CHAPTER V

RESULTS AND DISCUSSION

The results of this study have been explained under the following subsections:

5.1 Preliminary data of the fabrics used

5.2 Data of the finishing agents used

5.3 Effect of acrylamide polymer finish on shrink-resistance of,

(a) wool, cotton and cotswool (W_1, C and CW) fabrics

(b) all wool (W_1, W_2 and W_3) fabrics

5.4 Effect of acrylamide polymer finish on other related properties of wool, cotton and cotswool (W_1, C and CW) fabrics, namely (a) elastic recovery (b) tensile strength and elongation (c) tearing strength (d) stiffness (e) wrinkle recovery and (f) appearance rating after wrinkling and ironing

5.5 Effect of acrylamide polymer finish on pleat retention of wool, cotton and cotswool (W_1, C and CW) fabrics

5.6 Durability of acrylamide polymer finish on wool, cotton and cotswool (W_1 C and CW) fabrics

5.7 Effect of acrylamide polymer finish on other related properties of wool fabric (W_2)

5.8 Results on the application of acrylamide polymer finish on garments.

5.1 Preliminary data of the fabrics used

Three commercially available fabrics were initially

used in this study; one was wool fabric, second was cotton fabric and third was wool - cotton blend (cotswool) fabric. One more loom state wool fabric was included later. Preliminary data of these fabrics on count, thickness and weight per unit area have been given in Table 2.

Table 2 Preliminary data of the fabrics used

Fabric code	Fibre content and weave	Wt. per unit area oz./sq.yd (gm/sq.m)	Fabric count yarn inch (yarn cm.) Warp	Weft	Thickness inch (cm.)
W 1	100% Wool Twill Weave	5.86 (205.6)	64 (26)	55 (22)	.0036 (.009)
C	100% Cotton Plain Weave	4.05 (142.0)	64 (26)	44 (18)	.0051 (.0127)
CW	50% Wool 50% Cotton Twill Weave	3.30 (116.0)	83 (33)	73 (29)	.0052 (.013)
W 2	100% Wool Plain Weave	8.48 (297.2)	32 (13)	30 (12)	.0158 (.0395)

5.2 **Data of the finishing agents used**

Acrylamide monomer along with formaldehyde and a suitable catalytic system was used in this work. These have been listed in Table 3

Table 3 Data of the finihsing agents used

Name	Chemical composition
Acrylamide	$CH_2 = CH-CONH_2$
Formaldehyde (40%)	HCHO
Ammonium per sulphate	$(NH_4)_2S_2O_8$
Sodium thiosulphate	$Na_2S_2O_3$
Hydrogen peroxide (20 vol.)	H_2O_2
Teepol	$CH_3(CH_2)_xCH(CH_3).O.SO_3Na$
Trichloro acetic acid	CCl_3COOH

All were laboratory reagents.

Acrylamide is a white crystalling solid with M.P. 84-85 °C and it reacts readily with formaldehyde to form N-methylolacrylamide and gives a thermoplastic finish

$$CH_2=CH-CONH_2 + HCHO \longrightarrow CH_2 = CH-CONHCH_2OH$$

Ammonium persulphate, sodium thiosulphate, and hydrogen peroxide were used as redox catalytic system. Trichloro acetic acid was used to get improved durability of finish (noted on page55). (pH 4.6 was obtained in presence of trichloro acetic acid). Teepol was used in concentration of 2 gm/l as emulsifying media. Acrylamide finish was prepared in four concentrations, namely 2.5, 5.0, 7.5 and 10% (finish recipe on page54).

Analysis of data on shrink-resistance

5.3 **Effect of acrylamide polymer finish on shrink-resistance of,**

(a) wool, Cotton and Cotswool (W_1, C and CW) fabrics

(b) all- Wool (W_1, W_2 and W_3) fabrics.

In the processing of wool it is common to cause some shrinkage. This reduces the openness, and improves the texture, bulk, and gives rigidity to the fabric. In garments continuing shrinkage is however not desirable, as shape/size may change after washing. The shrinkage in wool fabrics is caused by (a) relaxation of strains (b) by felting (c) by matting together of fibres.

In cotton fabrics, the shrinkage is (a) partly due to the relaxation of the severe stretching of the cotton during manufacture and (b) partly due to the wet swelling causing compression.

It has been noted by researchers that fabrics can be made shrink-resistant with the use of resins. Bereck (6) has stated that the shrink-resistance obtained in wool fabric by acrylic copolymers can be attributed to film formation and spot welding. Feldtman and McPhee (41) have however noted that self-crosslinking polyacrylates reduce felting shrinkage, probably, due to the partial covering of fibre surface by polymer rather than to fibre bonding. Some bonding can occur and can produce such properties as reduced pilling and resistance to tumble drying shrinkage.

It was thus natural to expect that acrylamide finished fabrics in the present work would have resistane to shrinkage; the directional frictional effect in wool could be reduced and the cellulose chains in cotton could be restricted, possible by crosslinking or by the physical presence. This aspect was thus assessed first before studying other related properties.

(a) Wool, Cotton and Cotswool (W_1, C and CW) fabrics

The influence of this finish was studied for its effect on the shrinkage of these three fabrics and was noted as given below :

i) Wool fabric (W_1)
ii) Cotton fabric (C)
iii) Costwool fabric (CW)

i) Wool fabric (W_1)

It was noted from Table 4 and Figure 5 that the acrylamide treated wool fabric has shown less percent shrinkage as compared to untreated one. The acrylamide polymer finish thus improved the shrink-resistance of wool fabric. The shrink-resistance of wool fabric improved with incresing finish, attaining a good value at about five percent or so. With a furhter increase in the concentration of finish, shrinkage control values did not incease further. The resistance was noticed much better during initial washings and after that it decreased slightly in treated fabric, but it stabilizaed (after 120 minutes wash) in both directions. This can be explained on washing off of superficial finish after a few washes. Thereafter the durable finish resisted the continuing shrinkage.

The improvement in shrink-resistance of wool fabric can also be explained on the basis of the film formation. This has also been noticed by the abrasion test of the treated and untreated fabrics. Treated fabrics have better strength retention after abrasion as compared to untreated. This showed that a film on the surface protected the fibres. This was also studied by the

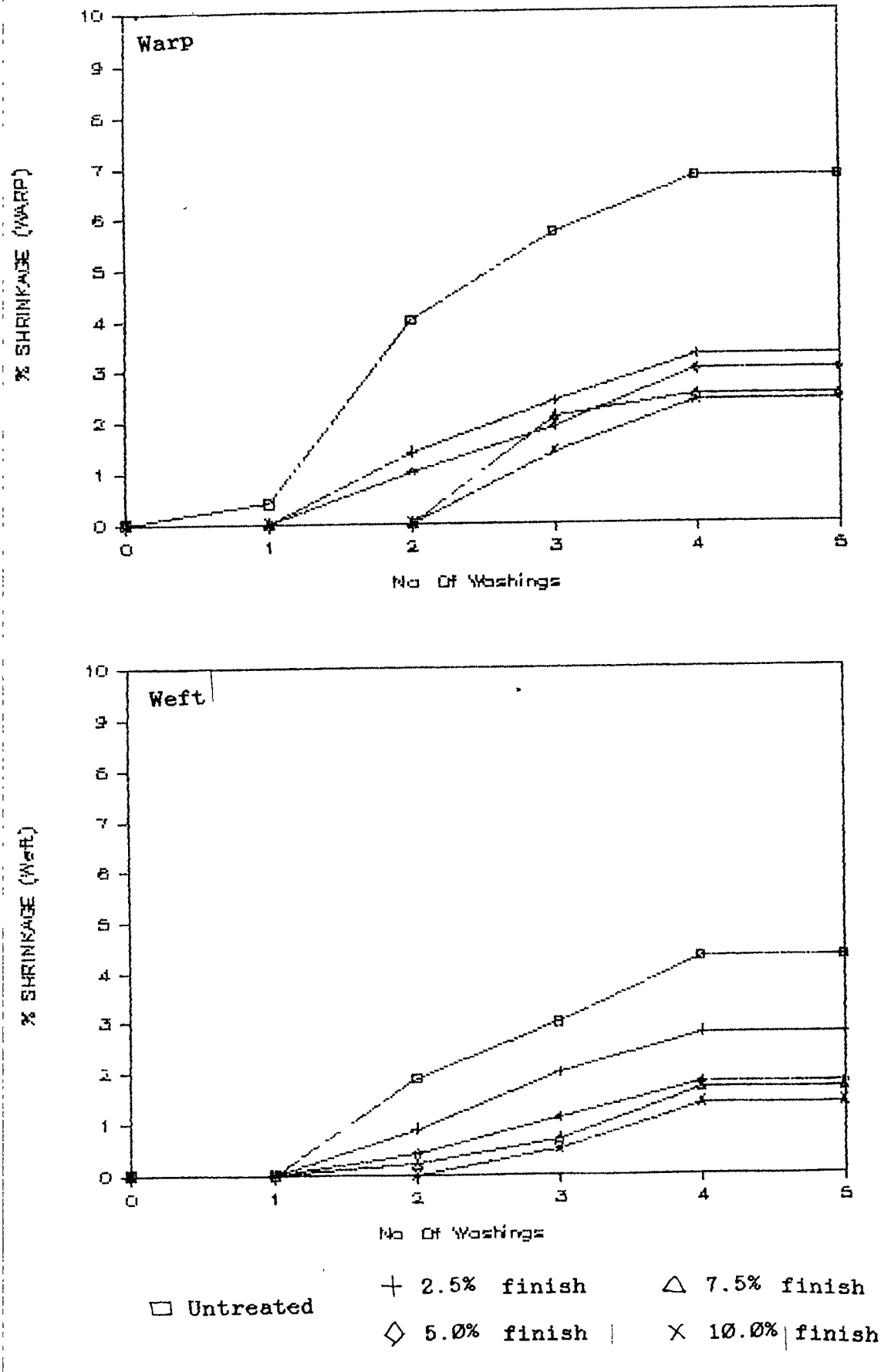
rubbing test. The treated fabric showed less fuzziness as compared to untreated.

Table 4 Percent shrinkage of wool fabric (W_1) treated with acrylamide polymer finish

Finish % / No. of washings	% Shrinkage				
	1	2	3	4	5
WARP					
Ø	Ø.4	4.Ø	5.7	6.8	6.8
2.5	Ø.Ø	1.4	2.4	3.3	3.3
5.Ø	Ø.Ø	1.Ø	1.9	3.Ø	3.Ø
7.5	Ø.Ø	Ø.Ø	2.1	2.5	2.5
1Ø.Ø	Ø.Ø	Ø.Ø	1.4	2.4	2.4
WEFT					
Ø	Ø.Ø	1.9	3.Ø	4.3	4.3
2.5	Ø.Ø	Ø.9	2.Ø	2.8	2.8
5.Ø	Ø.Ø	Ø.4	1.1	1.8	1.8
7.5	Ø.Ø	Ø.2	Ø.7	1.7	1.7
1Ø.Ø	Ø.Ø	Ø.Ø	Ø.5	1.4	1.4

Nuessle and Kine (83) also stated that acrylics improve resistance to felting of wool, partly by masking the scales so that they are less likely to interlock and partly by spot welding the fibres, thus reducing migration. In polymer deposition process the principal mechanism of shrink-proofing is probably scale masking (73).

Figure 5 Effect of acrylamide polymer finish on shrink-resistance in wool fabric (W_1)



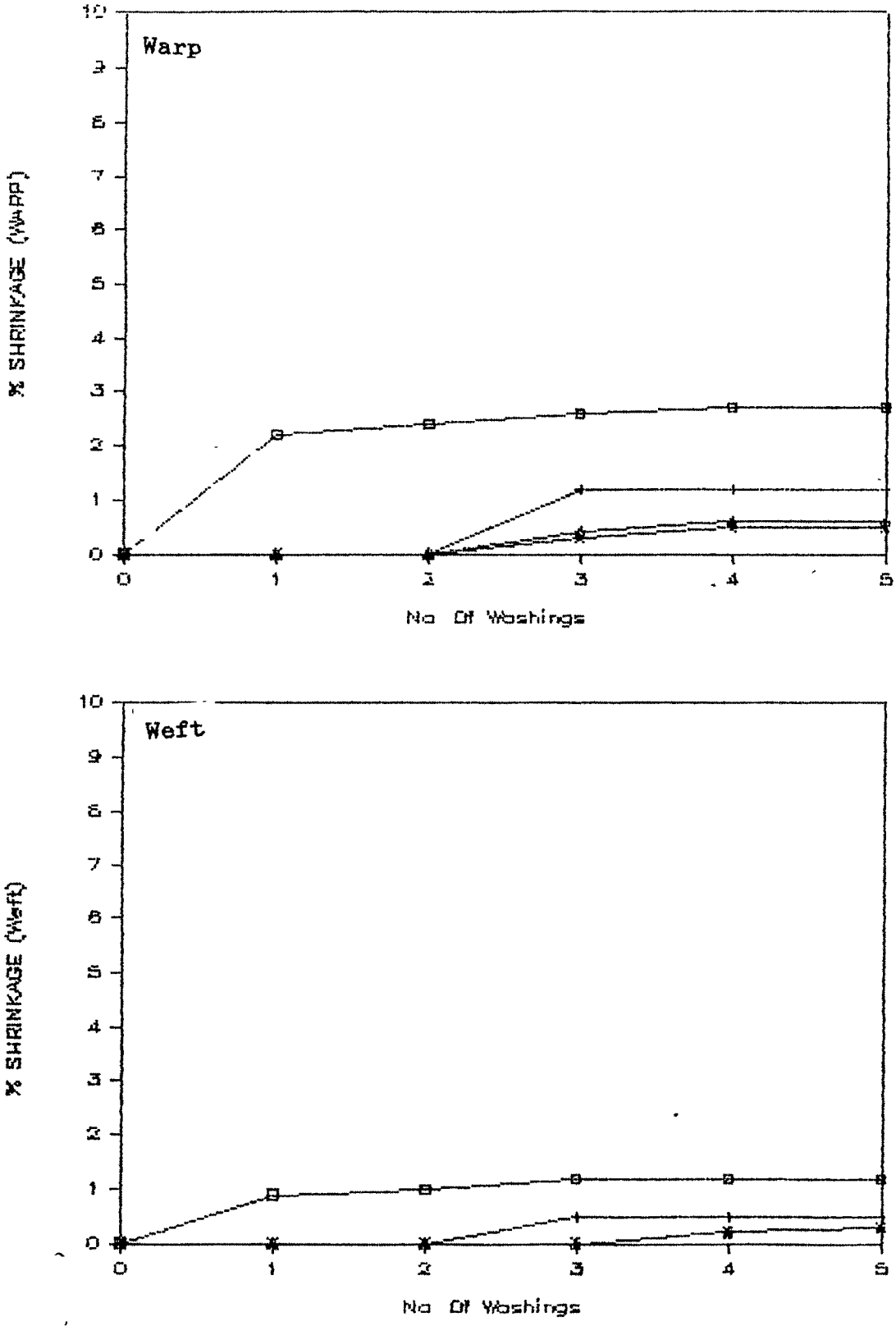
(ii) Cotton fabric (C)

The data on shrinkage control of cotton fabric is given in Table 5 and shown in Figure 6. It was found that acrylamide polymer finish has improved resistance to shrinkage, thereby giving dimensional stability. The effect was similar at higher concentrations (i.e. no further improvement was seen after five percent finish). This was explained on the reaction wherein crosslinkages are formed, which help to keep the fibres intact and prevent shrinkage. The reduction in elongation (page 109) also showed the formation of crosslinkages.

Table 5 Percent shrinkage of cotton fabric (C) treated with acrylamide polymer finish

Finish % / No. of washings.	% Shrinkage. 1	2	3	4	5
WARP					
Ø	2.2	2.4	2.6	2.7	2.7
2.5	Ø.Ø	Ø.Ø	1.2	1.2	1.2
5.Ø	Ø.Ø	Ø.Ø	Ø.4	Ø.6	Ø.6
7.5	Ø.Ø	Ø.Ø	Ø.4	Ø.6	Ø.6
1Ø.Ø	Ø.Ø	Ø.Ø	Ø.3	Ø.5	Ø.5
WEFT					
Ø	Ø.9	1.Ø	1.2	1.2	1.2
2.5	Ø.Ø	Ø.Ø	Ø.5	Ø.5	Ø.5
5.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.2	Ø.3
7.5	Ø.Ø	Ø.Ø	Ø.Ø	Ø.2	Ø.3
1Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.2	Ø.3

Figure 6 Effect of acrylamide polymer finish on shrink-resistance in cotton fabric (C)



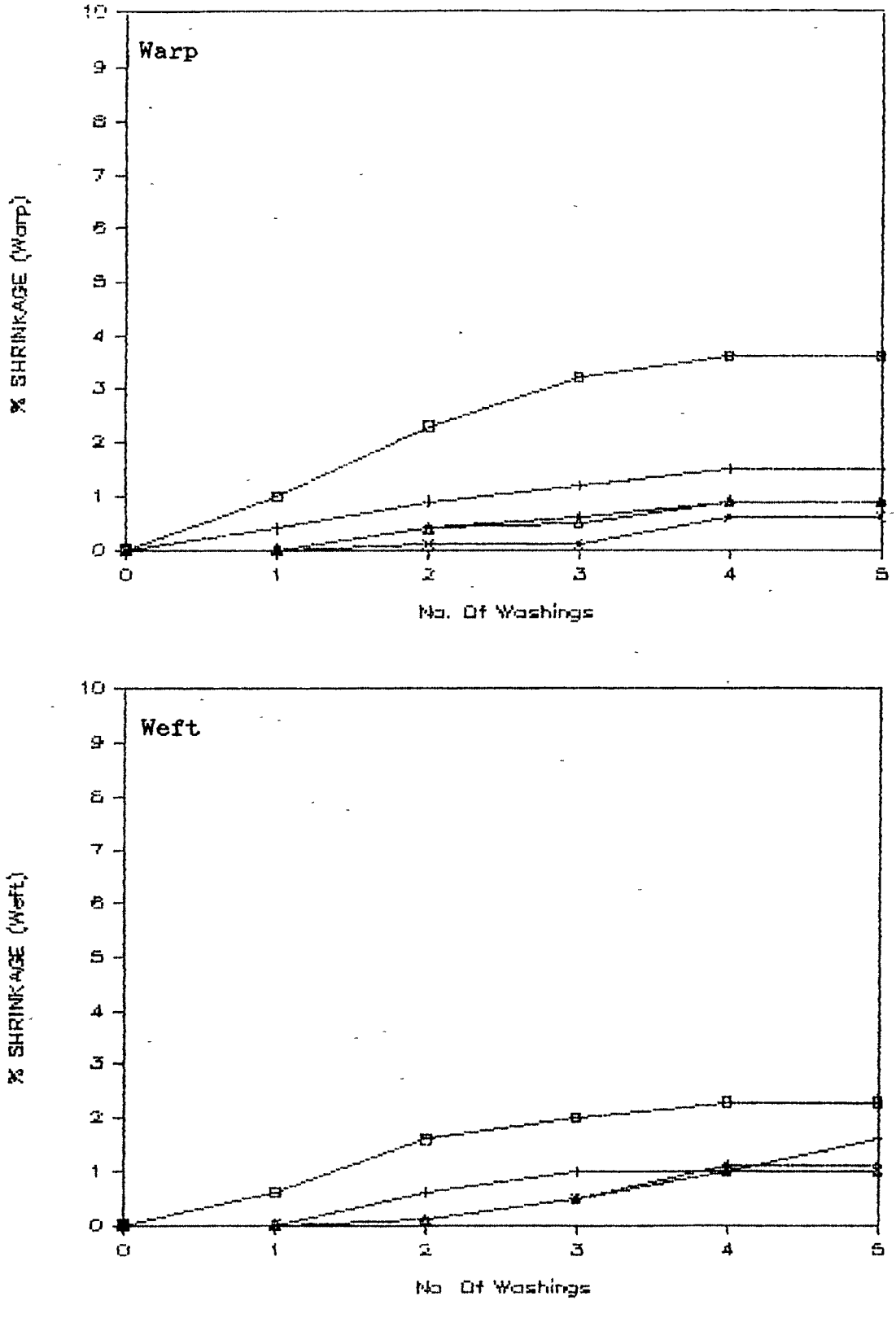
(iii) Cotswool fabric (CW)

The data on shrinkage contorl of cotswool fabric is given in Table 6 and shown in Figure 7 It was indicated that acrylamide polymer finish has helped to improve the shrink-resistance. The untreated fabric has more shrinkage (3.6%) as compared to treated fabric (Ø.6%), although after five percent finish the higher concentrations did not show any further influence of finish.

Table 6 Percent shrinkage of cotswool fabric (CW) treated with acrylamide polymer finish

Finish % / No. of washings.	% Shrinkage. 1	2	3	4	5
WARP					
Ø	1.Ø	2.3	3.2	3.6	3.6
2.5	Ø.4	Ø.9	1.2	1.5	1.5
5.Ø	Ø.Ø	Ø.4	Ø.6	Ø.9	Ø.9
7.5	Ø.Ø	Ø.1	Ø.1	Ø.9	Ø.9
1Ø.Ø	Ø.Ø	Ø.1	Ø.1	Ø.6	Ø.6
WEFT					
Ø	Ø.6	1.6	2.Ø	2.3	2.3
2.5	Ø.Ø	Ø.6	1.Ø	1.5	1.6
5.Ø	Ø.Ø	Ø.1	Ø.5	1.1	1.1
7.5	Ø.Ø	Ø.1	Ø.5	1.Ø	1.Ø
1Ø.Ø	Ø.Ø	Ø.1	Ø.5	1.Ø	1.Ø

Figure 7 Effect of acrylamide polymer finish on shrink-resistance in cotswool fabric (CW)



(b) All-Wool (W_1, W_2 and W_3) fabrics

i) Wool fabric (W_1)

The data for wool fabric W_1 has been given on page (80).

ii) Wool fabric (W_2)

As mentioned on page 76, another wool fabric was included in this study, this was of plain weave (W_2). The fabric was treated with five percent acrylamide polymer finish. It was noted earlier (page 49), that acrylamide polymer finish helped to make wool fabric shrink-resistant without affecting the other properties adversely. It was felt to know whether a loom, state plain weave fabric can be made shrink-resistant. As literature survey (39,73) has showed that pretreatments help to spread the finish more evenly and reduce shrinkage. As (W_2) was a loom state fabric, effect of acid-chlorination as pretreatement on shrink-resistance was also noted. Only wool fabric (W_2) was used, as different studies conducted in the department have confirmed that acrylamide finish improve the properties of cotton fabric. The data from Srivastava's (100) work on wool was also included for comparison in this section.

Results of the effect of pre-treatment (i.e. acid chlorination) only, acrylamide polymer finish alone and pre-treatment followed by acrylamide polymer finish on the wool fabric (W_2) are given in Table 7 and shown in Figure 8. It has been observed from Table and Figure that the treatments in comparison to untreated have protected wool fabric (W_2) from shrinkage. The chlorination (as a separate pretreatment), so also acrylamide polymer finish (as a single treatment) improved the

shrink - resistance of wool fabric (W_2). (Chlorination was used with wool fabric (W_2) as this was the only loom state fabric, others were commercial fabrics. The fabric shrinkage was not reduced by chlorination or by acrylamide polymer finish as separate steps, but was better controlled or was further stabilized, by their combination in sequence.

Table 7 Percent shrinkage of wool fabric (W_2) treated with chlorine and 5% acrylamide polymer finish

Finish % / No. of washings.	% Shrinkage				
	1	2	3	4	5
WARP					
To	1.3	4.Ø	5.3	5.5	5.5
T2	Ø.Ø	Ø.8	1.7	2.8	2.8
Tc	Ø.6	1.9	2.8	4.Ø	4.Ø
TcT2	Ø.Ø	Ø.4	1.5	1.8	1.8
WEFT					
To	1.5	3.3	4.Ø	4.8	5.1
T2	Ø.Ø8	Ø.4	1.6	3.2	3.5
Tc	Ø.3	1.6	3.5	4.2	4.2
TcT2	Ø.Ø	Ø.2	1.5	2.2	2.2

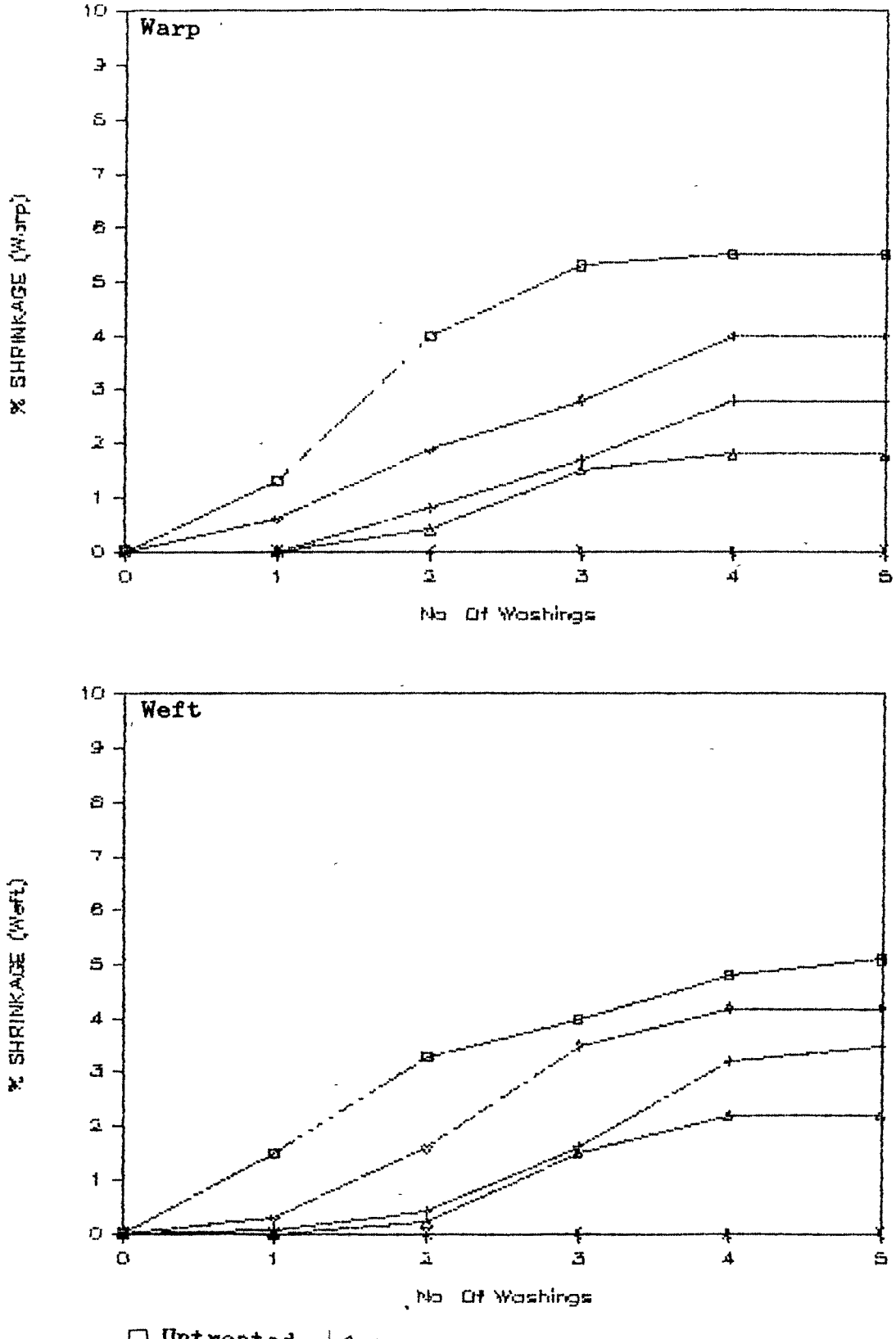
To = Untreated

T2 = 5% acrylamide finish

Tc = Chlorination as pretreatment

TcT2 = 5% acrylamide finish (on [Tc] chlorine pretreated)

Figure 8 Effcet of acid chlorination and 5% acrylamide polymer finish on shrink-resistance in wool fabric (W_2)



Chlorination pretreatment help shrinkage control by allowing the subsequent finish to be uniform over the surface of the fibre as was noted earlier by researchers (39,40,73). Five percent acrylamide finish was found to be adequate for providing a good shrink-resistance. The order of the efficiency of shrink-resistance was $TcT_2 > T_2 > Tc$.

iii) Wool fabric (W_3)

The results of wool fabric (W_3) reported here are from Srivastava's (100) study which was carried out in the Department of Clothing and Textiles, using the finish recipe of this work.

The data has been given in Table 8 and shown in Figure 9. From her work it was noted that shrinkage in wool fabric is considerably reduced by acrylamide finish, from 10% shrinkage (for unfinished) to 1.5% for (finished fabric). The finish concentrations were 2.5, 5.0 and 7.5% with (a) aqueous media, (b) solvent-aqueous media, and (c) solvent pretreatments (with 25% acetons and/or 25% rectified spirit), followed by acrylamide finish in aqueous media. The shrink-resistance with pretreatments followed by acrylamide finish in aqueous media was better than finish in aqueous media or in solvent aqueous media without any pretreatment.

Makinson (73) has stated that treatment with alcoholic solutions of caustic soda may hydrolyse peptide chains in the cuticle, this prevents the cortex because the wool is unswollen. Solvents also help to clean the fibre and to have even deposition of resins.

It was concluded that acrylamide finish controlled the shrinkage in wool fabrics and that more than optimum influence was achieved when solvent (25% acetone and/or 25% rectified spirit) were used as pretreatments.

Table 8 Percent shrinkage of wool fabric (W_3) treated with 5% acrylamide polymer finish

Treatments / No. of washings	% Shrinkage (Warp)				
	1	2	3	4	5
$T_Ø$	Ø.Ø	4.Ø	8.Ø	1Ø.Ø	1Ø.Ø
T_2	Ø.Ø	2.Ø	2.5	4.Ø	4.Ø
$T_a T_2$	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	2.Ø
$T_s T_2$	Ø.Ø	Ø.Ø	Ø.Ø	1.Ø	1.5
$T_2 A$	Ø.Ø	2.Ø	2.2	3.5	3.5
$T_2 S$	Ø.Ø	2.Ø	2.Ø	3.Ø	3.Ø

Data on fabric (W_3) is from Srivastava's work.

$T_Ø$ = Untreated

T_2 = 5% acrylamide finish

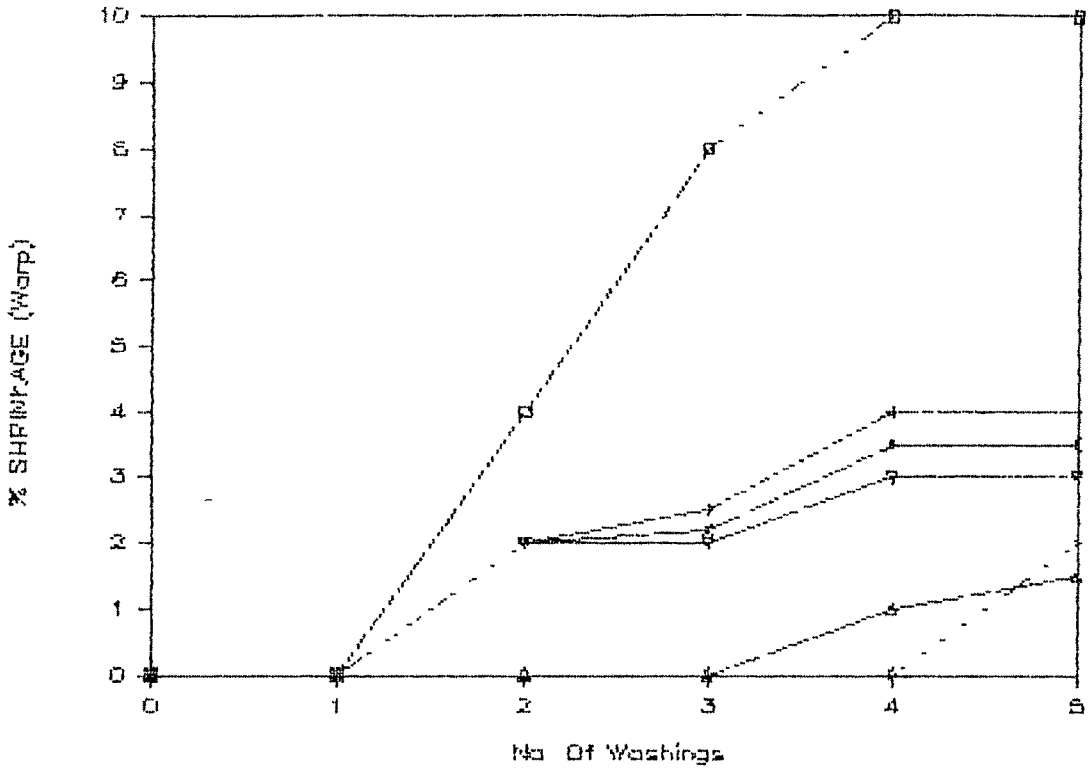
$T_a T_2$ = 5% acrylamide finish (on 25% acetone pretreated)

$T_s T_2$ = 5% acrylamide finish (on 25% rectified spirit pretreated)

$T_2 A$ = 5% acrylamide finish (in 25% acetone media)

$T_2 S$ = 5% acrylamide finish (in 25% rectified spirit media)

Figure 9 Effect of 5% acrylamide polymer finish on shrink-resistance in wool fabric (W_3)



□ Untreated

\+ 5% finish

◇ 5% finish (on 25% acetone pretreated)

△ 5% finish (on 25% rectified spirit pretreated)

× 5% finish (in 25% acetone media)

▽ 5% finish (in 25% rectified spirit media)

Comparison of the shrink-resistance of the three wool fabrics (W_1, W_2, and W_3)

The data on shrink-resistance of the three wool fabrics has been compared and has been given in Table 9 and shown in Figure 10.

The shrink resistance in all the three fabrics was improved with acrylamide polymer finish. It was noted that with acrylamide finish the shrinkage reduced from 6.8 to 3.0% in wool fabric W_1, from 5.5 to 2.8% in W_2 and from 10.0 to 4.0% in W_3. On calculation this resistance to shrinkage was as high as 50 to 60% in all the three fabrics. Comparison of the pretreatments can be very general, being on different fabrics, while the pretreatments followed by acrylamide polymer finish gave some what better shrink-resistance (above 60-70%) than that due to acrylamide finish alone. Almost complete shrink-resistance was obtained with diluted solvent pretreatment. It showed that pretreatments help to have the finish more evenly, either by affecting the scales or by cleaning the surface. The reappearance/residual 1-2% shrinkage, after 3-4 washings indicates the loss of loosely held finish.

Table 9 Percent shrinkage of wool fabrics (W_1, W_2, and W_3) treated with 5% acrylamide polymer finish

Fabric code	Treatments / No. of washings	% shrinkage (warp)				
		1	2	3	4	5
W_1	T_0	Ø.4	4.Ø	5.7	6.8	6.8
	T_2	Ø.Ø	1.Ø	1.9	3.Ø	3.Ø
W_2	T_0	1.3	4.Ø	5.3	5.5	5.5
	T_2	Ø.Ø	Ø.8	1.7	2.8	2.8
	$T_c T_2$	Ø.Ø	Ø.4	1.5	1.8	1.8
W_3	T_0	Ø.Ø	4.Ø	8.Ø	1Ø.Ø	1Ø.Ø
	T_2	Ø.Ø	2.Ø	2.5	4.Ø	4.Ø
	$T_a T_2$	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	2.Ø
	$T_s T_2$	Ø.Ø	Ø.Ø	Ø.Ø	1.Ø	1.5
	T_A 2	Ø.Ø	2.Ø	2.2	3.5	3.5
	T_S 2	Ø.Ø	2.Ø	2.Ø	3.Ø	3.Ø

T_0 = Untreated

T_2 = 5% acrylamide finish

$T_c T_2$ = 5% acrylamide finish (on chlorine pretreated)

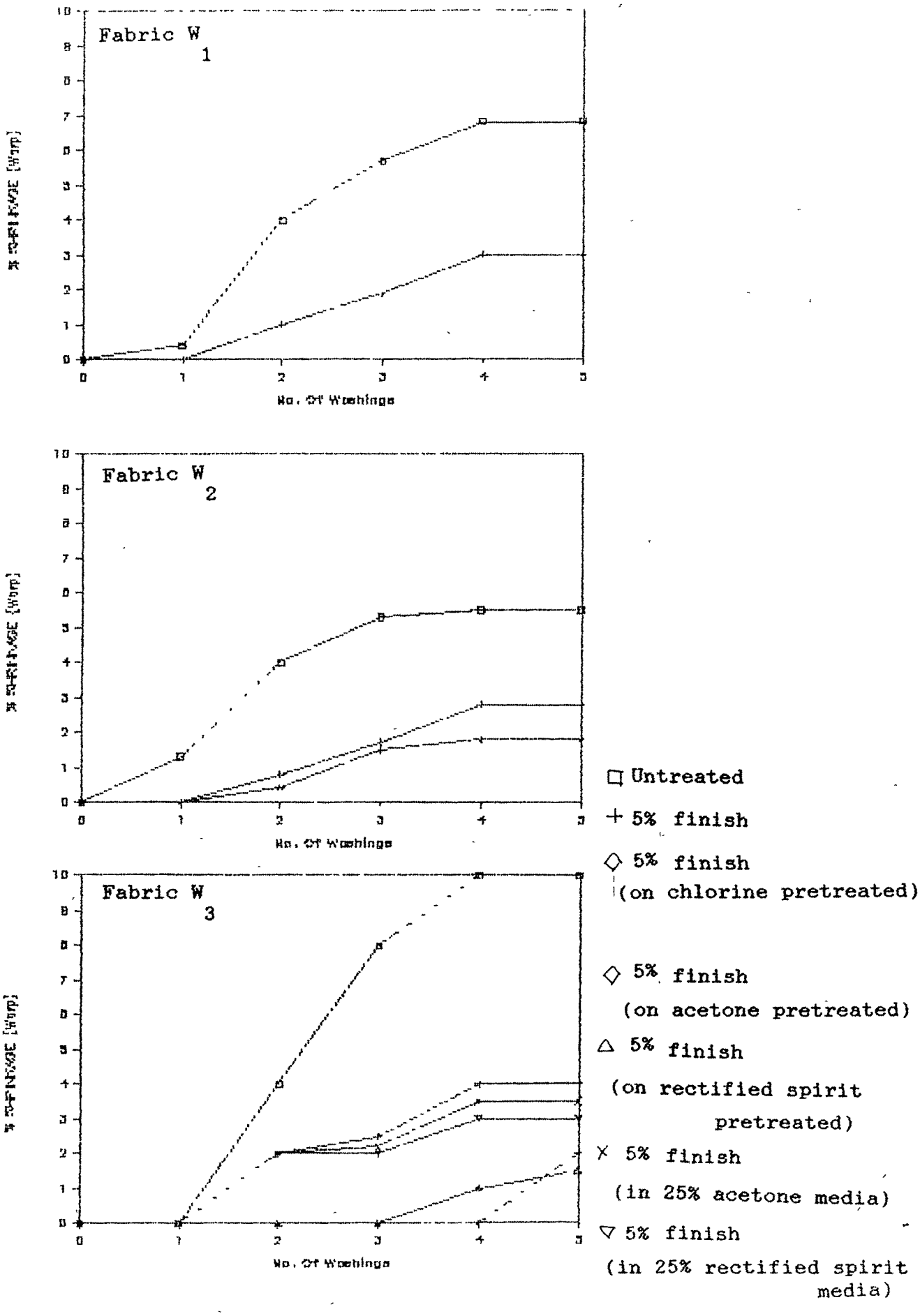
$T_a T_2$ = 5% acrylamide finish (on 25% acetone pretreated)

$T_s T_2$ = 5% acrylamide finish (on 25% rectified-spirit pretreated)

T_A 2 = 5% acrylamide finish (in 25% acetone media)

T_S 2 = 5% acrylamide finish (in 25% rectified spirit media)

Figure 1Ø Effect of 5% acrylamide polymer finish on shrink-resistance in wool fabrics (W_1, W_2 and W_3)



5.4 Effect of acrylamide polymer finish on other related properties of wool, cotton and cotswool (W_1, C and CW) fabrics.

Namely (a) elastic recovery (b) tensile strength and elongation (c) tearing strength (d) stiffness (e) wrinkle recovery, and (f) appearance rating after wrinkling and ironing.

In this study, shrinkage control obtained by acrylamide polymer finish was of major importance. From the discussion so far on the effectiveness of this finish, it has been obvious that this finish will be of good utility for fabrics as well as garments. However, when one property is positively influenced, there are often some properties which are affected sometimes adversely. The following related properties were thus studied,
(a) elastic recovery (b) tensile strength and elongation
(c) tearing strength (d) stiffness (e) wrinkle revcovery and
(f)appearance rating after wrinkling and ironing.

The mechanism by which finishes control the shrinkage in wool fabrics have been quoted by researchers (73, 104) say altering the surface properties due to adhering or film formation by the polymer on the surface, by increasing resistance of wool fabric to extension,and by decreasing power to recover from extension due to penetration of resin.

Acrylamide finish has improved the shrink-resistance of fabrics, so to see its influence, on elasticity and elongation of fabrics was thus obvious.

(a) Elastic recovery

Elasticity is the ability of a material to return to its original form after relieved form strain which caused its

change. In other words it is the property which helps the textile material to recover from any deformation. If it is from extension, it is expressed as elastic recovery. A constant load is applied onto a specimen for a specified time. After the removal of the load, the specimen recovers, rapidly at first and then more slowly, residual extension, if any is then called 'permanent set' (11).

The data on percent elastic recovery of the fabrics. (treated and untreated) has been given in Tables 10,11 and 12 and shown in Figures 11,12 and 13

(i) Wool fabric (W_1)

As shown in Table 10 and Figure 11 it was found that acrylamide polymer finish has slightly affected the elastic recovery property of wool fabric W_1, as there was a slight reduction in the elastic recovery especially at higher concentration. As the finish used masks the scale structure and bonds adjacent fibre chains together, the surface finish polymerized completely after curing, which was assessed from the increase in stiffness.

The polymerized finish on the surface which was holding the fibres together has broken or lossened during the stress-strain. Little changes in the elastic recovery of wool have been reported by researchers (104, 73). Since the changes in elastic recovery in this work were marginal, (reduction in elastic recovery) the above explanation, as masking of scales or film is acceptable. The utility of reduction in elasticity of wool has been explored later by permanent press effects.

Table 1Ø Percent elastic recovery of wool fabric W_1 treated with acrylamide polymer finish

Finish %	% elastic recovery			
	5 min.	3Ø min.	12 min.	24 hrs.
Ø	71.2	78.7	84.Ø	89.Ø
2.5	71.4	77.Ø	81.6	86.5
5.Ø	69.Ø	72.3	77.9	83.1
7.5	71.3	75.8	78.5	83.9
1Ø.Ø	7Ø.6	72.9	76.9	83.7

(ii) Cotton fabric (C)

The data given in Table 11 and shown in Figure 12 indicated that in cotton fabric, acrylamide polymer finish has affected the elastic recovery. The elastic recovery has increased with the increase in concentration of finish. It showed that the crosslinkages were formed in cotton material which tried to pull back the fibres to their original position. Bhargava (9) has also reported that acrylamide glyoxal polymer finish inceased the elastic recovery of cotton fabric.

(iii) Cotswool fabric (CW)

It was indicated from data in Table 12 and Figure 13 for cotswool fabric that acrylamide finish has not affected the elastic recovery property; a very small difference being noted in elastic recovery values of treated and untreated fabrics. Since the changes in elasticity of wool and cotton were opposite, it was

Figure 11 Effect of acrylamide polymer finish on elastic recovery of wool fabric (W_1)

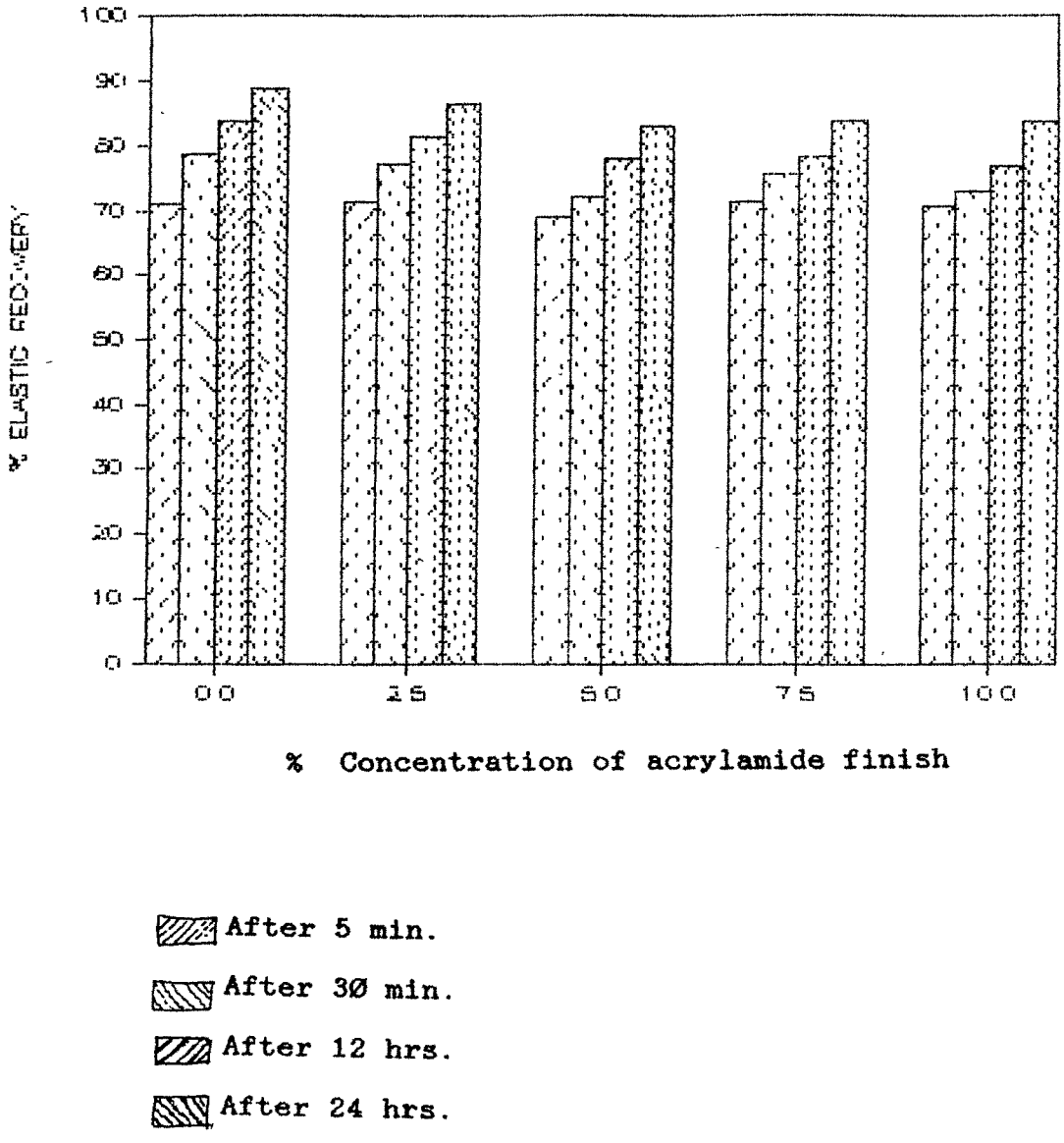


Table 11 Percent elastic recovery of cotton fabric (C) treated with acrylamide polymer finish

Finish %	% elastic recovery			
	5 min.	30 min.	12 hrs.	24 hrs.
0	52.6	59.0	63.0	72.5
2.5	52.7	59.2	65.8	79.8
5.0	59.4	61.2	73.9	86.5
7.5	59.4	62.3	72.8	86.8
10.0	57.1	65.1	76.2	87.5

obvious that with 50:50 wool/cotton (cotswool) blend, the changes in one will be nullified by the changes in the other fabric. Whether there can be mutually available for improvement in set is studied later.

Table 12 Percent elastic recovery of cotswool fabric (CW) treated with acrylamide polymer finish

Finish %	% elastic recovery			
	5 min.	30 min.	12 hrs.	24 hrs.
0	65.7	68.6	76.5	83.2
2.5	65.5	69.6	78.7	84.2
5.0	69.3	74.7	82.6	88.2
7.5	68.4	72.9	83.2	86.8
10.0	68.2	73.6	83.0	86.5

Figure 12 Effect of acrylamide polymer finish on elastic recovery of cotton fabric (C)

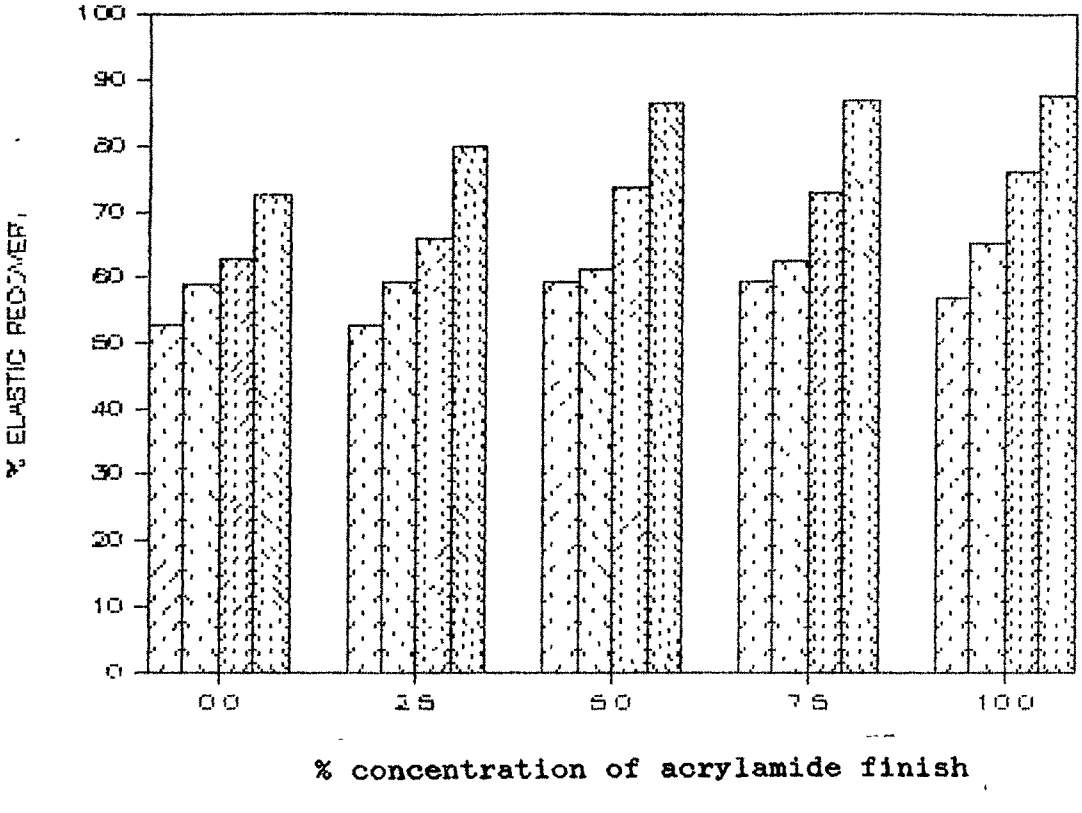
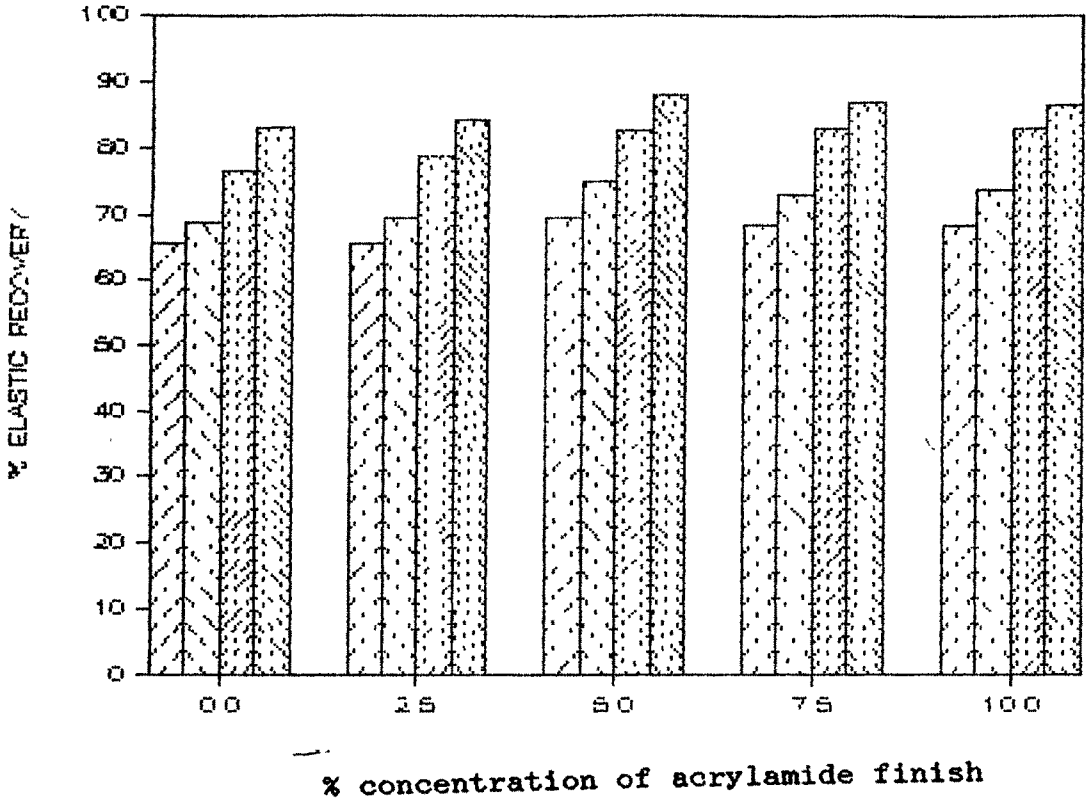


Figure 13 Effect of acrylamide polymer finish on elastic recovery of cotswool fabric (CW)



So it was noted that elastic recovery values were more affected in cotton as compared to wool. In wool a slight reduction in elastic recovery was noted.

b. Tensile strength and elongation

(i) Tensile strength

As observed from the discussion so far that this finish has improved the shrink-resistance of fabrics and has also affected the elastic property; it was necessary to know how this finish has affected the tensile strength. Which is one of the most important property of textiles.

The data obtained on tensile strength in warp and weft direction of fabric W ,C and CW has been given in Tables 13,14 and 15 and shown in Figures 14, 15 and 16.
1

(i) Wool fabric (W)
1

Results of the effect of acrylamide polymer finish on wool fabric (W) are given in Table 13 and shown in Figure 14.It was seen that acrylamide finish has affected the tensile strength of wool fabric W . Fabric treated with varying concentrations of finish showed slight increase upto five percent level of finish, thereafter tensile strength has decreased (although it was above the original). The increase in strength in wool fabric was due to the additive polymer treatment which masks the scale structure and bonds adjacent fibres together. The polymer finish helped in bonding forces in the amorphous region. These results were in accordance with those of Feldtman and McPhee (41) who found that tensile strength of wool fabrics increased with polyacrylates and

with those of Bereck and Kamein (7), who reported strength improvement with acrylic copolymers.

Table 13 Tensile strength of wool fabric (W_1) treated with acrylamide polymer finish

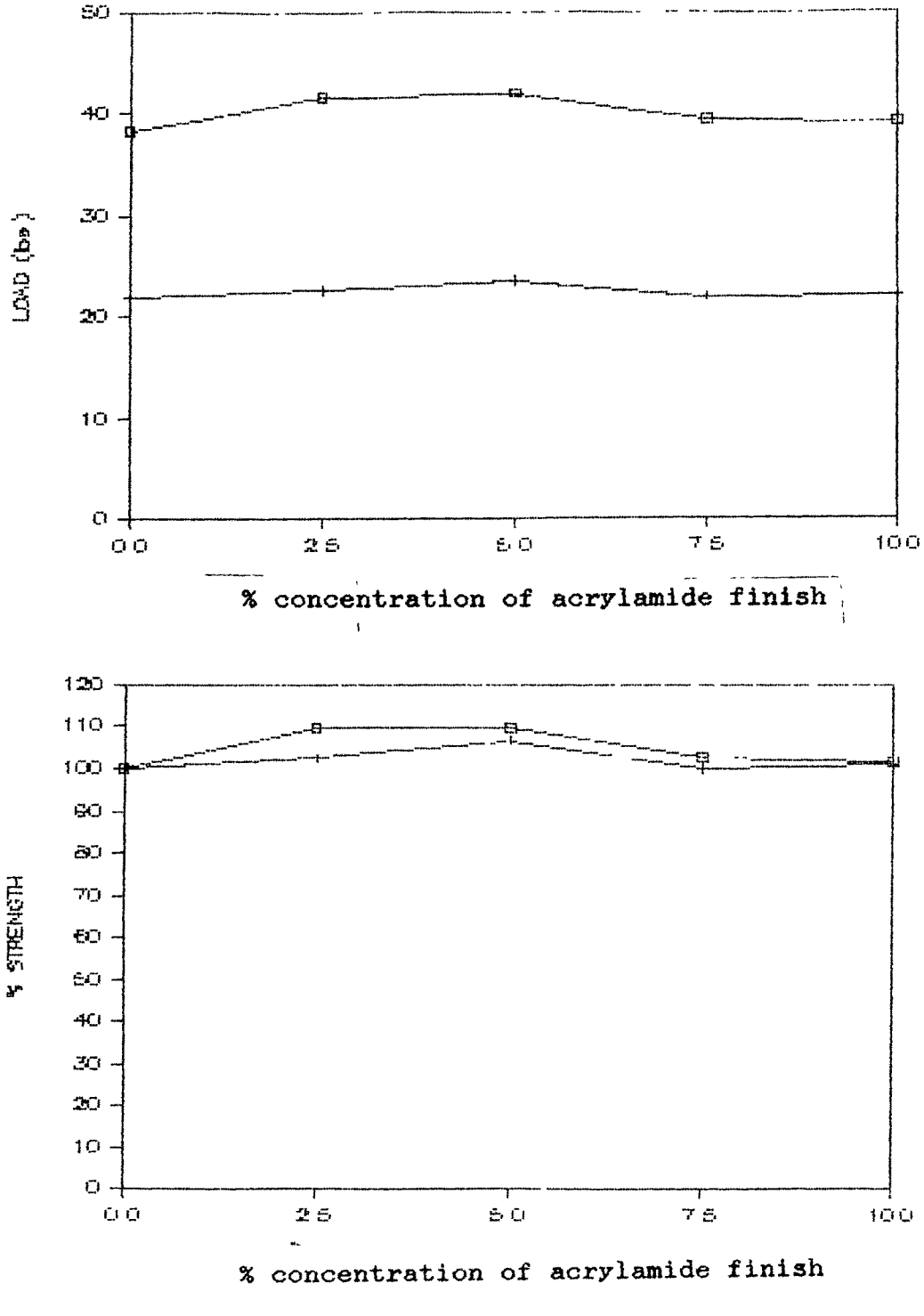
Finish %	Tensile strength			
	Warp		Weft	
	lbs.	%	lbs.	%
Ø	38.3	1ØØ.Ø	21.9	1ØØ.Ø
2.5	41.7	1Ø9.7	22.5	1Ø2.5
5.Ø	42.Ø	1Ø9.8	23.4	1Ø6.7
7.5	39.5	1Ø2.6	22.Ø	1ØØ.1
1Ø.Ø	39,2	1Ø1.8	22.2	1Ø1.3

(ii) Cotton fabric (C)

The data given in Table 14 and shown in Figure 15 is for cotton fabric. It was found that the acrylamide finish has decreasesd the tensile strength of cotton fabric. The loss in tensile strength related with an increase in concentration of finish. The tensile strength was marginally affected upto five per cent finish. At higher concentration (1Ø%) however the loss in strength was considerable.

When cellulose chains are crosslinked, this results in the creation of undesirable restraining forces. The stress arising in cellulose molecules break the cellulose chains and weaken the fibre. Kamogawa and Sekiya (66) graft polymerized acrylamide onto

Figure 14 Effect of acrylamide polymer finish on tensile strength of wool fabric (W_1)



cotton with ceric ammonium nitrate catalyst. The crosslinks between graft chains of different cellulose molecules by means of a methylene-bisamide linkage (-CONHCH$_2$HNOC-) were incorporated. Excellent crease resistance was obtained but the strength loss was high. The loss in strength with cotton fabric (C) was due to the reaction of fibre and finish, the reaction was established from the durability of finish.

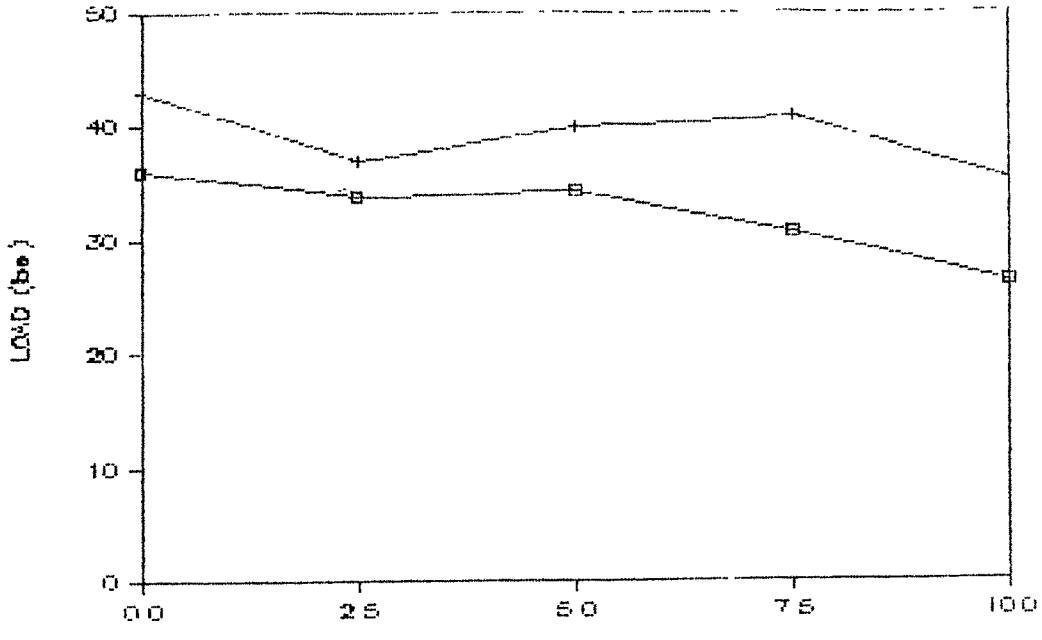
Table 14 Tensile strength of cotton fabric (C) treated with acrylamide polymer finish.

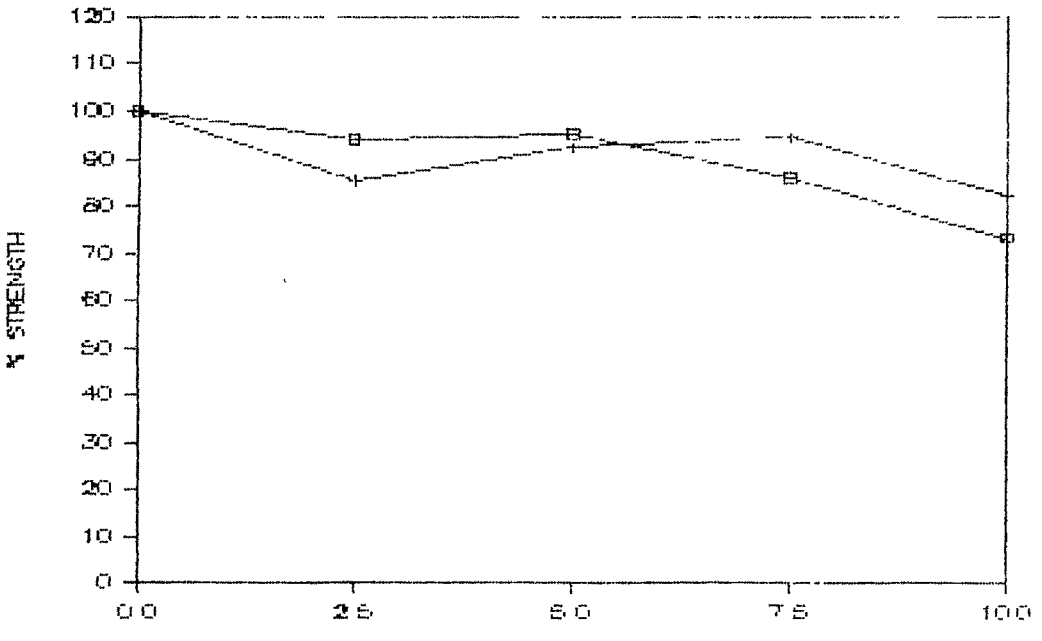
Finish %	Tensile strength			
	Warp		Weft	
	lbs.	%	lbs.	%
Ø	36.Ø	1ØØ.Ø	43.1	1ØØ.Ø
2.5	33.8	93.9	36.9	85.6
5.Ø	34.2	95.Ø	39.8	92.2
7.5	3Ø.6	85.8	4Ø.7	94.4
1Ø.Ø	26.4	73.3	35.4	82.Ø

(iii) Cotswool fabric (CW)

For cotswool fabric data has been given in Table 15 and shown in Figure 16. Acrylamide finish caused no appreciable change in tensile strength. After a marginal increase at 2.5% finish the strength decreased slowly with higher concentrations. These results showed more influence of acrylamide finish on

Figure 15 Effect of acrylamide polymer finish on tensile strength of cotton fabric (C)





□ warp

\+ weft

cotton than on wool fabric.

Table 15 Tensile strength of cotswool fabric (CW) treated with acrylamide polymer finish.

Finish %	Tensile strength			
	Warp		Weft	
	lbs	%	lbs	%
Ø	25.5	1ØØ.Ø	25.3	1ØØ.Ø
2.5	26.1	1Ø2.5	25.7	1Ø1.4
5.Ø	25.3	99.5	25.3	1ØØ.Ø
7.5	24.3	95.5	22.6	89.2
1Ø.Ø	23.3	91.3	22.3	88.Ø

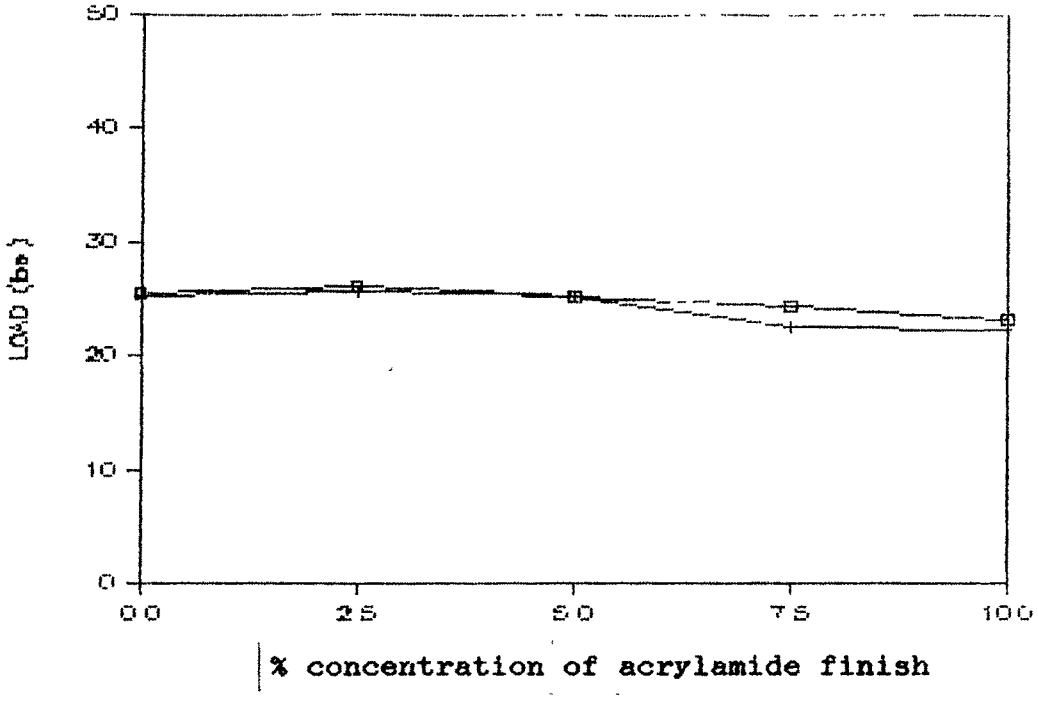
(ii) Elongation

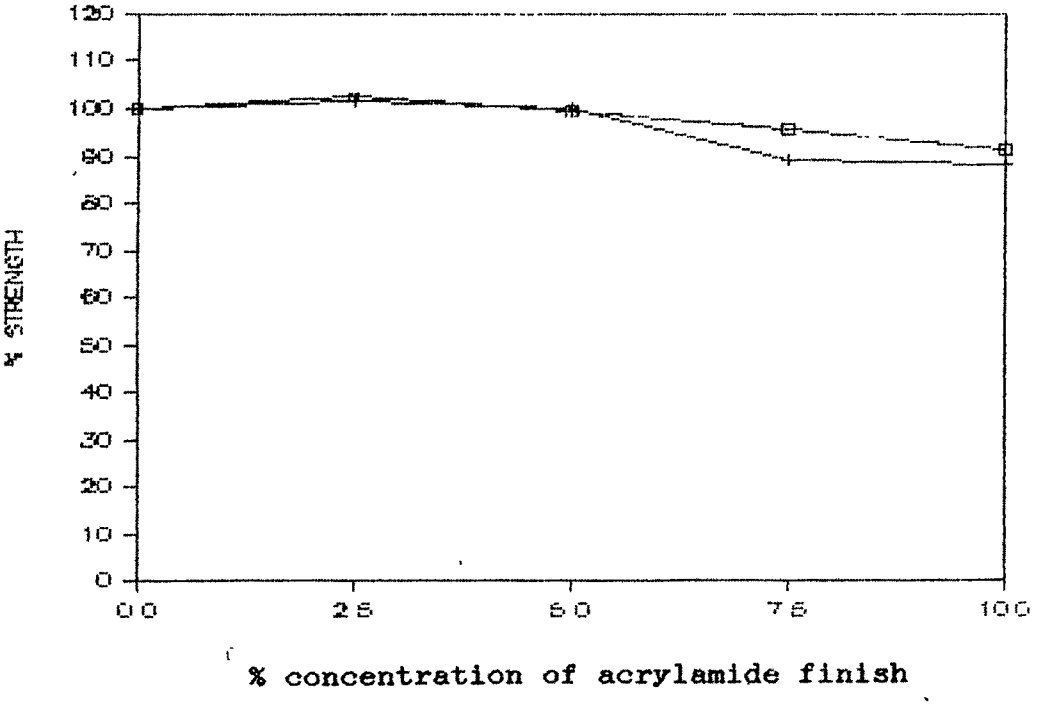
The comparison of the effect of concentrations of the finish on the three fabrics was also extended to the percent elongation at various intermediate loads. From the record obtained on the Scott Tester, the elongation values at intermediate loads were obtained and converted to percent elongation. The data on the percent elongation at different loads for the three fabrics has been given in Tables 16, 17 and 18 and shown in Figures 17, 18 and 19.

(i) Wool fabric (W_1)

The data for wool fabric on elongation has been given in Table 16 and shown in Figure 17. The analysis of the data revealed, that graphs (warp) with varying concentrations of finish were close to each other. In weft direction also, the

Figure 16 Effect of acrylamide polymer finish on tensile strength of cotswool fabric (CW)





□ warp

+ weft

graphs with varying concentrations of finish were close to each other. However, the elongation of treated fabrics decreased in comparison to untreated.

The decrease in elongation can be explained on the basis of the bonding of adjacent fibre molecules due to the additive nature of polymer which did not allow the fibres to elongate. However, this bonding did not affect the final breaking strength adversely, which is retained.

These results of decrease in elongation in wool fabric (W_1) were in accordance to the results given by Bereck and Kamein (7). Bereck and Kamein have reported that with the increase of methylmethacrylate and glycidylmethacrylate the elongation at break decreased. Lipson (72) has reported that the maximum resistance to extension with methacrylic acid and formaldehyde was noticed at pH 5.1. It was emphasized that at low pH preferential internal polymerization was promoted by the high concentration of acids inside the fibres.

(ii) Cotton fabric (C)

The data given in Table 17 and shown in Figure 18 for cotton fabric, indicated a decrease in percent elongation with finish. The lower concentration of finish did not affect the elongation much. However, higher concentrations caused a loss in the elongation considerably. This loss in elongation indicated that rigidity was introduced with acrylamide finish.

A decrease in elongation with increasing concentration of finish explained the reaction and adhesive nature of the finish.

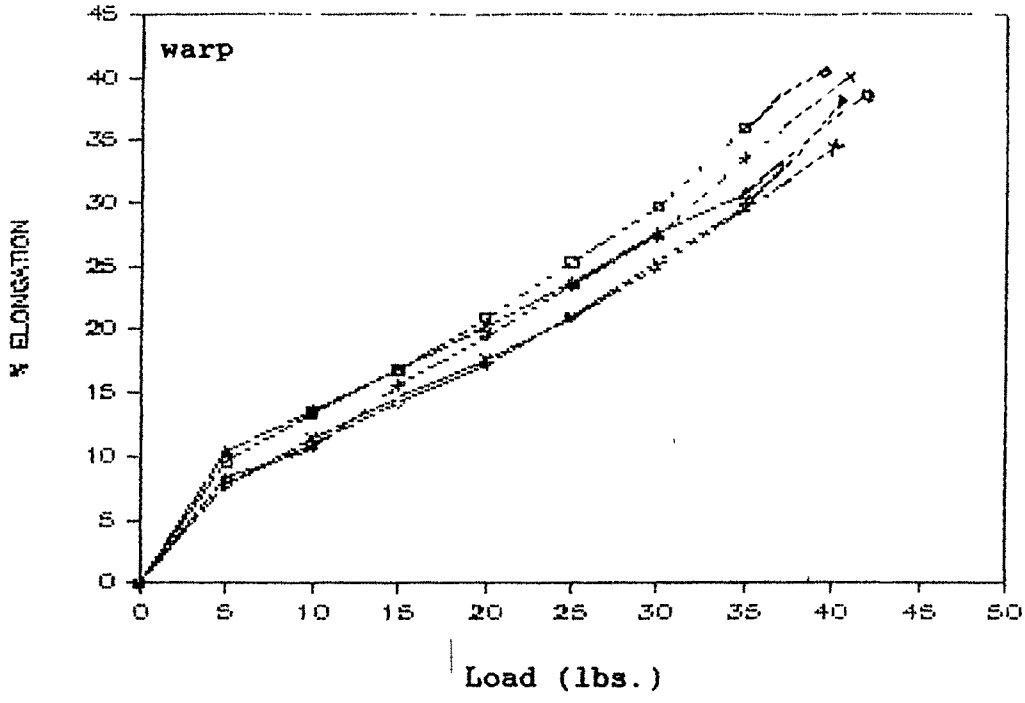
Table 16a Percent elongation of wool fabric (W_1) treated with acrylamide polymer finish (warp)

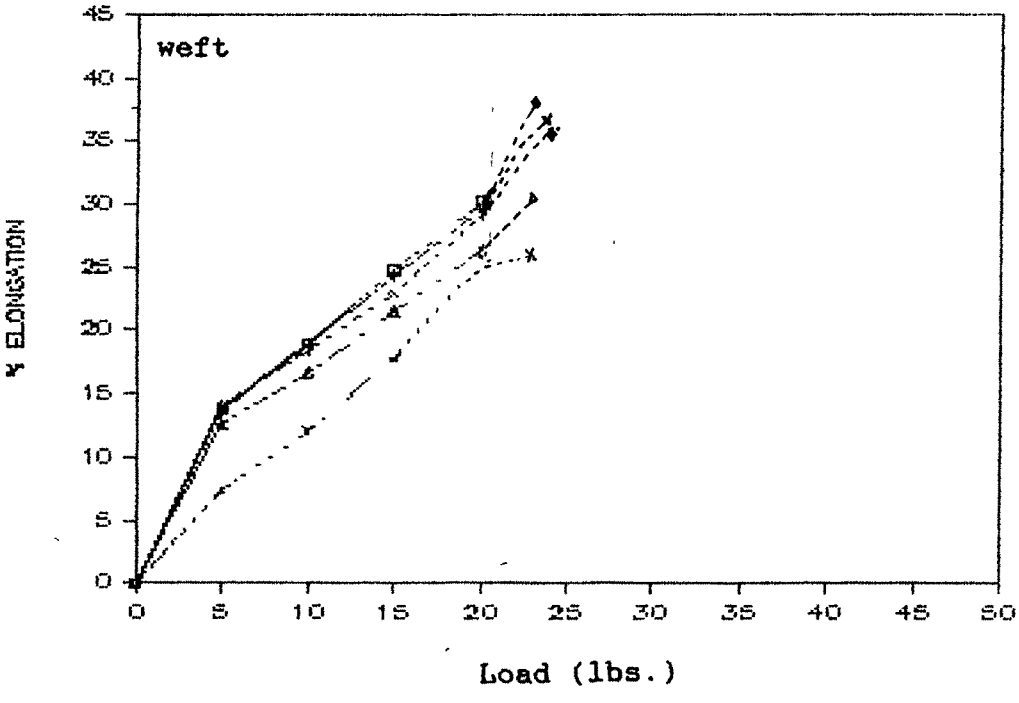
% Elongation (Warp)								
Load (lbs) / Finish %	5	1Ø	15	2Ø	25	3Ø	35	Breaking Load (lbs.)
Ø	9.6	13.5	16.8	21.Ø	25.4	29.7	36.Ø	4Ø.3 (38.3)
2.5	8.3	1Ø.17	15.7	19.6	23.6	27.4	33.7	38.9 (41.7)
5.Ø	7.8	11.Ø	14.2	17.2	21.1	25.3	29.8	37.2 (42.Ø)
7.5	1Ø.5	13.7	16.8	2Ø.3	23.8	27.6	3Ø.8	37.Ø (39.5)
1Ø.Ø	7.8	11.5	14.6	17.7	21.Ø	25.Ø	29.7	34.1 (39.2)

Table 16b Percent elongation of wool fabric (W_1) treated with acrylamide polymer finish (weft)

% Elongation (Weft)						
Load (lbs) / Finish %	5	1Ø	15	2Ø		Breaking Load (lbs.)
Ø	13.9	19.Ø	24.7	3Ø.2	37.7	(22.Ø)
2.5	13.6	18.8	24.4	29.6	36.7	(22.5)
5.Ø	14.Ø	18.5	23.Ø	29.2	36.Ø	(23.4)
7.5	12.6	16.6	21.5	26.4	3Ø.8	(22.Ø)
1Ø.Ø	7.4	12.Ø	17.8	25.6	25.6	(22.2)

Figure 17 Effect of acrylamide polymer finish on percent elongation of wool fabric (W_1)





□ Untreated

\+ 2.5% acrylamide finish

◇ 5.0% acrylamide finish

△ 7.5% acrylamide finish

× 10.0% acrylamide finish

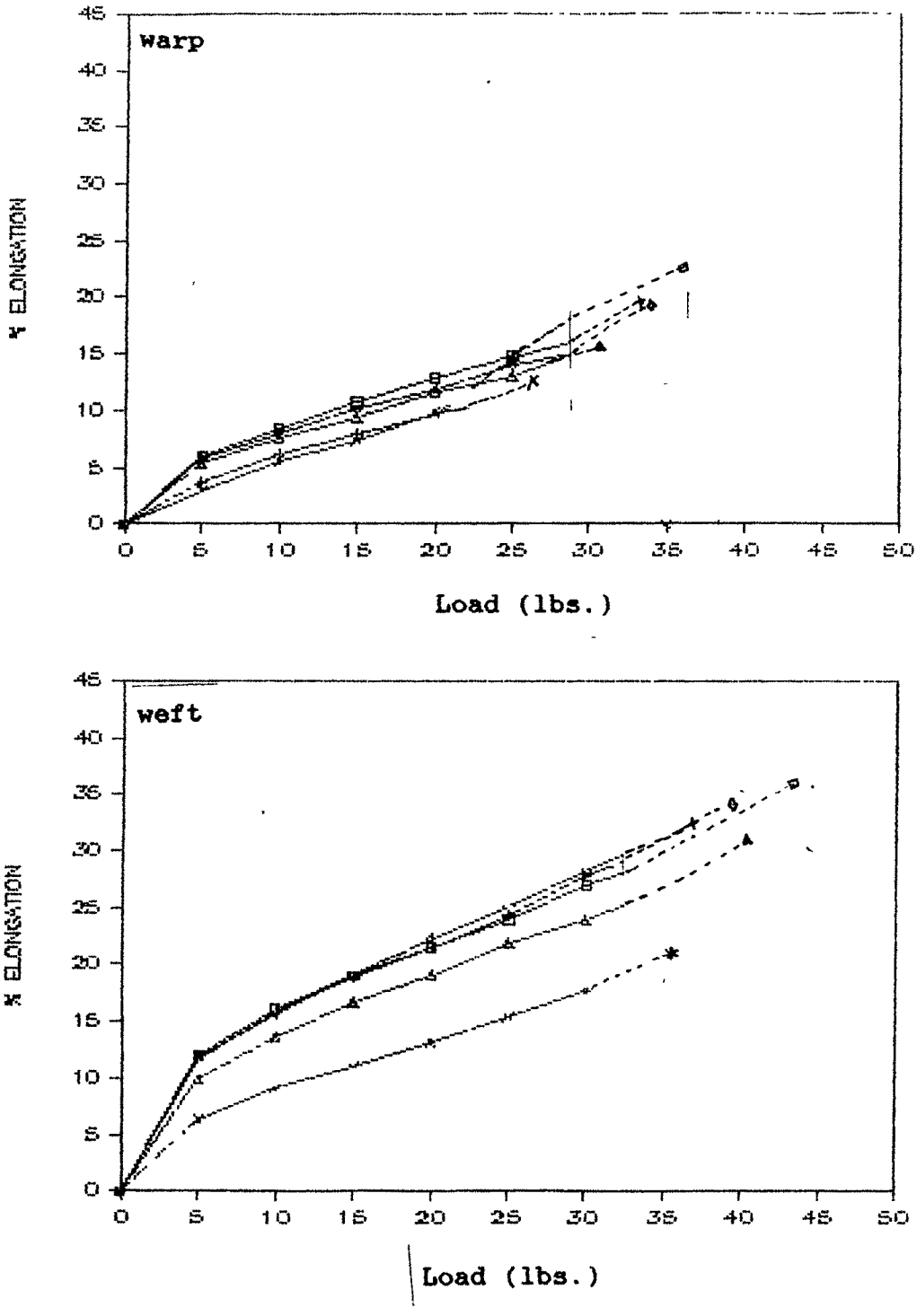
Table 17a Percent elongation of cotton fabric (C) treated with acrylamide polymer finish (warp)

% Elongation (Warp)						
Load (lbs) / Finish %	5	10	15	20	25	Breaking load (lbs.)
0	6.0	8.4	10.8	12.8	14.9	21.4 (36.0)
2.5	3.7	6.1	8.0	9.6	14.7	19.7 (33.8)
5.0	5.7	8.0	10.1	11.9	14.1	18.8 (34.2)
7.5	5.4	7.6	9.4	11.6	13.0	15.9 (30.6)
10.0	3.0	5.5	7.4	9.8	10.7	12.2 (26.4)

Table 17b Percent elongation of cotton fabric (C) treated with acrylamide polymer finish (weft)

% Elongation (Weft)							
Load (lbs) / Finish %	5	10	15	20	25	30	Breaking load (lbs)
0	12.1	16.1	19.0	21.6	24.0	27.0	35.3 (43.1)
2.5	11.7	15.9	18.9	21.5	24.3	27.7	34.3 (36.9)
5.0	11.9	15.6	19.0	22.3	25.1	28.3	34.7 (39.8)
7.5	9.9	13.7	16.7	19.1	21.9	24.0	30.5 (40.7)
10.0	6.4	9.1	11.1	13.2	15.4	17.7	20.4 (35.4)

Figure 18 Effect of acrylamide polymer finish on percent elongation of cotton fabric (C)



□ Untreated

\+ 2.5% acrylamide finish

◇ 5.0% acrylamide finish

△ 7.5% acrylamide finish

X 10.0% acrylamide finish

The marginal decrease in elongation was also reported by Kunzru (69), Jain (6Ø) in cotton fabric with acrylic finishes. Since the durability was achieved with the use of trichloro acetic acid, reaction was indirectly confirmed. This was at the cost of loss in strength for cotton, in contrast to wool.

(iii) Cotswool fabric (CW)

From the data given in Table 18 and shown in Figure 19 for cotswool fabric, a marginal change in the elongation from 2.5 to 7.5% finish was noticed. But higher concentration of finish (1Ø%) caused a considerable loss in elongatioin at break. The adhesive nature of finish which held the fibres together by reaction explains this reduction in elongation. The elongation loss, and strength loss were together.

It was noted in general that elongation decreased with this finish in all the fabrics.

(c) Tearing strength

Tearing strength was studied because it is an alternative way to study the strength of the fabrics.

(i) Wool fabric (W_1)

The data on tearing strength of wool fabric (W_1) has been given in Table 19 and shown in Figure 2Ø. It was noticed that at lower concentrations of finish the strength increased slightly. At higher concentration reduction in tearing strength was noticed but was retained near the original one.

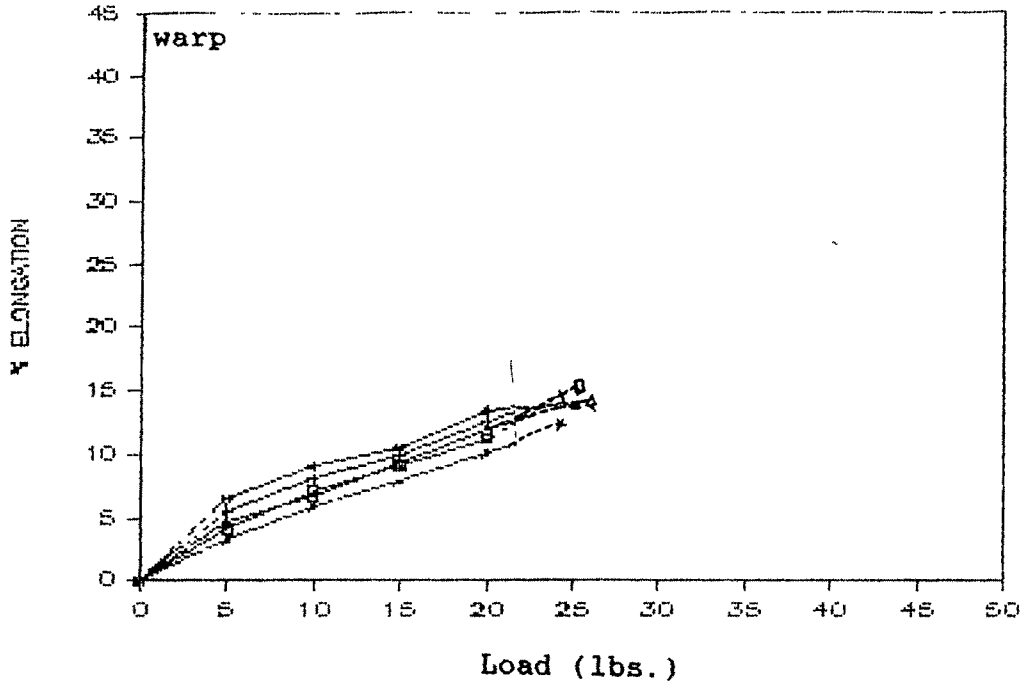
Table 18a Percent elongation of cotswool fabric (CW) treated with acrylamide polymer finish (warp)

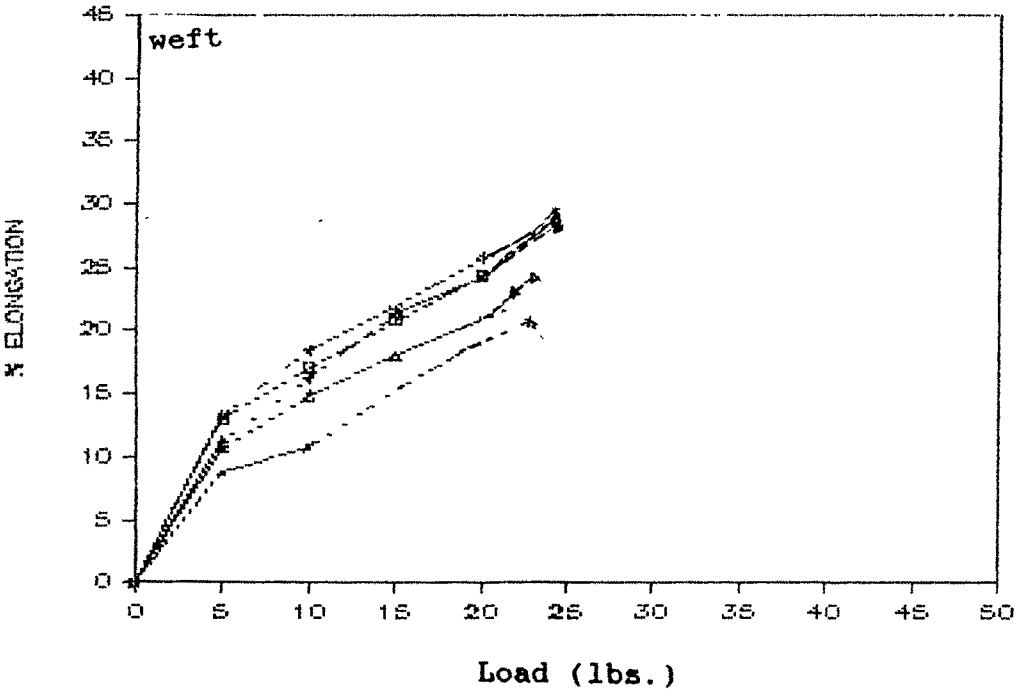
% Elongation (Warp)					
Load (lbs) / Finish %	5	10	15	20	Breaking load (lbs.)
0	4.1	7.1	9.2	11.3	15.2 (25.5)
2.5	5.5	8.1	10.0	12.7	15.1 (25.4)
5.0	6.5	9.1	10.7	13.5	14.7 (25.3)
7.5	4.7	6.8	9.3	12.0	14.3 (24.3)
10.0	3.3	6.0	7.9	10.2	12.0 (23.4)

Table 18b Percent elongation of cotswool fabric (CW) treated with acrylamide polymer finish (weft)

% Elongation (Weft)					
Load (lbs) / Finish %	5	10	15	20	Breaking load (lbs.)
0	13.0	17.1	20.8	24.3	28.5 (25.3)
2.5	11.2	16.2	21.3	24.3	28.7 (25.7)
5.0	13.3	18.4	22.0	25.8	28.2 (25.2)
7.5	10.7	14.8	18.0	21.0	23.3 (22.6)
10.0	8.7	10.8	15.2	19.3	19.7 (22.3)

Figure 19 Effect of acrylamide polymer finish on percent elongation of cotswool fabric (CW)





□ Untreated

\+ 2.5% acrylamide finish

◇ 5.0% acrylamide finish

△ 7.5% acrylamide finish

× 10.0% acrylamide finish

Whitfield *et al*. (113) has stated that the interfacial polymerization of polyamide imparted good shrink - resistance in wool fabric but the tear strength was almost unchanged.

(ii) Cotton fabric (C)

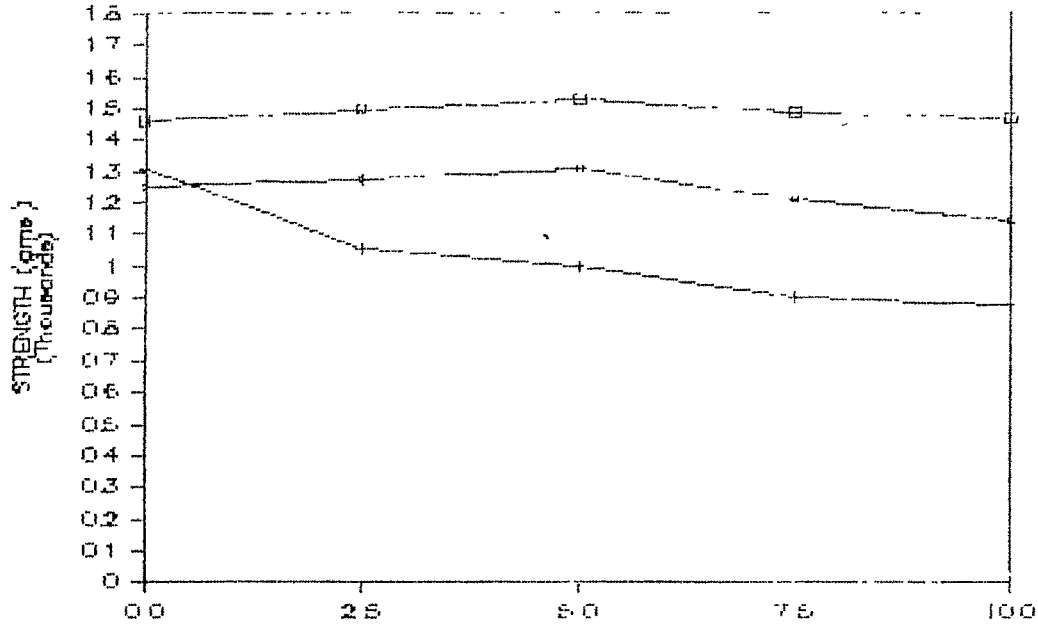
The data given in Table 19 and shown in Figure 2Ø is for cotton fabric. A gradual stength loss is seen with the increase in concentration of the finish.

Frick and Harper (46) found a strength loss of cotton fabric on treatment with acrylamide aldehyde products. Crosslinking treatments cause a loss of tearing strength of cotton. This is similar to that with DMDHEU, so also that with acrylamide glyoxal product.

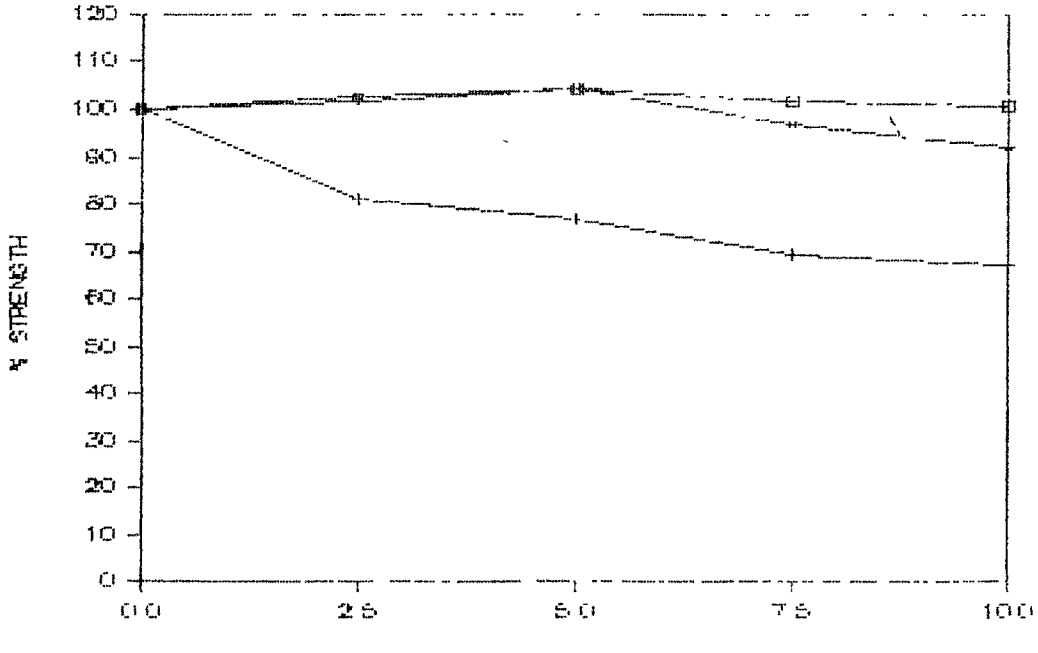
Table 19 Tearing strength of fabrics (W_1, C and CW) treated with acrylamide polymer finish

Finish %	WOOL (W_1)		COTTON (C)		COTSWOOL (CW)	
	Strength (gms.)	Strength (%)	Strength (gms.)	Strength (%)	Strength (gms.)	Strength (%)
Ø	146Ø	1ØØ.Ø	13Ø2	1ØØ.Ø	1252	1ØØ.Ø
2.5	1496	1Ø2.5	1Ø56	81.1	1272	1Ø1.6
5.Ø	1524	1Ø4.4	1ØØØ	76.8	13Ø8	1Ø4.4
7.5	1484	1Ø1.6	9Ø4	69.4	1212	96.8
1Ø.Ø	1468	1ØØ.5	876	67.3	1148	91.7

Figure 2Ø Effect of acrylamide polymer finish on tearing strength of fabrics (W_1, C, CW)



% concentration of acrylamide finish



% concentration of acrylamide finish

□ Wool fabric (W1)

+ Cotton fabric (C)

◇ Cotswool fabric(CW)

(iii) Cotswool fabric (CW)

Data in Table 19 and Figure 2Ø has been given for cotswool fabric. While at lower concentration of finish, a slight improvement in tearing strength was noted, but with higher concentration (7.5 and 1Ø.Ø%) loss in tearing strength was found.

(d) Stiffness

Since the superficial finish could cause stiffness, its assessment can be establish the cause-effect relation. It was important to study the stiffness of these fabrics which were shrink-resist with acrylamide polymer finish. In woollen fabrics with controlled degradative and/or additive treatments, shrink-resistance is improved (1Ø3,73). Additive treatment makes wool harsh and stiff. It was therefore thought that if the harshness is controlled, stiffness could then be controlled. A polymer finish can provide some weight gain to wool (instead of a weight loss as in degradative treatment) was a basis for this presumption, and since the acrylic is a soft thermoplastic polymer, it does not produce the harshness encountered with treatments comprising only thermosetting resins (1Ø3).

Cotton fabrics when finished with thermosetting resin finishes introduce rigidity due to crosslinking. So to counteract the harshness thermoplastic finishes are applied. With free radical polymerization the stiffness of treated fabrics depends on the time interval between preparation of padding bath and actual padding time. Higher the interval stiffer the fabric, because the free - radical polymerization starts in the bath itself (3Ø).

In this work the finish was to polymerize, react, cure on the fibre itself, so was expected give small changes in rigidity (and not as with precondensate involving a time gap).

The results of stiffness as bending length of fabrics are given in Table 2Ø and shown in Figure 21.

(i) Wool fabrics (W_1)

Results of the varying concentrations of acrylamide finish in wool fabric (W_1) are given in Table 2Ø and shown in Figure 21. It was noted that at all levels of finishing treatments, the stiffness has increased. Increase in stiffness was expected due to the additive treatment. However, the small increase in stiffness suggested the internal deposition of finish, which helped in shrinkage control.

Steiger (1Ø3) stated that the stiffness increases with the acrylic polymer (Rhodex HA -1 was used with a thermosetting resin) because it provides a weight gain to the wool fabric. But these soft acrylic finishes do not produce the boardiness, as noted with thermosetting resins. Bereck and Kamein (7) also noted that flexural rigidity of wool fabrics increased with acrylic copolymers. The finish used in this work is not just comparable in its influence to the finishing of others, but also does not cause harshness.

(ii) Cotton fabric (C)

Data on cotton fabric (C) is also included in Table 2Ø and Figure 21. As the concentration of the finish increased, there was some increase in the stiffness of cotton fabric.(Treated fabric has shown more stiffness as compared to untreated fabric). Deshpande and Chavan (3Ø) have stated that the stiffness of cotton fabric increased with acrylamide and acrylic acid finishes. The stiffness imparted was more with acrylic acid than with acrylamide, because with the same concentration of redox initiators the free - radical polymerization was very fast in acrylic acid in comparison to acrylamide.

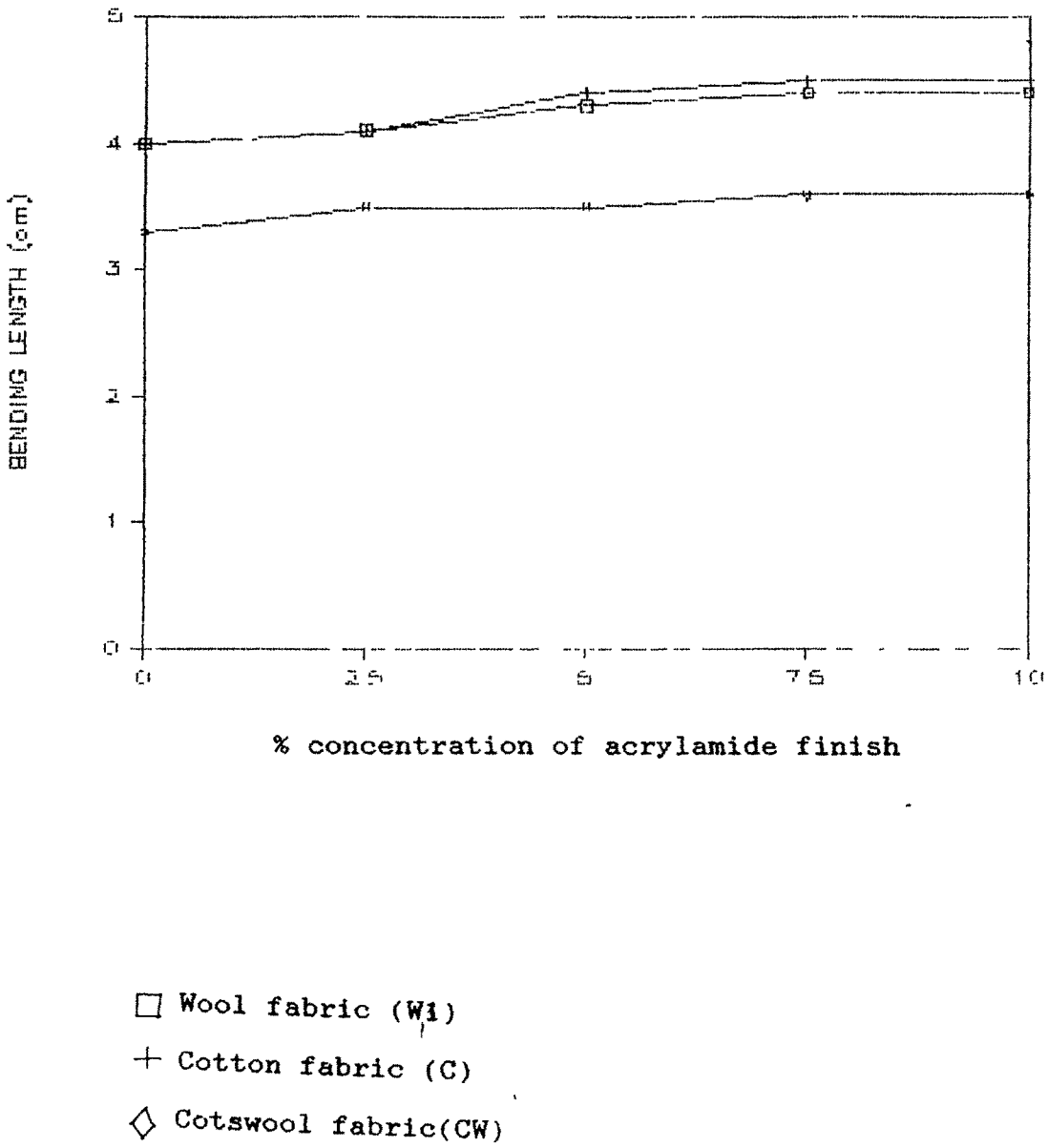
(iii) Cotswool fabric (CW)

In case of cotswool fabric (CW) from the data as given in Tabel 2Ø and Figure 21, it was found that the acrylamide finsih has increased the stiffness of cotswool fabric. The stiffness

Table 2Ø Bending length of fabrics(W_1, C and CW) treated with acrylamide polymer finish

FINISH %	Bending length (cms.)		
	Wool (W_1)	Cotton (C)	Cotswool (CW)
Ø	4.Ø	4.Ø	3.3
2.5	4.1	4.1	3.5
5.Ø	4.3	4.4	3.5
7.5	4.4	4.5	3.6
1Ø.Ø	4.4	4.5	3.6

Figure 21 Effect of acrylamide polymer finish on bending length of fabrics (W_1, C and CW)



increased with an increased concentration of the finish, as in the case of cotton fabrics.

Due to the additive and adhesive nature of finish, an increase in stifness was noted in all three fabrics.

(e) Wrinkle recovery

Wrinkle recovery includes both resistance to, and recovery from creasing. Resistance to creasing depends on the rigidity while recovery depends on the elasticity.

In the work carried out by Kunzru (69) on wash and wear finishing of textiles, it was noted that the wrinkle recovery of cotton fabric was improved with acrylamide finish at pH 3. Acrylamide, formaldehyde, epichlorohydrin with a redox catalytic system were used, pH was adjusted with acetic acid. In the present study pH obtained was 4.6 and that too with trichloro-acetic acid so as to improve the durability of the finish.

(i) Wool fabric (W_1)

Results of the effect of varying concentrations of acrylamide finish on wool fabric (W_1) are given in Table 21 and shown in Figure 22. It was noted that the treatment improved the wrinkle recovery angle slightly. Since wool has a good wrinkle recovery, this small improvement is considered acceptable.

(ii) Cotton fabric (C)

In the case of cotton fabric (C) from the results given in Table 21 and shown in Figure 22, it was noted that acrylamide finish has improved the wrinkle recovery angle. The wrinkle

recovery angle has increased with the increase in concentration of finish but after 7.5% it was not affected further.

Warburton (11Ø) has stated that in situ polymerization of N-methylolacrylamide helped to improve the crease recovery angle of cotton fabrics. Sharma and Daruwala (97) reported that graft polymerization of acrylamide, along with binary and tertiary mixture of selected vinyl monomers on cotton, polyacrylamide grafts were methyolated in situ and crosslinked. The finished fabric showed good wrinkle recovery property accompanied by satisfactory retention of breaking and tear strength.

(iii) Cotswool fabric (CW)

Data on cotswool fabric has been given in Table 21 and shown in Figure 22. A small improvement in wrinkle recovery angle was observed for acrylamide treated cotswool fabric. Results showed that till 7.5% concentration there was a small increase but after that a small decrease, it was retained above the original.

Harper and Mehta (55) reported that the wrinkle recovery angle of wool/cotton blend fabric was improved by polyacrylate when used with DMDHEU.

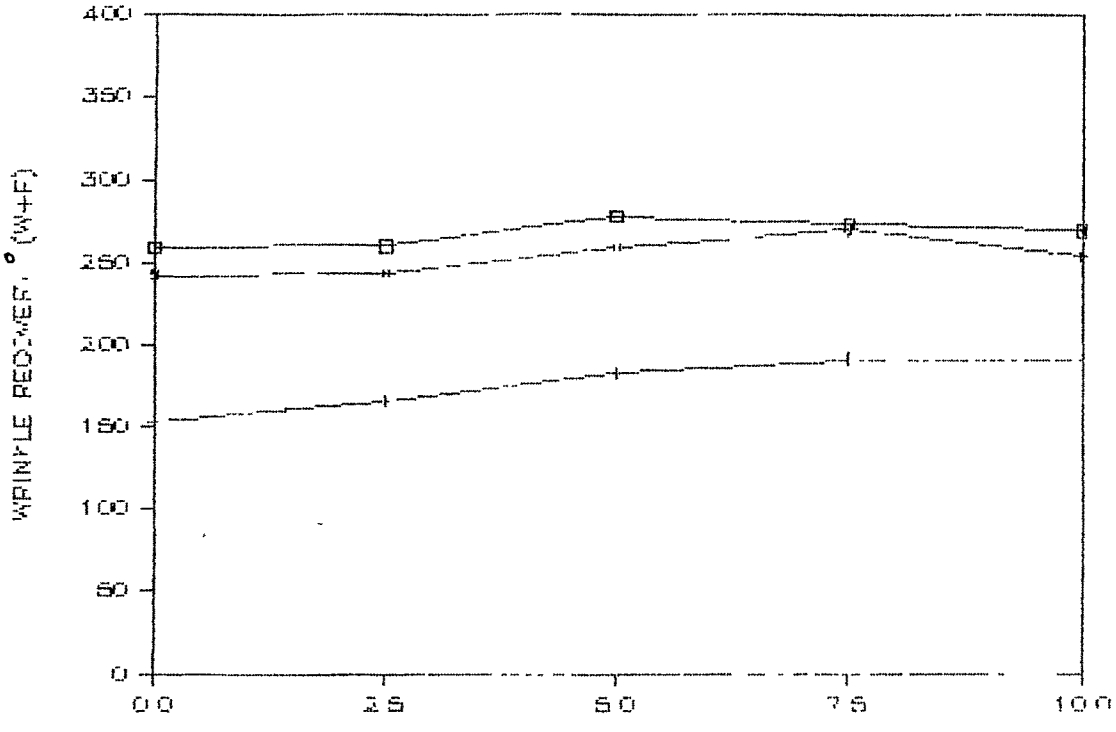
The behaviour of finish was similar in all fabrics. At lower concentration an improvement in wrinkle recovery was noted, which was slightly more in cotton as compared to wool.

Table 21 Wrinkle recovery^{0} of fabrics (W_1, C, CW) treated with acrylamide polymer finish

Fabric	Finish %	W	F	W + F
WOOL (W_1)				
	Ø	121.4	137.9	259.3
	2.5	123.2	136.8	260.Ø
	5.Ø	129.9	147.6	277.5
	7.5	127.8	145.7	273.5
	10.Ø	124.5	145.Ø	269.5
COTTON (C)				
	Ø	8Ø.Ø	73.3	153.3
	2.5	82.Ø	83.7	165.7
	5.Ø	88.1	94.4	182.5
	7.5	98.2	93.Ø	191.2
	10.Ø	95.3	95.Ø	19Ø.3
COTSWOOL (CW)				
	Ø	121.3	121.4	242.7
	2.5	121.3	121.9	243.2
	5.Ø	128.5	13Ø.7	259.2
	7.5	135.1	134.2	269.3
	10.Ø	121.Ø	132.7	253.7

W = Warp F = Weft

Figure 22 Effect of acrylamide polymer finish on wrinkle recovery° of fabrics (W_1, C and CW)



(f) Appearance rating after wrinkling and ironing

In a study by Kunzru (69) on cotton and cotton-polyester blend fabrics it was found that the thermoplastic nature of the acrylic finish gave an ease of ironing and a better retention of appearance to the fabric. Thermoplastic and thermosetting resins in combinations were used by Phadke (88). The performance of an acrylic based finish needs to be elevated if to be used alone or as a major component.

Garments are ironed with normal and hot iron, the possibility of ironing at a lower temperature can be considered as an improved property (i.e. ease of ironing). The appearance rating of a fabric specimen was evaluated according to AATCC 128-1982. The apperance of a sample (smooth or wrinkled) was observed under an overhead fluorescent lighting system, along with photographs of three dimensional replicas as standards, where the maximum wrinkled sample has No. 1 and the smooth sample has No. 5.

The data on the appearance rating has been represented in Table 22 and also illustrated in Figures 23,24 and 25. The appearance rating after ironing with cold iron indicated no improvement in these fabrics. (Cold iron was used to see any influence of the weight of the iron).

Kunzru (69) and Phadke (88) have also reported that cold ironing has no influence on appearance rating of cotton and cotton - polyester blend fabrics. The results have been discussed below :

(i) Wool fabric (W_1)

It was noted from the data given in Table 22 and shown in Figure 23 that the untreated and acrylamide treated wool fabric (W_1) showed improvement in appearance rating after 24 hours. This recovery of untreated fabric can be due to the better elastic recovery properties of wool fabrics. It is also comparable to wrinkle recovery angle of wool fabric (page 125). The treated fabric showed slightly higher values over untreated fabric. Improvement in appearance rating of treated fabric was noticed after warm ironing (at nylon setting). Acrylamide finish being thermoplastic in nature gave better appearance rating on warm ironing. The greater improvement in case of ironing with wool fabric (W_1) compared to cotton fabric can be attributed to the original high rating values of wool fabric. Other investigators (69,88) have also reported the improvement in case of ironing on acrylamide/acrylic treated fabrics.

(ii) Cotton fabric (C)

The data given in Table 22 and shown in Figure 24 indicated that acrylamide polymer finish has improved the recovery after 24 hours. Further improvement in appearance rating was slightly noted after warm ironing at nylon setting. Warburton (110) has reported that methylated acrylamide helped to improve appearance rating. In this work, however, the wash and wear performance, rating 4 - 5, could not be obtained.

Table 22 Appearance rating of fabrics (W_1, C and CW) treated with acrylamide polymer finish

Fabric	Finish %	Ratings A	B	C	D
Wool (W_1)	Ø	1.7	2.3	2.3	2.5
	2.5	2.Ø	2.7	2.7	3.2
	5.Ø	2.Ø	2.9	2.9	3.5
	7.5	2.Ø	2.5	2.6	3.4
	1Ø.Ø	2.Ø	2.5	2.9	3.4
Cotton (C)	Ø	1.1	1.3	1.3	1.5
	2.5	1.4	2.2	2.2	2.5
	5.Ø	1.8	2.4	2.5	3.2
	7.5	2.Ø	2.6	2.6	3.2
	1Ø.Ø	1.5	2.7	2.8	3.Ø
Cots-wool (CW)	Ø	1.4	1.6	1.6	1.8
	2.5	1.5	2.3	2.4	2.6
	5.Ø	2.Ø	2.5	2.5	3.2
	7.5	2.Ø	2.6	2.6	3.2
	1Ø.Ø	1.8	2.3	2.5	3.1

Maximum value = 5

A = After wrinkling

B = Twenty four hours after wrinkling

C = After ironing with cold iron

D = After ironing at nylon setting

Figure 23 Effect of acrylamide polymer finish on appearance rating of wool fabric (W_1)

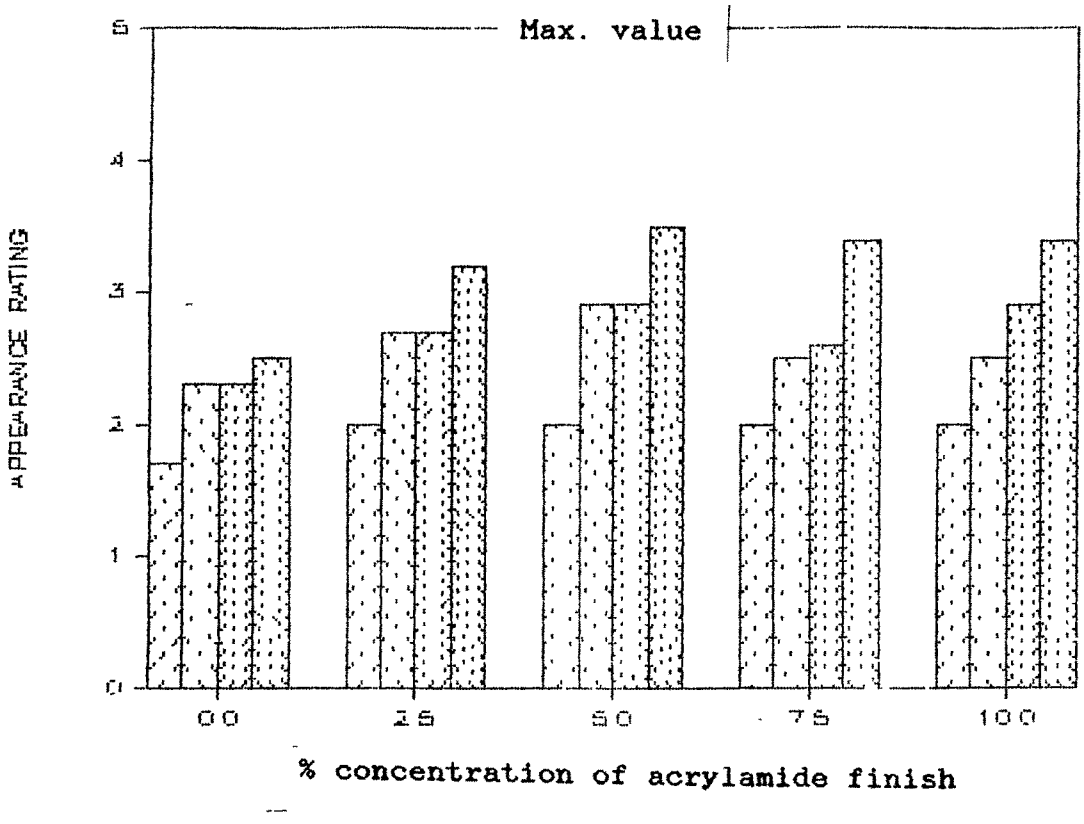


Figure 24 Effect of acrylamide polymer finish on appearance rating of cotton fabric (C)

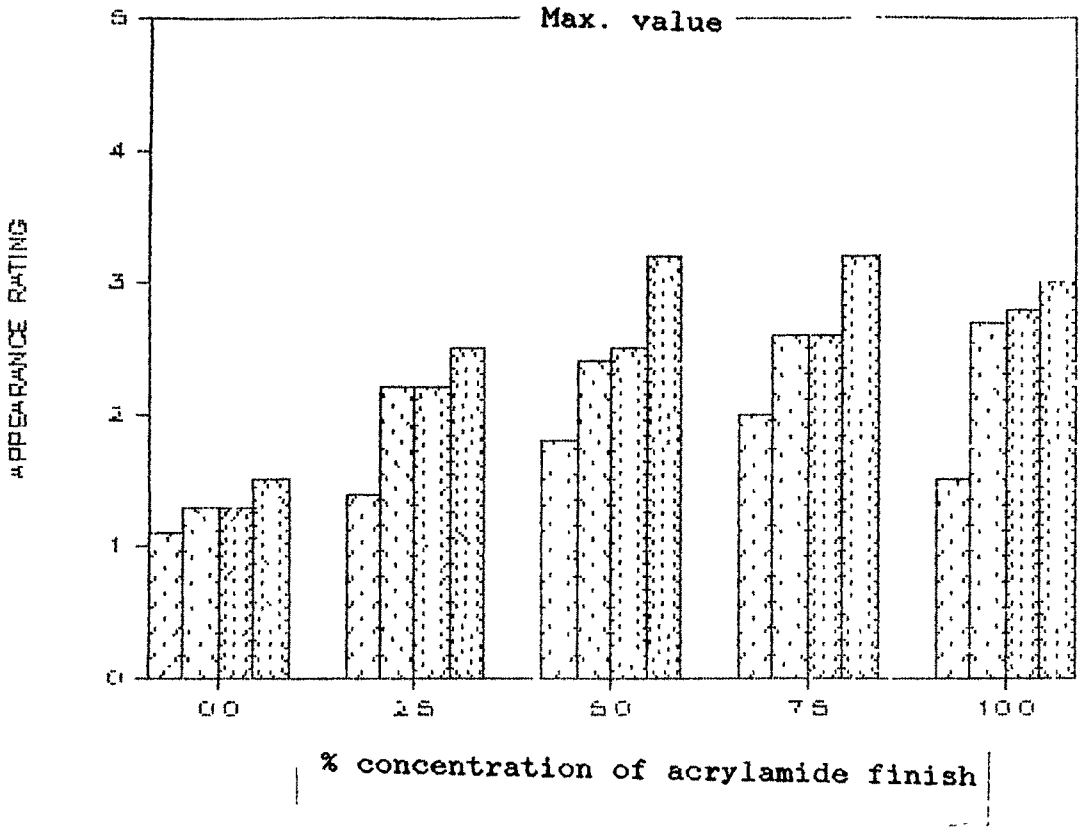
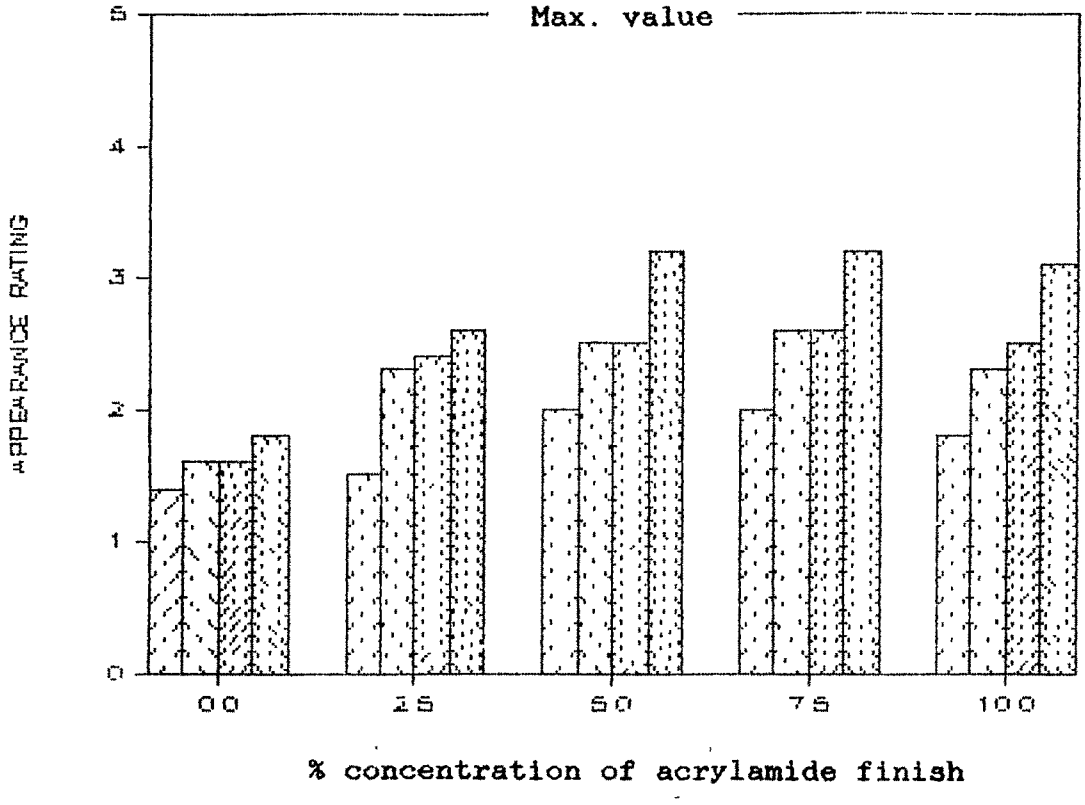


Figure 25 Effect of acrylamide polymer finish on appearance rating of cotswool fabric (CW)



(iii) Cotswool fabrics (CW)

The data on appearance rating for cotswool fabric is given in Table 22 and shown in Figure 25. An improvement in apperance rating is indicated. Acrylamide polymer finish helped in marginally improving the ease of ironing property since it was not very high. Harper and Mehta (55) have stated that polyacrylate when used with DMDHEU improved the rating. Effectiveness of the finish in this work seems to be limited.

The appearance rating was improved in all the three fabrics to some extent. It showed that acrylamide finish being thermoplastic in nature introduced thermoplasticity to the fabrics, and this gave better appearance rating on ironing.

5.5 Effect of acrylamide polymer finish on the pleat retention of wool, cotton and cotswool (W_1,C and CW) fabrics.

In practice, wool pleating is obtained by a setting process, involving the rearrangement of hydrogen bonds and disulphide bonds under the influence of heat, pressure and moisture to form a stable molecular structure, such as the new shape of a fabric or pleats in a garment. Loss of set in pleated wool occurs during machine washing, because hydrogen bonds and disulphide bonds can get rearranged during washing (112). It has been reported that crosslinking agents especially formaldehyde help in retention of pleats under acidic conditions (18). Acrylamide and chloroacetic acid also act as thiol blocking agents and prevent loss of set (26). Other acrylates like Primal K.3, H.A.8, H.A.12 and H.A.16 prevent loss of set when polymerized on wool fabrics.

In the cellulosic fibres hydrogen bonds help in the dimensional stability obtained by restrains and crosslinking with the fibre. Ability of acrylamide polymer finish used in this research was assessed for the stabilization obtained.

Review of literature (Chapter II) on wool has emphasized wet setting followed by its stabilization. This work has been aimed to see if a single step with a solution containing a reducing agent in the acrylamide polymer finish could set and stabilize the pleats in a woollen fabric. Acrylamide by its reaction with fibres would enhance the set stabilization to withstand during washing. The wet pleated fabric would set wool via the reducing agent (thiol-disulphide interchange when dried in the required configuration) along with normal hydrogen bond reformation in aquous media. The curing step for acrylamide polymer finish would cause crosslinks, this being possible in wool as well as cotton.

(i) Wool fabric (W_1)

These results on the effect on acrylamide finish on wool fabric (W_1) are given in Table 23 and shown in Figure 26. As seen from this the retention of pleats improved during static release upto five percent finish, therafter there was no further improvement. The static release data also does not distinguish the varying influences of finish, as the retentiion values were similar. However, even 2.5 percent finish helping the retention, as compared to no - finish (To), indicated the role of the finish. The pleat retention after washing even for treated fabrics was almost negligible. The drying step (in the required

configuration) however indicated the slight restoration of pleats in treated fabrics as compared to those in untreated. The loss of set during washing can be explained on swelling in wet condition. It can be that one bath could give shrink-resistance but not set - stabilization, which is the sequence of permanent set.

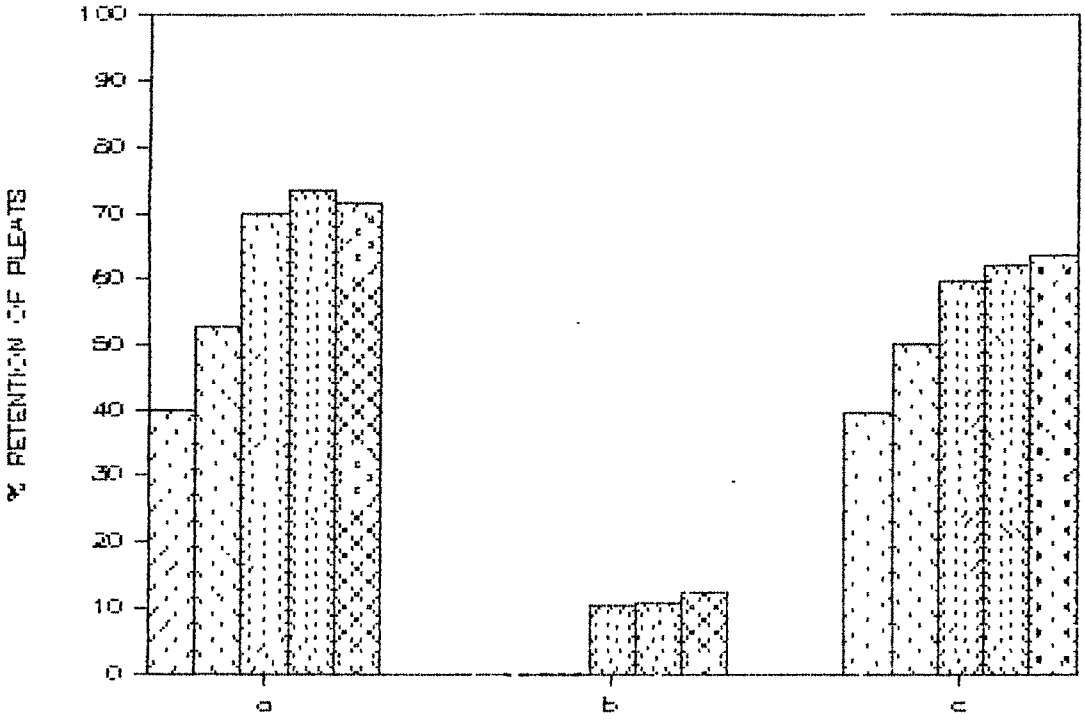
Table 23 Percent retention of pleats in wool fabric (W_1) treated with acrylamide polymer finish

Finish %	Static Release	After Washing	After Drying
Ø.Ø	39.8	Ø.Ø	39.5
2.5	52.7	Ø.Ø	49.9
5.Ø	69.9	1Ø.Ø	59.9
7.5	73.2	1Ø.8	62.2
1Ø.Ø	71.5	12.2	63.6

(ii) Cotton fabric (C)

The data on pleat retention on cotton fabric (C) is given in Table 24 and shown in Figure 27. The retention of pleats for treated cotton samples has improved considerably both during static release and also after washing. Retention was quite godd, even at low concentration; this improvement was further noticed at five percent finish (Further improvement above this concentration was not noticed). The stabilization of set was explained on the basis that some crosslinking reaction has taken place in cotton fabric.

Figure 26 Effect of acrylamide polymer finish on percent retention of pleats in wool fabric (W_1)



a. Static release

b. After washing

c. After drying

Untreated

2.5% acrylamide finish

5.0% acrylamide finish

7.5% acrylamide finish

10.0% acrylamide finish

(iii) Cotswool fabrics (CW)

The data in Table 25 and Figure 28 is for cotswool (CW) fabric. Acrylamide polymer finish improved the retention of pleats in cotswool fabric also. The result being intermediate (i.e. for wool and for cotton) were explained as the influence of fibre content (50 percent each).

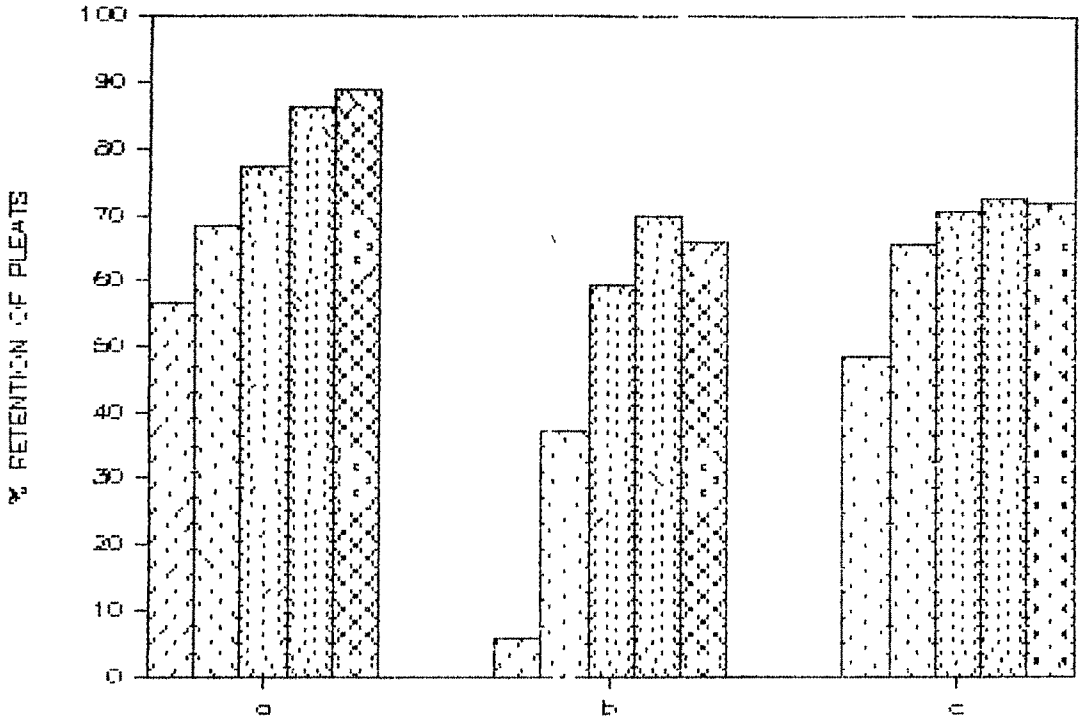
Table 24 Percent retention of pleats in cotton fabric (C) treated with acrylamide polymer finish

Finish %	Static Release	After Washing	After Drying
0.0	56.6	5.5	48.5
2.5	68.3	37.2	65.5
5.0	77.0	59.4	70.5
7.5	86.2	69.7	72.5
10.0	88.7	66.1	71.2

Table 25 Percent retention of pleats in cotswool fabric (CW) treated with acrylamide polymer finish

Finish %	Static Release	After Washing	After Drying
0.0	49.5	0.0	39.8
2.5	57.0	0.0	46.5
5.0	68.7	30.5	63.9
7.5	79.1	30.7	65.7
10.0	78.3	38.8	63.6

Figure 27 Effect of acrylamide polymer finish on percent retention of pleats in cotton fabric (C)



a. Static release

b. After washing

c. After drying

Untreated

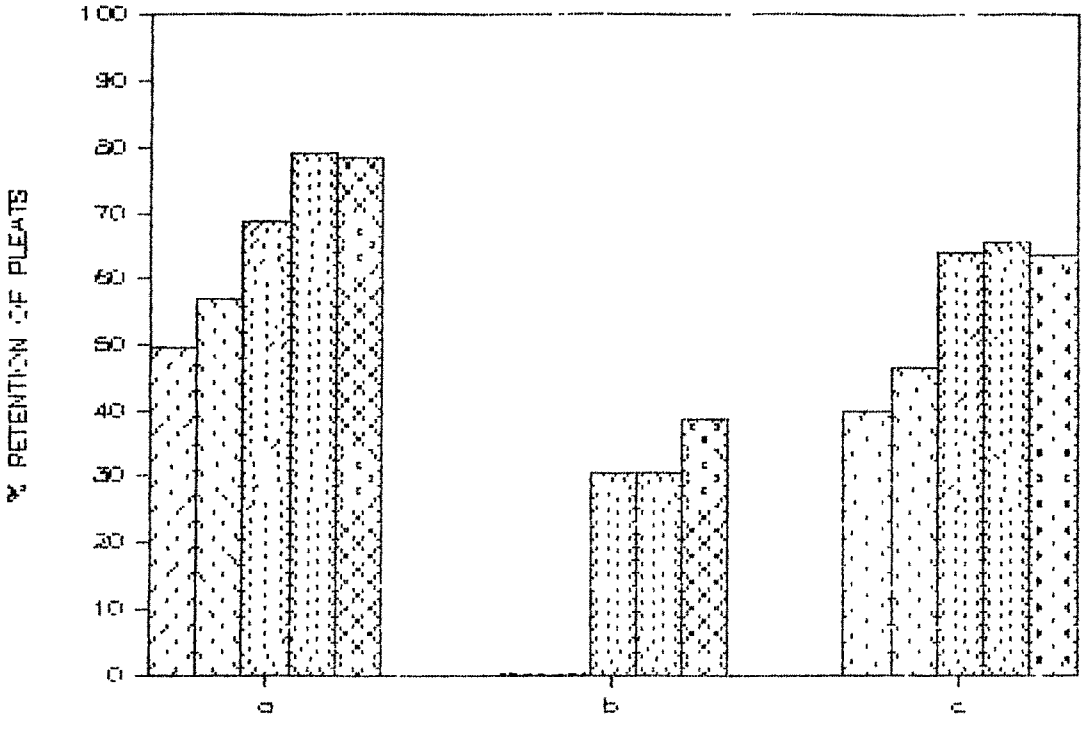
2.5% acrylamide finish

5.0% acrylamide finish

7.5% acrylamide finish

10.0% acrylamide finish

Figure 28 Effect of acrylamide polymer finish on percent retention of pleats in cotswool fabric (CW)



a. Static release

b. After washing

c. After drying

Untreated

2.5% acrylamide finish

5.0% acrylamide finish

7.5% acrylamide finish

10.0% acrylamide finish

5.6 **Durability of acrylamide finish on fabrics**

Durability was judged by the finish retained after washing. These results were also to check the finish, whether it was on the surface or internally crosslinked, and thereby explaining the possible improvement in the properties. The properties studied, before and after washing were (a) the percent finish (b) wrinkle recovery angle and (c) stiffness of fabrics.

(a) Finish retained

The data obtained on per cent finish on the treated fabrics, before and after washing has been reported in Table 26. The weight loss data indicated that the finish showed good durability, this durability was with the use of trichloro acetic acid, and is noted on (Page).

TAble 26 Percent finish on acrylamide treated fabrics (W_1,C,CW) before (a) and after (b) washing

Finish % (Aprox.)	Wool (W_1) a	b	% Finish	Cotton (C) a	b	% Finish	Cotswool (CW) a	b	% Finish
2.5	2.2	1.7	77.2	2.9	2.8	96.5	2.7	2.1	77.7
5.Ø	6.9	5.Ø	72.4	6.5	5.Ø	76.9	6.3	4.1	65.Ø
7.5	8.6	5.6	65.1	8.1	6.1	75.3	9.2	5.6	6Ø.8
1Ø.Ø	13.3	8.6	64.6	13.1	8.9	67.9	13.3	6.7	5Ø.3

Acrylamide finish was durable in general, although the durability was relatively more at lower concentration of the finish. The range was considered an experimental variation.

(b) Wrinkle recovery

The wrinkle recovery values before and after washing have been given in Table 27 and shown in Figure 29. Wool (W_1) and cotswool (CW) fabrics in general showed a slight improvement in wrinkle recovery but at higher concentration a loss in wrinkle recovery was noticed. The wrinkle recovery of cotton fabric (C) showed some improvement after washing. This marginal improvement in all the fabrics can be explained due to the loss of the rigidity of finish on surface.

(c) Stiffness

The changes in stiffness were given in Table 28 and shown in Figure 30. In general there was a small loss of stiffness at all concentrations after washing in wool (W_1) and cotswool (CW) fabric. No change was noticed in cotton fabric (C). The reduction in stiffness was due to the loss of superficial finish.

Jain (60) in her work on the effect of acrylamide finish on the physical properties of cotton, polyester and their blend fabrics has stated that lower concentration of the finish showed durability. An improvement in durability of finish was achieved by a two stage process where trichloro acetic acid and glyoxal were padded in the first stage and acrylamide and hydrogen peroxide in the second.

The approximate retention ranged between 65 - 70% for wool, 65 - 95% for cotton and 50 - 75% for cotswool. The results of this study indicated that an application of acrylamide polymer finish in possible, besides confirmity with the above work.

Table 27 Wrinkle recovery° of acrylamide treated fabrics (W_1, C and CW) before (a) and after (b) washing

Finish (%)	Wrinkle recovery° (W + F)					
	Wool (W_1)		Cotton (C)		Cotswool (CW)	
	a	b	a	b	a	b
Ø	259.3	268.5	153.3	167.7	247.7	255.Ø
2.5	26Ø.Ø	269.7	165.7	175.7	243.2	263.8
5.Ø	277.5	276.9	182.5	2Ø3.3	259.2	26Ø.7
7.5	273.5	261.5	191.2	194.8	249.3	247.2
1Ø.Ø	269.5	28Ø.Ø	19Ø.3	196.Ø	253.7	259.5

Table 28. Bending length of acrylamide treated fabrics (W_1, C, CW) before (a) and after (b) washing

Finish %	Bending length (Cm)					
	Wool (W_1)		Cotton (C)		Cotswool (CW)	
	a	b	a	b	a	b
Ø	4.Ø	3.7	4.Ø	4.Ø	3.3	3.3
2.5	4.1	3.8	4.1	4.1	3.5	3.3
5.Ø	4.3	3.9	4.4	4.4	3.5	3.4
7.5	4.4	3.9	4.5	4.4	3.6	3.5
1Ø.Ø	4.4	4.Ø	4.5	4.4	3.6	3.5

Figure 29 Effect of acrylamide polymer finish on wrinkle recovery of fabrics (W_1, C and CW) before and after washing.

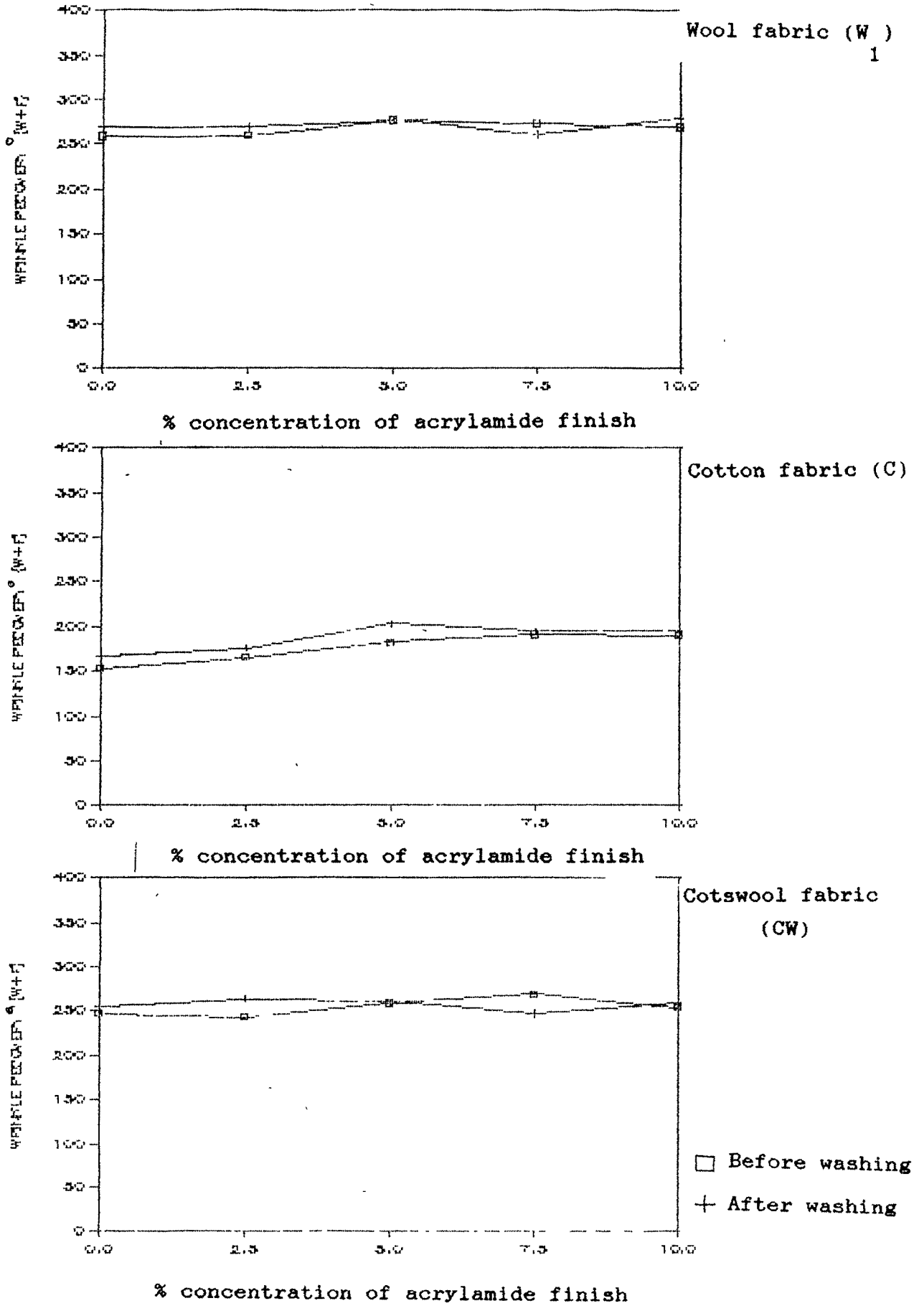
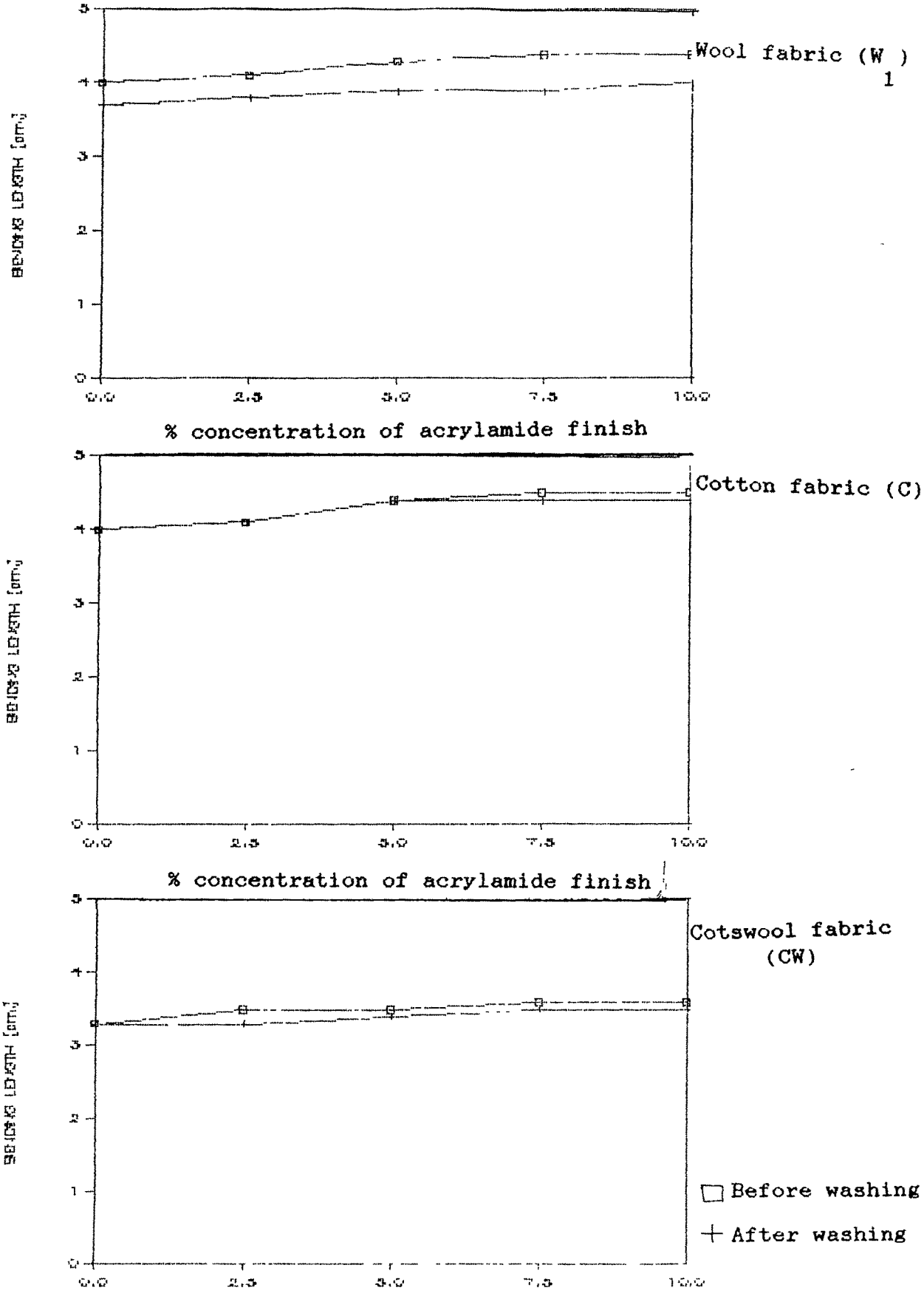


Figure 3Ø Effect of acrylamide polymer finish on bending length of fabrics (W_1, C and CW) before and after washing.



5.7 Effect of acrylamide polymer finish on other related properties of wool fabric (W_2)

As reported earlier (page 96) that another wool fabric W_2 was used to verify the influence of a plain weave. The results of shrink - resistance were given earlier in section 5.3. The effect on other related properties was also studied. These results are summarised in this section, while the detailed data is given in Appendix (page 181).

(a) Elastic recovery

Acrylamide polymer finish (5%) did not affect the elastic recovery, only a slight reduction in elastic recovery was noted. Influence of the finish on untreated and pretreated (chlorination) wool fabric was similar.

(b) Tensile strength and elongation

i. Tensile strength

Tensile strength increased in acrylamide treated fabric, so also in the chlorination followed by acrylamide finished fabric. No degradation was observed with acid chlorination and so it retained the strength. The bonding ability of the additive treatment was thus observed.

ii. Elongation

The elongation decreased in both the cases, namely 5% acrylamide polymer finish and the combinatioin (i.e. acid chlorination followed by finish). The reduction was noted to be more by the combination in seqnence. The pretreatment helped in

even distribution of finish. This is in confirmity with the results of Feldtman and Mcphee (39), who postulated clearing and spreading of finish by a pretreatment.

(c) Tearing strength

A slight improvement in tearing strength was also noted, as in the case of the results on tensile strength.

(d) Stiffness

5% acrylamide polymer finish has increased the stiffness of wool fabric (W_2). The less increase in stiffness of pretreated - finished samples was seen and this was indicated from the even distribution of finish as noted in elongation aspect also.

(e) Wrinkle recovery

Wrinkle recovery changes were less. The wrinkle recovery of wool is already high so treatments had less influence.

(f) Appearance rating after wrinkling and ironing

The improvement in appearance rating of treated fabric was noted after warm ironing. It shows that some thermoplasticity has been introduced, which gave ease of ironing, and so, low temperature ironing is practicable.

(g) Pleat retention

Studies (18,36) have noted that shrink-proofing, setting and then stabilization as a sequence helped in the pleat retention in wool. In this fabric (W_2) also a chlorine pretreatment improved the shrink-resistance. In the one bath treatment (for set and

stabilization, using 5% acrylamide polymer finish), it was noted that pleat retention improved during static release only. The retention after washing in acrylamide treated fabric was negligible, whereas the cumulative effect was noted to be better. It shows that pretreatment which improved shrink - resistance also helped in pleat retention.

The percent retention of pleats in both wool fabrics (W_1 and W_2) treated with 5% acrylamide finish were almost same, whereas cumulative effect in fabric W_2 was better than acrylamide finish when used alone.

(h) Durability of finish

The durability of the finish was also assessed. The percent finish retained was better when pretreatment was given as compared to acrylamide finish alone. Wrinkle recovery after washing was unaffected, whereas stiffness decreased slightly in acrylamaide treated fabric but was unaffected when finish was used on chlorine pretreated fabric.

These results of wool fabrics showed that acrylamide finish helped to reduce shrinkage in all the wool fabrics (W_1, W_2 and W_3), without adversely affecting the other properties. The results on wool fabric (W_2) and on (W_3) have shown further that pretreatments do help to give better shrink - resistance (and also without affecting the properties adversely). Chlorine pretreatment which alone gave some shrink - resistance also helped in pleat retention, which was slightly better than acrylamide finish when used alone. The durability of finish was

also better on chlorine pretreated fabric. It shows that pretreatment helps to adhere the finish film better.

(The detail data on related properties of wool fabric (W_2) has been given in Tables 30 - 41 and shown in Figures 34 - 44 in Appendix).

5.8 Results on the application of acrylamide polymer finish on garments

Retention of pleats in garments

The practicability of obtaining permanent creases in all - wool trousers by the clothing manufacturers with the application of a chemical solution was the development of SIRO - SET process (112). In cotton fabrics the delayed curing process was reported by Cooper et al. (22) for introducing creases in pants cuffs. Here crosslinking resins at selected regions of fabrics were applied.

In this work the effect of acrylamide finish on the retention of pleats in garments (like half skirts) was studied. The distance between five knife pleats on half skirts was measured (when it was hung under its own weight and the for wet - static release, wash and dry). This was converted into percent retention. The data on the percent retention of pleats, under varying conditions of release, for the three fabrics (W_1, C and CW) have been given in Table 29 and shown in Figure 31, 32, 33.

(a) Wool skirt

The data given in Table 29 and illustrated in Figure 31 , for wool skirt indicated an improvement in percent retention of

pleats from original (T_0) to treated (T_2). Pleat retention for initial dry state after hanging under its own weight and for static - release - were similar; however treated skirt data was slightly higher than the untreated skirt data. While finished skirts showed no better pleat retention after washing but this was restored slightly after drying.

(b) Cotton skirt

For cotton skirt the retention was improved after treatment. This is indicated in Table 29 and illustrated in Figure 32 The pleat retention improved slightly after static release, also after washing and drying. The improvement in retention of pleats as a result of treatment was thus noted.

(c) Cotswool skirt

The pleat retention of cotswool skirt has been given in Table 29 and illustrated in Figure 33. The retention of pleats has improved with treatment. The retention improved on drying, when compared to the readings before drying.

The retention of pleats was thus better in treated cotton and cotswool skirts but was not improved much in wool skirt under washing conditions. The improvement in retention of pleats in cotton can be explained as that delayed curing in the required configuration helped to retain the pleats, whereas in wool one step process, i.e. shrink - proofing and set - stabilzation, could not achieve more and so improvement in pleat retention was not noticed much.

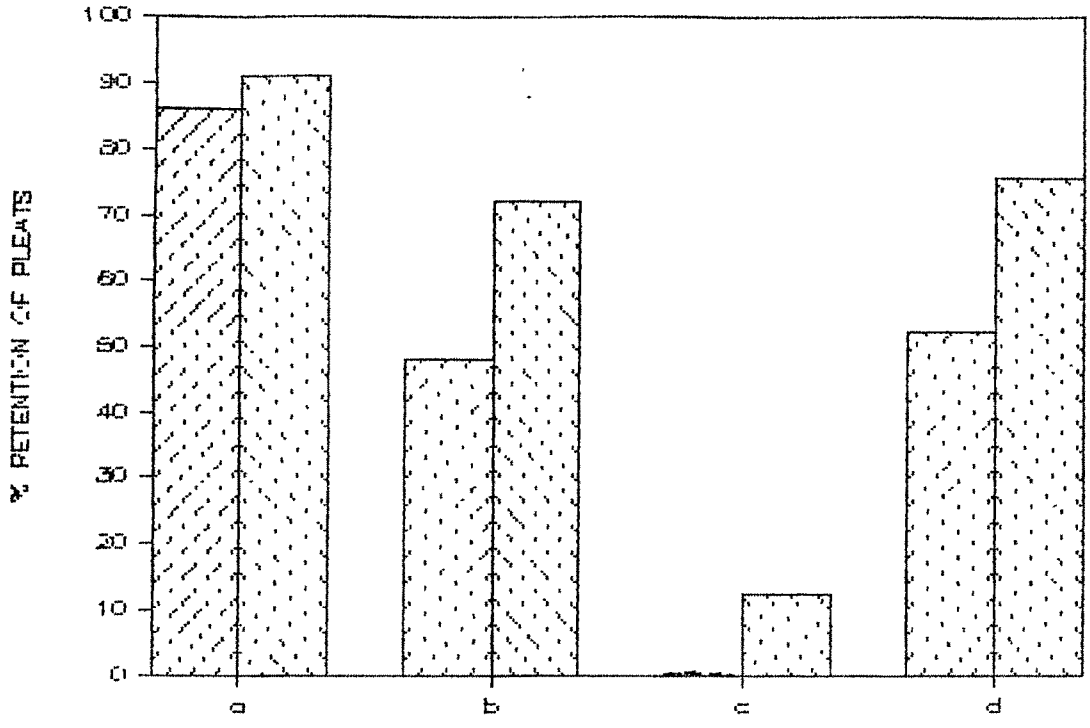
Table 29 Percent pleat retention in garments (half skirts) of wool, cotton and cotswool (W_1, C and CW) fabrics treated with 5% acrylamide polymer finish

FABRIC	TREATMENT	% - RETENTION			
		HANGING UNDER OWN WEIGHT	STATIC RELEASE	AFTER WASHING	AFTER DRYING
WOOL (W_1)	$T_Ø$	86.Ø	48.Ø	Ø.Ø	52.Ø
	T_2	91.Ø	72.Ø	12.5	75.8
COTTON (C)	$T_Ø$	93.Ø	69.5	43.8	79.5
	T_2	95.8	81.5	62.5	88.8
COTSWOOL (CW)	$T_Ø$	91.Ø	59.5	12.5	62.5
	T_2	94.5	78.5	28.6	83.8

$T_Ø$ = Untreated

T_2 = 5% Acrylamide finish

Figure 31 Effect of acrylamide polymer finish on retention of pleats in half skirt of wool fabric (W_1)



Untreated

5.Ø% acrylamide polymer finish

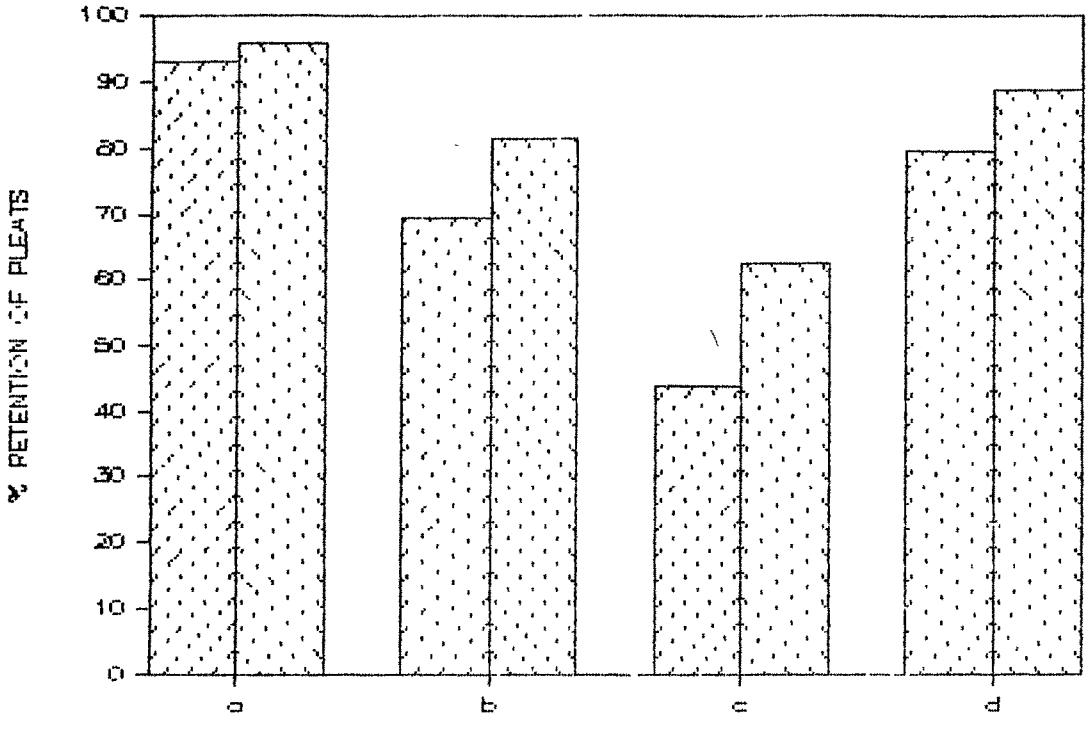
a. Under own weight

b. Static release

c. After washing

d. After drying

Figure 32 Effect of acrylamide polymer finish on retention of pleats in half skirt of cotton fabric (C)



Untreated

5.Ø% acrylamide polymer finish

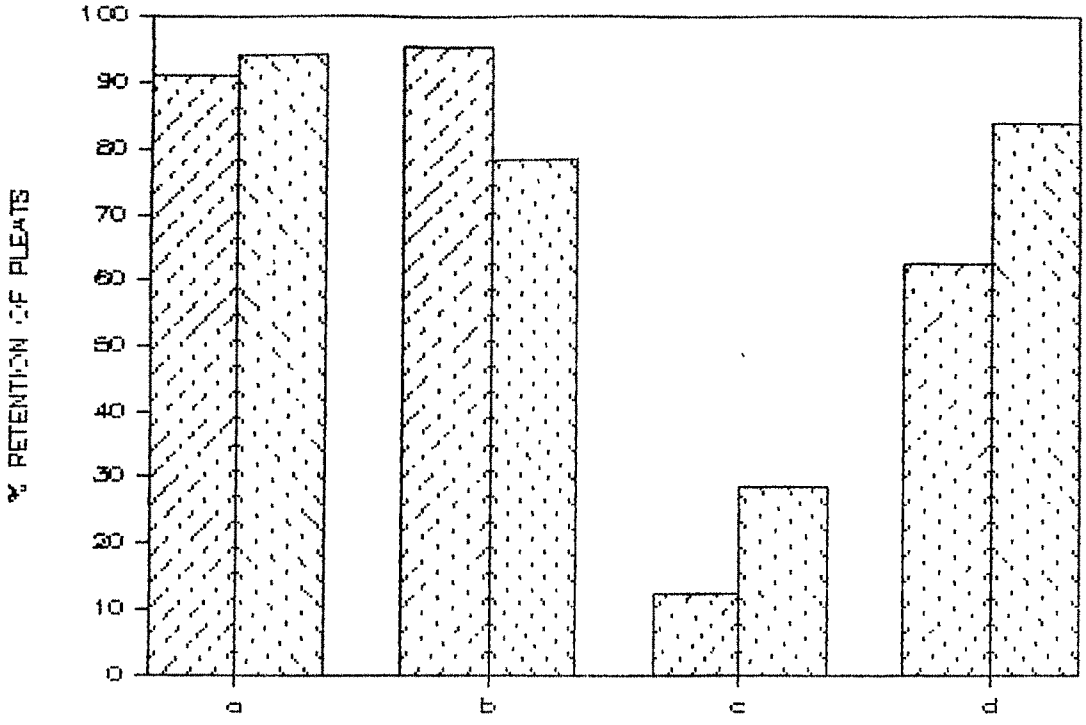
a. Under own weight

b. Static release

c. After washing

d. After drying

Figure 33 Effect of acrylamide polymer finish on retention of pleats in half skirt of cotswool fabric (CW)



Untreated

5.0% acrylamide polymer finish

a. Under own weight

b. Static release

c. After washing

d. After drying

1 Half skirt constructed from finished wool fabric (W_1)

2 Half skirt constructed from finished cotton fabric (C)

3 Half skirt constructed from finished Cotswool fabric (CW)

Applications of this work

Acrylamide polymer finish used in this study was found suitable for making the fabrics used as shrink - resistant without much adverse effects on their other related properties. The finish was noted to be more suitable for cotton as compared to wool as far as the pleat retention only was concerned.

Besides shrinkage control this finish can be used (i)For permanent pleating on garments (as in cotton, even after washing, retention of pleats was noted quite high). (ii) As a binder for pigment printing as noted by Saini (93) (iii) With simultaneous dyeing and finishing in one bath, tie and dye, and batik effects can be produced. New designs can be developed as noted by Saini (93).

(The finish recipe of this work was studied by Saini (93) for these supplementary effects).

The Acrylamide finish noted to be suitable for commercial application can be also used on a small scale, by consumer with curing by hot iron at 120 ^{o}C wool-rayon setting. The durability however, can be achieved by prolonged ironing.

Finish was not suitable for some dyed cotton fabrics because it affected the shade or caused slight discolouration, which could be due to the acidic pH of the finish. The acidic pH was due to the use of trichloro acetic acid, and being sublimable did not affect the other properties adversely, in fact it helped the durability observed in the work. Further work specifically to ascertain the reactive nature of the finish will be helpful.