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by

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THE AUTOCLAVE STEAM-CURING OF COTTON FABRICS TREATED WITH VARIOUS AMINOPLAST RESINS

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ABSTRACT

Cotton fabric treated with aminoplast resins can be cured in an autoclave steamer, provided that the samples are sealed in aluminium foil or cooking bags. The crease recovery angles of the fabrics sealed in aluminium foil generally increase with an increase in the time or temperature of steaming. In the case of the cooking bags, however, the crease recovery angles tend to decrease with an increase in the steaming time, due to some moisture pick-up by the samples.

Various aminoplast resins were evaluated and it was found that a methylol-melamine type produced the highest crease recovery angles. In general fabrics treated with 10 per cent aminoplast resin plus 1,0 per cent $MgC\ell_2$/citric acid catalyst were found to show strength losses of about 30 per cent after steam curing for 10 minutes at 100 to 120°C, and had dry crease recovery angles higher than 270 degrees, wet crease recovery angles higher than 240 degrees and DP ratings of about 3,0.

INTRODUCTION

Today most of the durable-press treatments for cotton fabrics are carried out according to the pad-dry-cure process[1]. In this process an aqueous solution of an aminoplast resin and a catalyst is applied to the cotton, followed by drying at relatively low temperatures and curing at elevated temperatures. Depending on the type of resin and catalysts used, the curing temperature may vary between 110°C to 180°C, while the curing time may vary from 10 minutes to less than 30 seconds.

There are several other techniques whereby the aminoplast resin can be cured to produce durable press fabrics[2]. The best-known techniques are the mild-cure, wet-fixation and poly-set processes. In the mild-cure process[3] the fabric is impregnated with an aqueous solution of an aminoplast resin and a mineral acid catalyst, then heated under mild conditions without drying, followed by neutralization, washing and drying. Not all aminoplast resins are suitable for this process. The best results are obtained with dimethylol carbamate resins. The mild-cure process is similar to the moist-cross-linking process which has become fairly popular in Europe, but the mild-cure process appears to be more suited to American finishing practice. In the wet-fixation process[4,5] the fabric is first treated with a combination of aminoplast resins (a so-called polymer builder and a cross-linking type) under acidic aqueous conditions. After the wet-fixation step the fabric is washed, dried and treated with a conventional catalyst, followed by drying and curing. The poly-set process[6] involves two different pad-dry-cure treatments. In the first step the cross-linking agent is deposited in the fibre by weak acid catalysts. The second step requires the use of a strong latent acid catalyst to cause more extensive cross-linking. Methylolmelamine resins generally produce excellent results, and methylol carbamates are the least efficient.

The use of steam as a possible method for the curing of resin-treated cotton was investigated by several research workers. Hollies *et al*[7] found, for example, that the reaction time in the wet-fixation process could be reduced from 15 minutes to 30 seconds by the use of steam. It was claimed that optimum fabric performance was obtained by this method, due to the quick swelling of the fibres and an even distribution of resin within the individual fibres. Furthermore the efficiency of resin fixation increased from 25 to 75 *per cent*, with the result that the resin content of the bath could be reduced considerably.

The treatment of cotton fabrics with aminoplast resin and conventional catalysts, followed by curing in superheated steam generally failed to produce satisfactory results[8-11]. The process appeared to be successful only when special active catalysts were employed. The reason for the ineffectiveness of conventional catalysts in steam curing was not known at the time. At a later stage Frick and Gautreaux[12] stated that it was likely that the conventional catalysts failed because suitable curing conditions were not found. They also demonstrated that conventional catalysts, such as zinc nitrate and magnesium chloride, could be used for cross-linking reactions in superheated steam, provided that the proper conditions were selected.

It has been claimed that the curing of aminoplast resins on cotton fabrics with superheated steam produces wrinkle-resistant cotton with greater-than-usual retention of strength and abrasion resistance. Curing in steam prevents complete deswelling of the fibres during the cross-linking reaction and as a result the fibres retain a greater ability to swell and a greater moisture absorptivity.

A survey of the literature shows that the steaming of the fabrics can be carried out in different ways. In one investigation, for example, the fabric was subjected to steam in a laboratory steamer, or a pilot-plant flash-ager operated at a slow speed[8]. In another publication[10] a special technique was referred to where the fabric was padded with the resin solution and sealed in *aluminium foil* containing a small vent. The sample was then heated in a convection oven at 150°C, which resulted in a steam atmosphere due to the evaporation of water. Little is known, however, about the possible use of an autoclave steamer for the curing of aminoplast resins on cotton fabrics. Since this information could be of use to knitters and certain cotton mills it was decided to investigate this matter and to establish whether curing conditions could be found which would produce crease-resistant fabrics without excessive strength losses.

EXPERIMENTAL

A plain weave cotton fabric (185 g/m^2) was used in this investigation. All chemicals used were of laboratory grade quality. The following aminoplast resins were used: ®Aerotex M3 (a methylolmelamine type resin), ®Aerotex 23 Special (a urea-formaldehyde-melamine type), ®Fixapret CP (a dimethylol dihydroxyethylene urea (DMDHEU) type), ®Fixapret AC (dimethylolethylene urea plus methylolmelamine), ®Fixapret AH (dimethylolethylene urea), ®Fixapret PH (dimethylolpropylene urea), ® Fibraset GM (modified glyoxal) and ® Fibraset TC Paste (monomeric urea-formaldehyde precondensate).

The fabrics were padded with aqueous solutions of the various aminoplast resins and catalysts on a Benz laboratory padder, followed by air-drying at room temperature. All percentages were based on mass of cotton.

Various experiments were carried out. Initially the air-dried fabrics were steamed in an autoclave in the unsealed state, but later the samples were sealed in aluminium foil or cooking bags made from ®Mylar film prior to the steaming treatment. In the case of the Mylar cooking bags the sample was transferrred to the bag and the open end of the bag was then folded and sealed with tape. Some samples were sealed in aluminium foil in a similar manner, except that the folded ends were not sealed with tape. The aluminium foil had a thickness of 0,03 mm and that of the cooking bag was 0,01 mm .

The autoclave (an Andrews Auto-setter, cubic capacity 2 662 litres), was evacuated to 127 mm Hg before the steam was injected. The samples were steamed at the required temperature for the predetermined time, after which they were removed from the autoclave. Some control experiments were also carried out by *curing* the air-dried fabrics in a laboratory curing oven.

After the treatments the fabrics were rinsed and dried. The physical properties of the fabrics were determined in the usual manner.

RESULTS AND DISCUSSION

Initially, cotton fabrics were treated with a DMDHEU type resin and various catalysts, followed by steaming under different conditions in an autoclave. The results, given in Table I, were generally very disappointing, and no crease recovery angle higher than 200 degrees was obtained. However, certain trends were noticed. A comparison of the various catalysts showed that $MgC\ell_2$/citric acid (1:1) gave the best results. When the steaming time was kept constant at 10 minutes, the crease recovery angle of the fabrics generally increased when the temperature increased, up to the highest temperature investigated, namely 140°C. When the steaming time at 140°C was increased from 10 to 30 minutes, however, there was a significant decrease in the crease recovery angles of the fabrics. Furthermore, it was found that an increase in the catalyst concentration from 1,0 *per cent* to 2,5 *per cent* had practically no effect on the crease recovery angles of the fabrics. Table I also shows that the fabric which was subjected to atmospheric steam for 5 minutes had approximately the same crease recovery angle as the fabrics which were steamed in the autoclave.

TABLE I

CREASE RECOVERY ANGLES OF FABRICS TREATED WITH A DMDHEU TYPE RESIN AND VARIOUS CATALYSTS AFTER STEAMING IN AN AUTOCLAVE UNDER DIFFERENT CONDITIONS

Treatment	Curing Conditions	Crease Recovery Angle (degrees)	Bursting Strength (kN/m^2)
	Autoclave:		
10% DMDHEU + 1,0% $A\ell(OH)_xC\ell$	110°C - 10 mins	142	1167
10% DMDHEU + 1,0% $A\ell(OH)_xC\ell$	120°C - 10 mins	141	1187
10% DMDHEU + 1,0% $A\ell(OH)_xC\ell$	130°C - 10 mins	149	971
10% DMDHEU + 1,0% $A\ell(OH)_xC\ell$/ lactic acid	110°C - 10 mins	157	991
10% DMDHEU + 1,0% $A\ell(OH)_xC\ell$/ lactic acid	120°C - 10 mins	160	991
10% DMDHEU + 1,0% $A\ell(OH)_xC\ell$/ lactic acid	130°C - 10 mins	159	912
10% DMDHEU + 1,0% $Zn(NO_3)_2$	110°C - 10 mins	137	1206
10% DMDHEU + 1,0% $Zn(NO_3)_2$	120°C - 10 mins	135	1157
10% DMDHEU + 1,0% $Zn(NO_3)_2$	130°C - 10 mins	147	1040
10% DMDHEU + 2,5% $Zn(NO_3)_2$	130°C - 10 mins	146	932
10% DMDHEU + 2,5% $Zn(NO_3)_2$	130°C - 30 mins	160	912
10% DMDHEU + 2,5% $Zn(NO_3)_2$	140°C - 10 mins	182	814
10% DMDHEU + 2,5% $Zn(NO_3)_2$	140°C - 30 mins	120	883
10% DMDHEU + 1,0% $MgC\ell_2$/citric acid	110°C - 10 mins	169	1147
10% DMDHEU + 1,0% $MgC\ell_2$/citric acid	120°C - 10 mins	167	961
10% DMDHEU + 1,0% $MgC\ell_2$/citric acid	130°C - 10 mins	185	1069
10% DMDHEU + 2,5% $MgC\ell_2$/citric acid	130°C - 10 mins	184	736
10% DMDHEU + 2,5% $MgC\ell_2$/citric acid	130°C - 30 mins	176	637
10% DMDHEU + 2,5% $MgC\ell_2$/citric acid	140°C - 10 mins	197	530
10% DMDHEU + 2,5% $MgC\ell_2$/citric acid	140°C - 30 mins	153	559
10% DMDHEU + 1,0% $MgC\ell_2$/ citric acid	Benz. Open atmospheric steam 5 mins	172	–
Untreated control	–	126	1196

Some further experiments were then carried out by sealing the resin-treated fabrics in *aluminium foil*, followed by autoclave steaming under various conditions. Two different types of resin were used, namely a DMDHEU and metholomelamine type. The results obtained are given in Table II. It can be seen that the sealing of the fabrics in aluminium foil prior to the steaming treatment increased the crease recovery angles of the DMDHEU treated fabrics significantly, compared to the results shown in Table I. The values obtained varied from about 240 to 270 degrees, depending on the steaming conditions. When the fabrics were steamed for 5 minutes, the crease recovery angles increased as the temperature increased from 110°C to 130°C. When the fabrics were steamed for 30 minutes, however, there was practically no difference between the crease recovery angles of the fabrics treated at the different temperatures. Finally Table II shows that the methylolmelamine type resin gave significantly higher crease recovery angle results (on average about 16 degrees) than the DMDHEU type. This is an interesting observation since the opposite is normally found in the case of the conventional pad-dry-cure process. Table II also shows that the bursting strength of the fabrics treated with the methylolmelamine resin was higher than that of the samples treated with the DMDHEU resin.

Table III gives a comparison between *aluminium foil* and *Mylar cooking bags* as a sealing or isolating medium for the fabrics during steaming. It can be seen that the samples sealed in *aluminium foil* had higher crease recovery angles than the samples sealed in *cooking bags*. The differences were relatively small when the fabrics were steamed for periods of up to 5 minutes, but became larger when the fabrics were steamed for a longer period (30 minutes). In the case of the *aluminium foil* the crease recovery angles of the fabrics increased when the time of steaming increased, but in the case of the *cooking bags*, however, the crease recovery angles generally decreased when the time of steaming increased. The decrease was more pronounced at higher temperatures. The bursting strength of the fabrics which were steamed in *cooking bags* increased with an increase in the time of steaming. This increase, as well as the decrease in crease recovery angle, indicate that some of the polymerized resin might have been hydrolized by the prolonged steaming treatment.

The behaviour of different types of resins during steam-curing in an autoclave is shown by the results in Table IV. In the case of the samples sealed in *aluminium foil*, the best results were obtained with the methylolmelamine type resin, followed by the resin comprising dimethylolethylene urea plus methylolmelamine. The average crease recovery angle of the fabrics steam-cured with the former resin was 268 degrees, followed by a value of 261 degrees for the fabrics treated with the latter. These values compare favourably with the results obtained by the normal pad-dry-cure process. With certain other resins, however, the crease recovery angles obtained by steam-curing were significantly lower than those obtained by the pad-dry-cure process. Similar conclusions could be drawn from the results obtained on samples sealed in the *cooking bags*. Once again it was found that the crease recovery angles

TABLE II

THE EFFECT OF AUTOCLAVE STEAMING OF RESIN-TREATED FABRICS SEALED IN ALUMINIUM FOIL ON THEIR CREASE RECOVERY ANGLE AND BURSTING STRENGTH

Treatment	Curing Conditions	Crease Recovery angle (degrees)	Bursting Strength (kN/m^2)
10% DMDHEU + 1,0% $MgC\ell_2$/Citric acid	110°C - 5 min	237	775
10% DMDHEU + 1,0% $MgC\ell_2$/Citric acid	110°C - 30 min	269	667
10% DMDHEU + 1,0% $MgC\ell_2$/Citric acid	120°C - 5 min	243	775
10% DMDHEU+ 1,0% $MgC\ell_2$/Citric acid	120°C - 30 min	271	588
10% DMDHEU + 1,0% $MgC\ell_2$/Citric acid	130°C - 5 min	263	618
10% DMDHEU + 1,0% $MgC\ell_2$/Citric acid	130°C - 30 min	268	500
10% Methylolmelamine + 1,0% $MgC\ell_2$/Citric acid	110°C - 5 min	258	794
10% Methylolmelamine + 1,0% $MgC\ell_2$/Citric acid	110°C - 30 min	281	755
10% Methylolmelamine + 1,0% $MgC\ell_2$/Citric acid	120°C - 5 min	268	677
10% Methylolmelamine + 1,0% $MgC\ell_2$/Citric acid	120°C - 30 min	283	657
10% Methylolmelamine + 1,0% $MgC\ell_2$/Citric acid	130°C - 5 min	274	716
10% Methylolmelamine + 1,0% $MgC\ell_2$/Citric acid	130°C - 30 min	285	667
Untreated control	–	126	1196

TABLE III

A COMPARISON OF THE EFFECTS OF ALUMINIUM FOIL AND COOKING BAGS AS SEALER FOR THE STEAMING OF COTTON FABRICS

Curing Conditions	Crease Recovery Angle (degrees)		Bursting Strength (kN/m^2)	
	Foil	Cooking Bags	Foil	Cooking Bags
100°C - 2 minutes	256	261	780	834
100°C - 5 minutes	264	263	866	851
100°C - 30 minutes	288	260	834	832
105°C - 2 minutes	253	261	883	819
105°C - 5 minutes	264	263	832	809
105°C - 30 minutes	279	255	861	897
110°C - 2 minutes	262	268	827	817
110°C - 5 minutes	274	263	799	910
110°C - 30 minutes	289	238	861	915
120°C - 5 minutes	269	253	782	799
120°C - 30 minutes	263	238	785	892
130°C - 5 minutes	252	237	785	892
130°C - 30 minutes	268	225	787	949

* 10% methylolmelamine + 1,0% $MgC\ell_2$/Citric acid

of the fabrics sealed in the *cooking bags* were significantly lower (on average about 27 degrees) than those of the samples treated in *aluminium foil*. Only the methylolmelamine resin gave crease recovery angles higher than 250 degrees. The values obtained with the other resins varied from about 190 to 220 degrees. Furthermore, it can be seen that the crease recovery angles of the fabrics treated with the various resins decreased with an increase in the steaming time.

There could be several possible reasons for the observation that the *aluminium foil* consistently produced better results than the *Mylar cooking bags.* In an attempt to obtain more information about this phenomenon, the moisture uptake and crease recovery angles of resin-treated fabrics steamed under various conditions in an autoclave were determined. The results are given in Table V. It can be seen that most of the samples treated in *aluminium foil* showed a slight loss in mass after steaming.

TABLE IV
THE EFFECT OF VARIOUS STEAMING CONDITIONS ON THE CREASE RECOVERY ANGLES OF COTTON FABRICS TREATED WITH DIFFERENT RESINS

Resin Treatment*	Curing Conditions	Crease Recovery Angle (degrees)		
		Aluminium foil	Cooking Bags	Conventional pad-dry-cure**
10% Methylolmelamine	100°C - 5 minutes	253	258	261
10% Methylolmelamine	100°C - 30 minutes	275	236	
10% Methylolmelamine	110°C - 5 minutes	260	247	
10% Methylolmelamine	110°C - 30 minutes	271	245	
10% Methylolmelamine	120°C - 5 minutes	261	263	
10% Methylolmelamine	120°C - 30 minutes	287	247	
10% Urea – formaldehyde – melamine	100°C - 5 minutes	238	233	264
10% Urea – formaldehyde – melamine	100°C - 30 minutes	256	206	
10% Urea – formaldehyde – melamine	110°C - 5 minutes	249	223	
10% Urea – formaldehyde – melamine	110°C - 30 minutes	235	212	
10% Urea – formaldehyde – melamine	120°C - 5 minutes	252	229	
10% Urea – formaldehyde – melamine	120°C - 30 minutes	258	215	
10% DMDHEU	100°C - 5 minutes	231	211	267
10% DMDHEU	100°C - 30 minutes	254	207	
10% DMDHEU	110°C - 5 minutes	235	225	
10% DMDHEU	110°C - 30 minutes	262	199	
10% DMDHEU	120°C - 5 minutes	253	215	
10% DMDHEU	120°C - 30 minutes	270	216	
10% Dimethylolpropylene urea	100°C - 5 minutes	209	196	230
10% Dimethylolpropylene urea	100°C - 30 minutes	200	179	
10% Dimethylolpropylene urea	110°C - 5 minutes	208	194	
10% Dimethylolpropylene urea	110°C - 30 minutes	192	187	
10% Dimethylolpropylene urea	120°C - 5 minutes	207	190	
10% Dimethylolpropylene urea	120°C - 30 minutes	211	189	
10% Dimethylolethylene urea + methylolmelamine urea	100°C - 5 minutes	245	236	262
10% Dimethylolethylene urea + methylolmelamine urea	100°C - 30 minutes	244	209	
10% Dimethylolethylene urea + methylolmelamine urea	110°C - 5 minutes	263	233	
10% Dimethylolethylene urea + methylolmelamine urea	110°C - 30 minutes	253	214	
10% Dimethylolethylene urea + methylolmelamine urea	120°C - 5 minutes	247	228	
10% Dimethylolethylene urea + methylolmelamine urea	120°C - 30 minutes	256	208	
10% Dimethylolethylene urea	100°C - 5 minutes	203	202	236
10% Dimethylolethylene urea	100°C - 30 minutes	223	186	
10% Dimethylolethylene urea	110°C - 5 minutes	224	208	
10% Dimethylolethylene urea	110°C - 30 minutes	228	183	
10% Dimethylolethylene urea	120°C - 5 minutes	228	190	
10% Dimethylolethylene urea	120°C - 30 minutes	224	207	
10% Urea-formaldehyde precondensate	100°C - 5 minutes	199	193	208
10% Urea-formaldehyde precondensate	100°C - 30 minutes	187	184	
10% Urea-formaldehyde precondensate	110°C - 5 minutes	210	187	
10% Urea-formaldehyde precondensate	110°C - 30 minutes	205	188	
10% Urea-formaldehyde precondensate	120°C - 5 minutes	218	190	
10% Urea-formaldehyde precondensate	120°C - 30 minutes	209	197	
10% Modified Glyoxal	100°C - 5 minutes	225	215	271
10% Modified Glyoxal	100°C - 30 minutes	242	196	
10% Modified Glyoxal	110°C - 5 minutes	235	215	
10% Modified Glyoxal	110°C - 30 minutes	256	216	
10% Modified Glyoxal	120°C - 5 minutes	240	213	
10% Modified Glyoxal	120°C - 30 minutes	258	202	
Untreated control	–	126		

* 1,0% $MgCl_2$/Citric Acid was used as catalyst in all cases
** 3 minutes at 120°C

TABLE V
THE MOISTURE UPTAKE AND CREASE RECOVERY ANGLE OF RESIN TREATED FABRICS AFTER STEAMING UNDER VARIOUS CONDITIONS IN AN AUTOCLAVE

Treatment	Moisture Uptake (%)				Crease Recovery Angle (degrees)				Bursting Strength (kN/m^2)			
	Foil		Cooking Bags		Foil		Cooking Bags		Foil		Cooking Bags	
100°C, 5 min	–0,1	–0,1	1,4	0,2	274	270	282	273	755	707	790	792
100°C,15 min	–0,2	–0,3	3,0	2,9	278	282	271	275	814	850	873	824
100°C,30 min	–0,2	–0,4	2,0	2,1	284	284	271	269	826	834	839	853
110°C, 5 min	–0,3	–0,2	0,8	2,1	276	276	276	271	802	814	834	834
110°C,15 min	0,9	–0,1	2,9	2,7	285	286	285	266	777	728	826	804
110°C,30 min	–0,5	2,6	3,0	3,4	286	260	279	261	711	880	848	831
120°C, 5 min	0	–0,1	2,6	2,0	284	292	280	277	755	807	848	814
120°C,15 min	–0,6	–0,3	2,9	2,8	297	292	274	270	753	824	836	853
120°C,30 min	0,9	0,2	5,0	5,3	286	292	254	251	799	782	831	868
110°C, 5 min, 2 layers	–0,1	–0,1	0,3	1,3	274	284	263	270	809	770	785	792
110°C, 5 min, 3 layers	0,1	—	0,7	0,6	280	280	270	273	821	785	763	868
110°C, 5 min, 4 layers	–0,2	–0,2	0,4	0,1	274	266	260	273	797	848	780	826
110°C,30 min, 2 layers	–0,2	–0,4	2,1	3,3	274	279	269	271	831	821	816	824
110°C,30 min, 3 layers	–0,2	–0,3	1,7	2,5	271	284	285	272	819	782	812	834
110°C,30 min 4 layers	–0,5	–0,4	2,4	2,2	273	275	285	279	802	750	848	790
Untreated control					178				1071			

* A minus sign indicates a mass loss

The samples steamed in the *cooking bags,* however, showed significant increases in mass after steaming. The moisture uptake in general seemed to increase with increasing time or temperature of steaming. Furthermore the crease recovery angles decreased when the moisture uptake increased, i.e. with increasing steaming time or temperature. This implies that the *cooking bags* were not as efficient in sealing off the samples from the steam as was the *aluminium foil.* Upon prolonged steaming of the former samples a gradual hydrolysis of the polymerized resin occurred, resulting in a decrease in the crease recovery angle. Frick and Gautreaux[10] pointed out that when cotton is steamed and water is present in the fibre, hydrolysis could destroy the crosslinks as rapidly as they are formed. Table V also shows that the sealing of the samples in several layers (up to four) of *cooking bags* did not have a significant effect on the moisture uptake or crease recovery angles of the fabrics.

The effect of autoclave steaming on certain physical properties of the resin-treated fabrics is shown in Table VI. It can be seen that under the conditions studied, namely steaming for 10 minutes at 100°C or 120°C, there was little difference between the results obtained on the samples sealed in *aluminium foil* and those sealed in *Mylar cooking bags.* Furthermore, there was little difference between the samples treated with the methylolmelamine and the DMDHEU type resins, with the latter giving marginally higher strength losses and DP ratings, but lower crease recovery angles than the former. On average, the treatment of cotton fabric with 10 *per cent* aminoplast resin, followed by steam curing in an autoclave, resulted in a decrease in breaking strength of about 26 *per cent*, a decrease in bursting strength of about 34 *per cent* and a decrease in flex abrasion resistance of 24 *per cent*, with practically no effect on the resistance to flat abrasion. The average dry crease recovery angle of the fabrics exceeded 270 degrees, the wet crease recovery angle exceeded 240 degrees, and the fabrics had DP ratings of about 3,0. Some control fabrics, which were cured in an oven for 3 minutes at 120°C, showed marginally higher strength losses and DP ratings and slightly lower crease recovery angles than the fabrics cured in the autoclave.

SUMMARY AND CONCLUSIONS

The possible use of an autoclave steamer for the curing of aminoplast resins on cotton fabrics was studied. When unsealed resin-treated fabrics were steamed in the autoclave, very disappointing results were obtained. However, when the resin-treated fabrics were air-dried, sealed in *aluminium foil* or *Mylar cooking bags,* followed by steaming in an autoclave, a significant increase in the crease recovery angles of the fabrics was obtained.

The crease recovery angles of the fabrics sealed in *aluminium foil* were, on average, slightly higher than those of the fabrics sealed in *cooking bags.* This was probably due to the fact that the *cooking bags* were not as efficient in sealing off the samples from the steam as was the *aluminium foil.* The samples sealed in *aluminium foil* showed a slight loss in mass after steaming, while the fabrics sealed in *cooking bags* increased in mass during steaming. The moisture uptake generally

TABLE VI
THE EFFECT OF STEAM-CURING IN AN AUTOCLAVE ON CERTAIN PHYSICAL PROPERTIES OF RESIN-TREATED COTTON FABRICS

Treatment			Breaking Strength (N)	Breaking Extension (%)	Bursting Strength (kN/m2)	Flat Abrasion (% mass loss after 10 000 cycles)	Flex Abrasion (cycles to rupture)	Crease recovery angle (degrees)		DP rating
Resin	Sealed in	Autoclave steamed						Dry	Wet	
10% Methylolmelamine	Foil	100°C, 10 min	540	15,6	824	2,0	285	273	239	3,0
10% Methylolmelamine	Cooking bag	100°C, 10 min	526	15,0	740	2,1	291	276	242	2,3
10% Methylolmelamine	Foil	120°C, 10 min	504	14,0	755	2,1	314	278	252	2,7
10% Methylolmelamine	Cooking bag	120°C, 10 min	519	15,3	777	2,0	350	283	220	2,7
10% Methylolmelamine	Foil	Oven-cured*	514	14,4	834	2,6	276	235	210	2,3
10% Methylolmelamine	Cooking bag	Oven-cured*	482	14,3	829	2,1	266	223	211	3,0
10% DMDHEU	Foil	100°C, 10 min	421	13,2	704	2,3	250	265	235	3,0
10% DMDHEU	Cooking bag	100°C, 10 min	481	15,0	799	2,1	369	277	253	3,0
10% DMDHEU	Foil	120°C, 10 min	453	15,3	750	2,4	317	266	241	3,3
10% DMDHEU	Cooking bag	120°C, 10 min	500	13,7	777	2,2	278	260	241	3,0
10% DMDHEU	Foil	Oven-cured*	462	13,6	669	2,6	197	264	246	3,5
10% DMDHEU	Cooking bag	Oven-cured*	457	13,3	694	2,7	219	260	240	3,2
Untreated Control			**660**	**17,4**	**1147**	**2,2**	**404**	**144**	**122**	**1,0**

* 3 minutes at 120°C

increased with increasing time or temperature of steaming, and appeared to result in a gradual hydrolysis of the polymerized resin. The sealing of the samples in several layers (up to four) of *cooking bags* did not have a significant effect on the moisture uptake or the crease recovery angles of the fabrics.

The crease recovery angles of the fabrics sealed in *aluminium foil* generally increased when the time or temperature of steaming increased. In the case of the *cooking bags,* however, the crease recovery angle tended to decrease when the steaming time increased. The decrease was more pronounced at higher temperatures.

The behaviour of different types of resins during steam-curing in an autoclave was subsequently investigated. In general, a methylolmelamine type resin produced the highest crease recovery angles, followed by a resin comprising of methylolmelamine plus dimethylolethylene urea.

The effect of autoclave steaming on certain physical properties of cotton fabrics was also investigated. In general, the treatment of cotton with 10 *per cent* aminoplast resin plus 1,0 *per cent* $C\ell_2$/citric acid catalyst, followed by steam curing in an autoclave, resulted in a decrease in fabric breaking strength of about 26 *per cent* and a decrease in bursting strength of about 34 *per cent*. In general the fabrics had dry crease recovery angles exceeding 270 degrees, wet crease recovery angles exceeding 240 degrees and DP ratings of about 3,0.

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PROPRIETARY NAMES

The fact that products with proprietary names have been used in this investigation (® denotes registered trade marks) in no way implies that SAWTRI recommends them or that there are not substitutes which may be of equal or even better value.

Aerotex is the registered trade mark of Messrs Cyanamid; Fixapret of Messrs BASF and Fibraset of Messrs Textile Chemicals.

REFERENCES

1. Manly, R. H., Durable Press Treatments of Fabrics. Recent Developments, *Noyes Data Corporation, New Jersey,* 1976.
2. Kopacz, B. M. and Perkins, R. M., A Status Report on All-cotton Durable Press Research, *Text, Chem. Col.* 1 (3), 22/80 (1969).
3. Reinhart, R. M., Cashen N. A. and Reid, J. D., A Mild Cure Process for Wrinkle-Resistant Cotton Fabrics, *Text, Chem. Col.* 1, (20), 33/415 (1969).
4. Hollies, N. R. S. and Getchell, N. F., Wet-fixation Process for Improved Durable-press Cotton, *Text. Res. J.* **37**, 70 (1967).
5. Vail, S. L., Young, A. H. P., Verburg, G. B., Reid, J. D. and Reeves, W. A., DP via Wet-fixation, *Textile Ind.*, **131**, 184 (1967).

6. Reeves, W. A., Hamalainen, C. S. H. H. and Cooper, A. S., Poly-set Process for Producing Durable-press Cotton Goods, *Text. Res. J.*, **37**, 76 (1967).
7. Hollies, N. R., Chafitz, S. R. and Farquhar, K. A., Rapid and Efficient Wet Fixation by the Use of Steam, *Text. Res. J.*, **39**, 497 (1969).
8. Parikh, D. V., Frick, J. G. and Reid, J. D., Investigations in the Steam-curing of Methylol Amides on Cotton, *Am. Dyestuff Rptr.*, **60**, (2), 48 (1971).
9. Parikh, D. V., Frick, J. G. and Iwata, A., Post-cure Finishing of Cotton with a Steam-cure Process, *Am. Dyestuff Rptr.*, **60**, (10), 58 (1971).
10. Parikh, D. V., Frick, J. G., and Reid, J. D., Smooth-drying Cotton by Steam-cure Finishing, *Research and Industry*, **15**, 3 (1970).
11. Verburg, G. B., Parikh, D. V., and Vail, S. L., Low Temperature Steam Setting of Resins, *Text. Chem. Col.* **1**, (27), 595/17 (1969).
12. Frick, J. G. and Gautreaux, G. A., Catalysts for Steam Curing of Methylol-amides on Cotton, *Text. Chem. Col.*, **4**, (5), 37/127 (1972).

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