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Studies of Some Wool/Acrylic Woven Fabrics

Part I: Untreated Plain and 2/2 Twill Weave Fabrics from Wool Blended with Regular Acrylic

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ABSTRACT

Wool/acrylic intimate blend yarns, ranging from all-wool to all-acrylic, were prepared by blending a 64's quality merino wool with either a 3,3 or 4,9 decitex regular acrylic, and processed into plain and 2/2 twill weave lightweight fabrics.

The overall fabric performance, when compared with that of a similar all-wool fabric, improved with increasing acrylic content, except for the crease recovery angle and the resistance to flex abrasion which were reduced. The 2/2 twill fabrics had better dry wrinkle and crease recovery and marginally better strength characteristics than the plain weave fabrics, but were inferior to the plain with regard to washing shrinkage, appearance after washing, resistance to pilling and resistance to flat abrasion. Air permeability and stiffness were the only fabric properties affected by both the acrylic fibre fineness and the finishing procedure.

INTRODUCTION

The three most important synthetic fibres used in apparel today are polyester, nylon and acrylic. Acrylic (polyacrylonitrile) fibres are not used as much as polyester (polyethylene terephthalate) and nylon (polyamide)[1] but each fibre type has certain unique properties and certain preferred end uses[2]. The tenacity and toughness of acrylic fibres are inferior to those of polyester and nylon but acrylic has other attribures. Apart from being the most "wool-like" of all the synthetic fibres, acrylic fibres also have tactile and visual aesthetics, good dimensional stability, dyeability, warmth retention, comfort in wear, durability, weatherproofing, high bulkiness, etc.[2, 3, 4]. Many modified acrylic fibre types, each engineered to solve a weakness (or deficiency) of acrylic fibres, have been developed so that there are now anti-static, flame retardant, anti-pilling, acid-dyeable fibres, etc.[4].

The processing into yarn of wool/Courtelle blends has been examined[5, 6]. Yarn strength increased with an increase in the Courtelle content of the blend[5]. The relationship between yarn extension and the blend ratio depended upon the twist factor. At the lowest twist factors the all-wool yarns had the lowest extension and the extension increased as the Courtelle content increased. At the higher twist factors the yarn extension also increased with increasing Courtelle content, although the all-wool yarn was more extensible than the wool-rich blends. Some tensile properties of worsted blend yarns were examined by Aldrich and Grobler[7] and their findings on wool/Orlon blend yarns were in general agreement with the foregoing.

Edwards and Sneyd[6] examined the production and finishing of woven fabrics from Courtelle/wool blend yarns and determined certain mechanical properties of the fabrics. They found that the Shirley crease recovery angles of the wool/Courtelle blend fabrics were virtually independent of the acrylic (Courtelle) content, the washing shrinkage decreased considerably as the Courtelle content increased, the resistance to abrasion improved as the Courtelle level increased and there was no evidence of pilling. Other aspects investigated included dye fastness, pleating, seam strength and the effect of dry cleaning and Hoffman pressing.

In a comprehensive report on the effect of different fibre blends and blend ratios on the properties of 2/2 twill woven suitings (8 oz/yd^2 or 270 g/m^2) Subramanian[8], *inter alia,* also examined wool/Orlon blend tropical and serge fabrics. His findings were very similar to those of Edwards and Sneyd[6]. The fabrics containing acrylic (Orlon) had improved dimensional stability, better press retention, higher bulk and better tensile strength than the all-wool fabrics. The tear strength and the resistance to abrasion were largely unaffected by the Orlon content. It should be noted, however, that in these trials the yarns were spun to the same *diameter* rather than to the same linear density (count) and therefore, because of the greater bulk of the acrylic fibres, yarns of lower linear density were spun as the percentage acrylic in the blend increased. Increasing the acrylic content was found to reduce the crease recovery and to increase the flammability of the fabrics. Creasing at higher humidities and temperatures led to poorer crease recovery, relative to the all-wool fabrics, at all blend ratios.

To supplement previous studies[9, 10] on wool/polyester blend fabrics, work was initiated in which regular acrylic was to be blended with wool in various proportions, the objectives being to establish what effects blend proportion and fibre linear density (dtex or denier) have on fabric properties and to compare the fabric properties of acrylic/wool blends with those of polyester/wool blends.

EXPERIMENTAL

Materials

A 64's quality merino wool top was blended with each of two undyed regular acrylic (relaxed Orlon) tops. These acrylic tops differed in that the fibre linear density of the one was 3,3 dtex and of the other was 4,9 dtex. Some of the fibre properties of the respective lots are given in Table I, the tests being the same as those employed in a previous investigation[10].

The wool and acrylic were blended in top form during four passages through an intersecting gill box. Tops were prepared in the following blends from each of the two lots of acrylic fibres:

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

These tops were then processed in the normal way to produce R42 tex S400/2 Z650 worsted yarns. Each blend was woven into square fabrics of both plain and 2/2 twill structure of nominally 22 ends and 22 picks per cm. The fabrics were finished to a fabric mass per unit area of approximately 190 g/m^2. The various finishing sequences for the different blend ratios are set out briefly in Table II. The finishing procedures were selected to suit the blend. Some of the intermediate blends were subjected to two finishing procedures enabling the effect of finishing to be studied.

Yarn Tests

All the yarns were tested under standard atmospheric conditions (20 ± 2°C and 65 ± 2% RH). Tests were carried out on both the singles and two-ply yarns.

The yarn linear density (in tex) and CV of linear density of the singles yarn was calculated from the mass of ten 100 metre lengths, each 100 metre length being taken from a different spinning tube. Similarly, four 100 metre lengths, one from each of four different cones were used for estimating the linear density of the two-ply yarns.

The singles yarn twist was determined on a Zweigle automatic twist tester using the double untwist-twist test method. For this purpose ten twist determinations were carried out on each of five different cones. The plying twist was determined manually on the same tester. Five tests per cone were carried out on each of four different cones in the case of the plying twist. A test length of 50 cm was employed for all the twist determinations.

TABLE I

PROPERTIES OF FIBRES USED IN THE BLENDS*

TYPE OF FIBRE	MEAN FIBRE LENGTH (mm)	MEAN FIBRE BREAKING STRENGTH (cN)	SINGLE FIBRE TENACITY (cN/tex)	SINGLE FIBRE EXTENSION (%)	BUNDLE TENACITY (cN/tex)
Wool, 64's – 20,1 μm	72 (44,4)	5,1 (44,6)	14,6 (40,4)	40,7 (24,4)	10,4
Acrylic (Orlon) – 3,3 dtex	84 (59,3)	7,0 (22,8)	21,1	26,8 (24,0)	19,3 (4,9)
Acrylic (Orlon) – 4,9 dtex	90 (43,6)	10,1 (17,2)	20,7	27,5 (23,0)	18,7 (3,7)

*Figures in parenthesis indicate coefficient of variation in *per cent.*

TABLE II

FINISHING PROCEDURES FOR THE VARIOUS BLEND RATIOS

BLEND	HEAT-SETTING	CRABBING	HEAT-SETTING	WINCH SCOUR
100% Wool	–	10–15 min + non-ionic	–	–
80% Wool/ 20% acrylic	–	10–15 min + non-ionic	170°C x 60 sec	–
60% Wool/ 40% acrylic	–	5 min + non-ionic	170°C x 60 sec	–
60% Wool/ 40% acrylic	170°C x 60 sec	5 min + non-ionic	–	–
40% Wool/ 60% acrylic	170°C x 60 sec	5 min + non-ionic	–	–
40% Wool/ 60% acrylic	170°C x 60 sec	–	–	40–60°C (20 min)
20% Wool/ 80% acrylic	170°C x 60 sec	–	–	40–60°C (20 min)
100% Acrylic	170°C x 60 sec	–	–	40–60°C (20 min)

All the fabrics were subsequently steamed, brushed, cropped and decatised.

The yarn breaking strength and extension at break were measured on an Uster automatic breaking strength tester with the mean time to break adjusted to fall within the range 20 ± 3 s. For the singles yarn 20 tests per spinning tube on each of 10 spinning tubes were carried out and for the two-ply yarn 25 tests were carried out on each of four cones.

The yarn irregularity (CV in %) and the frequencies of imperfections (i.e. thin places, thick places and neps per 1 000 metre) were measured on the Uster series of evenness testing equipment. For both the singles and the two-ply yarn the testing speed was 100 m/min and the duration of the test was 2,5 min. For the singles yarn, one such test was carried out on each of the 10 spinning tubes while in the case of the two-ply yarn one such test was carried out on each of 4 cones. This meant that a total of 2 000 metres of singles yarn and 1 000 metres of two-ply yarn were tested per blend. The yarn faults were monitored on an Uster Classimat fault classifying instrument.

Fabric Tests

Where possible standard testing procedures were employed for measuring the mechanical and wrinkling properties of the fabrics. These procedures were generally the same as those used in previous studies and were briefly as follows: The threads per cm were measured according to British Standards (BS) test method 2 862: 1972. The fabric mass per unit area was determined according to test method BS 2471: 1971 (Section 2). The fabric thickness was measured on a Reynolds and Branson tester – the area of the presserfoot was 1 cm^2 and the thickness was measured at a pressure of 0,49 kPa (5 gf/cm^2) at ten different places on the fabric. Except for the pressure used, the method was the same as the British Standards (BS) test method 2 544: 1967. The cantilever bending length (or stiffness of the cloth) and the assessment of the drape of the fabrics were determined according to test methods BS 3356: 1961 and BS 5058: 1973, respectively. The drape coefficient was obtained on samples of 30 cm diameter. The flexural rigidity was also calculated from the bending length results. The air permeability of the fabrics was measured on a WIRA Air-Permeameter at 98 Pa and 490 Pa (i.e. 1 cm and 5 cm) water pressure, respectively. Ten specimens were tested in each case using the method given in the Shirley Institute Test Leaflet (see also BS Handbook 11: 1974; methods of test for textiles, p4/171).

The tear strength of the fabrics was measured on an Elmendorf Tester according to ASTM D1424-63 (Reapproved 1970). Three specimens in each fabric direction were tested.

The bursting strength (pressure) of the fabrics was determined on a Mullen tester. The method was similar to that of British Standard (BS) test method 4768: 1972 but the time taken to burst the fabric was approximately one fifth of the prescribed breaking time. In addition, the diaphragm diameter was slightly different from that prescribed, being about 32 mm.

The fabric breaking strength and the fabric extension at break were measured on an Instron tensile tester (constant rate of extension) using the Draft International Standard (ISO/DIS 5081 – 1976). Fabric strips with an unravelled width of 50 mm were extended at constant rate so as to break within 30 ± 5 s. The test length was

20 cm and the pretension one *per cent* of the breaking load. The fabric tenacity (in cN/tex) was calculated from the breaking strength of these strips, the thread count per cm and the yarn linear density.

The resistance to flex abrasion was determined on a Stoll Universal wear tester according to ASTM test method D 1175-71. The parameter measured was the number of cycles required to rupture a fabric strip which had been unravelled to a width of 25,4 mm (i.e. on inch). A headload of 4,45 N (1 lbf) and a blade tension of 17,8 N (4 lbf) were used.

The resistance to flat abrasion was determined on a WIRA (Martindale) abrasion tester according to the WIRA method (see also BS Handbook 11: 1974, Methods of test for textiles, p4/49). A rubbing pressure (headload) of 12,1 kPa (28 oz/in^2) was used and the percentage mass loss was determined after 10 000 cycles.

Estimates of the resistance to pill formation were also obtained on the Martindale abrasion tester according to IWS test method 196. In this case the rubbing pressure was 3,0 kPa (7 oz/in^2) and the fabric was rubbed self on self. The pill ratings were obtained on both the square and the smaller disc by comparison with the standard set of IWS photographs after both 1 000 cycles and 2 000 cycles of rubbing.

The relaxation shrinkage was determined according to IWS TM9 while further shrinkage (termed felting shrinkage) was determined according to IWS TM185 which involves a 3 hr Cubex wash at 40°C. The durable press ratings of the fabrics were obtained, after the fabrics had been subjected to the wash test already described (i.e. IWS TM185), by comparison with the AATCC Three-Dimensional Durable Press Replicas[11]. It may be noted that this wash test is probably a lot more severe than that normally used for assessing the DP performance of cotton and other fabrics. This means that the DP values obtained here would tend to be low.

The crease recovery angle was determined by AATCC Test Method 66-1972 using Monsanto crease recovery testers. Before creasing, the fabrics were de-aged by a process similar to that published elsewhere[12, 13]. The de-ageing process involved immersing the fabrics in water (a small amount of wetting agent added) at 20°C for 30 minutes, brief hydroextraction, Hoffman pressing while the fabrics were still damp and finally oven drying at 40–45°C for 90 minutes. The fabrics were then conditioned for approximately 18 hours at either 65% RH/20°C or 75% RH/27°C, depending upon the atmosphere in which the fabrics were to be tested. In all cases recovery after creasing was allowed to take place in a standard atmosphere (i.e. 65% RH/20°C).

The standard deviation of the FRL wrinkling curve in mm (or the wrinkle height, "H") was measured according to the method developed by Slinger[14]. The fabrics were de-aged and then conditioned at 75% RH and 27°C. Subsequently the fabrics were creased on an FRL wrinkle tester for 20 minutes (also at 75% RH and 27°C) and allowed to recover for one hour at 65% RH and 20°C after which the fabric profile was traced and the wrinkle height calculated.

TABLE III

PHYSICAL PROPERTIES OF YARNS

BLEND	YARN LINEAR DENSITY		BREAKING STRENGTH		YARN TENACITY (cN/tex)	EXTENSION		IRREGULARITY (CV in%)	THIN PLACES PER 1 000 m	THICK PLACES PER 1 000 m	NEPS PER 1 000 m	CLASSIMAT FAULTS PER 100 000 METRES (Two-ply yarn)	
	Mean (tex)	CV (%)	Mean (cN)	CV (%)		Mean (%)	CV (%)					Total*	"Objectionable"**
SINGLES YARN													
100% Wool	20,4	1,4	125	13,1	6,1	9,4	31,5	20,6	328	129	53	–	–
3,3 dtex Acrylic													
80% Wool/20% acrylic	20,6	1,2	147	12,0	7,2	9,2	27,0	19,8	229	70	47	–	–
60% Wool/40% acrylic	20,7	1,1	188	13,4	9,1	13,6	23,2	19,1	143	50	43	–	–
40% Wool/60% acrylic	21,1	1,3	242	11,9	11,5	16,0	18,3	17,8	74	34	50	–	–
20% Wool/80% acrylic	20,7	2,7	290	12,2	14,0	18,0	13,3	17,3	52	29	42	–	–
100% Acrylic	20,7	3,9	347	10,0	16,8	19,8	9,1	16,3	32	19	40	–	–
4,9 dtex Acrylic													
80% Wool/20% acrylic	20,6	1,6	140	14,8	6,8	8,6	29,3	20,7	304	99	59	–	–
60% Wool/40% acrylic	21,2	1,7	181	15,0	8,5	11,3	26,2	20,1	245	85	44	–	–
40% Wool/60% acrylic	20,5	0,9	218	15,1	10,7	14,3	21,8	19,7	205	68	46	–	–
20% Wool/80% acrylic	21,2	2,1	275	15,5	13,0	17,1	17,8	19,6	183	63	36	–	–
100% Acrylic	21,2	1,7	321	13,7	15,1	18,5	13,6	19,6	170	42	14	–	–
TWO-PLY YARN													
100% Wool	41,2	1,0	280	9,7	6,8	12,2	22,6	14,5	8	3	4	63	6
3,3 dtex Acrylic													
80% Wool/20% acrylic	41,5	0,5	340	8,8	8,2	13,5	19,0	13,9	1	2	7	85	4
60% Wool/40% acrylic	41,8	0,5	448	6,9	10,7	17,3	9,7	12,4	0	0	0	100	4
40% Wool/60% acrylic	43,0	2,2	535	8,6	12,4	19,8	11,7	11,9	0	0	0	138	3
20% Wool/80% acrylic	42,8	2,9	657	8,0	15,4	21,4	7,5	11,4	0	0	0	410	5
100% Acrylic	42,3	2,3	752	7,0	17,8	23,5	7,2	10,8	0	0	0	539	9
4,9 dtex Acrylic													
80% Wool/20% acrylic	41,2	1,3	324	10,5	7,9	12,5	21,1	14,6	7	5	5	45	2
60% Wool/40% acrylic	42,7	0,3	431	10,9	10,1	16,8	15,5	14,4	8	5	6	26	3
40% Wool/60% acrylic	41,7	1,7	520	9,0	12,5	18,6	11,4	14,0	5	0	7	47	3
20% Wool/80% acrylic	43,2	0,9	620	8,2	14,3	20,5	10,7	13,9	2	0	5	81	8
100% Acrylic	42,9	1,4	713	9,5	16,6	22,2	9,2	13,7	5	1	4	111	13

* $A_1 + B_1 + C_1 + D_1$
** $B_4 + C_3 + D_2$

RESULTS AND DISCUSSION

YARN PROPERTIES

The physical properties of the yarns (both singles and plied) are given in Table III. From these it can be seen that the yarn strength increased almost linearly with an increase in acrylic content from approximately 6,5 cN/tex for the 100 *per cent* wool yarns to approximately 16,5 cN/tex for the 100 *per cent* acrylic yarns. The yarns containing the 3,3 dtex acrylic fibres were always slightly stronger than those containing the 4,9 dtex acrylic fibres. The mean difference in breaking strength between the yarns comprising the two acrylic fibres was about 7 *per cent* for the singles and about 5 *per cent* for the plied yarn at all blend ratios (the percentage difference was based on the breaking strength of the 4,9 dtex yarns). The yarn tenacity showed differences of the same order and in the same direction. The average ratio of plied to singles breaking strength was 2,3:1 and that for the tenacity was 1,1:1.

The yarn extension increased almost linearly as the acrylic content increased for both the singles and plied yarns. The 100 *per cent* wool yarns had an extension of approximately 10 *per cent* whereas the 100 *per cent* acrylic yarns had an extension about double this value. The extensions of the yarns containing the 4,9 dtex acrylic fibres were always slightly lower than those of the yarns containing the 3,3 dtex acrylic fibres. There was a larger difference between the extension of the two-ply and singles yarns than between the two different fibre linear densities.

The yarn irregularity and the frequencies of thick and thin places and neps generally decreased as the acrylic content increased. The rate at which the improvements occurred with increasing acrylic content depended upon the acrylic fibre linear density (dtex). The use of the finer acrylic fibres resulted in greater improvements in all the irregularity properties except for the nep frequency which seemed to be more or less independent of fibre linear density. The yarn irregularity (CV %) was virtually independent of the acrylic content in the case of the yarns containing the 4,9 dtex acrylic fibres. All this is consistent with Martindale's[15] theory on the dependence of yarn irregularity on the number of fibres in the yarn cross-section.

In the case of the plied yarns, the frequencies of imperfections were only slightly dependent upon the acrylic content, generally these frequencies being so low that no differences of any practical consequence could be detected between the different acrylic fibres. Only for yarn irregularity (CV %) could trends similar to those observed for the singles yarns be detected for the two-ply yarns. The Classimat results show a clear difference between the yarns produced from the two different acrylic fibre lots with the 4,9 dtex acrylic fibre lot generally superior. When the 3,3 dtex acrylic fibres were blended with the wool the total number of Classimat faults increased with increasing acrylic content.

FABRIC PROPERTIES

The various fabric properties are given in Tables IV and V.

TABLE IV

CERTAIN FABRIC MECHANICAL PROPERTIES

BLEND LEVEL*	Sett (Threads per cm)		Fabric Mass per Unit Area (g/m^2)	Thickness (in mm) Measured at 0,5 kPa	Air Permeability ($ml/s/cm^2/cm$ of water pressure)		Cantilever Bending Length (cm)			Cantilever Flexural Rigidity (mN.mm)			Drape Coefficient (%)	Bursting Strength (kN/m^2)	Elmendorf Tear Strength (N)			Fabric Breaking Strength (N)		Fabric Breaking Tenacity (cN/tex)		Mean Fabric Tenacity (cN/tex)	Extension at Break (%)		
	W	F			Measured at 1 cm water pressure	Measured at 5 cm water pressure	W	F	Mean	W	F	Mean			W	F	Mean	W	F	W	F		W	F	Mean
Plain Weave – 4,9 dtex																									
100% Wool	24,3	18,9	191	0,399	10,6	8,8	1,76	1,51	1,64	10,4	6,6	8,5	53,7	813	22,0	13,2	17,6	355	248	7,1	6,4	6,7	37,6	31,1	34,4
80% Wool/20% acrylic	23,9	18,6	186	0,399	12,3	9,6	1,80	1,65	1,73	10,8	8,4	9,6	56,2	882	18,1	15,7	17,0	398	321	8,2	8,4	8,2	29,2	28,1	28,7
60% Wool/40% acrylic	23,0	18,5	188	0,401	8,3	6,9	1,88	1,83	1,86	12,5	11,5	12,0	59,2	1107	19,2	16,4	17,8	514	422	10,5	10,7	10,6	30,0	27,1	28,6
60% Wool/40% acrylic	23,8	18,6	191	0,421	7,0	6,2	1,82	1,74	1,78	11,5	10,1	10,8	60,1	1098	21,6	18,2	19,9	519	422	10,2	10,6	10,4	30,4	29,2	29,8
40% Wool/60% acrylic	23,0	18,4	186	0,429	7,3	6,1	1,83	1,92	1,88	11,4	13,1	12,3	61,9	1254	23,0	20,2	21,7	620	497	12,9	13,0	13,1	27,6	28,6	28,1
40% Wool/60% acrylic	21,9	19,8	187	0,473	11,5	8,9	2,24	2,04	2,14	21,0	15,9	18,5	71,3	1176	22,0	19,8	20,9	572	541	12,5	13,1	12,8	35,3	25,7	30,5
20% Wool/80% acrylic	22,0	19,3	191	0,506	12,8	9,4	1,90	2,14	2,02	13,1	18,7	15,9	65,6	1333	23,0	20,9	22,0	723	620	15,2	14,9	15,1	35,8	23,8	29,8
100% Acrylic	21,9	19,0	186	0,507	16,0	11,8	1,86	2,08	1,97	12,0	16,7	14,4	62,0	1372	23,1	21,9	22,5	744	664	15,8	16,3	16,1	36,1	24,3	30,2
Plain Weave – 3,3 dtex																									
80% Wool/20% acrylic	23,9	19,4	192	0,401	7,8	6,6	1,74	1,61	1,68	10,1	8,0	9,1	56,1	911	17,5	15,0	16,3	450	326	9,1	8,1	8,6	27,8	24,2	26,0
60% Wool/40% acrylic	23,5	19,6	193	0,380	6,6	5,7	1,74	1,71	1,73	10,2	9,7	10,0	55,6	1107	19,0	15,6	17,3	541	449	11,0	11,0	11,0	31,0	30,0	30,5
60% Wool/40% acrylic	23,5	19,6	189	0,408	6,4	5,7	1,75	1,69	1,72	10,1	9,1	9,6	56,3	1107	19,7	17,1	18,4	514	466	10,5	11,3	10,9	30,9	28,4	29,7
40% Wool/60% acrylic	23,1	17,7	186	0,404	7,6	6,4	1,84	1,76	1,80	11,6	10,1	10,9	55,4	1284	24,9	20,1	22,5	668	494	13,5	13,0	13,2	28,1	27,1	27,8
40% Wool/60% acrylic	22,1	19,2	190	0,489	10,1	7,8	1,87	2,05	1,96	12,4	16,4	14,4	60,0	1176	22,9	20,5	21,8	582	515	12,3	12,5	12,4	32,9	23,6	28,3
20% Wool/80% acrylic	22,2	19,4	192	0,486	11,1	8,7	1,80	1,98	1,89	11,2	14,9	13,1	58,0	1294	22,0	18,2	20,1	656	564	13,8	13,6	13,7	32,3	24,8	28,6
100% Acrylic	22,2	19,0	181	0,462	15,9	11,5	1,76	1,92	1,84	9,7	12,8	11,3	53,6	1441	24,6	21,5	23,0	813	684	17,3	17,0	17,2	33,3	22,3	27,8
2/2 Twill – 4,9 dtex																									
100% Wool	24,7	19,0	195	0,552	22,3	18,7	1,84	1,50	1,67	12,1	6,6	9,4	46,9	823	35,3	31,6	33,4	341	244	6,7	6,2	6,5	24,8	26,2	25,5
80% Wool/20% acrylic	24,2	19,0	185	0,515	21,3	17,3	1,86	1,65	1,76	11,9	8,3	10,1	46,5	882	35,8	37,2	36,6	384	340	7,7	8,7	8,2	21,1	23,3	22,2
60% Wool/40% acrylic	23,0	18,5	190	0,551	19,0	16,2	1,98	1,60	1,79	14,7	7,8	11,3	48,6	1117	34,4	33,2	33,8	503	406	10,2	10,3	10,3	23,7	25,7	24,7
60% Wool/40% acrylic	24,1	18,9	189	0,501	16,7	14,3	1,89	1,55	1,72	12,8	7,0	9,9	48,5	1117	39,5	36,3	37,9	509	372	9,9	9,2	9,6	23,9	26,5	25,2
40% Wool/60% acrylic	22,4	18,8	184	0,490	14,8	12,7	1,94	1,60	1,77	13,4	7,5	11,6	49,3	1303	46,8	45,1	46,0	588	493	12,6	12,6	12,6	23,9	26,7	25,3
40% Wool/60% acrylic	23,1	19,7	183	0,560	31,3	22,9	1,91	1,75	1,83	12,8	9,8	11,3	52,5	1333	40,0	35,8	37,7	558	497	11,6	12,1	11,8	26,0	25,3	25,7
20% Wool/80% acrylic	22,8	18,6	187	0,567	34,2	23,7	1,95	1,81	1,88	13,9	11,1	12,5	51,2	1548	36,4	32,5	34,5	704	620	14,3	15,4	14,9	27,3	25,3	26,3
100% Acrylic	23,0	19,2	179	0,544	40,8	27,6	2,00	1,78	1,89	14,3	10,1	12,2	49,6	1676	43,2	36,5	40,0	785	645	15,9	15,7	15,8	25,7	26,2	26,0
2/2 Twill – 3,3 dtex																									
80% Wool/20% acrylic	26,0	20,2	193	0,512	16,1	13,7	1,80	1,51	1,66	11,3	6,6	9,0	45,9	911	33,9	37,8	35,9	406	295	7,5	7,0	7,3	20,9	27,4	24,2
60% Wool/40% acrylic	24,3	19,6	188	0,449	14,6	12,6	1,81	1,57	1,69	11,1	7,3	9,2	47,1	1117	34,5	31,7	33,1	526	415	10,4	10,1	10,2	23,7	25,6	24,7
60% Wool/40% acrylic	24,4	19,8	190	0,499	12,8	11,6	1,77	1,80	1,79	10,5	11,1	10,8	46,1	1127	37,3	34,4	35,9	525	399	10,3	9,6	10,0	23,8	27,0	25,4
40% Wool/60% acrylic	23,4	18,9	191	0,482	13,2	11,2	1,79	1,49	1,64	11,0	6,3	8,7	46,6	1323	38,3	33,6	36,0	621	480	12,3	11,8	12,1	23,9	25,4	24,2
40% Wool/60% acrylic	23,9	19,7	190	0,568	24,5	18,3	1,76	1,64	1,70	10,4	8,4	9,4	47,9	1382	39,5	33,3	36,5	614	500	12,0	11,8	11,9	25,3	24,3	24,8
20% Wool/80% acrylic	22,7	20,5	191	0,538	23,3	17,6	1,66	1,67	1,67	8,7	8,9	8,8	46,5	1548	34,4	31,0	32,7	694	596	14,3	13,6	13,9	26,4	25,6	26,0
100% Acrylic	22,6	20,0	185	0,560	31,4	22,3	1,78	1,62	1,70	10,4	7,7	9,1	45,5	1647	41,7	36,4	39,1	803	695	16,8	16,4	16,6	28,5	26,0	27,3

*The fabrics are arranged according to the sequence shown in Table II.

TABLE V

FABRIC ABRASION, PILLING, SHRINKAGE AND WRINKLING PROPERTIES

BLEND LEVEL*	STOLL FLEX ABRASION (Cycles to rupture)			FLAT ABRASION (% Mass Loss at 10 000 cycles)	RELAXATION SHRINKAGE (% Area Shrinkage)	FELTING SHRINKAGE (% Area Shrinkage)	DP RATING	MONSANTO CREASE RECOVERY ANGLE (in degrees) At 20°C/65% RH De-aged			MONSANTO CREASE RECOVERY ANGLE (in degrees) At 27°C/75% RH De-aged			FRL WRINKLING (SD of FRL Curve in mm) at 27°C/75% RH, De-aged			MARTINDALE PILLING (pill rating** obtained on disc)	
	W	F	Mean					W	F	W + F	W	F	W + F	W	F	Mean	After 1 000 cycles	After 2 000 cycles
Plain Weave – 4,9 dtex																		
100% Wool	1745	2351	2048	3,0	9,4	19,3	1,0	158	160	318	141	139	280	1,48	0,89	1,18	5	5
80% Wool/20% acrylic	1101	775	938	4,0	6,9	5,9	3,3	151	153	304	145	142	287	1,21	0,97	1,09	5	5
60% Wool/40% acrylic	566	506	536	3,2	4,4	1,2	3,7	146	154	300	140	137	277	0,95	0,89	0,92	5	5
60% Wool/40% acrylic	622	595	609	3,0	4,6	0,3	3,3	144	148	292	134	137	271	1,05	1,00	1,03	5	5
40% Wool/60% acrylic	564	477	521	3,6	3,5	0,3	3,9	136	143	279	130	131	261	1,20	0,92	1,06	5	5
40% Wool/60% acrylic	482	626	554	2,9	2,8	0,7	3,2	143	139	282	131	124	255	0,98	0,97	0,97	5	5
20% Wool/80% acrylic	452	412	432	3,7	2,3	0,2	3,7	131	123	254	125	110	235	0,93	0,98	0,95	5	5
100% Acrylic	355	357	356	4,1	1,3	0,2	4,2	128	112	240	114	101	215	0,76	0,96	0,86	5	5
Plain Weave – 3,3 dtex																		
80% Wool/20% acrylic	738	861	800	3,4	7,0	6,1	3,3	148	153	301	138	139	277	1,13	0,90	1,01	5	5
60% Wool/40% acrylic	526	514	520	3,4	4,3	3,1	4,0	146	148	294	139	138	277	0,95	0,99	0,97	5	5
60% Wool/40% acrylic	550	602	576	3,0	4,6	2,9	4,0	142	146	288	137	134	271	1,27	0,95	1,11	5	5
40% Wool/60% acrylic	495	673	584	3,1	3,0	0,5	3,8	134	139	273	133	126	259	1,18	0,79	0,98	5	5
40% Wool/60% acrylic	476	607	542	2,9	3,2	2,1	3,7	142	137	279	137	123	260	0,79	0,84	0,81	5	5
20% Wool/80% acrylic	417	538	478	3,2	1,9	0,2	3,8	138	131	269	122	109	231	0,88	0,83	0,85	5	5
100% Acrylic	372	429	401	3,3	1,0	0,5	3,8	122	111	233	114	99	213	1,08	0,74	0,91	5	5
2/2 Twill – 4,9 dtex																		
100% Wool	2136	1644	1890	14,2	10,0	67,2	1,0	158	159	317	138	145	283	1,03	0,88	0,95	3,9	4,3
80% Wool/20% acrylic	1240	1202	1221	19,2	7,5	62,0	1,0	153	157	310	135	138	273	0,89	0,77	0,83	4,7	4,7
60% Wool/40% acrylic	693	684	689	8,0	5,0	30,0	1,0	149	156	305	140	141	281	0,87	0,87	0,87	4,3	4,3
60% Wool/40% acrylic	735	406	571	6,7	4,6	31,6	1,0	149	155	304	139	141	280	0,91	0,59	0,75	4,3	4,8
40% Wool/60% acrylic	669	510	590	4,9	3,2	7,5	3,8	138	143	281	138	142	280	0,79	0,58	0,68	4,7	4,4
40% Wool/60% acrylic	536	420	478	5,2	3,2	8,6	4,0	144	150	294	137	135	272	0,70	0,81	0,75	4,8	4,8
20% Wool/80% acrylic	432	422	427	6,1	2,4	3,6	3,8	143	146	289	134	136	270	0,83	0,73	0,78	4,8	4,6
100% Acrylic	287	318	303	3,9	1,0	1,9	3,4	134	134	268	127	131	258	0,91	0,75	0,83	4,8	4,9
2/2 Twill – 3,3 dtex																		
80% Wool/20% acrylic	1118	718	918	12,9	7,4	54,0	1,0	157	160	317	–	–	–	1,10	0,80	0,95	4,7	4,4
60% Wool/40% acrylic	622	521	572	6,5	5,2	25,9	1,0	152	157	309	140	138	278	1,04	0,72	0,88	4,0	3,9
60% Wool/40% acrylic	876	530	703	6,5	4,7	27,9	1,0	147	150	297	135	136	271	0,88	0,69	0,79	4,1	3,4
40% Wool/60% acrylic	594	386	480	6,7	2,9	6,7	4,0	144	150	294	138	136	274	0,97	0,64	0,81	3,7	3,6
40% Wool/60% acrylic	614	444	529	6,8	3,0	7,6	4,0	146	152	298	134	137	271	0,89	0,79	0,84	4,6	3,7
20% Wool/80% acrylic	459	407	433	5,2	1,8	3,5	3,8	141	141	282	130	135	265	0,72	0,71	0,71	4,8	4,6
100% Acrylic	419	417	418	2,9	1,6	2,2	3,2	137	144	281	125	129	254	0,78	0,67	0,72	4,7	4,1

*The sequence and finishing of each group of fabrics are the same as those in Table II.

** 1 is poor
5 is good

Tensile Properties

The fabric tensile properties were plotted against the acrylic content in Figs 1 to 3. The averages of the warp and weft tensile properties were taken for purposes of plotting these graphs, and, where a particular blend was subjected to two different finishing procedures, the results were also averaged for the graphs since the effect of this on the fabric tensile properties was generally small.

The fabric tensile properties (i.e. the breaking strength, the bursting strength and the tear strength) increased with an increase in the acrylic content although the increase in tear strength with increasing acrylic content was not very pronounced (see Fig. 2). Fibre fineness (dtex) and fabric finishing sequence (Table IV) had little effect on the fabric tensile properties.

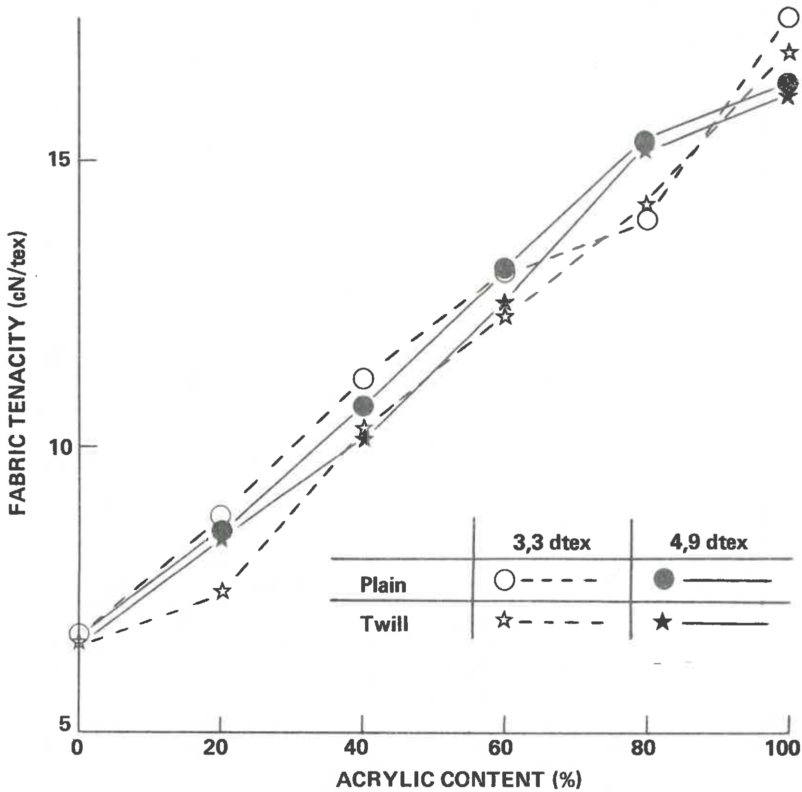

FIGURE 1

The Relationship Between Fabric Tenacity and Acrylic Content for the Two Different Weaves and Acrylic Fibre Linear Densities

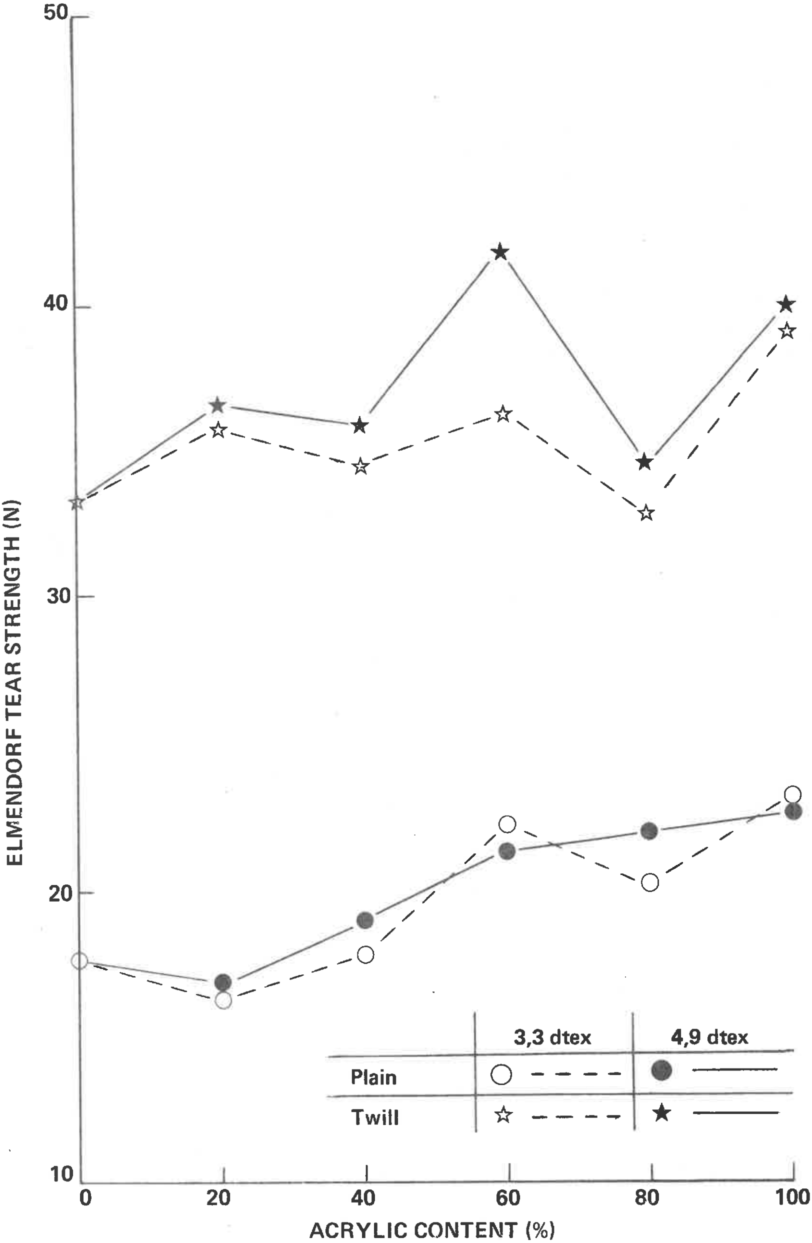

FIGURE 2

The Relationship Between Tear Strength and Acrylic Content for the Two Different Weaves and Acrylic Fibre Linear Densities

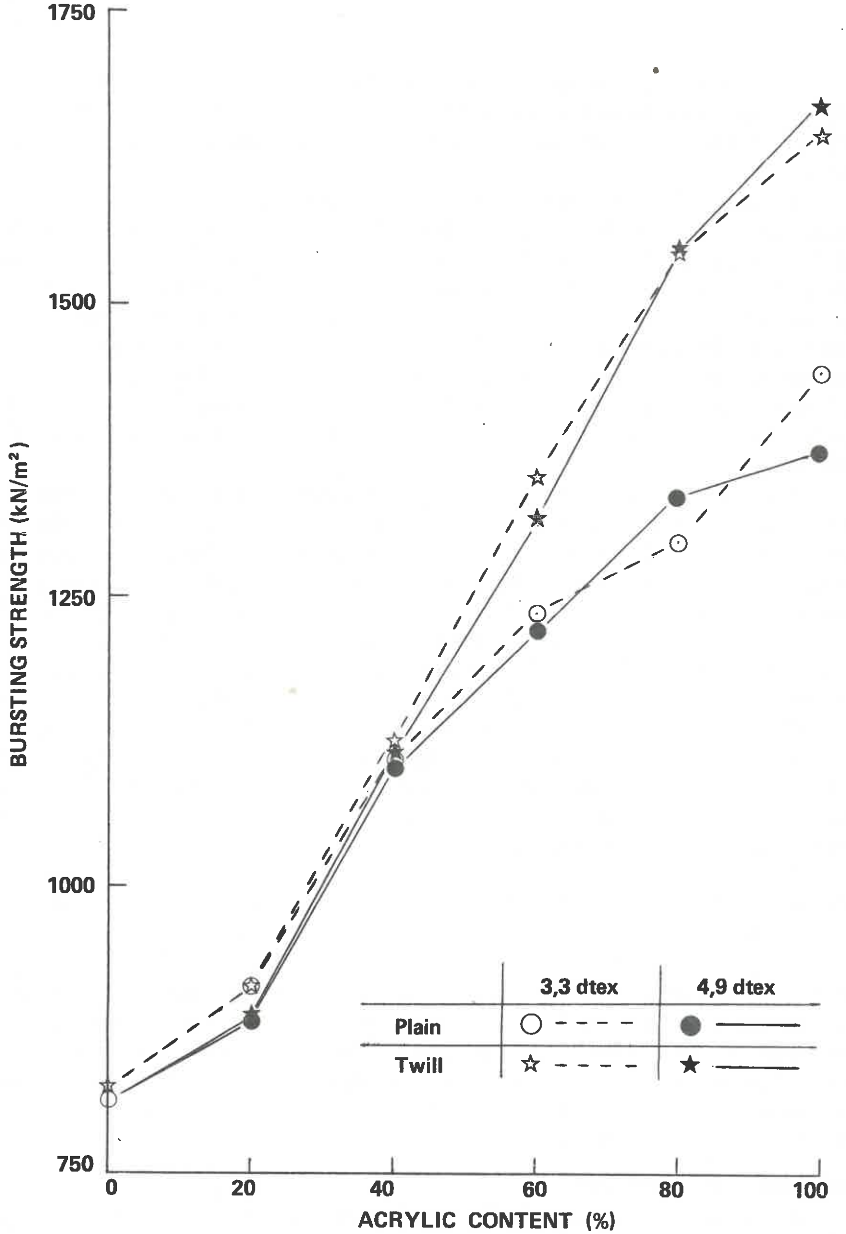

FIGURE 3

The Relationship Between Bursting Strength and Acrylic Content for the Two Different Weaves and Acrylic Fibre Linear Densities

The fabric breaking tenacity increased linearly from about 7 cN/tex for the 100 *per cent* wool fabrics to about 17 cN/tex for the 100 *per cent* acrylic fabrics (Fig. 1). These values were approximately of the same magnitude as those for the yarns.

By increasing the acrylic content in the blend the tear strength of the plain weave fabrics was increased slightly from about 18 N for the 100 *per cent* wool fabric to about 23 N for the 100 *per cent* acrylic fabric and for the 2/2 twill weave fabrics from about 34 N for the 100 *per cent* wool fabric to about 40 N for the 100 *per cent* acrylic fabric (Fig. 2). The points on these curves lie somewhat scattered which could be partly due to the different finishing routines employed. The fineness (dtex) of the acrylic fibres had very little effect on the tear strength, the 3,3 dtex acrylic fibres resulting in a slightly lower tear strength than the 4,9 dtex acrylic fibres. The tear strength of the 2/2 twill fabric was almost twice that of the plain weave fabric (Fig. 2).

The bursting strength increased approximately linearly with an increase in acrylic content (Fig. 3). The bursting strength was not greatly affected by the linear density of the acrylic fibres. In the case of the plain weave fabrics there seemed to be an effect due to the finishing procedure, with that applied to the acrylic-rich fabrics apparently causing a deterioration in bursting strength (Table IV). The bursting strength was affected to some extent by the weave, with the 2/2 twill weave fabrics tending to have the higher bursting strength. For both weaves the 100 *per cent* wool fabric had a bursting strength of approximately 824 kN/m^2 (or 8,4 kgf/cm^2) whereas the 100 *per cent* acrylic fabric had bursting strengths of 1 402 kN/m^2 (or 14,3 kgf/cm^2) and 1 657 kN/m^2 (or 16,9 kgf/cm^2) for the plain and 2/2 twill weaves, respectively. The bursting strength was linearly related to the breaking (tensile) tenacity but, because bursting strength was dependent upon the weave, their relationship likewise depended upon the weave.

The extensions of the plain weave fabrics were higher than those of the 2/2 twill weave fabrics (see Table IV). The extension at break of the 2/2 twill weave fabrics was of the order of 25 *per cent* and that of the plain weave blend fabrics about 29 *per cent*. The extension at break, however, was not affected to any great extent by the fineness of the acrylic fibres, the finishing sequence or the blend level except in the case of the plain weave structure where the 100 *per cent* wool fabric had an extension at break slightly higher than those of the blends. In contrast to this finding the *yarn* extension was very dependent upon the blend level with the extension for the 100 *per cent* acrylic yarn being almost double that of the 100 *per cent* wool yarn (Table III).

Resistance to Flat Abrasion

In the case of the resistance to flat abrasion, the two weaves behaved entirely differently (see Fig. 4). For the plain weave structure the percentage mass loss at 10 000 cycles was practically independent of all the parameters investigated, the average mass loss being approximately 3,5 *per cent* (see Fig. 4 and Table V). In the case of the 2/2 twill weave there was a linear decrease in the resistance to flat abrasion (i.e. a linear increase in percentage mass loss) with an increase in wool content (Fig. 4). The percentage mass loss ranged from approximately 14 *per cent* for the 100 *per cent* wool fabric to about 3,5 *per cent* for the 100 *per cent* acrylic fabric. Since the 100 *per cent* acrylic fabrics (both plain and twill) had the same mass loss after 10 000 cycles, it would seem that the increase in mass loss with an increase in wool content in the case of the twill weave might have been due to the removal of wool fibres which were ruptured and removed more easily because of

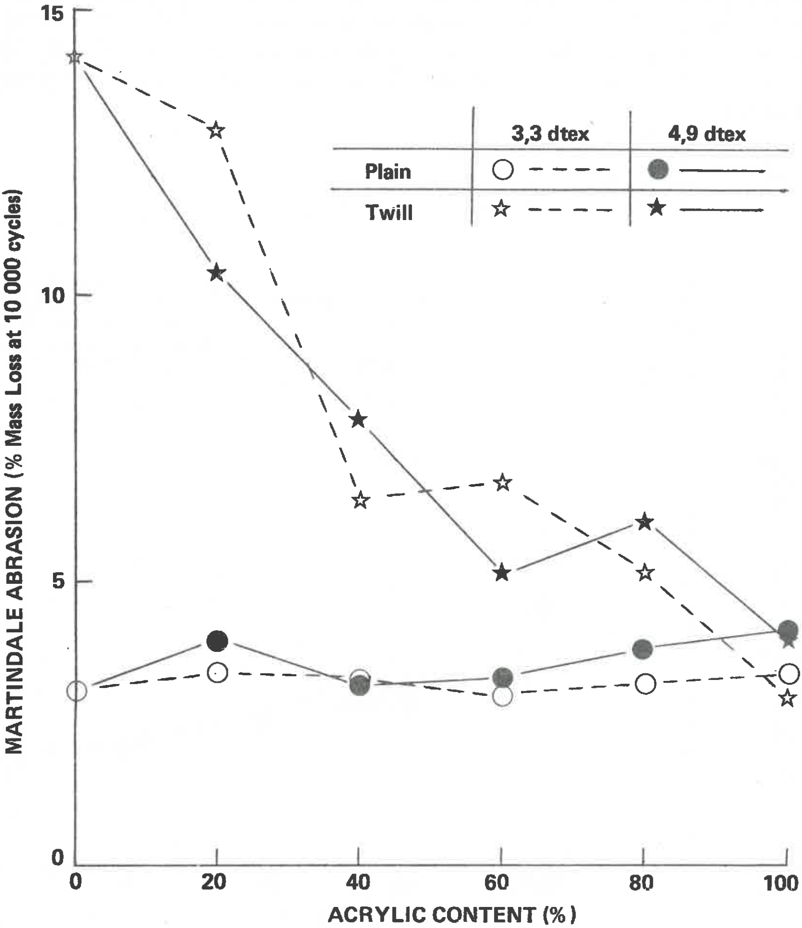

FIGURE 4

The Relationship Between Resistance to Flat Abrasion and Acrylic Content for the Two Different Weaves and Acrylic Fibre Linear Densities

the longer floats (i.e. more loose structure) of the 2/2 twill weave. The resistance to abrasion of the 2/2 twill weave was not affected in a consistent manner by the fineness of the acrylic fibres nor, apparently, by the finishing procedure (Fig. 4 and Table V).

Resistance to Flex Abrasion

From Fig. 5 it is apparent that, for both the plain and 2/2 twill weaves, the resistance to flex abrasion decreased assymptotically from about 2 000 cycles for the 100 *per cent* wool fabrics to about 400 cycles for the 100 *per cent* acrylic fabrics (Fig. 5). This contrasts sharply with the results obtained for resistance to flat abrasion (Fig. 4). The resistance to flex abrasion was not significantly affected by the fineness (dtex) of the acrylic fibres, the weave or the finishing sequence (Table V).

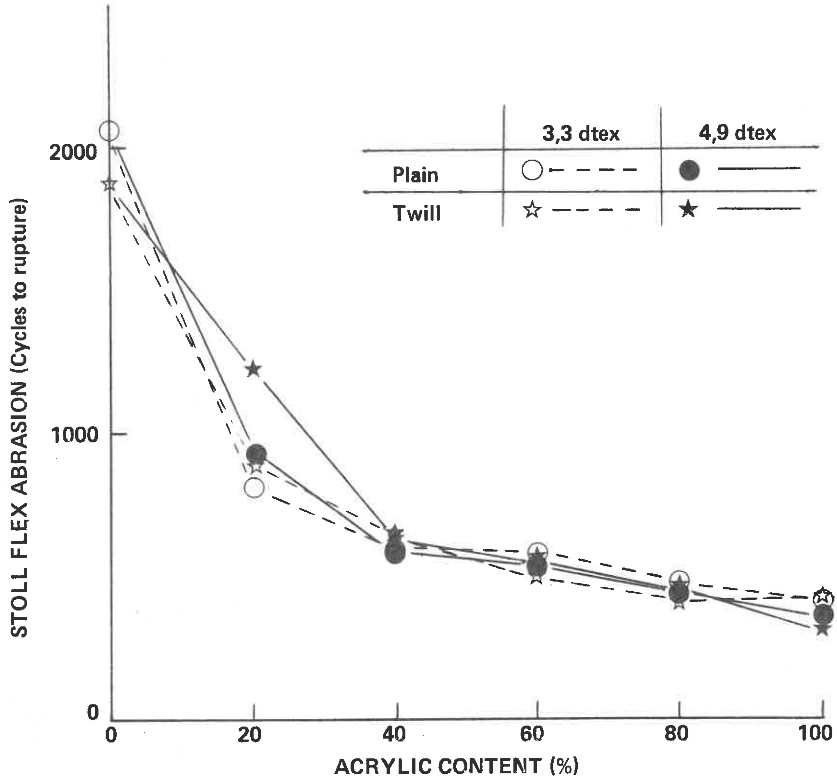

FIGURE 5

The Relationship Between Resistance to Flex Abrasion and Acrylic Content for the Two Different Weaves and Acrylic Fibre Linear Densities

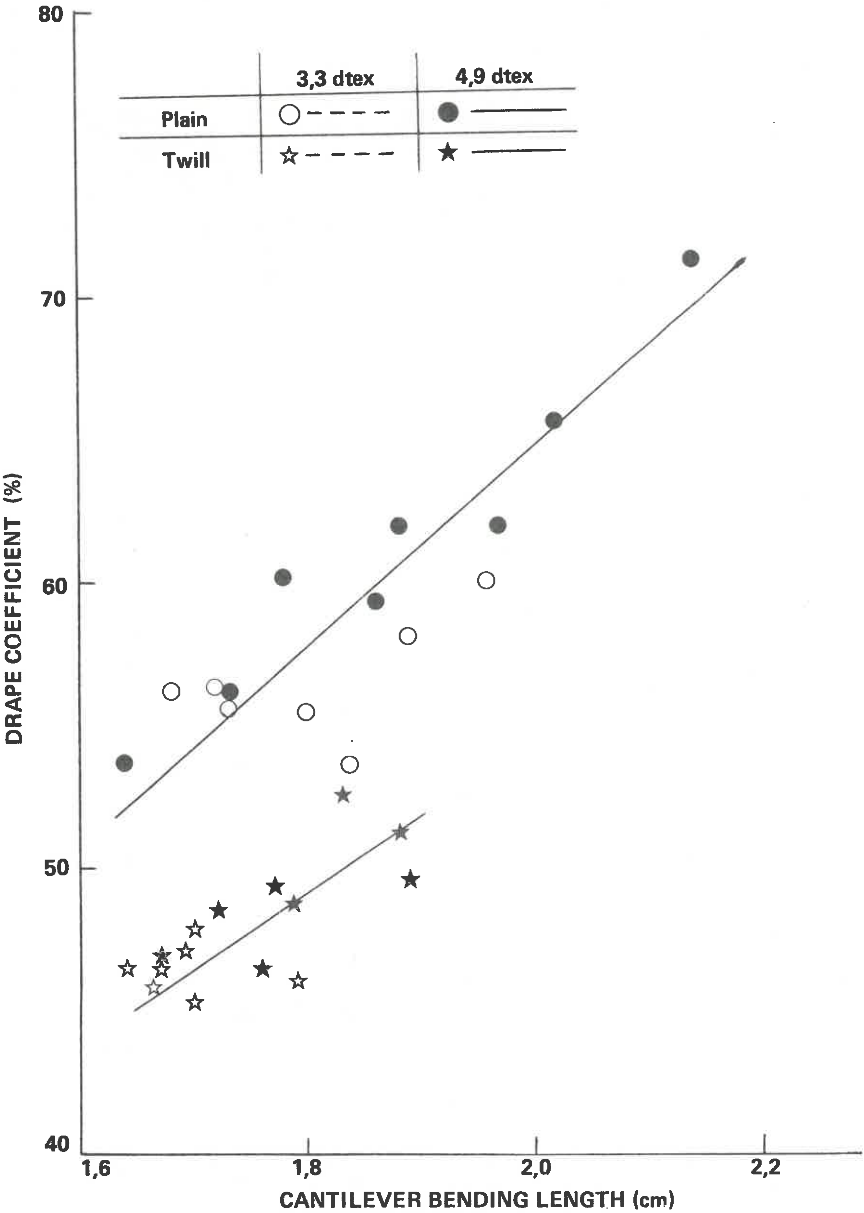

FIGURE 6

The Relationship Between Drape Coefficient and Cantilever Bending Length for the Two Different Weaves and Acrylic Fibre Linear Densities

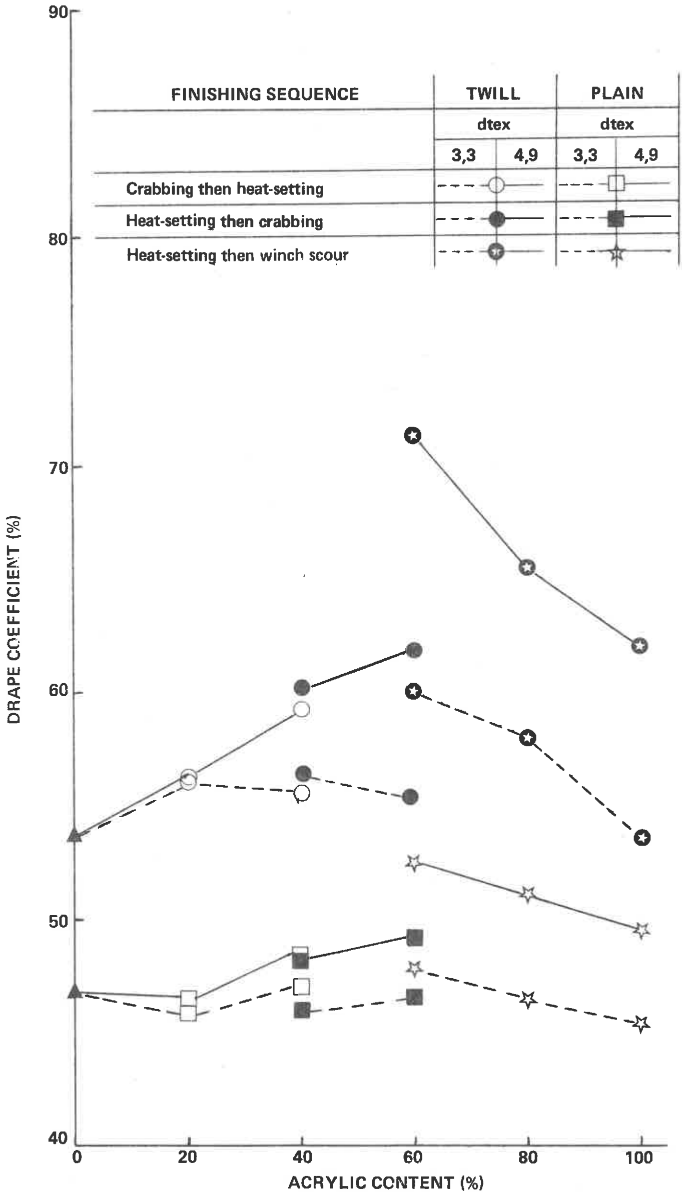

FIGURE 7

The Relationship Between Drape Coefficient and Acrylic Content for the Two Different Weaves and Acrylic Fibre Linear Densities

Fabric Stiffness

Fabric drape coefficient has been plotted against bending length in Fig. 6. The relationship between the drape coefficient and bending length, or the flexural rigidity since the fabric mass per unit area was constant, was linear. This relationship, however, was dependent upon the weave of the fabric. At the same bending length the plain weave fabrics had higher drape coefficients than the 2/2 twill weave fabrics mainly due to differences in shear between these two structures.

All the stiffness properties (i.e. bending length, flexural rigidity and drape coefficient) generally followed similar trends, with the finishing procedure having a significant effect on fabric stiffness (Table IV). The use of the finer acrylic fibres resulted in the fabrics being less stiff (i.e. more flexible) than when the coarser acrylic fibres were used. This is consistent with theoretical predictions. As the acrylic content of the blend increased so the difference attributable to the fineness of the acrylic fibres increased. The plain weave fabrics were stiffer than the twill weave fabrics with the difference between the two weaves increasing as the acrylic content increased (see Table IV).

The fabric stiffness properties tended to increase with increasing acrylic content but this relationship was influenced by the finishing procedure applied. The 100 *per cent* wool fabrics (crabbed only) had the lowest stiffness. The 80% wool/ 20% acrylic and 60% wool/40% acrylic fabrics (crabbed then heat set) were stiffer than the 100 *per cent* wool fabrics. The 60% wool/40% acrylic and 40% wool/60% acrylic fabrics which were heat-set and then crabbed were slightly more flexible than the fabrics which were first crabbed and then heat-set, i.e. the curve was displaced slightly in the direction of decreasing stiffness. The increase in stiffness with an increase in acrylic content was still apparent at this stage. In the case of the fabrics containing 60 *per cent* and more acrylic, and which were heat-set and winch scoured, the curve was also displaced, but this time in the direction of increasing stiffness. These trends, which are illustrated in Fig. 7, were more pronounced for the twill weave fabrics than for the plain weave fabrics. There was a tendency for the fabric stiffness to decrease with increasing acrylic content for acrylic levels of 60 *per cent* and higher provided the same finishing procedure was applied.

Pilling

At neither 1 000 nor 2 000 cycles did the plain weave fabrics show any signs of pilling regardless of the acrylic content, the finishing procedure or the acrylic fibre fineness (Table V and Fig. 8). The 2/2 twill weave fabrics pilled slightly and the resistance to pilling tended to increase with an increase in acrylic content (see Fig. 8). All the other variables, except perhaps finishing procedure, did not seem to affect the pilling properties of the 2/2 twill weave fabrics (Note – this discussion was based on the pill ratings obtained on the smaller discs since the larger squares, which should normally be rated, did not pill at all).

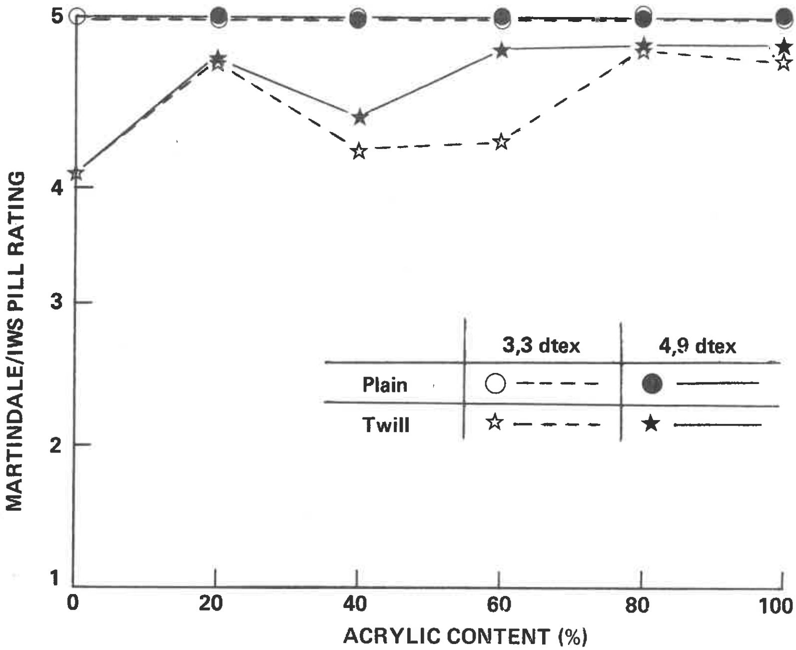

FIGURE 8

The Relationship Between Pill Rating (after 1 000 cycles) and Acrylic Content for the Two Different Weaves and Acrylic Fibre Linear Densities

Wrinkle Recovery

The FRL wrinkle height (H) decreased slightly (i.e. the wrinkle resistance was improved) as the acrylic content increased (Fig. 9). It is difficult to assess how much of this decrease was due to the acrylic component and how much was due to the finishing procedure, although the impression was gained that the finishing procedure had only a slight effect (Table V). Whatever the case may be it is clear that, at corresponding blend levels, and for similar fabric structure and mass, these fabrics wrinkled more than the wool/polyester blend fabrics reported on earlier[10].

The 2/2 twill weave fabrics wrinkled less than the plain weave fabrics with the wrinkle height (H) of the 2/2 twill weave fabrics about 20 *per cent* lower than that of the plain weave fabrics.

The fineness of the acrylic fibres did not appear to have a consistent effect on the wrinkling behaviour of the fabrics.

Crease Recovery Angle

The Monsanto crease recovery angle was measured on de-aged[11, 12] fabrics at both 65% RH/20°C and 75% RH/27°C. Recovery after creasing was always at

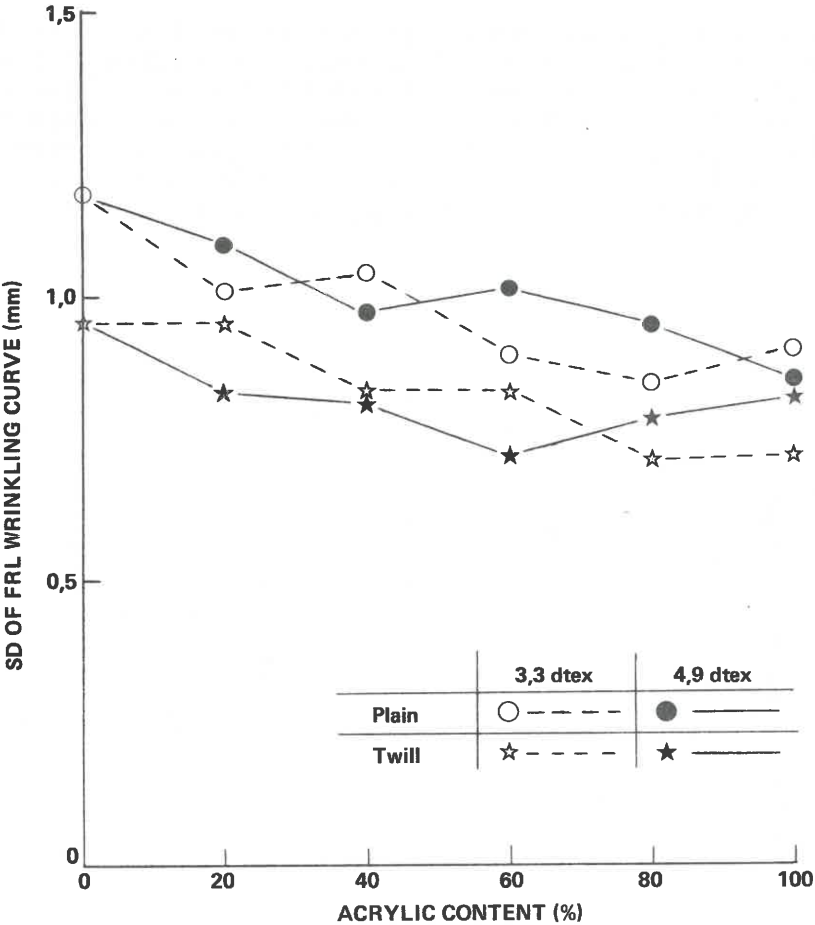

FIGURE 9

The Relationship Between FRL Wrinkling (75% RH/27°C) and Acrylic Content for the Two Different Weaves and Acrylic Fibre Linear Densities

65% RH/20°C. The crease recovery angles obtained at 75% RH/27°C were always lower than those obtained at 65% RH/20°C for all blend levels (compare Figs 10 and 11). This difference could be ascribed to the combination of increases in temperature and RH, the latter having a greater effect on the wool than on the acrylic component due to the higher regain of wool while the effect of temperature was greater on the acrylic than on the wool component. Under both atmospheric conditions the crease recovery angles decreased (i.e. the fabrics creased more) with an increase in the acrylic content. This contrasts sharply with the FRL wrinkle results (Fig. 9) where a small *improvement* in wrinkle resistance was observed with an increase in the acrylic content. These results highlight the lack of consistency between the different tests used to obtain a measure of the wrinkling performance of fabrics in wear, and it is clear that research ought to be directed towards clarifying this anomaly. Nevertheless, if the results obtained here are compared with those obtained previously[10] on the wool/polyester blend fabrics, it is obvious that both the Monsanto and FRL tests rated the wool/acrylic blends worse than the wool/polyester blends. The crease recovery angles of the all-wool fabrics obtained

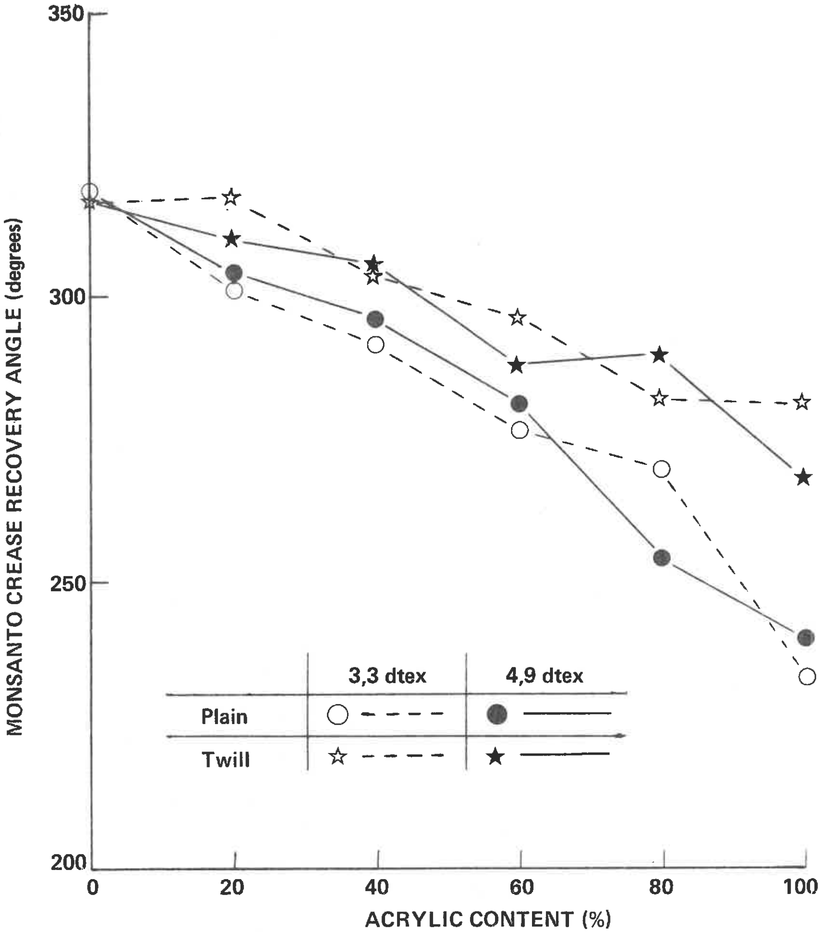

FIGURE 10

The Relationship Between Monsanto Crease Recovery Angle (65% RH/20°C) and Acrylic Content for the Two Different Weaves and Acrylic Fibre Linear Densities

in this report were of approximately the same order as those given for the all-wool fabrics in a previous report[10].

The crease recovery angles of the pure wool fabrics were not significantly affected by the weave, but those of the wool/acrylic fabrics were affected by the weave. As the acrylic content was increased so the difference between the twill and the plain weave fabrics became greater with the performance of the plain weave fabrics deteriorating relative to that of the twill weave fabrics. As in the case of the FRL wrinkle results, the plain weave fabrics performed worse than the twill weave

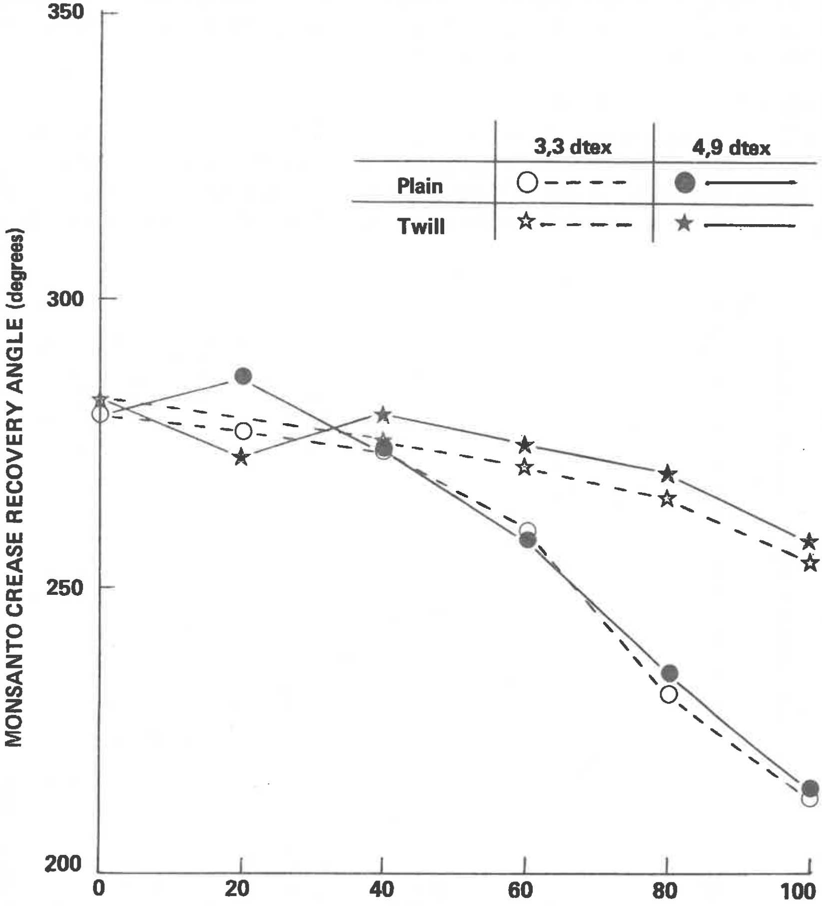

FIGURE 11

The Relationship Between Monsanto Crease Recovery Angle (75% RH/27°C) and Acrylic Content for the Two Different Weaves and Acrylic Fibre Linear Densities

fabrics. Neither the fineness (dtex) of the acrylic fibres nor the finishing procedure appeared to have a noticeable effect on the crease recovery angles (Table V).

Relaxation Shrinkage

The area relaxation shrinkage decreased almost linearly with an increase in acrylic content from about 10 *per cent* for the 100 *per cent* wool fabrics to about 1,3 *per cent* for the 100 *per cent* acrylic fabrics (Fig. 12). These levels were of the same order as those obtained for the polyester blends[10] indicating that the relaxation shrinkage was predominantly affected by the wool component. The relaxation shrinkage was not materially affected by the fineness (dtex) of the acrylic fibres, the fabric structure or the finishing procedure.

Felting Shrinkage during Washing

The shrinkage which occurs during the three hour Cubex wash test, i.e. subsequent to the relaxation test, is normally taken as a measure of felting shrinkage. The felting shrinkage decreased drastically with an increase in the acrylic content (Fig. 13). The plain weave fabrics shrank much less than the 2/2 twill weave fabrics.

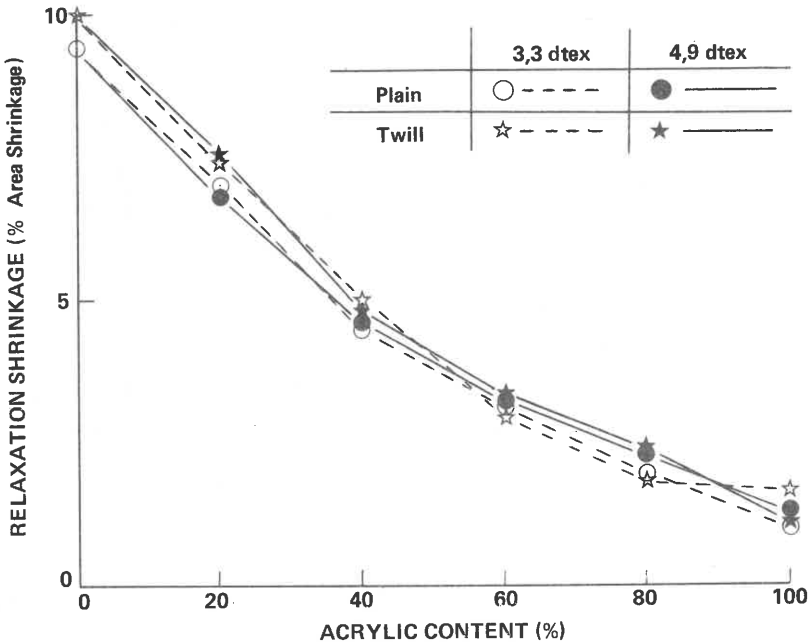

FIGURE 12

The Relationship Between Relaxation Shrinkage and Acrylic Content for the Two Different Weaves and Acrylic Fibre Linear Densities

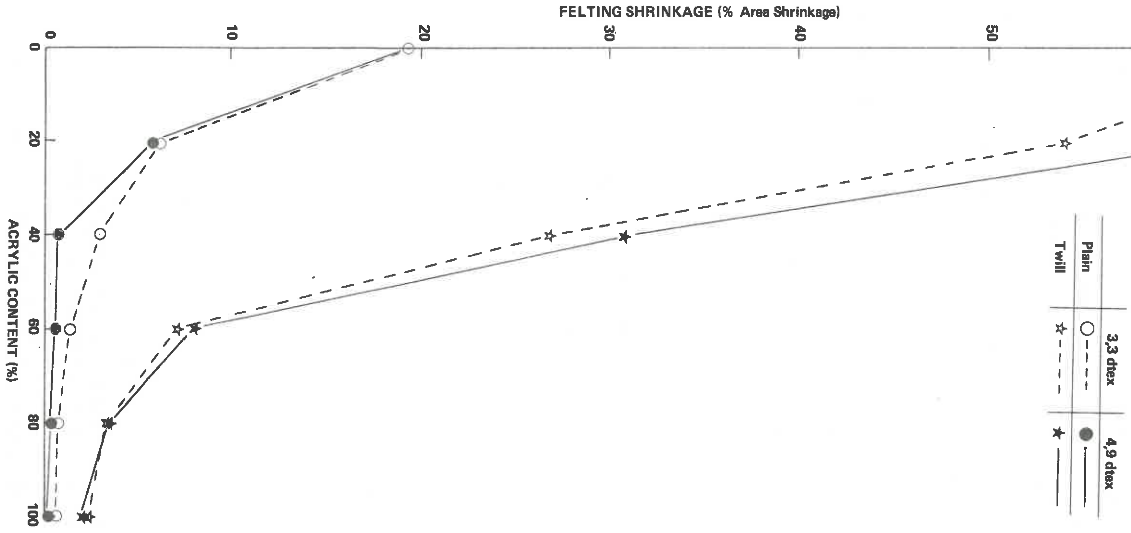

FIGURE 13

The Relationship Between Felting Shrinkage and Acrylic Content for the Two Different Weaves and Acrylic Fibre Linear Densities

In the case of the former, most of the reduction in shrinkage occurred with an addition of 20 *per cent* to 40 *per cent* of acrylic, with the felting shrinkage decreasing from approximately 20 *per cent* for the 100 *per cent* wool fabric to approximately 2 *per cent* for the 60% wool/40% acrylic fabric. Thereafter, very little further improvement occurred with increasing acrylic content. In the case of the 2/2 twill weave fabrics the felting shrinkage decreased from approximately 70 *per cent* for the 100 *per cent* wool fabrics to approximately 8 *per cent* after 60 *per cent* of acrylic had been incorporated in the blend.

The effects of the fineness of the acrylic fibres and the finishing procedure were small in comparison with those due to acrylic content and fabric structure. If the wool/acrylic plain weave fabrics are compared with the wool/polyester fabrics studied previously[10], it is apparent that the "felting" shrinkages of the fabrics were similar with, if anything, the latter being superior.

Appearance after Washing

The appearance after washing (i.e. DP ratings) appeared to be affected by neither the acrylic fibre fineness nor the finishing procedure but a marked improvement occurred with an increase in the acrylic content of the blend (Fig. 14). For

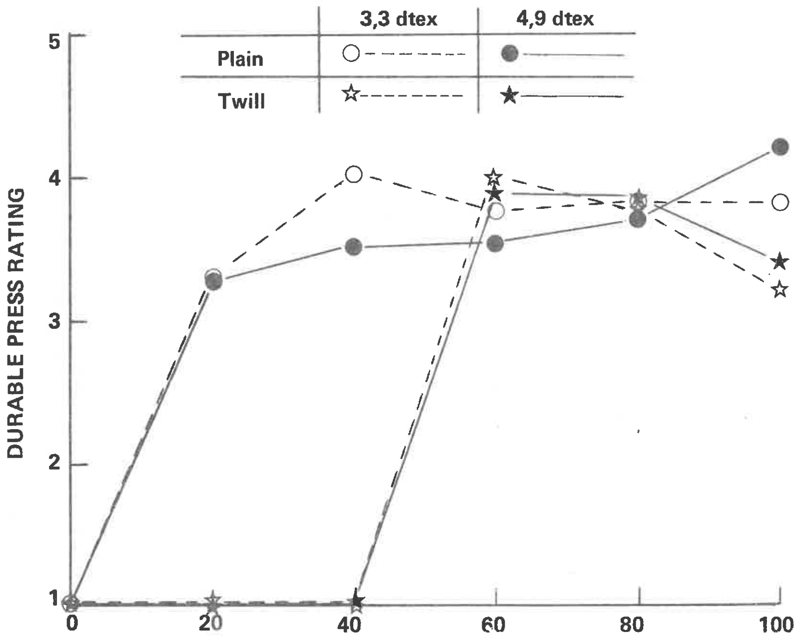

FIGURE 14

The Relationship Between Durable Press Rating and Acrylic Content for the Two Different Weaves and Acrylic Fibre Linear Densities

the plain weave fabrics, the DP ratings improved from 1 to approximately 3 with the inclusion of 20 *per cent* acrylic in the blend. At higher acrylic levels the DP ratings were slightly higher (approximately 3,6) but tended to be independent of the acrylic content. The DP ratings of the twill weave fabric was only improved when more than 40 *per cent* of acrylic was incorporated. At levels of acrylic lower than 60 *per cent* the appearance after washing of the twill weave fabrics was unacceptable. It may be noted, however, that the wash test applied here was rather severe and better DP ratings might have been obtained had the wash test recommended for cotton and other fibre types been employed.

The appearance after washing of the wool/acrylic plain weave fabrics was slightly inferior to that of the wool/polyester plain weave fabrics reported on previously[10].

Air Permeability

The air permeability of the fabrics has been plotted against acrylic fibre content in Fig. 15. From this figure and Table IV, it appears that the finishing procedure applied to the fabrics had an overriding effect on the fabric air permeability, with the finishing procedure applied to the acrylic-rich blends (i.e. heat-setting followed by a winch-scour) increasing the air permeability drastically. In the light of the effect of finishing procedure, it becomes difficult to establish the effect of acrylic level on air permeability. It is clear, however, that the finer (3,3 dtex) acrylic fibres resulted in air permeabilities which were noticeably lower than those obtained with the coarser (4,9 dtex) acrylic fibres. This is consistent with theoretical considerations. It is apparent, too, that the twill weave fabrics were much more permeable than the plain weave fabrics.

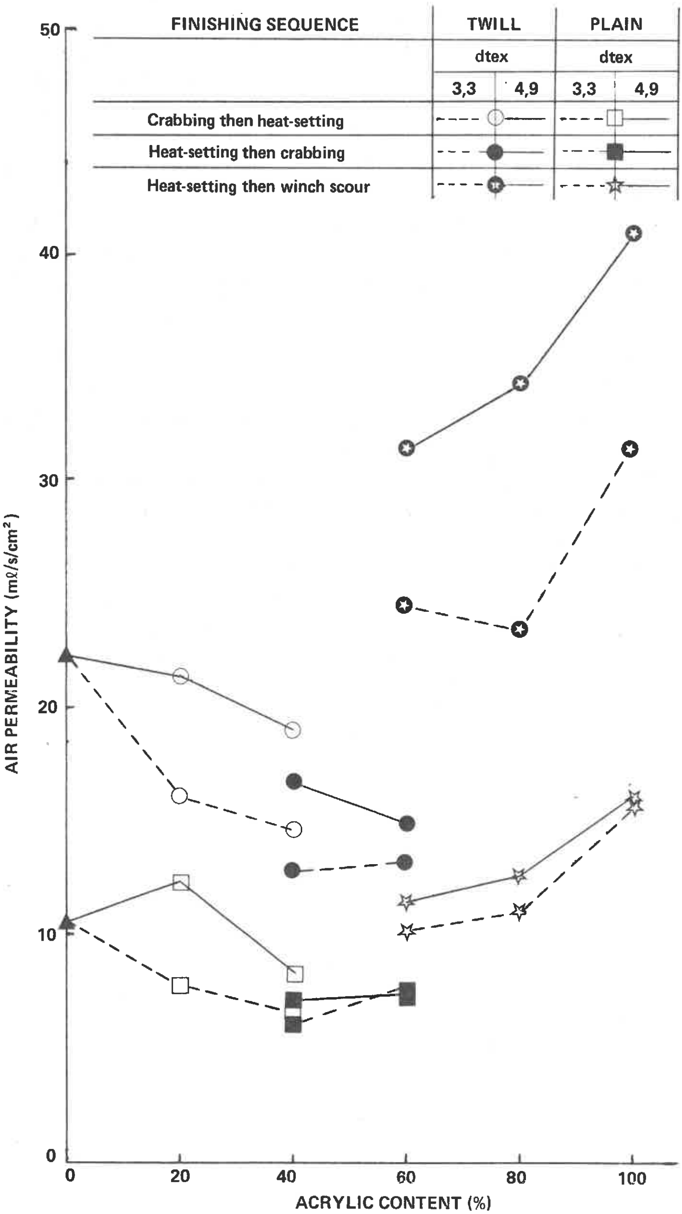

FIGURE 15
The Relationship Between Air Permeability and Acrylic Content for the Two Different Weaves and Acrylic Fibre Linear Densities

SUMMARY AND CONCLUSIONS

The mechanical properties of lightweight (190 g/m^2) plain weave and 2/2 twill weave fabrics produced from blends of a 64's quality wool with either 3,3 or 4,9 decitex regular acrylic fibres were compared. In addition, the tensile and irregularity properties of the yarns were compared. The finishing procedures applied were selected to suit the blend level but the experimental design to some extent allowed the effects of this variable to be determined.

Of all the parameters investigated the acrylic content had the greatest effect on the fabric and the yarn properties. The yarn tensile and irregularity properties generally improved with an increase in the acrylic content with the yarns containing the finer acrylic fibres being superior to those containing the coarser (4,9 dtex) fibres. The yarns comprising the coarse (4,9 dtex) acrylic fibres contained fewer Classimat faults than those comprising the fine (3,3 dtex) acrylic fibres.

The fabric tensile properties, resistance to flat abrasion, resistance to pilling (only slightly in the case of the 2/2 twill weave), felting shrinkage, relaxation shrinkage, appearance after washing and the FRL wrinkle resistance (slightly) were all improved with an increase in acrylic fibre content while the resistance to flex abrasion and the Monsanto crease recovery angles deteriorated. Generally, air permeability increased and the fabrics became stiffer as the acrylic content increased. Since there were effects due to the finishing procedure in the case of these two properties, accurate conclusions were not possible.

Acrylic fibre fineness (dtex) had very little effect on most of the fabric properties. The finer acrylic fibres reduced the air permeability and the stiffness of the fabrics, an observation which is consistent with theory.

Only the air permeability and the various parameters characterising fabric stiffness were affected markedly by the finishing procedure. It seems that the finishing procedure used for the intermediate blend levels (i.e. heat-setting prior to crabbing) reduced both the stiffness and the air permeability while the finishing routine applied to the acrylic-rich blends (i.e. heat-setting followed by winch scouring) appeared to increase the stiffness and air permeability of the fabrics.

The fabric tenacity, flex abrasion and relaxation shrinkage were not materially affected by the weave while all the other fabric properties were. For instance, the bursting strength, tear strength, air permeability, FRL wrinkle resistance and the Monsanto crease recovery angles of the 2/2 twill weave fabrics were higher than those of the plain weave fabrics. In contrast to this the resistance to flat abrasion, the durable press performance, the felting shrinkage, the resistance to pilling and the extension of the 2/2 twill weave fabrics were inferior to those of the plain weave fabrics. The plain weave fabrics were stiffer than the 2/2 twill weave fabrics.

The performance of the wool/acrylic blend fabrics studied here was, in general, inferior to that of the wool/polyester blend fabrics studied previously[10]. This was particularly evident for the fabric tensile properties, the air permeability (lower), the resistance to flat abrasion, the resistance to flex abrasion, the wrinkle resistance and the crease recovery properties. The wool/acrylic blend fabrics had a performance almost equal to that of the wool/polyester blend fabrics in the following properties: flexural rigidity (stiffness), felting shrinkage and appearance after washing.

On considering all the technical and aesthetic factors it may be concluded that, for an optimum untreated *plain weave* fabric to be obtained, approximately 40 *per cent* of acrylic should be included in the blend. For a 2/2 *twill weave* fabric, however, at least 60 *per cent* acrylic should be included in the blend because of the poor durable press performance of these fabrics when containing less acrylic. These fabrics would, however, still require resin treatment to reduce felting shrinkage to an acceptable level of ten *per cent* total shrinkage.

Obviously, the above conclusions are critically dependent upon the end use of the fabric and also on whether the fabric is to be subjected to machine washing or dry-cleaning. In practice, the relative importance attached to the various fabric properties will greatly influence the blend level which may be regarded as optimum.

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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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