SAWTRI TECHNICAL REPORT

NO 244

Dimensional Stability of Wool/Acrylic Single Jersey Fabrics

by

H. M. Silver and N. van Heerden

SOUTH AFRICAN
WOOL AND TEXTILE RESEARCH
INSTITUTE OF THE CSIR

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

ISBN 0 7988 0582 X

DIMENSIONAL STABILITY OF WOOL/ACRYLIC SINGLE JERSEY FABRICS

by H. M. SILVER and N. VAN HEERDEN

ABSTRACT

Wool tops were chlorinated and then blended with acrylic staple fibres to produce blends of 75 per cent wool/25 per cent acrylic and 60 per cent wool/40 per cent acrylic Satin stitch single jersey fabrics produced from the blends were machine-washable after autoclave decatising. The curliness of the fabrics had been largely eliminated. The application of a resin, such as Navadine LT or Aerotex M-3 was not necessary for machine-washability of the fabric and after the application of the resin no significant improvement in the physical properties was found.

Fabrics were also produced from yarns which comprised untreated wool fibres and acrylic staple. These yarns were blended in the same proportions as described in the previous paragraph. The fabrics were set by either autoclave decatising or heat setting in a tenter which was followed by the application of either 1,0 per cent (o.m.w.) of polyurethane resin or 2,0 per cent (o.m.w.) of a silicone resin. These fabrics were found to be machine-washable and the curliness was largely eliminated in those fabrics which had been autoclave decatised. Certain physical properties of the fabrics treated with the silicone resin were tested. The application of the resin did not cause any improvement in these properties.

KEY WORDS

Wool/acrylic–single jersey–semi-locknit–satin stitch fabric–autoclave decatised heat set–resin treatment.

INTRODUCTION

The problems associated with the production of dimensionally stable, knitted wool fabrics have received increasing attention in recent years. The increase in production of knitted fabrics is one of the reasons for the increasing interest in this problem.

A number of papers dealing with the dimensional stability of all-wool and wool-rich knitted fabrics [1-3] have been published by SAWTRI. While machine washability of double jersey fabrics has been achieved [4,5] single jersey fabrics,

due to their greater instability, have created problems. Buys *et al* [6] produced a dimensionally stable wool-rich single jersey fabric by *feeder blending* wool with either a continuous filament polyester or a cotton yarn.

In the present report, the dimensional stability of single jersey fabrics produced from *intimate blends* of wool and acrylic fibres is discussed.

EXPERIMENTAL

The experimental layout for the various treatments and blends is shown in Figure 1.

Chlorination:

The wool top (64's) was continuously chlorinated at pH 1,8 with DCCA according to the process of Hanekom and Barkhuysen [7]. The level of chlorination was 1,5 *per cent,* active chlorine (o.m.f.).

Combing, Drawing and Spinning:

(a) Two lots of chlorinated wool (approx 12 kg) were treated by Hercosett and amino-plast resin, respectively. Each lot was subdivided into two sub-lots for blending with acrylic top comprising 75 *per cent* wool/25 *per cent* acrylic and 60 *per cent* wool/40 *per cent* acrylic.

All the lots were gill-blended three times on a Schlumberger intersecting gill box using a nominal draft of 6,8 and a faller pin density of 5 p.p. cm . At this stage it was noticed that the slivers contained too many neps and some slubs. It was decided to *re-comb* before drawing. A St. Andrea Comb was used for re-combing with the following settings: 26 gauge, 5 mm feed, 110 n.p. min and total input linear density of 259 ktex. The re-combed slivers were autolevelled on a Schlumberger intersecting gill box using a draft of 6 and a faller pin density of 6 pins/cm .

The first drawing (following the autolevelling) was carried out on a Schlumberger intersecting gill box using a draft of 7 and a faller pin density of 6 pins/cm and a sliver density of 12 ktex.

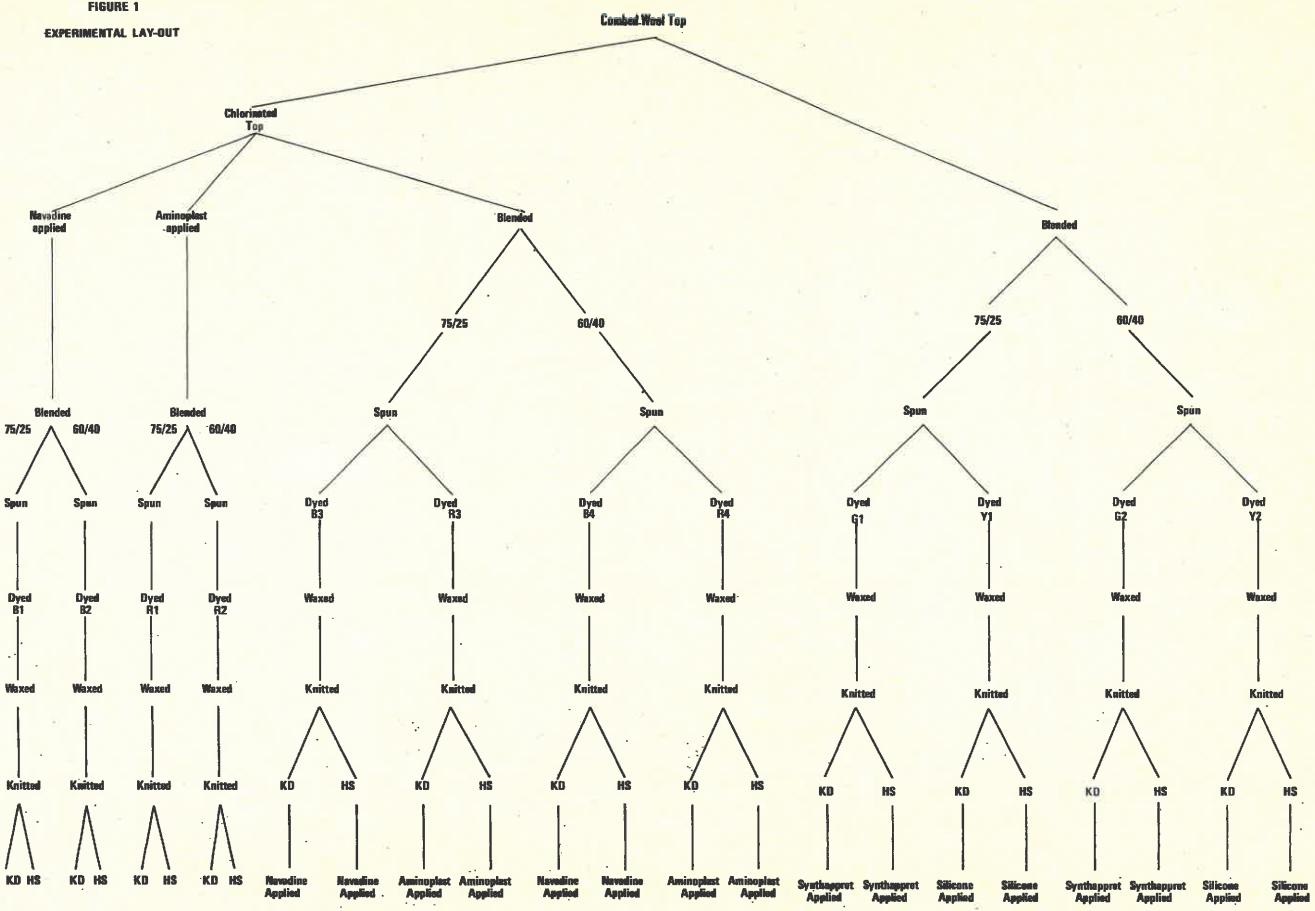
These slivers were further reduced to a roving with a linear density of 2,8 ktex before spinning.

(b) A further two lots of *chlorinated* wool (but not treated with resin) were blended with acrylic tops in the same ratios as under (a) and passed through drawing under identical conditions.

(c) Unchlorinated wool top was blended with acrylic top in the ratios as above (31 kg each per lot). Each blended lot was re-combed and drawn under the conditions set out under (a).

FIGURE 1

EXPERIMENTAL LAY-OUT



Spinning of 20 tex Yarns:

(a) Drawing

A 12,0 ktex sliver was used.

1st Drawing Schlumberger. GN.4

Conditions were as follows:
Input 36,0 ktex (total); Doublings 3; Draft 6,0;
Delivery 6,0 ktex; Front ratch 30 mm; Fallers 9 pins/cm;
Delivery speed 40 m/min.

2nd Drawing Schlumberger. GN.4

In this case the following settings were used:
Input 18,0 ktex (total); Doublings 3; Draft 6,0;
Delivery 3,0 ktex; Front ratch 30 mm; Fallers 9 pins/cm;
Delivery Speed 40 m/min.

Roving:

Schlumberger High Draft Double Apron Draw Frame:

The following conditions applied:
Input 6,0 ktex (total); Doublings 2; Draft 17,2;
Delivery 350 tex; Rubs/minute 370; Delivery speed 40 m/min.

(b) Spinning

Rieter H 6 Ring Spinner (Reduced Balloon Spindles)

For the spinning of the yarns the following conditions applied:
Input 350 tex; Draft 17,5; Delivery 20 tex; Turns per metre 580; Spindle speed 7 500 r/min; Traveller 26.

Steam Setting:

The yarns were set at 110°C for 10 minutes with a vacuum of 660 mm (one cycle).

Dyeing:

The yarns were dyed in cheese form using reactive dyes. The depth of shade was approximately 1 *per cent* (o.m.f.) for all shades. The procedures were as follows:

Prescour: The yarns were scoured in a bath set at 40°C, containing 0,5 g/*l* Eriopon HD (Ciba Geigy) and 4 *per cent* (o.m.f.) sodium chloride for 15 mins. The scour was followed by a warm (40°C) and a cold rinse.

Dyeing Procedure:

A 2,5 *per cent* (o.m.f.) ammonium sulphate
1,0 *per cent* (o.m.f.) Albegal A (Ciba-Geigy)
0,25 *per cent* (o.m.f.) Albegal B (Ciba-Geigy)

B adjust pH to 5 – 5,5 with acetic acid
add Lanasol dye (Ciba-Geigy)

C adjust pH to 4,5 – 5
add Maxilon dye (Ciba-Geigy)

D cool to 60°C at two degrees per minute.

Rinses:

E. Warm rinse – 15 minutes at 40°C

F. Cold rinse – 15 minutes at room temperature.

Knitting:

Twelve lots of yarn (20 tex) in the various blends were waxed and cleared before being knitted into a satin stitch fabric.

Machine Details:

The fabrics were knitted on a Bentley Jacquart Single Jersey (JSJ) machine, 26" diameter, 28 gg running at 15 r/min with a medium take-down tension.

The yarn input tension was 3 gf and the yarn speed 59 m/min.

Fabric Details:

The fabrics were knitted at a Machine Tightness factor of 12,21 (CF = 1,04), the SCSL being 0,366 cm (0,145 in.).

The resultant fabrics weighed approximately 150 g/m² having 14 courses/cm and 16 wales/cm .

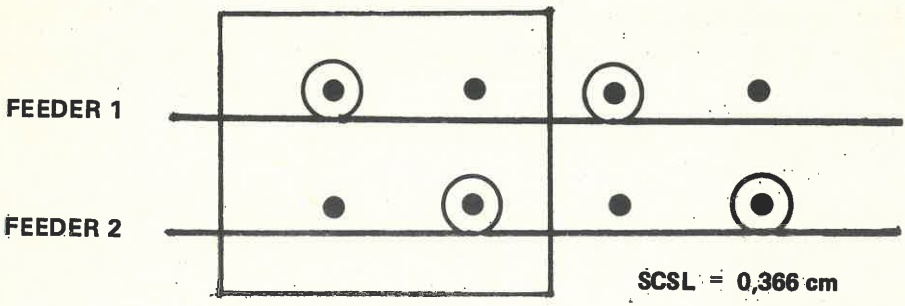


FIGURE 2
Satin Stitch Fabric (Semi-locknit)

Finishing:

All the knitted fabrics were dry-cleaned in perchloroethylene for 2 minutes prior to finishing. Each lot (of the twelve) was split into two sub-lots – one lot was heat set (HS) at 190°C for 45 seconds on an Artos Stenter, whereas the other lot was autoclave decatised (KD) on a Gessner machine at a steam pressure of 1 kg/cm^2 for 4 minutes (steaming for 2 minutes from outside to inside and 2 minutes from inside to outside).

Resin Applications:

(i) **Polyamide-epichlorhydrin**

(a) Applied to top: The chlorinated top was padded to a pick-up of 100 *per cent* with various concentrations of Navadine LT (25 *per cent* solids, Bayer) and 20 g/*l* sodium bicarbonate. The pH of the solution was adjusted (if necessary) to between 7,5 and 8,5. The tops were dried and the resin then cured at 90°C for 15 minutes.

(b) Applied to fabric: The fabrics were padded through a solution of Navadine LT at various concentration levels and 20 g/*l* sodium bicarbonate to effect a pick-up of 100 *per cent*. The fabrics were then dried and the resin finally cured at 90°C for 15 minutes.

(ii) **Amino-plast resin**

(a) Applied to top: The chlorinated top was padded through a solution containing an amino-plast resin of the alkylated methylolmelamine type at various concentration levels and Mystolube S (25 *per cent* solids, S.A. Cyanamid) in the proportion of 1:2 with resin to effect a total wet pick-up of 100 *per cent.* The tops were dried and the resin then cured at 110°C for 10 minutes[5].

(b) Applied to fabric: The fabrics from the chlorinated tops were padded through a solution containing 1,0 g/*l* amino-plast resin of the alkylated methylolmelamine type and 3,33 g/*l* Mystolube S to effect a pick-up of 100 *per cent.* The fabrics were dried and the resin was then cured at 110°C for 10 minutes.

(iii) **Polyurethane resin**

The fabrics were treated with Synthappret LKF (80 *per cent*, Bayer) at various concentration levels, with or without Synthappret LW in a Permac Böwe SF25 drycleaning machine [8], followed by steaming in an Andrews Autosetter for 2 min at 0,35 kg/cm^2, set for a double vacuum cycle[9].

(iv) **Silicone resin**

The fabrics were treated with DC 109 (Silicone) resin (Dow Corning) at various concentration levels in a Permac Böwe ST25 drycleaning machine[10]. The fabrics were then air-cured for 48 hours.

Testing of the Fabrics:

All the samples were relaxed according to IWS TM9 and then washed in an International Cubex machine for 3 hours according to IWS. Test Method 185 to

assess the effectiveness of the various treatments. Total area shrinkages less than 10 *per cent* were considered as a prerequisite for machine washability.

The following physical properties of the fabrics were determined:

(i) Fabric mass and thickness.
(ii) Bursting strength.
(iii) Air permeability[11] on a WIRA Air Permeameter utilising 1 cm water pressure
(iv) Celanese bagging[12]
(v) Pilling propensity after 2 000 cycles on a Martindale apparatus using a 200 g head weight.
(vi) Resistance to abrasion tested on a Martindale apparatus using a head weight of 795 g.
(vii) Curliness, ranked subjectively.
(viii) Wrinkling.

DETAILS OF TEST METHODS

1. FRL Wrinkling

Samples were creased for 20 min. at 27°C and 75% RH and allowed to recover for 1 hr. at 20°C and 65% RH before measuring. The lower the wrinkle height in mm (H) the better.

2. Celanese Bagging Test

Percentage Immediate Recovery (IR%) was measured; the higher the value the lower the bagging propensity.

3. Thickness was determined at a pressure of 5 g/cm^2.

4. Pilling

(a) Visual comparison with ICI snagging standards.
(b) N^2W index – a measure of number and mass of pills. (200 g headweight evaluated after 1000 cycles and 2000 cycles on a Martindale tester).

5. Curliness

The tendency of fabrics to curl was subjectively assessed in both the wale and course directions and the average taken as a measure of curliness.

RESULTS AND DISCUSSION

To determine what concentrations of Navadine LT and Aerotex M-3 were required to render the fabrics highly shrink-resistant, increasing concentrations of either Navadine LT or Aerotex M-3 were applied to either the chlorinated top or fabric (resulting from the chlorinated top).

The area felting shrinkages of the *resin-treated fabrics* are given in Table I.

TABLE I

PERCENTAGE AREA FELTING SHRINKAGE OF FABRICS TREATED WITH AEROTEX M–3 AND NAVADINE LT

Percentage Resin*		60% Wool/40% Acrylic		75% Wool/25% Acrylic	
		Autoclave De-catised (KD)	Heatset (HS)	Autoclave De-catised (KD)	Heatset (HS)
0% Resin (Chlorination only)		–0,1	2,7	0,8	–0,2
0,5%	Navadine	0,3	3,4	1,0	2,7
0,75%	"	0,5	2,2	2,5	2,9
1,0%	"	0,8	1,5	0	3,1
1,25%	"	0,5	0,2	–0,5	1,7
1,5%	"	0,5	1,5	–0,5	0,8
2,0%	"	0,7	0,3	0	0,8
0,1%	Aerotex M–3	–3,0	–1,5	1,0	–0,3
0,25%	"	–1,2	1,0	1,0	2,9
0,5%	"	1,0	–0,3	1,5	0,5
0,75%	"	0	2,5	0,8	4,1
1,0%	"	0,3	1,2	1,5	1,9

(* based on mass of wool)

It would appear that chlorination only of the wool top resulted in fabrics having a low felting shrinkage when blended with the acrylic fibre in the above proportions, followed by a setting treatment. The use of a resin would therefore, only be justified if the resin improves the physical properties of the fabrics produced from the chlorinated tops.

To obviate prechlorination of top, samples of fabrics were treated with increasing concentrations of either Synthappret LKF or Dow Corning DC 109 resin, washed and the area felting shrinkages of these samples are given in Table II.

TABLE II
PERCENTAGE AREA FELTING SHRINKAGE OF RESIN-TREATED FABRICS (NO PRIOR CHLORINATION OF WOOL TOP)

	75/25-Wool/Acrylic		60/40-Wool/Acrylic	
Resin	KD	HS	KD	HS
NONE	29,0	48,8	8,8	25,7
1% Synthappret LKF	2,4	3,4	2,4	2,0
" + 0,15% Synthappret LW	3,4	2,5	1,0	3,4
1,5% Synthappret LKF	0,5	1,1	1,4	1,6
" + 0,2% Synthappret LW	1,9	1,9	0,5	3,1
2% Synthappret LKF	1,5	2,9	1,5	2,4
" + 0,25% Synthappret LW	1,9	0,7	1,0	0,9
1,5% Silicone resin	4,7	14,4	1,4	2,7
2,0% Silicone resin	3,1	3,4	0,5	3,4
2,5% Silicone resin	1,7	0,7	–1,0	1,5
3,0% Silicone resin	1,0	2,5	–0,3	2,9
3,5% Silicone resin	1,2	1,7	–0,5	3,8
4,0% Silicone resin	0,3	0,5	0	1,0

One *per cent* (o.m.f.). Synthappret LKF proved to be sufficient to render fabrics highly shrinkresistant for either setting procedure or blend of fibres. The handle of the fabric was not noticeably improved if a softener (Synthappret LW) was added. The application of 1,5 *per cent* (o.m.f.) Dow Corning DC 109 silicone resin to the 60/40-wool/acrylic blend was sufficient to produce fabrics of low felting propensity, after setting (KD or HS) of the fabrics. With the 75/25-blend, 2,0 *per cent* (o.m.f.) silicone resin was required.

In Table III the relaxation and felting shrinkages of fabrics treated at various levels are shown.

TABLE III

PERCENTAGE AREA RELAXATION AND FELTING SHRINKAGES OF FABRICS USING CHLORINATION AND CERTAIN RESIN TREATMENTS

Resin	Conc. (%)	Blend of wool acrylic	Stage Resin Applied	% Area Shrinkage			
				Heat Set		Autoclave decatised	
				Relax-ation	Felt-ing	Relax-ation	Felt-ing
None (Chlorination only)	–	75/25	–	4,8	3,8	1,0	3,1
Navadine LT	0,5	75/25	Fabric	4,8	–0,5	4,4	–0,2
Navadine LT	1,5	75/25	Top	4,7	1,7	1,0	1,1
Navadine LT	1,5	60/40	Top	7,1	–0,5	3,4	0
Aerotex M–3	1,0	75/25	Top	9,5	3,6	3,8	1,2
Aerotex M–3	1,0	60/40	Top	6,2	2,4	2,9	1,0
None (untreated)	–	75/25	–	19,0	35,8	3,1	28,3
Synthappret LKF	1,0	75/25	Fabric	1,7	4,2	1,5	6,0
None (untreated)	–	60/40	–	10,0	18,1	2,7	10,2
Synthappret LKF	1,0	60/40	Fabric	–0,2	3,2	2,2	3,6
DC 109 Silicone Resin	2,0	75/25	Fabric	4,5	2,9	3,6	1,0
DC 109 Silicone Resin	2,0	60/40	Fabric	4,3	1,9	2,0	0,5

The application of 1 *per cent* (o.m.w.) Synthappret LKF to the set (HS or KD) fabrics was sufficient to produce machine washable fabrics (see Table III). The effectiveness of autoclave decatising in stabilizing the fabrics is clearly seen by comparing the relaxation shrinkages of the heat-set and autoclave decatised, untreated (unchlorinated) fabrics. Application of the 2,0 *per cent* Silicone resin was also sufficient to achieve machine washability.

The physical properties of the fabric produced from a chlorinated top with a final resin treatment with Navadine LT were measured. Five fabrics were tested: before setting treatment; after head set treatment (HS or KD) and after head set and resin application. These properties are listed in Table IV.

TABLE IV

PHYSICAL PROPERTIES OF FABRIC (75/25-WOOL/ACRYLIC) TREATED WITH NAVADINE LT

Property	Before any heat-set treatment	After HS	After HS + resin	After KD	After KD + resin
Mass (g/m^2)	171	161	156	171	168
Bursting strength (kg/cm^2)	5,2	4,9	4,3	5,1	4,7
Abrasion (% mass loss after 10 000 cycles)	16,7	18,0	12,0	19,1	17,3
Pilling (rating after 1 000 cycles)	2,9	2,7	2,5	2,7	2,7
Pilling (rating after 2 000 cycles)	2,3	2,8	3,5	2,5	2,7
Fabric thickness (mm)	0,77	0,71	0,78	0,60	0,69
Air permeability ($cm^3/sec/cm^2$)	118	135	167	90	129
FRL (s.d.)	—	—	—	0,54	0,57
CURLINESS*	3,0	3,5	1,5	0,5	0
CELANESE BAGGING (IR%)	33,5	48,5	49,9	45,8	52,3

* A low value implies little curliness, a high value high curliness

TABLE V

PHYSICAL PROPERTIES OF FABRICS (75/25 AND 60/40) KD-TREATED FOLLOWED BY 2,5% DC 109 SILICONE RESIN APPLICATION

Property / Composition	KD-Treated only		KD-Treated+ Silicone Resin		Untreated (Light Blown Finish Only)	
	75/25	60/40	75/25	60/40	75/25	60/40
Mass (g/m^2)	170	168	170	181	172	163
Thickness (mm)	0,53	0,55	0,53	0,69	0,71	0,64
Bursting strength (kg/cm^2)	5,9	6,5	5,5	6,0	5,7	6,6
Air permeability ($cm^3/sec/cm^2$)	64,4	67,3	61,0	75,0	112,3	101,8
Abrasion resistance (% mass loss after 10 000 cycles)	15,3	10,1	13,0	11,9	11,8	9,8
Wrinkling (FRL) Mean Wrinkle height in mm(H)	0,54	0,55	0,73	0,91	–	–
Pilling propensity (after 1 000 cycles)	2,38	2,25	2,63	2,0	2,38	1,88
Visual rating and N^2W-index	104	116	143	143	90,8	158
Celanese Bagging (% IR)	56,7	52,4	48,9	46,1	53,6	54,0
Curliness* (mean ranking score)	0	0	0	0	4,5	4,0

* A low value implies low curliness whereas a high value indicates excessive curliness.

The results in Table IV show that the application of a resin to the fabric from the chlorinated top did not improve the physical properties of the fabric. There is therefore no justification for the use of a resin as it improves neither the machine washability nor the physical properties of the fabrics. Setting will, however, be necessary in order to reduce the curliness of the fabrics and autoclave decatising would appear to be the more successful setting process. Fabrics treated with 2,0 *per cent* (o.m.f.) Dow Corning DC 109 silicone resin were washed and the physical properties of the fabrics also measured. The shrinkage results are listed in Table III while the physical properties are given in Table V.

Once again it can be seen that the application of a resin is not justified in terms of the mechanical properties of the fabrics.

SUMMARY

Untreated (unchlorinated), chlorinated and chlorinated plus resin-treated 64's quality wool tops were blended with 3 – 4 den acrylic fibres to produce yarns comprising 75% wool/25% acrylic and 60% wool/40% acrylic. The yarns were knitted into a satin stitch fabric (semi-locknit structure) with a mass of about 150 g/m^2.

The fabrics produced from the yarns containing the *untreated* (unchlorinated) wool fibres were either autoclave decatised or heat-set in a tenter, followed by the application of either 1,0 *per cent* (o.m.w.) of a polyurethane resin or 2,0 *per cent* (o.m.w.) of a silicone resin. These fabrics were found to be highly resistant to felting shrinkage and curliness was largely eliminated in those fabrics which had been autoclave decatised and resin-treated

The fabrics produced from the yarns containing *chlorinated* wool fibres were set as described above and then treated with either 0,1 *per cent* (o.m.w.) of an amino-plast resin or 0,5 *per cent* (o.m.w.) of a polyamide-epichlorhydrin resin. It was found that excellent resistance to felting shrinkage was obtained by chlorination alone so that the application of the resin was apparently unnecessary.

The fabrics produced from the yarns containing the wool fibres which had been *chlorinated* as well as *resin-treated* in the top with either an amino-plast or polyamide-epichlorhydrin resin were set either by autoclave decatising or heat-setting and were also found to be machine washable.

Certain physical properties of the fabrics treated with either the polyamide-epichlorhydrin or silicone resin were investigated. The application of the resin did not effect any major improvement in these properties.

ACKNOWLEDGEMENTS

The authors wish to thank Miss Pam Schouten for valuable technical assistance and the Division of Textile Physics for carrying out the physical tests.

REFERENCES

1. Knapton, J. J. F., Relaxation and Felting Shrinkage of All-wool knitted fabrics, *S.A. Wool Text. Res. Inst.* Techn. Rep. No. 116 (March, 1969).
2. Knapton, J. J. F. Schwartzkopff, K. K. H., Dimensional Properties of All-Wool Punto-di-Roma Structure, *S.A. Wool Text. Res. Inst.* Techn. Rep. No. 122 (July, 1968).
3. Wolfaardt, C., Slinger, R. I. and Buys, J. G., Wool-rich blends in Double Jersey Knitting, *S.A. Wool Text. Res. Inst.* Techn. Rep. No. 166 (May, 1972).
4. Van der Merwe, J. P. and Silver, H. M., The finishing of wool-rich double Jersey fabrics containing Nylon Filament, *S.A. Wool Text. Res. Inst.* Techn. Rep., No. 174 (Sept. 1972).
5. Hanekom, E. C., de Mattos, G. W. P. and Fryer, D. B., Shrink-resist treatment of Wool Fabrics with an Alkylated Methylolmelamine resin, *S.A. Wool Text. Res. Inst.* Techn. Rep. No. 154 (Sept., 1971).
6. Buys, J. G., Van der Merwe, J. P. and van Rooyen, A., The Dimensional Stability of Single Jersey Fabrics from Wool Rich Blends, *S.A. Wool and Text. Res. Inst.* Techn. Rep. No. 221 (May, 1974).
7. Hanekom, E. C., and Barkhuysen, F. A., An Improved Process for the Chlorination of wool with DCCA, *SAWTRI Bulletin,* **8,** No. 2, p. 19, (June 1974).
8. Bayer, Synthappret LKF, Leverkussen (July, 1969).
9. Van der Merwe, J. P. and Van Rooyen, A., Dimensional Stability of Knitted Fabrics treated with Synthappret LKF., *S.A. Wool Text. Res. Inst.* Techn. Rep. No. 144 (Jan., 1971).
10. Dow Corning Bulletin: 22 – 151 – 01, 6/73.
11. Shilöh, M., Kruger, P. J. and Slinger, R. I., Properties of Some Fabrics from Wool/Nylon Core Spun Yarns, *S.A. Wool Text. Res. Inst.* Techn. Rep. No. 176 (Oct., 1971).
12. Thomas, W., Celanese Bagging Test for Knit Fabrics, *Text. Chemist & Colorist,* 231 (Oct., 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.

ISBN 0 7988 0582 X