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MIRIAM SHILOH, E. C. HANEKOM

and

R. I. SLINGER

SOUTH AFRICAN WOOL TEXTILE RESEARCH INSTITUTE
P.O. BOX 1124
PORT ELIZABETH

MECHANICAL PROPERTIES OF A RESIN TREATED WOOL/COTTON BLEND FABRIC

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ABSTRACT

A 55/45 wool/cotton blend fabric was treated with various amounts and types of resin and crosslinking agents. Although the dry wrinkle recovery could not be improved, the wash-and-wear properties were improved to a level which may be commercially acceptable.

KEY WORDS

Wool/cotton blends, wrinkle resistance, wash-and-wear, resins, crosslinkers

INTRODUCTION

Fabrics having widely differing physical properties can be obtained by intimately blending fibres having disparate mechanical properties. Studies have been made by Coplan[1] in which binary blend fabrics were considered as single fibre component fabrics having a bimodal distribution of their mechanical properties. In this particular investigation attempts were made to estimate the contribution of fibres of each of the components in the blend to the mechanical properties of the fabric but it was found that the predicted effect was not always observed. The tensile behaviour of blend fabrics was also studied by Kemp and Owen[2] who noted that the tensile properties of nylon/cotton blend fabrics were higher than predicted by their assumptions of the fibre distribution.

When blending different fibres, it is usually attempted to accentuate the best characteristics of both components and mask the worst. Comparing the mechanical properties of cotton and wool it appears that the cotton fibre is approximately twice as stiff and more than twice as strong as the wool fibre. Owing to the high extensibility of the wool fibre its work-to-rupture is approximately four times higher than that of a cotton fibre. Wool is also more resilient and recovers more and faster from strain. As a result, the crease resistance of wool at moderate humidities is much higher than that of cotton. Owing to the complex factors involved, however, it is rather difficult to predict how a certain blend of cotton and wool will behave in respect of strength, crease recovery, or any other mechanical property. The properties of such a yarn or fabric will not necessarily be intermediate between those of the yarns and fabrics made from the component fibres.

Some of the less advantageous properties of wool are felting shrinkage and low abrasion and pilling resistance. In intimate blending the second fibre acts as a dilutant and a sharp decrease in felting shrinkage, can for instance, be anticipated when increasing the percentage of the other, non-felting, fibre. In the case of cotton, it is known that certain 50/50 wool/cotton blend fabrics have been labelled as washable without any need for chemical treatment. On blending wool with another fibre to mask its undesirable characteristics it is essential to retain its superior qualities, viz. drape, handle extensibility, warmth, resilience and relative non-flammability. It can be expected that on blending with cotton these qualities as well as crease recovery will worsen but a higher strength and durability will be gained. Again it is not possible to predict the extent to which these properties will be affected. In this regard, however, work by O'Connell, Pardo and Fong[3, 4, 5] has indicated that, with suitable durable press treatments, commercially acceptable wool/cotton blend garments can be made.

In recent years commercially advantageous properties have been imparted to cotton by chemical modification and through special finishing processes. By means of permanent press treatments dry wrinkle recovery in cotton fabrics has been improved to a large extent, but sometimes the loss in strength which is associated with the resin treatment precludes such treatments. If a fabric, which consists of a blend of cotton and another fibre, is chemically treated in the same process as the pure cotton fabric, it is not quite clear what the result will be since the uptake of resin in the cotton component of the blend will be difficult to assess and control. Over-treatment of the cotton fibres in the blend may occur much more easily than in the pure cotton fabric. In such a case the cotton fibre could become much weaker which can lead to deterioration of the mechanical properties of the fabric. On the other hand, it is also possible that some modification or resin coating of the other component may occur.

It is because of the unpredictable nature of this blend component-resin interaction that studies of resin treatment of wool/cotton blends were commenced. In this preliminary investigation, effects of certain permanent press treatments, which are known to be successful for pure cotton fabrics or pure wool fabrics[6], were applied to wool/cotton blend fabrics and the changes in the physical properties were assessed.

EXPERIMENTAL

Materials:

A 45/55 cotton/wool fabric was woven, using intimately blended R28 tex/2 yarn spun after gilling on the continental system. The folding twist was 420 t.p.m. while the singles twist was 450 t.p.m. The 64's wool (mean fibre length 6,1 cm) was blended with $1\frac{1}{8}''$ long staple cotton. The yarns were woven to produce a square plain weave fabric with 17,4 picks and ends per cm (44 $inch^{-1}$) and the fabric's density was 180 g/m^2 before scouring. It was crabbed and lightly scoured after weaving so that the final density increased to 210 g/m^2. Out of this fabric samples, measuring 90 cm X 30 cm, were cut.

Experimental Design and Treatments:

The design of the experiment was that of a 2^3 factorial plus a control fabric. Each treatment was repeated three times.

The first factor was the resin Aerotex M-3 (Cyanamid) (an alkylated methylol-melamine resin) at two different levels of application. The second factor was crosslinker and was either Fixapret CPN (B.A.S.F.) (4,5 -dihydroxy dimethylol ethylene urea) or Aerotex Reactant 82 (Cyanamid) (methylolated alkyl carbamate). The last factor was softener, this being Mystolube S (Catomance) a polyethylene emulsion. In all cases a catalyst, zinc nitrate hexahydrate, and a wetting agent, Tergitol Speedwet (0,2%) were used.

The samples were Hoffmann pressed and padded to 75% weight pick-up. The samples were air dried for 16–24 hours and before curing they were steam pressed on a Hoffmann press in the following manner:–

10 seconds open press,
30 seconds closed press,
30 seconds baking,
5 seconds vacuum.

Finally the samples were predried for 5 mins at 100°C and cured for 5 mins at 160°C.

The eight different combinations of treatments together with the standard, untreated fabric, provided 27 fabric samples and these are described in detail in Table I.

TABLE I

TREATMENT APPLIED TO WOOL/COTTON FABRICS

Sample	% Aerotex M-3 (owf)	% Fixapret (owf)	% $(Zn(NO_3)_2 .6H_2O$ (owf)	% Mystolube S (owf)	% Aerotex Reactant 82 (owf)
A	2,5	2,5	0,5	2	–
B	2,5	2,5	0,5	0	–
C	5	5	1	2	–
D	5	5	1	0	–
E	2,5	–	0,5	2	2,5
F	2,5	–	0,5	0	2,5
G	5	–	1	2	5
H	5	–	1	0	5

TABLE II

PHYSICAL PROPERTIES OF WOOL-COTTON FABRICS

Test Sample	Density (g/m^2)	% Area shrinkage		Yellowness Ranking before washing	Cantilever Flexural Rigidity mg-cm^2/cm			Mean Crease recovery angle (W + F)		F.R.L. H (mm)	Smoothness score of fabric after		Breaking Load (kg)
		3 mins	48 mins		Before Washing	After Washing	% Decrease	Before washing Degrees	After washing Degrees		One washing	Two washings	
Control	212	4,8	11,0		251	205	18,3	241,8	226,5	0,81			45,9
A	228	3,5	3,5	8 (most)	398	243	38,9	246,2	242,6	0,56	27	24	43,3
B	224	1,9	3,4	2	251	220	12,4	246,8	228,3	0,79	8	8	44,1
C	234	1,8	1,3	7	542	282	49,0	239,6	239,5	0,69	46	48	42,5
D	232	2,7	1,6	1 (least)	278	200	28,1	255,5	241,0	0,49	37	32	44,1
E	224	2,1	1,9	4	532	266	50,0	236,1	240,0	0,77	22	40	41,6
F	218	2,7	4,5	5	200	227	-13,5	252,8	218,6	0,64	14	16	35,7
G	230	2,7	3,2	6	798	285	64,3	242,5	246,7	0,80	45	64	34,3
H	227	2,1	2,5	3	290	218	24,8	254,3	232,4	0,47	53	48	34,3

Physical Tests:

The flexural rigidity (cantilever method), crease recovery angle and FRL wrinkle resistance of the fabrics were measured by methods published elsewhere[7]. The fabric shrinkage was determined in accordance with the AWB specifications[8]. in the Cubex and the smooth drying properties obtained by ranking of the visual appearance after drip drying. The breaking load was determined by means of the I.W.T.O. (tentative) method.

RESULTS AND DISCUSSION

The mean results of some of the measured physical properties are presented in Table II. A summary of the analysis of variance of these is given in Table III.

The diluting effect of the cotton component was most noticeable in the shrinkage of the cloths (Table II) since the untreated standard fabric shrank only 11% after 48 mins washing in the Cubex. All the treatments given to the fabrics further reduced the shrinkage. Due to the low levels of shrinkage it was not possible to draw any further, more specific, conclusions as to the effect of resin, crosslinker or softener, on shrinkage.

The gravest drawback of these treatments was that the fabrics yellowed, stiffened and possessed a poor handle. Examination of the yellowness ranking results indicated that the main source of yellowing appeared to be the softener. The presence of softener and resin also increased the flexural rigidity enormously and to obviate this it was decided to wash the fabrics since this is a simple method of breaking the inter fibre bonds formed by the resin.. The decrease in the flexural rigidity after washing was large so that all the fabrics could now be considered to possess a satisfactory flexural rigidity, with the largest decrease occurring in the fabrics which had been treated with resin softener mixtures. Whereas before washing resin, crosslinker and softener had affected the flexural rigidity, now only the latter still had a significant effect (the difference due to the presence of softener after washing was about 20%). Furthermore, after washing the discolouration of the treated fabrics was hardly visible.

The crease recovery angle of these fabrics was determined and, besides the fact that the crease recovery relative to a pure wool fabric was generally poor, it appeared that the presence of softener was again deleterious to this mechanical property. The FRL wrinkling test (which gives results similar to the wrinkle height defined by Shiloh[9]) was also carried out but apart from confirming the overall poor wrinkle resistance no significant effects could be detected. After washing the fabrics, however, the crease recovery angle of the fabric treated with softener improved to such an extent that a slight preference for the addition of softener was indicated. Rather surprisingly the level of resin made only a small difference while the type of cross-linker made no difference at all to the crease recovery of the fabrics.

The smooth appearance of the fabrics after washing was assessed by means of ranking scores and these are given in Table II (a high value denotes a smooth

TABLE III

ANALYSIS OF VARIANCE ON CERTAIN PHYSICAL PROPERTIES

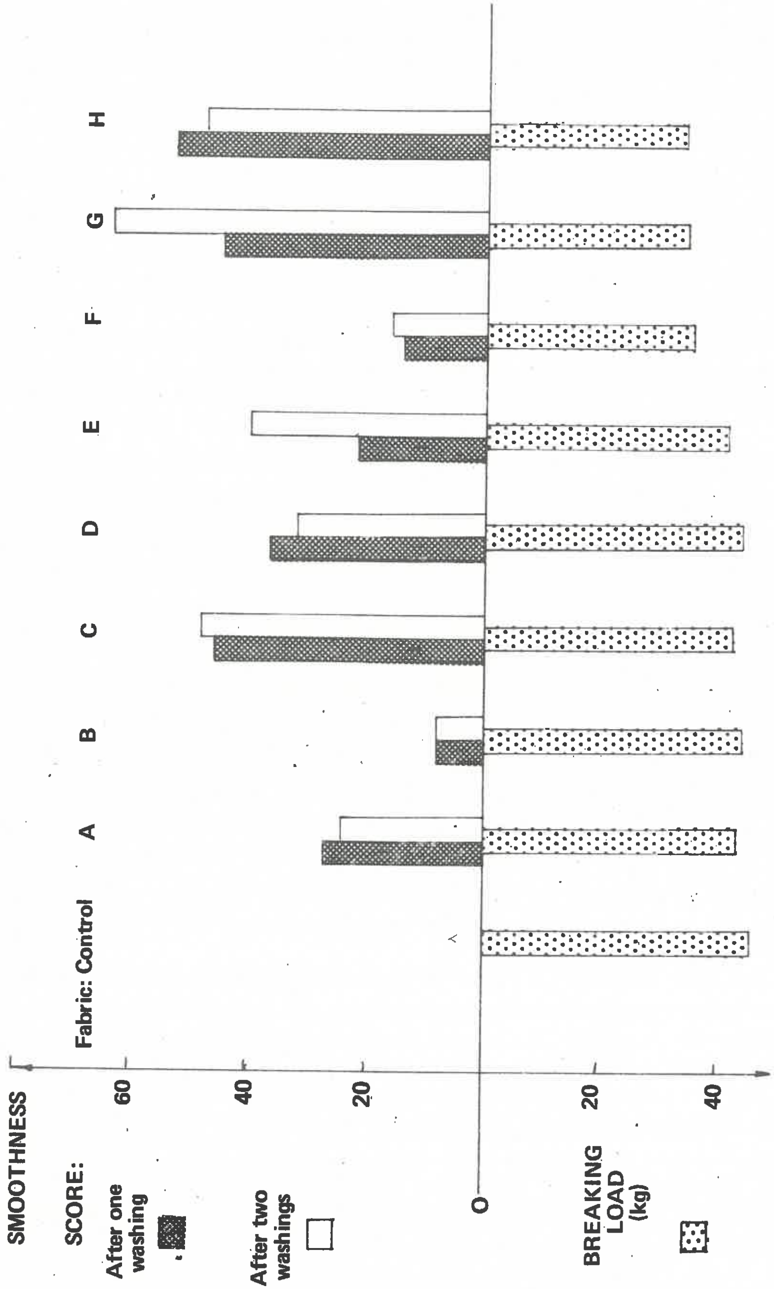
Source of Variance	df	Flexural Rigidity before Washing F	Flexural Rigidity after Washing F	Crease Recovery Angle F
Crosslinker	1	6,68*	0,66	0,22
Resin	1	17,83**	0,38	3,25
Softener	1	97,19***	19,23***	67,76***
Direction	1	4,70*	25,02***	0,52
C x R	1	1,69	0,06	1,17
C x S	1	10,49**	0,02	4,71*
R x S	1	6,00*	4,08	3,61

* denotes a statistical significance of 5%
** denotes a statistical significance of 1%
*** denotes a statistical significance of 0,1%

appearance). The standard fabric, which was also the fabric which shrank the most, was the fabric judged to have the most wrinkled appearance. A second assessment was made after a second wash in order to confirm that the first wash had not destroyed the effects of the treatments. It was clear that this did not happen and from Table II it appears that softener, once again, had a most pronounced effect, this time to enhance the smooth appearance of the fabric. A high resin level improved the appearance of the fabric appreciably as well but the difference between cross-linkers was marginal with Aerotex Reactant 82 possibly being very slightly better. Judging by these results, therefore, it appears that 5% resin with softener provides a fabric which would rate very high on the AATCC wash-and-wear standards[10] and would quite possibly be considered as possessing commercially acceptable smooth drying properties.

The last property monitored was that of the breaking strength of the fabrics. The breaking strength of the Fixapret-treated fabrics was of the same order of magnitude as the control breaking strength while the fabrics treated with Aerotex reactant 82 crosslinker sustained a loss of about 9 kg (20%) in breaking strength. On the other hand Martindale abrasion resistance results (not given in the table) showed no particular loss in strength up to 20 000 cycles, and flex abrasion decreased by approximately 40% for all fabrics. In this respect, these results differed from the results obtained by O'Connell *et al* since the decrease in flex abrasion due to treatments on their fabrics was close to 90%.

Fig. 1 has been included to provide a guideline for the most suitable treatment, In this figure the breaking strength and the smooth drying properties of these fabrics



SMOOTH DRYING APPEARANCE AND BREAKING LOADS OF WOOL/COTTON TREATED FABRICS are depicted. From the figure it appears that the best smooth drying properties were obtained with treatments D, G and H. The loss in breaking strength of the latter two fabrics is quite large, however, and it may, therefore, be concluded that the 5% resin plus 5% Fixapret, with or without softener, provided the most acceptable fabric.

In conclusion, the overall effect of these resin treatments was to improve the wet wrinkle resistance considerably but to worsen the dry wrinkle resistance. The latter observation may be due to the way in which the resins were applied and this aspect is therefore the subject of further investigations. As was stated before, the appearance after washing of certain of the treated fabrics could possibly be commercially accepted as drip-dry. Initially the stiffness of the fabrics was very high but this was remedied by breaking the inter-fibre resin bonds by means of physical agitation. Finally, the yellowing caused by the treatments was negligible, and after washing, the loss in mechanical strength was not so high as to disqualify the treatments.

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Permission by the S.A. Wool Board to publish this report is appreciated.

THE USE OF PRODUCTS WITH PROPRIETARY NAMES

The fact that certain products with proprietary names have been used in this investigation in no way implies that they are recommended or that there are not others which are as good or better.

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