SAWTRI TECHNICAL REPORT

No. 251

Studies of some Wool/Polyester Woven Fabrics

Part III: Untreated plain weave fabrics from wool blended with a normal and a special low-pilling polyester, respectively.

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REPUBLIC OF SOUTH AFRICA

ISBN 0 7988 0590 0

STUDIES OF SOME WOOL/POLYESTER WOVEN FABRICS

PART III : UNTREATED PLAIN WEAVE FABRICS FROM WOOL BLENDED WITH A NORMAL AND A SPECIAL LOW PILLING POLYESTER, RESPECTIVELY

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ABSTRACT

Plain weave lightweight fabrics were woven from wool/polyester intimate blends using two polyester types (low-pilling and normal) and six blend levels ranging from 100 per cent polyester to 100 per cent wool.

The strength, abrasion resistance, FRL wrinkle resistance (but not crease recovery angles), flexural rigidity (stiffness), dimensional stability and D.P. ratings of the fabrics increased markedly with increasing polyester content.

The fabrics containing the normal polyester type generally performed better, although sometimes only marginally better, than similar fabrics containing the low-pilling polyester types except for the crease recovery angles where the latter held a very slight advantage.

The strength properties of autoclave-decatised fabrics were not much different from those of the decatised fabrics. Autoclave-decatising decreased the flexural rigidity and improved the wrinkle and crease recovery performance, the dimensional stability and the appearance after washing (D.P. ratings).

KEY WORDS

Normal polyester — low-pilling polyester — wool/polyester blends — plain weave — decatising — autoclave-decatising — mechanical properties — abrasion resistance — fabric stiffness — wrinkle recovery — crease recovery angle — washing shrinkage — durable press rating.

INTRODUCTION

Previously[1] the properties of some wool-rich wool/polyester plain weave fabrics were determined and compared. Three types of polyester, namely normal (Trevira type 220), low-pilling (Trevira type 350) and high-bulk (Trevira type 550) were blended with a 64's quality merino wool and the performance of each type when blended with wool was compared. As expected, increasing the polyester content improved the mechanical performance of the fabrics and the different polyester types produced fabrics differing in their mechanical properties. Thus fabrics containing the normal polyester had tensile properties superior to those containing the other two polyester types, with the high-bulk polyester fabrics performing the worst. Fabrics made from high-bulk polyester had comparatively high extension, low tenacity, low abrasion resistance, increased flexural rigidity and inferior wrinkling performance compared with the other two types. Fabrics containing the low pilling polyester fibres generally had better wrinkling properties than those containing the other two types.

The flexural rigidity (stiffness) of the fabrics increased with polyester content while autoclave-decatising reduced the stiffness. The normal polyester produced fabrics with the lowest stiffness while the high-bulk polyester resulted in the stiffest fabrics.

With untreated wool blends it was found that, if *autoclave-decatised,* 40 *per cent* polyester was sufficient to obtain satisfactory durable press performance. In the *decatised* state the polyester content had to be 20 *per cent* higher to obtain a similar performance.

In view of the extensive use of *Trevira type 330* (a special low-pilling polyester) by the worsted sector of the South African textile industry, it was decided to extend the work previously carried out to cover also this particular type. In this study, therefore, the *normal* polyester (Trevira type 220) was compared with this *low-pilling* polyester (Trevira type 330). The normal polyester was included as a control so that the performance of the Trevira type 330 could be related indirectly to that of the other types previously investigated.

EXPERIMENTAL

The materials used in this work, namely a 64's quality merino wool and the undyed polyester fibres (Trevira types 220 and 330) were tested for mean fibre length, mean fibre diameter (Visopan), bundle tenacity (1/8" – 3,2 mm Stelometer) and single fibre breaking strength and extension (Instron, 10 mm gauge length and 10 mm/min rate of extension). The results of these tests are given in Table I.

The following tops were prepared:

100% polyester;
80% polyester/20% wool;
60% polyester/40% wool;
40% polyester/60% wool;
20% polyester/80% wool and
100% wool.

TABLE I

FIBRE PROPERTIES *

TYPE OF FIBRE	MEAN FIBRE DIAMETER (µm)	MEAN FIBRE LENGTH (mm)	MEAN FIBRE BREAKING STRENGTH (gf)	SINGLE FIBRE TENACITY (gf/tex)	SINGLE FIBRE EXTENSION (%)	BUNDLE TENACITY (gf/tex)
Wool, 64's	20,1 (24,1)	72 (44,4)	5,23 (44,6)	14,9 (40,4)	40,7 (24,4)	10,6
Normal Polyester Trevira Type 220 – 3,6 dtex	18,3 (9,3)	82 (16,0)	16,6 (11,2)	50,7 (8,7)	39,3 (21,2)	36,3
Low Pilling Polyester Trevira Type 330 – 3,6 dtex	18,1 (9,2)	94 (36,0)	14,4 (11,1)	45,4 (13,0)	41,0 (27,0)	34,1

* Figures in parenthesis indicate coefficient of variation in per cent

These tops were processed in the normal way to produce R42 tex S400/ 2Z 650 yarns. The yarns were tested, their properties having been reported on in a previous publication[2].

Each blend was woven into a square, plain weave fabric with approximately 22 ends and picks per cm, and finished to a fabric mass per unit area of about 200 g/m^2.

The fabrics were divided into two sub-lots. One lot was finished as in the case of the "D"-series (decatised series) and the other lot as in the case of the "K"-series (autoclave-decatised series) of the previous investigation[1]. Immediately after crabbing the fabrics were cooled in cold water.

The mechanical and wrinkling properties were measured according to methods used elsewhere[1, 3, 4]. The wrinkle severity index (H x T) of the fabrics was measured after FRL wrinkling (27°C and 75% RH) after both 1 hour and 24 hour recovery periods at 20 °C and 65% RH. No de-ageing process was applied to the fabrics. Pilling was determined both by means of an Atlas Random Tumble Tester (30 and 60 minutes, respectively) and a Martindale abrasion tester (1 000 and 2 000 cycles, respectively). In addition, the fabric tear strength[5] was measured and the fabrics were evaluated for DP-ratings, using the AATCC Three-Dimensional Durable Press Replicas[6]. Relaxation shrinkage was determined by the Australian Wool Board (A.W.B.) test method and the I.W.S. (TM 9)[7] test method, respectively, while further shrinkage (termed felting shrinkage) was determined in the former case by the 45 min A.W.B. test[8] and in the latter by a method similar to the I.W.S. TM 185 three-hour wash test, with a temperature of 60°C instead of 40°C being employed.

Those test results not plotted in the various graphs are given in Table III except the crease recovery angles which are shown in the table and in one of the figures.

RESULTS AND DISCUSSION

The fabric structural parameters are summarised in Table II. From the results it appears that autoclave-decatising caused slight consolidation shrinkage of the fabrics. This was shown by the tendency for the sett, fabric mass per unit area and fabric cover factor to be slightly higher after autoclave-decatising than after decatising.

Air Permeability

From Table III it is apparent that the air permeability of the fabrics increased significantly with *increasing* polyester content, the fabrics produced from the low-pilling polyester generally being more permeable than

TABLE II

FABRIC STRUCTURAL DETAILS

BLEND	FINISHING	SETT		FABRIC MASS PER UNIT AREA	COVER * FACTOR	FABRIC THICKNESS (mm)
		Ends/cm	Picks/cm	(g/m^2)		
100% Wool	D	23,0	21,5	188	21,8	0,40
	KD	23,2	22,2	194	22,0	0,41
TREVIRA TYPE 220						
80% Wool/20% Trevira	D	22,6	22,6	198	22,2	0,44
	KD	22,4	24,3	208	22,7	0,42
60% Wool / 40% Trevira	D	22,2	22,6	197	21,9	0,43
	KD	22,4	23,1	199	22,1	0,43
40% Wool/60% Trevira	D	22,1	23,1	205	22,5	0,44
	KD	22,1	23,5	210	22,7	0,43
20% Wool/80% Trevira	D	22,1	22,6	203	22,1	0,43
	KD	21,8	23,6	205	22,3	0,40
100% Trevira	D	21,7	24,4	189	22,1	0,41
	KD	21,7	25,5	194	22,5	0,38
TREVIRA TYPE 330						
80% Wool/20% Trevira	D	22,3	22,2	191	21,8	0,41
	KD	22,4	22,4	214	21,9	0,42
60% Wool/40% Trevira	D	20,6	21,4	186	21,2	0,41
	KD	20,3	22,8	192	21,5	0,40
40% Wool/60% Trevira	D	20,3	21,7	189	21,5	0,40
	KD	20,2	23,2	192	22,0	0,39
20% Wool/80% Trevira	D	20,2	21,7	193	21,3	0,42
	KD	20,0	22,7	187	21,6	0,38
100% Trevira	D	20,2	22,2	187	21,4	0,38
	KD	20,1	23,4	189	21,8	0,37

D = Decatised

KD = Autoclave Decatised

*The cloth cover factor (K_C) was calculated from:

$$K_C = 0{,}1045\sqrt{tex}\left[W_p + W_f - 0{,}00373\sqrt{tex}\,(W_p \times W_f)\right]$$

where W_p and W_f are the number of warp and weft threads per centimetre and the yarn tex is the same in the warp and weft directions.

those produced from the normal polyester. Autoclave-decatising reduced the air permeability significantly, probably due to it compacting the fabric (i.e. reducing the interstitial spaces) as shown by the increase in mass per unit area and the decrease in thickness of the fabrics (see Table II).

TABLE

CERTAIN PHYSICAL

BLEND % WOOL / % POLYESTER	FINISHING	CANTI-LEVER BENDING LENGTH (cm)	DRAPE COEFFICIENT (%)	EXTENSION AT BREAK (%)	BURSTING STRENGTH (kgf/cm 2)	AIR PERMEABILITY (cm 3/sec/cm2/cm of water pressure)	
						Measured at 1 cm water pressure	Measured at 5 cm water pressure
100/0	D	1,68	56,8	26,5	8,1	9,5	8,3
	KD	1,65	52,1	25,4	8,0	8,2	7,5
TREVIRA TYPE 220							
80/20	D	1,74	56,6	32,0	12,4	10,5	8,4
	K D	1,69	56,5	33,1	12,2	7,2	6,4
60/40	D	1,79	60,9	32,2	16,7	13,0	9,5
	K D	1,70	57,0	35,8	16,3	11,8	9,3
40/60	D	1,91	64,6	34,4	20,1	12,0	8,9
	K D	1,75	57,8	33,7	18,5	11,7	8,9
20/80	D	1,90	64,0	34,5	24,2	17,3	11,6
	K D	1,77	60,7	33,9	23,4	14,0	11,5
0/100	D	1,83	64,2	31,6	26,5	18,1	12,3
	K D	1,79	59,1	32,8	27,0	20,5	13,7
TREVIRA TYPE 330							
80/20	D	1,76	59,4	29,2	11,5	11,4	9,4
	K D	1,71	54,3	28,7	11,3	10,2	8,7
60/40	D	1,77	58,4	29,1	15,0	21,0	14,6
	K D	1,75	56,0	28,8	14,5	15,8	12,0
40/60	D	1,92	65,2	30,7	19,3	21,4	14,3
	K D	1,83	60,1	30,4	18,3	16,6	12,0
20/80	D	1,96	65,0	27,7	21,4	24,5	15,8
	K D	1,86	60,3	29,6	21,2	22,9	15,0
0/100	D	1,94	64,1	29,9	24,2	29,0	17,8
	K D	1,87	60,8	28,9	22,7	25,5	16,2

The Tensile Properties

Some of the fabric tensile properties have been plotted in Figures 1 and 2. In each case the warp and weft results were averaged and plotted against the polyester content (in *per cent*) of the blend.

The fabric tenacity at break (rupture) and the bursting strength showed similar trends and only the results of the former have been plotted. There was a very good linear relationship between these two parameters. The fabric tenacity increased almost linearly with an increase in the polyester content (see Fig 1). An increase of 20 *per cent* (absolute) in polyester content increased fabric tenacity by approximately 66 *per cent* in the case of the low-pilling polyester and by approximately 72 *per cent* in the case of

III

PROPERTIES OF THE FABRICS

SHIRLEY CREASE RECOVERY ANGLE (W+F) (in degrees)		MONSANTO CREASE RECOVERY ANGLE (W + F) (in degrees)		RELAXATION SHRINKAGE (% Area Shrinkage)		FELTING SHRINKAGE FOR A.W.B. TEST (% Area Shrinkage)	DURABLE PRESS RATING AFTER 48 min A.W.B. TEST
RH 65% (20 °C)	RH 75% (27 °C)	RH 65% (20 °C)	RH 75% (27 °C)	A.W.B. Test (3 min)	I.W.S. TM 9		
318	269	327	303	4,5	6,0	5,3	1,0
315	273	337	304	1,6	3,4	4,1	1,0
311	276	331	302	2,3	2,1	0,4	2,0
315	280	331	312	0,7	1,5	1,0	2,0
309	274	326	308	1,0	1,4	0,7	3,0
320	286	335	312	0,7	0,8	0,5	3,6
310	276	322	304	0,3	0,5	0,0	3,5
317	287	332	317	0,2	0,2	0,0	3,7
295	270	320	301	0,3	-0,1	-0,2	3,4
311	282	329	314	0,2	-0,4	-0,1	4,4
289	255	316	297	-0,2	-1,0	-0,3	3,7
299	278	325	322	-0,4	-0,8	-0,4	3,9
313	279	328	305	2,1	2,5	1,3	1,7
316	278	336	318	1,4	1,1	1,4	2,0
313	279	328	309	1,5	2,1	0,6	2,8
319	290	336	311	0,5	0,4	0,3	3,2
310	279	327	316	1,2	1,6	0,0	3,6
316	290	332	316	0,1	-0,3	0,1	3,9
305	283	328	310	1,1	0,7	0,2	4,2
310	288	335	320	0,2	-0,6	-0,2	4,3
300	280	320	302	0,6	-0,2	-0,1	3,8
317	290	328	316	-0,3	1,2	0,0	4,8

the normal polyester type. For bursting strength the corresponding increases were 39 *per cent* and 47 *per cent* for the low-pilling and normal polyester types, respectively. The differences between the two polyester types were not very large although blends containing the normal polyester type consistently performed better than those containing the low-pilling polyester. The autoclave-decatised fabrics were, if anything, marginally weaker than the decatised fabrics.

Increasing the polyester content also increased the Elmendorf tear strength although the effect was less pronounced above 60 *per cent* polyester content (see Fig 2). This test shows a greater difference between the two polyester types than that observed for bursting and tensile strength.

Fabrics containing the normal polyester had higher extension at break values (mean of all the blends containing the normal polyester was 33,4

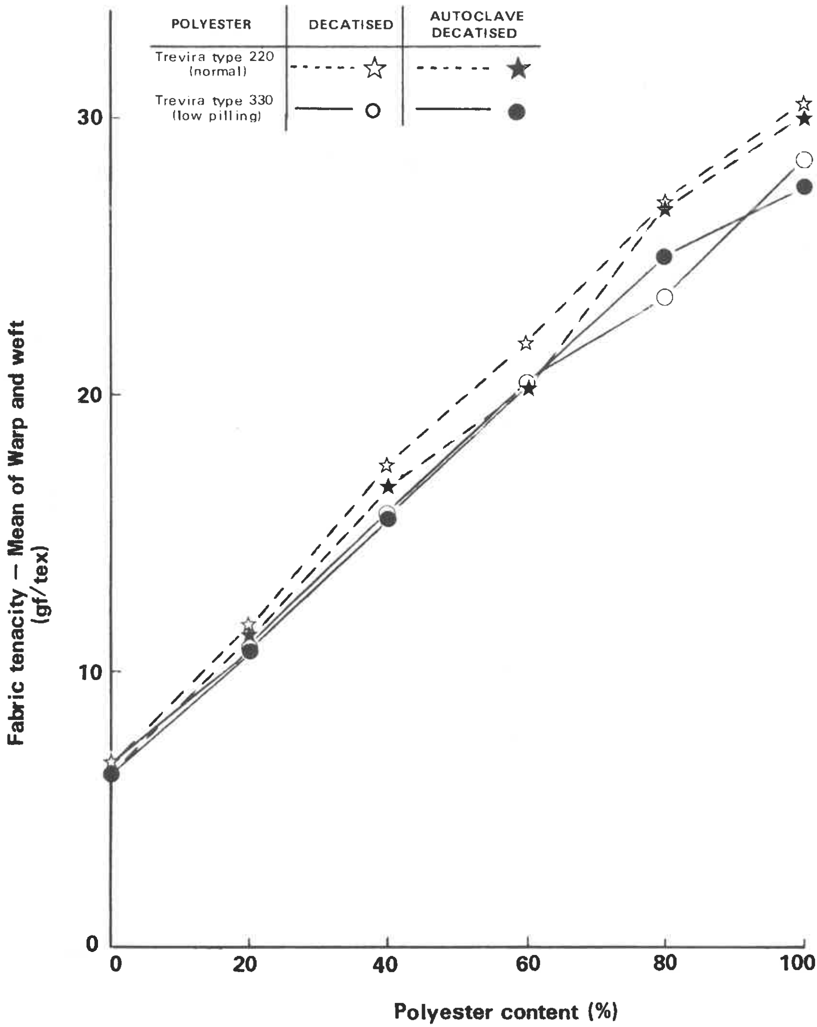

Fig 1 The relationship between fabric tenacity and polyester content

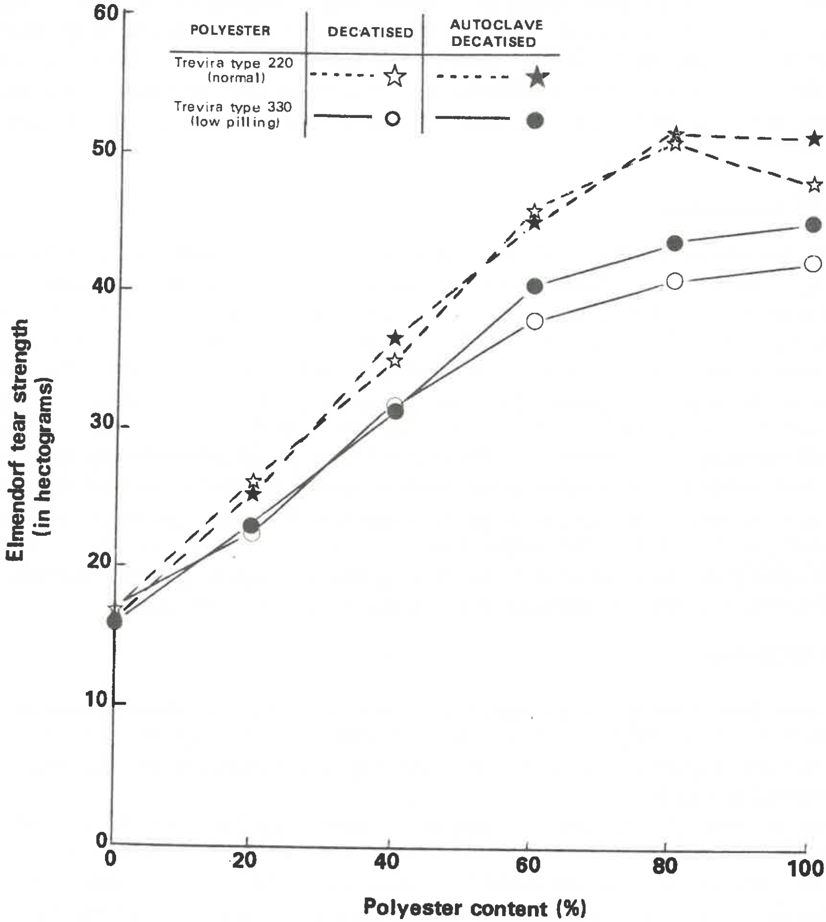

Fig 2 The relationship between tear strength and polyester content

per cent) than fabrics containing the low-pilling polyester (mean of the latter blends was 29,3 *per cent*). Within a polyester type the blend level had little effect on the extension at break although it was lowest for the pure wool fabrics. No consistent difference in the extension at break could be detected between the decatised and the autoclave-decatised fabrics (see Table III).

Abrasion Resistance

The results of the flat and flex abrasion tests have been plotted in Figs 3 and 4, respectively. From these figures it is clear that the abrasion resistance of the fabrics increased significantly as the percentage polyester increased. The normal polyester performed better than the low-pilling polyester particularly in the case of the flex abrasion. There appears to be no consistent difference between the flex abrasion of the fabrics which were decatised and those which were autoclave-decatised. In the case of flat abrasion, however, the autoclave-decatised fabrics had abrasion resistance which was inferior (i.e. higher mass losses during abrasion) to that of the decatised fabrics. The difference in resistance to flat abrasion between the autoclave-decatised and decatised fabrics was greatest for the pure wool fabrics indicating that autoclave-decatising had a slightly greater degradative effect on the wool component than on the polyester component.

Fabric Stiffness

Linear relationships were found between the drape coefficient and the cantilever bending length, and between the drape coefficient and the cantilever flexural rigidity. Only the flexural rigidity results have, therefore, been plotted in Fig 5.

The all-wool fabric had the lowest flexural rigidity and the flexural rigidity of the fabrics increased considerably with increasing polyester content. At corresponding blend levels the decatised fabrics had higher flexural rigidities than the autoclave-decatised fabrics. In the decatised state there was not a consistent difference between fabrics made from the two polyester types while there was a consistent difference between the polyester types in the autoclave-decatised state, fabrics containing the low-pilling polyester type being stiffer than those containing the normal polyester with the difference becoming greater as the polyester content increased.

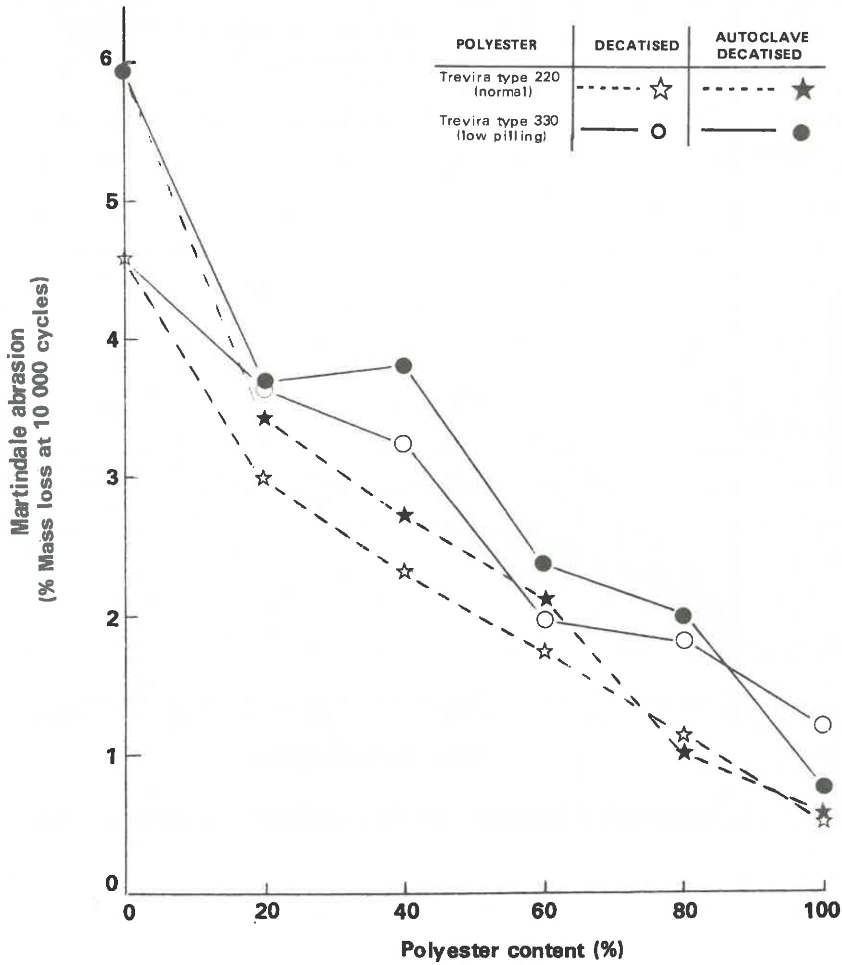

Fig 3 The relationship between Martindale flat abrasion and polyester content

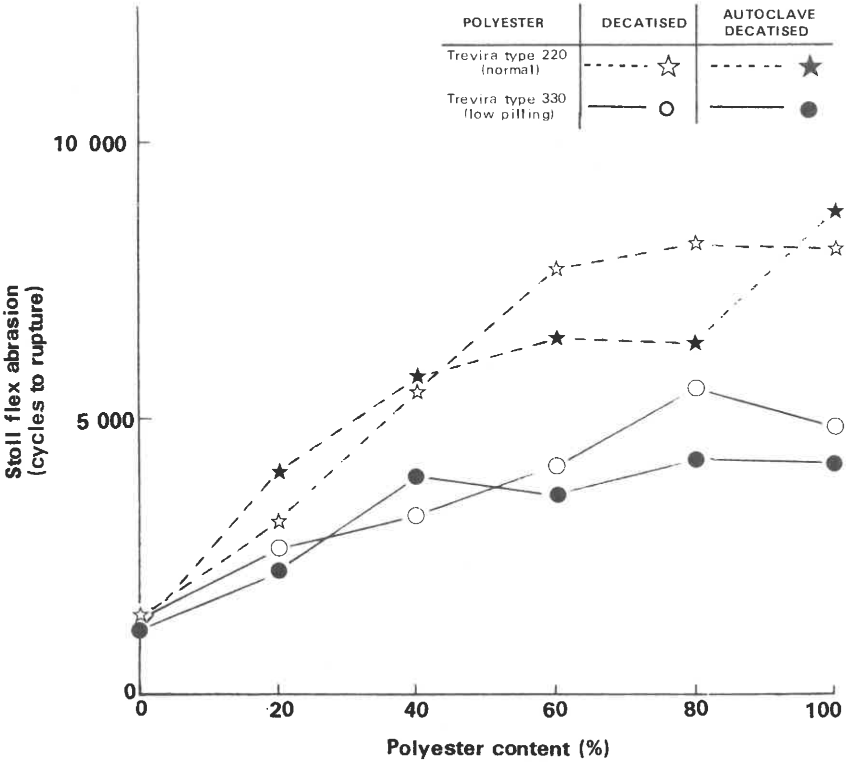

Fig 4 The relationship between Stoll flex abrasion and polyester content

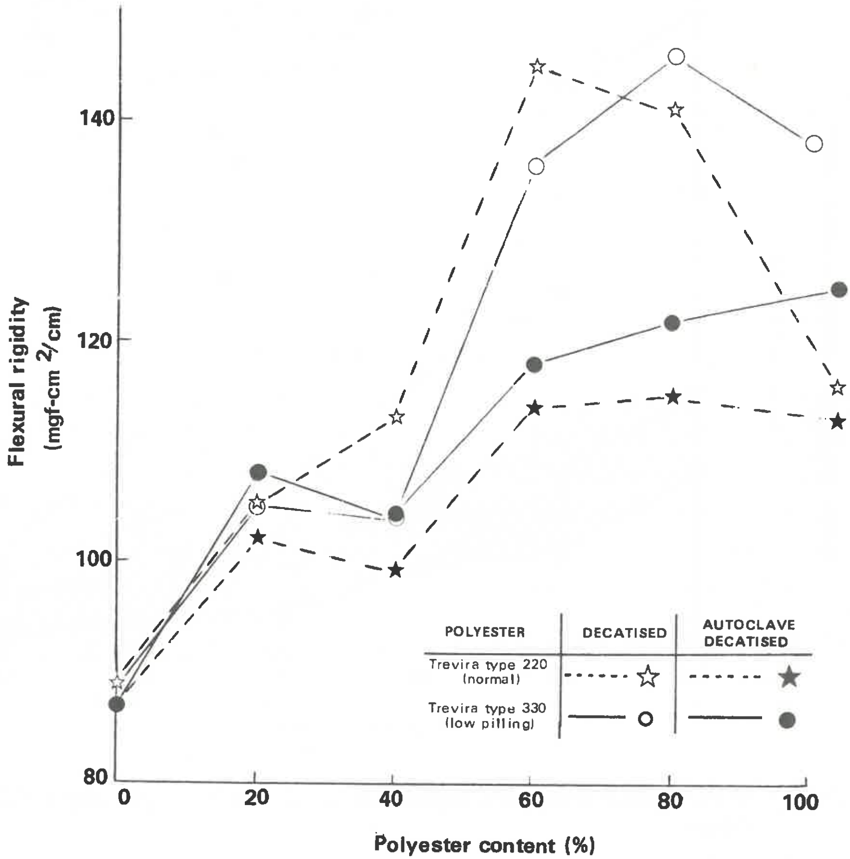

Fig 5 The relationship between flexural rigidity and polyester content

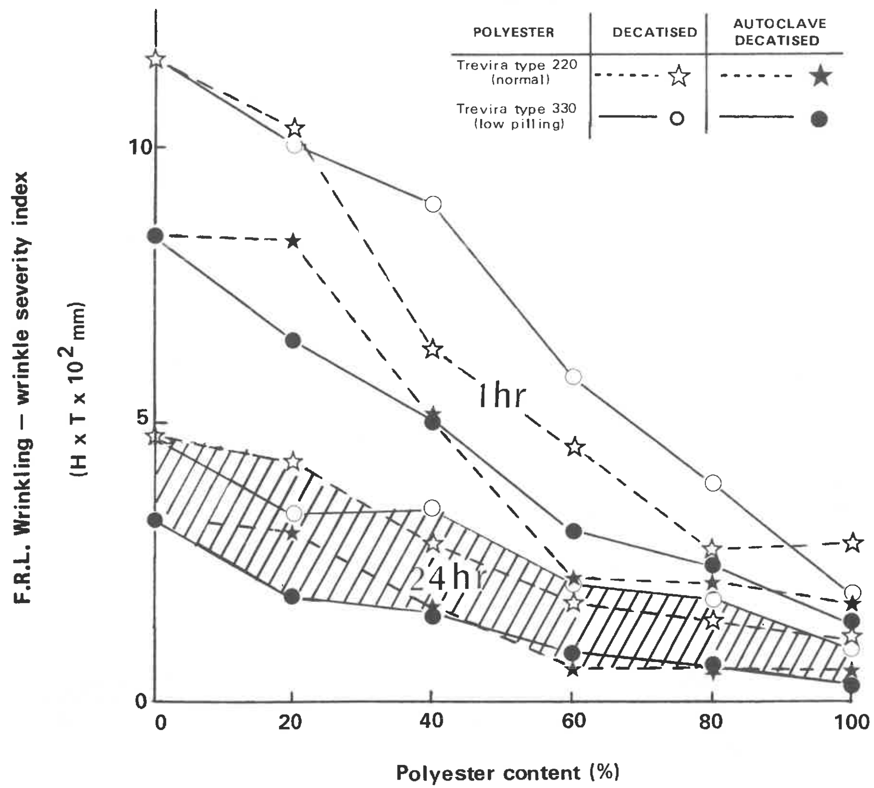

Fig 6 The relationship between wrinkle severity index (H x T) and polyester content

The drape coefficient showed the same trends with increasing polyester content and the state of finishing as did flexural rigidity but no difference could be detected between the polyester types.

Pilling

The resistance to pilling (results omitted) of the fabrics was very good and no differences were noticeable between any of the fabrics tested.

Wrinkle Recovery

The wrinkle severity index (H x T) was measured after FRL wrinkling (27°C and 75% RH) after both 1 hour and 24 hour recovery periods at 20°C and 65% RH (see Fig 6). From Fig 6 it is apparent that, for both recovery

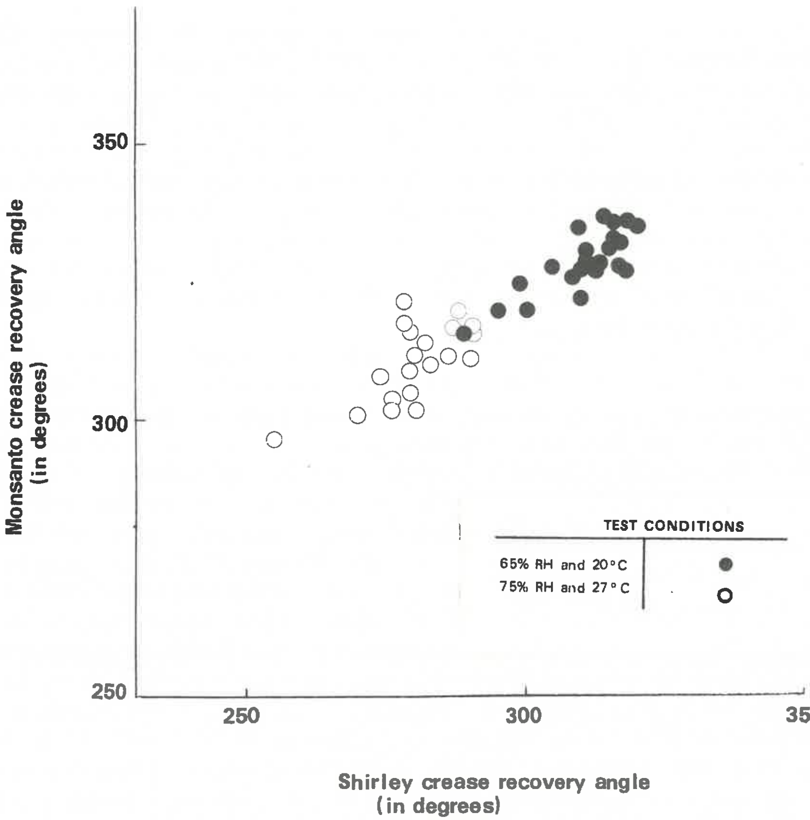

Fig 7 The relationship between Monsanto and Shirley crease recovery angles

periods, the wrinkle severity index decreased with increasing percentages of polyester implying that the wrinkling propensity of the fabrics increased with increasing wool content. No consistent difference could be detected between the two different types of polyester. Autoclave-decatising, on the other hand, effected large decreases in the H x T values (i.e. improvements in the wrinkling performance). In the case of the one hour recovery values the difference between decatised and autoclave-decatised fabrics was largest for the wool-rich blends and decreased as the polyester content increased until it virtually disappeared at very high polyester content. In the case of the 24 hour recovery the difference remained roughly constant, independent of the polyester level.

Crease Recovery Angle

The crease recovery angles were measured by both the Monsanto and the Shirley Methods at 65% RH/20°C and 75% RH/27°C without applying any de-ageing process. Recovery after creasing was under standard atmospheric conditions (20°C and 65% RH) in both cases. The relationship between the Monsanto and Shirley crease recovery angles is illustrated in Fig 7 for both the atmospheric conditions employed. It is apparent that, although the values are correlated, there is a considerable scatter in the results. Under both atmospheric conditions larger crease recovery angles were obtained by the Monsanto crease recovery method than by the Shirley crease recovery method. The effect of atmospheric conditions on the crease recovery angles is also apparent from the figure.

From Table III it is apparent that, whereas the wrinkle severity index clearly indicated an *improvement* in the resistance to wrinkling with increasing amounts of polyester, the Monsanto crease recovery angles changed little with increasing amounts of polyester in the blends. The same was apparent from the results obtained by means of the Shirley method. As could be expected, the fabrics wrinkled more (i.e. lower crease recovery angles) under the high humidity/high temperature conditions than under the low humidity/low temperature conditions. At 75% RH and 27°C the crease recovery angles tended to increase with increasing polyester content while at 65% RH and 20°C the opposite tended to occur. These trends could be ascribed to the fact that polyester has a relatively low equilibrium regain and is more sensitive to temperature whereas wool has a relatively high equilibrium regain and is less affected by temperature than by humidity (moisture).

The difference in crease recovery angle due to the different polyester types is small but, contrary to the FRL wrinkling results (wrinkle severity index), the low-pilling polyester performed slightly better, although it is doubtful whether this difference is of any practical consequence.

The crease recovery angles of the autoclave-decatised fabrics were higher (better) than those of the decatised fabrics confirming the results obtained by means of the FRL wrinkling test.

Washing Shrinkage

The "felting" shrinkage which occurred during the three hour Cubex wash test has been plotted against polyester content in Fig. 8. Although the area shrinkage was mush larger for the three hour Cubex wash test than for the A.W.B. wash test (compare results plotted in Fig 8 with those given in Table III) the results obtained showed the same trends in both cases; the shrinkage first dropped sharply with the introduction of 20 *per cent* of poly-

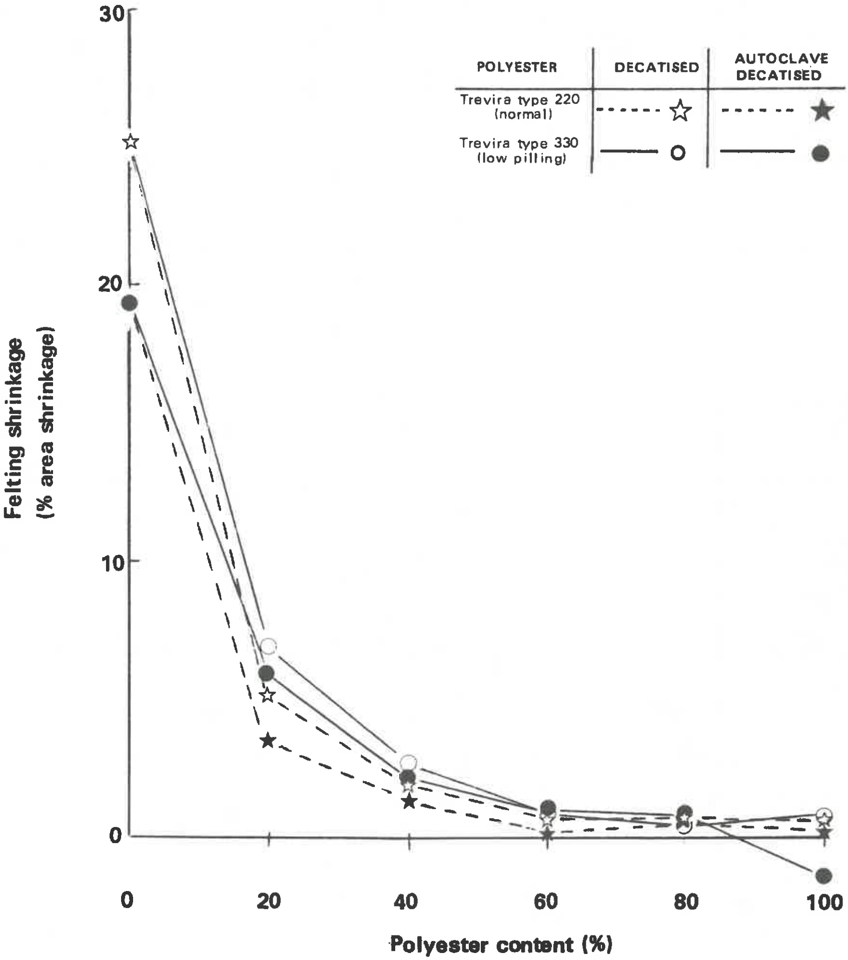

Fig 8 The relationship between felting shrinkage (3 hr Cubex wash) and polyester content

ester in the blend, after which the reduction was more gradual.

The blends containing the normal polyester performed slightly better than those containing the low pilling polyester while the autoclave decatised fabrics shrank less than the decatised fabrics. Differences in "felting" shrinkage due to the polyester type and the finishing process were larger for the wool-rich blends than for the polyester-rich blends.

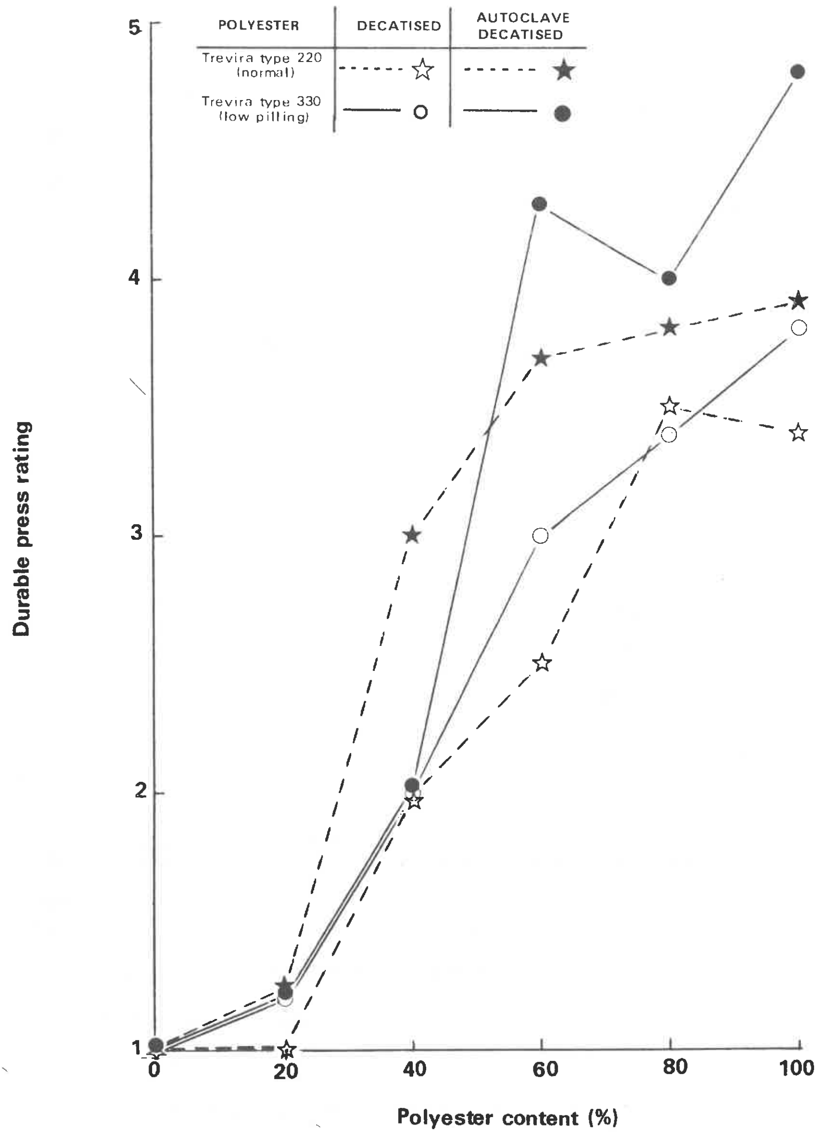

Fig 9 The relationship between durable press rating (3 hr Cubex wash) and polyester content

The relaxation shrinkage in area (see Table III) results followed more or less the same pattern as the "felting" shrinkage in area.

Appearance After Washing (Durable Press)

The durable press ratings were determined after both wash tests with those obtained after the three hour Cubex wash test plotted against polyester content in Fig 9. The trends for the two tests were the same except that the DP ratings were lower in the case of the more severe 3 hour Cubex wash test. It must be emphasized, therefore, that even better DP ratings could have been obtained had a less severe wash test been used.

The effect of polyester content on the durable press rating was very great. There was also a small improvement due to autoclave-decatising while the polyester type did not appear to affect the durable press rating materially.

Comparison Between the Present Results and those Obtained in a Previous Study.

If the performance of the normal polyester (Trevira type 220) is used as a basis of reference, it appears that the performance of the special low-pilling polyester type (Trevira type 330) studied here is similar to that of the low-pilling polyester type (Trevira type 350) previously studied[1] although the former gave higher tensile and air permeability and lower flexural rigidity values than the latter.

SUMMARY AND CONCLUSIONS

Certain mechanical properties of lightweight (200 g/m^2) plain weave fabrics consisting of blends of wool with either a low-pilling polyester type (Trevira type 330) or a normal polyester type (Trevira type 220) were compared. In this way the results obtained on the fabrics containing the low-pilling polyester (Trevira type 330) could also be related to those of fabrics containing wool and blends of other polyester types and which were studied in a previous investigation. Fabrics which had been autoclave-decatised were also compared with those which had been decatised only. Large increases in air permeability, strength, abrasion resistance, wrinkle resistance (but not crease recovery angles which hardly changed with polyester content) and flexural rigidity (stiffness) and improvements in easy-care properties (e.g. washing shrinkage and DP ratings) occurred with increasing polyester content.

The fabrics containing the normal polyester had slightly better strength and resistance to flat abrasion, slightly improved dimensional stability on washing (reduced washing shrinkage), lower fabric stiffness and air permeability and much greater resistance to flex abrasion, compared with those containing the low-pilling polyester. The two polyester types differed little in wrinkle recovery and durable press ratings, while the crease recovery angle results favoured the low-pilling polyester slightly.

Tensile strength and flex abrasion of both the autoclave-decatised and decatised fabrics were similar while the resistance to flat abrasion of the autoclave-decatised fabrics was slightly inferior to that of the decatised fabrics. Autoclave-decatising also decreased the air permeability and flexural rigidity of the fabrics and improved the wrinkle and crease recovery performance, the dimensional stability (i.e. reduced the area shrinkage during washing) and the appearance after washing (i.e. DP ratings).

The low-pilling polyester (type 330) covered in the present study appeared to give higher tensile and air permeability and lower flexural rigidity values than the low-pilling polyester (type 350) studied previously although their performance was similar in other respects.

ACKNOWLEDGEMENTS

The authors are indebted to the Weaving and Finishing departments at SAWTRI for the production and finishing of the fabrics. The technical assistance of Miss C. Goedhals and Mrs E. Dobson and permission by the S.A. Wool Board to publish these results are gratefully acknowledged.

THE USE OF PROPRIETARY NAMES

The fact that products with proprietary names have been used in this investigation does not imply that there are not others equally good or better.

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ISBN 0 7988 0590 0

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 P.U.D. Repro (Pty) Ltd., P.O. Box 44, Despatch