been drawn out resulted in a more open fabric structure. This effect was only slightly more pronounced in the pure wool fabric than in the core-spun ones. The Martindale abrasion test results are expressed as the loss in mass after a certain number of cycles. The *untextured* core fabric was, surprisingly, affected most by this test, as the dyed wool fibres had been removed from the rubbed area the white core becoming exposed at a much earlier stage than in the case of the other core fabrics and than in the pure wool, as can be seen in Figure 3. The fabric which was most resistant to flex abrasion now performed worst in the flat abrasion. It seems therefore as if the untextured core could very well support the successive loading cycles in the flex abrasion tests so that its flex abrasion resistance to rupture was high, whereas the cohesion between the wool sheath and the core seems to have been so low that its resistance to flat abrasion was the poorest amongst the tested fabrics. While the resistance to flex abrasion is considered to be the predominant factor in actual wear trials, the resistance to flat abrasion is more important from an aesthetic point of view: early "frosting" can disqualify the apparel fabric at a much earlier stage before it is actually worn out.

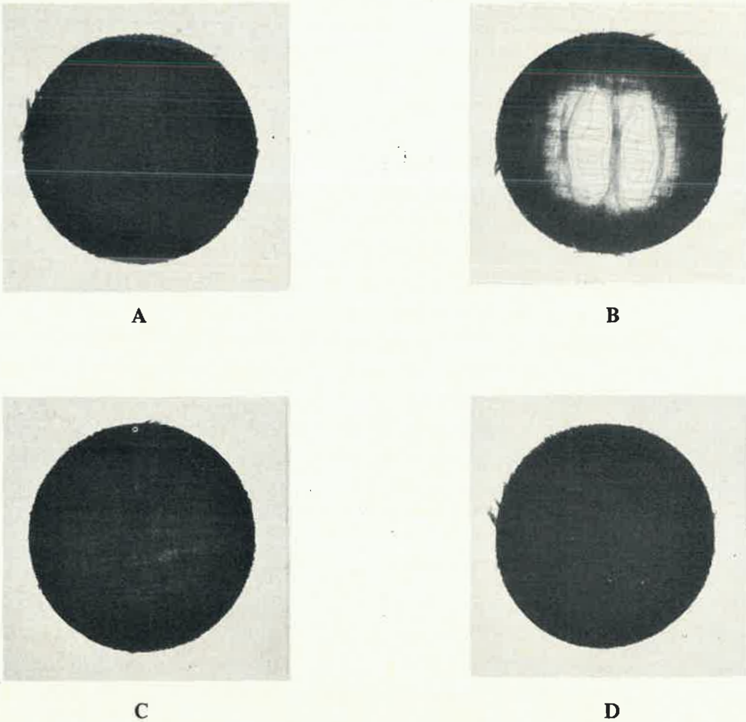

FIGURE 3

The appearance of Dyed Fabrics after 40 000 rubbing cycles

A Pure Wool
B 88/12 Wool-Untextured Core
C 88/12 Wool-Textured Core
D 88/12 Wool-Textured Core with Alon

Besides the abrasion test results, the differences between the untextured and textured core fabrics were only marginal. The choice between these cores should therefore be made according to economic considerations which are involved in manufacturing these fabrics for their particular end-uses.

CONCLUSIONS

Wool-rich fabrics from core-spun yarns can be utilized for apparel end-uses, replacing pure wool fabrics. Such fabrics also show some advantageous properties. Their tensile properties are improved without any noticeable stiffening and harshening effects, as the handle and resilience of the outer wool fibres are maintained. Dye-uptake is also not adversely affected.

TABLE V

SOME PROPERTIES OF FABRICS AFTER DYEING ("D" FINISHED)

Fabric	Breaking Strength (kgf)			Flex Abrasion (cycles)	Bursting Strength (Kgf/cm^2)	Air Permeability*			Mass loss after 15 min pilling (%)	Martindale Abrasion Mass loss (%) cycles:			Owen's Bending	
	1" warp	After 500 cycles	% loss			Before dyeing	After dyeing	After 15 min pilling		10^4	2×10^4	4×10^4	Mo (mg cm per cm)	B ($mg\ cm^2$ per cm)
100% wool	18,1	9,9	45	803	8,7	10,3	7,4	9,2	2,15	4,9	7,5	14,3	9,1	52,1
88/12 untextured	23,7	19,0	20	5342	11,4	7,1	7,8	8,2	1,93	4,9	9,9	38,1	13,7	50,0
88/12 textured	25,0	18,9	24	4735	11,6	7,8	5,8	7,6	1,98	4,5	7,4	15,5	10,3	49,0
88/12 textured with Alon added	24,4	19,4	21	2379	11,2	6,3	5,6	7,2	2,16	4,4	7,4	20,5	22,2	55,5

* In cm^3 per sec per cm^2 at 1 cm water pressure

The wrinkling performance of the fabrics is superior to that of the pure wool fabrics especially in terms of wash-and-wear. The wool and polyester blend, however, is superior to the core-spun fabrics in respect of both its tensile properties and its wrinkle resistance, bearing in mind the difference in composition and structure.

The effect of finishing on these fabrics is very marked, and autoclave decatizing improves their wrinkling performance to a large extent, without a marked deleterious effect on their mechanical properties. It is possible that by some modifications in the autoclave decatizing procedures such fabrics can be made acceptable even with untreated wool tops such as those used in the present study.

The Alon additive improved the yarn tensile test results and only slightly improved those of the fabrics. The textured core is not better than the untextured core in both tensile and wrinkling performance tests. Whereas the untextured core seems to be best in the fabric's resistance to flex abrasion where the core supports the flexing of the yarns, it seems to be least resistant to surface abrasion where the wool fibre sheath is removed at an early stage so that it is inferior even to the pure wool fabric in this respect.

ACKNOWLEDGEMENTS

The authors wish to thank the following persons who contributed to the investigations: Mr. G. A. Robinson who was responsible for the weaving of the fabrics; Mr. J. P. van der Merwe who carried out the finishing treatments, Mr. H. Silver who carried out the dyeing test and shade evaluations, and Mrs. B. Jamison, Miss T. Gouws, Mrs. I. Botha and Mr. S. Smuts who took part in the testing and statistical analysis.

The photographs were taken by Mr. P. de W. Olivier.

REFERENCES

1. Miller, G. G., The Preparation of Core Yarns on a Conventional Doubler, *J. Text. Inst.*, **56**, T73 (1965).
2. Johnson, A., For Cheaper Plied Yarns Try Core Spinning, *Text. World*, March, 128 (1951).
3. Johnson, A., Core Spun Yarns in Fabrics, *Text. Manuf.*, **85**, 116 (1959).
4. Kruger, P. J., Core-Spinning of Wool with Textured Filaments, A Preliminary Report, *S. African Wool Text. Res. Inst.* Techn. Rep. No. 146, July 1971.
5. Robinson, G. A., Weaving of Core Spun Yarns, *S. African Wool Text. Res. Inst.* Techn. Rep. – To be published.
6. Strandring, P. T. and Westrop, K. J., The Properties and Uses of some Terylene Polyester Core-Spun Yarns, *J. Text. Inst.*, **49**, T453 (1958).
7. Robinson, G. A., Weft Skewing in Wool Worsted Fabrics, Part II, *S. African Wool Text. Res. Inst.* Techn. Rep. No. 120, May 1969.

8. Australian Wool Board, Standard Requirements for Machine Washable Wool Products, Melbourne, 1969.
9. Shiloh, M., The Evaluation of Wrinkles and Creases in Wool Fabrics, Applied Polymer Symposium, No. 18, 1025 (1971).
10. Coats, E. and Rigg, B. J., The Measurement of Colour, Part I, An Introduction to Tristimulus Colorimetry, *J. Soc. Dyers Col.*, **81**, 469 (1965).
11. Dawes, V. and Owen, J. D., The Assessment of Fabric Handle, Parts I & II, *J. Text. Inst.*, **62**, 233 (1971).

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.