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Effects of Resin Finish on Cotton Blended Woven Fabrics

Azmary Akter Mukthy, Abu Yousuf Mohammad Anwarul Azim
Department of Textile Engineering, Primeasia University, Dhaka-1213, Bangladesh
Corresponding Email: kanak_butex@yahoo.com

Abstract--*Resin or wrinkle free finishing is widely used in the textile industry to impart wrinkle-resistance to cotton fabrics and garments. Considerable loss in strength of the finished fabrics has been a major concern for the industry. The overall objectives of this work are to investigate the effect of resin finish on wrinkle recovery, tensile strength, bending length & DP ratings of cotton and cotton blended fabrics. However the changes due to crease resist finish are found to be statistically significant. In addition, the wrinkle recovery angle increases approximately 42% , breaking strength reduces about 64% , Stiffness increases 8% after the crease resistant finishing. To find out the varieties of cotton blended fabrics in order to develop market viable new products is also another purpose of this project.*

Keywords-- Crease resistant finish, Tensile Strength, Bending length, Wrinkle recovery angle and DP.

I. Introduction

Resin finishing has been able to maintain its position in the finishing of textiles based on cellulosic fibres despite various disadvantages such as strength losses, shade changes, reduced whiteness, and controversy about formaldehyde content. In fact, recently there has been a resurgence in its importance, because it allows textile finishers to stand out from the competitors by producing fabrics with enhanced quality.

II. The Advantages Of Resin-Finished Over Unfinished Textiles, Especially After Washing, Are:

- Improved dimensional stability and shape retention
- Less tendency to creasing
- Easier to iron
- Softer and smoother
- Better appearance and therefore more durable
- Less change in shade
- Improved wet fastness of dyeing and prints
- Less tendency to pilling, especially of fibre blends
- Greater wash resistance of mechanically produced lustre and embossed finishes and finishes with softeners, stiffening agents, water-repellents and oil-repellents. Cellulosic fiber-containing fabrics are made wrinkle resistant by a durable press wrinkle-free process which comprises treating a cellulosic fiber-containing fabric.

- Crosslinking agent
- Catalyst
- Additives
- Surfactants

Crosslinking agents

Resin finishing is carried out with products known as crosslinking agents. These change woven and knitted fabrics composed of cellulosic fibres and their blends with synthetic fibres in such a way that the resulting textiles are easier to care for.

Catalysts

Another essential component of the resin-finishing recipe is the catalyst. It allows the reaction to be carried out within the 130 –180 °C temperature range usually employed in the textile industry, and within the usual curing times (several minutes in the case of curing machines and several seconds in the case of stenters).Three classes of catalysts are distinguished in the dry crosslinking process commonly used today:

- Ammonium salts, e. g. ammonium chloride, sulfate and nitrate
- Metal salts, e. g. magnesium chloride, zinc nitrate, zinc chloride, aluminium sulfate and aluminium hydroxychloride
- Catalyst mixtures, e. g. magnesium chloride with added organic and inorganic acids or acid donors.

Additives

The purpose of the additives is to offset partly or completely the adverse effects of the crosslinking agent. Thus softening and smoothing agents are applied not only to improve the handle, but also to compensate as much as possible for losses in tear strength and abrasion resistance. Other additives serve to impart a particular character to the fabric. Examples are stiffening and filling agents, water-repellents, hydrophilizing agents, etc. Additives may be the following categories:-

- Polymers based on acrylic monomers, vinyl monomers, siloxanes, amides, urethanes and ethylene

• Low-molecular substances such as fatty acid derivatives and quaternary ammonium compounds

• Mixtures of these substances

Surfactants

Every resin-finishing recipe contains surfactants as emulsifiers, wetting agents and stabilizers. These surface-active substances are necessary to ensure that the fabric is wet rapidly and thoroughly during padding and to stabilize the recipe components and liquors. An enormous variety of surfactants exists. Only the most important group of nonionic surfactants for resin finishing, the ethoxylates, will be discussed here. The general formula of an ethoxylate is: R–O–$[CH_2CH_2O]_n$–H

R = long-chain fatty alcohol or alkylphenol group the recipe components and liquors.

III. Causes Of Crease Formation

Deep wrinkles in fabric--or creases--are most often a result of day-to-day wear. The pressure from sitting or leaning for extended periods of time will cause folds in the fabric to form creases in garments. Some creases, however, result from improperly folding or storing clothing. Many textile scientists have studied new methods to measure wrinkle resistances of fabrics [1-7]. It is best to hang clothes when not being worn to reduce wrinkling [8]. Not all wrinkles are the result of pressure, and some fabrics are more likely to wrinkle than others. In addition to the weave and thread-count of a textile, the fibers manufacturers use to produce fabric can affect how a fabric will wrinkle. Cellulose materials such as cotton, viscose and linen have a very poor resistance to creasing [9] . The primary cause of the shrinkage of cellulosic fibres is the fact that these fibres can readily absorb moisture. This absorbed moisture facilitates internal polymer chain movements in the amorphous fibre areas by lubrication. It disrupts the internal hydrogen bonding between these polymer chains. When a moisture laden cellulosic fibre is stressed, the internal polymer chains of the amorphous areas are free to move to relieve that stress. Hydrogen bonds can reform between the polymer chains in their shifted positions, in effect locking in the new configuration. With no restoring forces available, a newly formed wrinkle or crease will remain until additional processes (ironing for example) apply adequate moisture and mechanical forces to overcome the internal forces.

IV. Mechanisms of Easy-Care Finishing

The swelling of cellulosic fibres by moisture can be reduced by the application of self crosslinking urea or melamine products as well as by products that mainly crosslink with cellulose molecules. Without such a crosslinking finish, cellulose fibres can take up more than 10 % of their weight in water. As the fibres swell, the

fabric must crease and shrink to relieve the internal stresses caused by the swelling. The new arrangement of the cellulose molecules in the swollen form of the fibre is fixed by newly formed hydrogen bonds between adjacent cellulose molecules, mostly in the amorphous fibre area. Therefore the uneven and wrinkled appearance of the cellulose fabric remains after drying, in contrast to fabrics made of nonswelling synthetic fibres.Two different chemical approaches have been used commerciall to producenon-swelling or durable press cellulose fabrics. The original approach is theincorporation of a polymerised finish in the pores of the fibres, so that water molecules cannot easily penetrate the fibre. The newer approach is the reaction of multifunctional crosslinking agents with the hydroxyl groups of adjacent cellulose molecules that hinder the swelling of the cellulose fibre.

V. Cross-Linking Agent

The first resin-finishing agents – developed in the 1930s to improve the poor wet strength of viscose staple fabrics – were compounds of formaldehyde and urea, though compounds of formaldehyde and melamine were later also used. In recent years the importance of this group of crosslinking agents has declined because of the controversy about the high levels of free formaldehyde in the products and on the finished goods. With the appearance of easycare synthetic fibres in the 1950s, heterocyclic crosslinking agents were developed to improve the competitiveness of cotton. Heterocyclic crosslinking agents are based on urea, formaldehyde, and various other substances such as diamines and, in particular, glyoxal of the crosslinking agents that are formaldehyde-free, only products made from dimethyl urea and glyoxal have gained a small share of the market. Other formaldehyde-free crosslinkers have remained insignificant because of high toxicity, high manufacturing costs, inadequate wash resistance or poor effects. Since practically all effective resin-finishing agents are based on formaldehyde, they have become part of the public debate about the toxicity of this substance. This debate has strongly influenced and stimulated the development of crosslinking agents in recent years. New crosslinkers for low-formaldehyde finishing and formaldehyde-free resins were developed. With the revival of resin finishing, processes that were almost forgotten, such as postcuring and moist crosslinking, are being applied again.

The crosslinking agents that result in the permanent press finish are often derivatives of urea. A popular agent is DMDHEU, di-methylol dihydroxyethyleneurea [10].

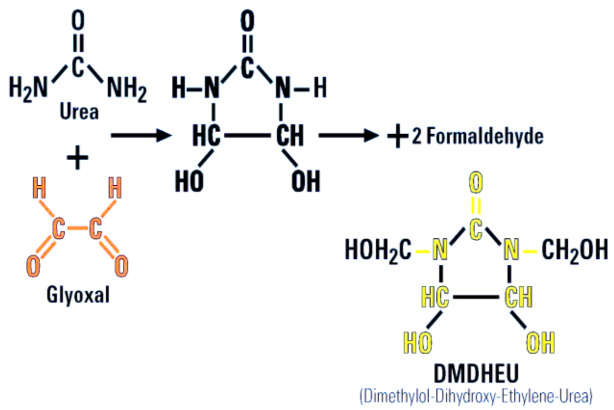

Figure 1. Synthesis of DMDHEU

The principal reaction of DMDHEU products is the crosslinking of adjacent cellulose molecules, as shown in Figure 2.

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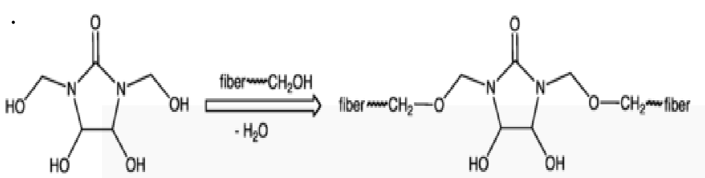

Figure 2. The permanent press effect arises from crosslinking of molecules of cellulose by chemical agents such as DMDHEU

- The catalysts used for DMDHEU systems, such as magnesium chloride, cause degradation of cellulose, thus reducing the tensile and tear strength of cotton fabric. The magnitude of fabric strength loss is affected by temperature, time, and concentration of the catalyst. Fabric strength loss also depends on both the cation and anion of the catalyst. An activated catalyst system, which includes an organic acid, causes more severe fabric tensile strength loss[11].

- Tensile strength loss of cotton fabric treated with DMDHEU is due to both the cross-linking of cellulose and the degradation of cellulose caused by the catalyst. Because a catalyst system plays such an important role in influencing the strength loss of cotton fabrics cross-linked by DMDHEU, the selection of the catalyst system and its concentration is crucial for optimising the tensile strength retention of the finished fabrics [12-14].

6. Effect Of Cross-Linking On Fabric Properties

The reaction with cross-linking agents depends on changes in the physico-chemical properties of the fibres, such as swelling and solubility behavior [15-17]. As consequence of the cross-links in the structure, fibre mechanical properties are changed by gaining weight, moisture and on dimensional stability that imparts the qualities like freedom from wrinkles, crease recovery, tensile strength, tearing strength and abrasion resistance. These give cotton some elastic and resiliency properties. Such cross-linked cotton can recover from deformation stresses and thus wrinkles will not form [18].

VII. Types Of Cross-Linking Process

The resin-finishing process involves padding and drying the open-width, cellulosic-fibre-based fabric and then curing it by one of a number of methods.

The following different crosslinking processes are used in resin finishing:

- Dry crosslinking process
- Moist crosslinking process
- Wet crosslinking process
- Postcure process
- Precure process
- Dip-dry process

Dry crosslinking process

The most important of these processes is dry crosslinking, in which the fabric is cured in a dry state. After being padded, the fabric is usually dried on the stenter and then cured in a curing apparatus, or on the stenter immediately after drying (flash-curing process).

Moist crosslinking process

In moist crosslinking, the fabric is cured in a moist, partially swollen state (about 6 –12 % residual moisture). The fabric is padded with liquor containing a mineral-acid catalyst in addition to the crosslinker. BASF recommends sulfuric acid, because hydrochloric acid is problematic for various reasons including hydrogen chloride in the exhaust air. The fabric is subsequently dried to a residual moisture content of 6 –12 %. After being batched for one or two days at a temperature of 25 – 35 °C, the fabric is washed, neutralized and dried. Afterwards it is usually further treated with handle-finishing agents. The process is very expensive, because several drying steps are necessary. Moreover, in practice it is difficult to maintain the exact conditions required, such as residual moisture content and batching temperature. Very good easy care effects, low formaldehyde values and low strength losses are obtained only if these conditions are exactly maintained. The process has regained importance in recent years, following an interval of more than 20 years, in the manufacture of virtually non-iron, all-cotton textiles of acceptable strength.

Wet crosslinking process

In wet crosslinking, the reaction takes place when the fabric is in a wet, fully swollen state. Today this method is no longer used, even though it is much easier to carry out than moist crosslinking, because the dry crease recovery is almost the same as that of untreated cotton textiles. As in the moist crosslinking process, a liquor containing a strong mineral acid is applied and the batch of wet fabric is rotated for about 20 hours at room temperature. The fabric is then washed, dried, neutralized and, if necessary, aftersoftened. Because of the repeated drying required, this process is also expensive.

Postcure process

The postcure process is another old process that has experienced a revival, beginning in the USA. It belongs to the dry crosslinking methods and is the most significant permanent-press method. The fabric is treated as in standard dry crosslinking but not cured. The treated fabric is subsequently made up into garments and provided with crease lines or pleats in the steam press before being oven-cured. Earlier permanent-press methods, for example the Koratron process, have disappeared as a result of a number of disadvantages, such as a formaldehyde odour problem during steaming (more than 1000 ppm in the AATCC 112 test!) and a pronounced shade change because of the zinc nitrate that had to be used to achieve the necessary high reactivity. Today's postcure process can be carried out with low-formaldehyde crosslinkers that are reactive enough to be catalysed with magnesium chloride, and formaldehyde-free crosslinkers that have the additional advantage of producing an even better tensile strength.

Precure process

Crosslinking in the precure process is also carried out in the dry state. Another permanent-press method, it is a special case in which blended wovens of synthetic and cellulosic fibres (usually PES/CO or PES/CV with over 60 % PES) are provided with permanent creases. In the first step, the cellulosic component undergoes standard continuous resin-finishing by the dry crosslinking process. After making-up, the finished garment is shaped by heat setting the synthetic fibres at high temperature and under high pressure in special ironing presses. Today, the name "precure process" is occasionally given to the dry crosslinking process to distinguish it from the postcure process. The original precure process is no longer important.

Dip-dry process

The dip-dry process is a special case of the permanent-press or postcure process. The fabric is first made up into garments, which are dipped to impregnate them with the finishing liquor, centrifuged, dried, ironed and cured. This process has also experienced a revival.

VIII. Experimental

VIII.1. Materials:

Fabrics used:

1. 100% cotton woven fabric
2. 99% cotton & 1% spandex blended woven fabric
3. 98% cotton & 2% spandex blended woven fabric
4. 65% cotton & 35% polyester (PC) blended woven fabric

VIII.2. Experimental tools & equipment

- Resin used:
- Formaldehyde resin, DMDHEU(BASF)
- Concentration of resin: High
- Methods of application: Padding and Curing

VIII.3. Methods

Pre-Cure process:

The samples fabrics are cut into 35cmx35cm for padding in padding machine. At first samples are padded into a padding machine at 5.5 bar pressure. After padding these samples were dried at 120ºC for 2 min and cured at 170ºC temperature for 45 seconds in a pre-heated oven of 50ºC.

The following recipe is used for padding:

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1. Fixapret Resin CL: 100g/l
2. Fixapret Catalyst F-M: 30g/l
3. Perapret Additive PEP: 30g/l
4. Siligen Softener SIE: 20g/l
5. Kieralon Washoff XC-J Conc : 1g/l
6. PH: 5.5
7. Padder pressure 1.5 bar
8. Pick-Up% :65-75%

In figure 3 samples image are shown.

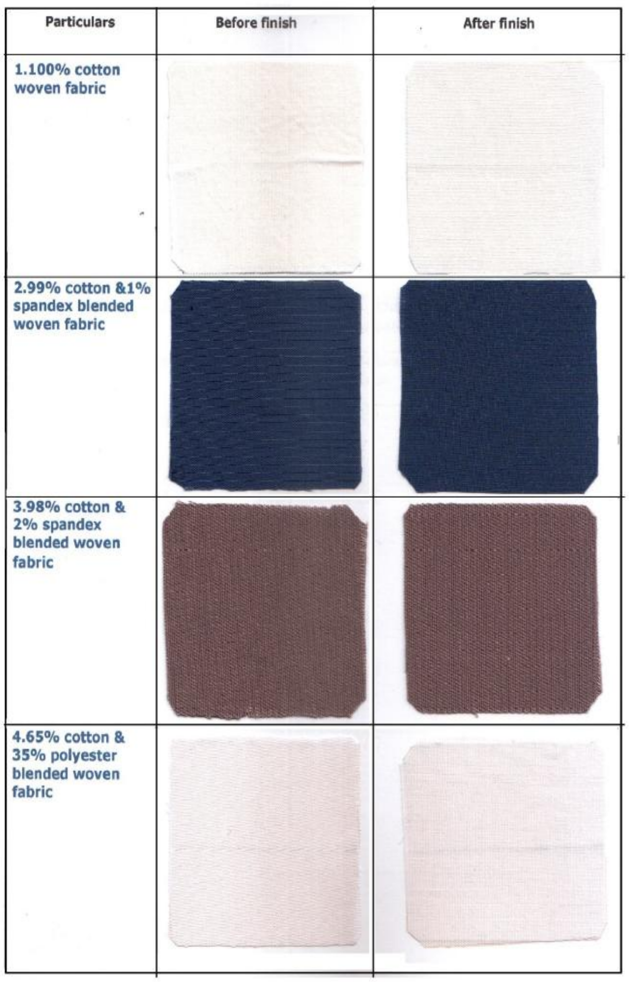

Figure 3. Image Of Different Types Of Fabrics Before And After Resign Finish

IX. Result

IX. 1. Recovery angle

Machine: Shirley Crease Recovery tester

Sample size: 4.4cmx1.5cm

Table 1. Recovery angle of different types of fabrics before and after resign finish

Particulars	**Warp way angle (de-gree)**		**Weft way angle (degree)**	
	Before finish	**After finish**	**Before finish**	**After finish**
1.100% cotton woven fabric	76	142	80	125
2.99% cotton &1% spandex blended woven fabric	64	126	100	130
3.98% cotton & 2% spandex blended woven fabric	124	154	58	84
4.65% cotton & 35% polyester blended woven fabric	98	92	107	116

IX.2. Stiffness:

Machine: Shirley Stiffness Tester

Sample size: 6inX1in

IX. 3. Tensile strength

Machine: Good brand vertical strength tester

Sample size: 8inx2in

Table 4. Tensile strength different types of fabrics before and after resign finish (Warp way)

Particulars	Tensile strength (Pound)	
	Before finish	After finish
1.100% cotton woven fabric	142	71
2.99% cotton &1% spandex blended woven fabric	99	64
3.98% cotton & 2% spandex blended woven fabric	130	79
4.65% cotton & 35% polyester blended woven fabric	45	40

Table 5. Tensile strength different types of fabrics before and after resign finish (Weft way)

Particulars	Tensile strength (Pound)	
	Before finish	After finish
1.100% cotton woven fabric	170	119
2.99% cotton &1% spandex blended woven fabric	166	130
3.98% cotton & 2% spandex blended woven fabric	212	111
4. 65% cotton & 35% polyester blended woven fabric	171	165

IX. 4. DP rating

Method: ISO Home Wash & Tumble dry: 30 min at 60-900C

Table 6. DP rating of different types of fabrics

Particulars	Durable Press (DP) Rating
1. 100% cotton woven fabric	Close to 4
1. 99% cotton &1% spandex blended woven fabric	Close to 4
2. 98% cotton & 2% spandex blended woven fabric	Close to 4
3. 65% cotton & 35% polyester blended woven fabric	Close to 4

X. Result Discussion

- *Effect of treatment on wrinkle recovery*

The results of wrinkle recovery of treated fabric are shown in **table 1** It is observed from the table that in all the treatments the wrinkle recovery is increased but the increase is not the same in all cases significant increase in wrinkle recovery has been observed .On comparing wrinkle recovery of fabrics, it is observed that the treated fabrics show 42% increase in wrinkle recovery angle in warp direction and 32% increase in weft direction over untreated fabrics. This is due to the accelerated catalytic reaction at high temperature.

- *Effect on bending length:*

Table 2 and 3 shows that all the treated fabrics generally had smaller bending length meaning that all the treated fabrics were stiffer when compared to the untreated fabric. It is observed that the treated fabrics show 8% increase in bending length in warp (**Table 2**) direction and 6% increase in weft direction (**Table 3**) over untreated fabrics. This is due to the accelerated catalytic reaction at high temperature. When the treated fibres were dried during the curing step the finishing agent molecules present inside would react with the cellulose surfaces and the reactivity is higher pre-cure technique due to high temperature which gives higher activation energy to both the hydroxyl groups of the substrate and the finishing agent. As the cross links introduced between the hydroxyl groups were covalent bonds that held the cellulose molecules together, they would function as a swelling restraint (Kling, 2001). When the fibre cross sectional area increases and other factors remain constant, the stiffness will increase (Frushour and Knorr, 1983).

- Effect of treatment on Tensile Strength:

To evaluate the effect of treatment on fabric strength, tensile strength of the fabric was analysed which is shown in Table 4 and 5, the tensile strength of the fabric is found to be reduced in both warp (**Table 4**) & weft (**Table 5**) direction. It is found that the decrease in tensile strength of finish fabric as compared to unfinished fabric is 64% in warp direction and 43% in weft direction .The acidity (pH-5.5) of the finishing agent has a significant effect on the reduction of tensile strength of the treated fabric.

XI. Conclusion

From the findings of the study it can be concluded that there is:

1. Increased crease recovery
2. Increased stiffness
3. Decreased in tensile strength
4. Improved DP rating
5. Free from chemical residues due to aging

XII. Suggestions

Similar studies should be carried out on all the varieties of cotton blended fabrics in order to develop market viable new products.

XIII. Acknowledgement

We wish to express my sense of gratitude to all the people who have contributed towards the preparation of this project. Our sincere gratitude is to Mr. Khaled Mamun to help us in successfully completed this project with a deep sense of self contentment. We are extremely thankful to my supervisor Dr. Ummul Khair Fatema for supervising my work by giving information, methodology of the project and extremely thankful to the management of BASF for providing all the chemicals, machine for my experiment. We also thankfully place on record the untiring support rendered to me by Mr. Kashem Anamul to provide me the fabrics.

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Table 2. Stiffness of different types of fabrics before and after resign finish (Warp way)

Particulars	Front Left		Front Right		Back Left		Back Right	
	Before Finish	After Finish	Before Finish	After Finish	Before Finish	After Finish	Before Finish	After Finish
1. 100% Cotton woven fabric	2.2	2.3	2.1	2.2	2.0	2.1	2.2	2.0
2. 99% Cotton & 1% Spandex blended fabric	2.25	2.4	2.2	2.5	2.4	2.45	2.5	2.6
3. 98% Cotton & 2% Spandex blended fabric	3.0	3.6	2.6	2.8	2.6	3.9	3.0	3.6
4. 65% Cotton & 35% Polyester blended fabric	3.6	4.1	3.7	3.8	3.3	4.0	3.2	4.1

Table 3. Stiffness of different types of fabrics before and after resign finish (Weft way)

Particulars	Front Left		Front Right		Back Left		Back Right	
	Before Finish	After Finish	Before Finish	After Finish	Before Finish	After Finish	Before Finish	After Finish
1. 100% Cotton woven fabric	2.5	2.6	2.6	2.7	2.5	2.8	2.5	2.6
2. 99% Cotton & 1% Spandex blended fabric	2.2	2.4	2.2	2.3	2.0	2.2	2.0	2.3
3. 98% Cotton & 2% Spandex blended fabric	2.6	2.9	2.45	2.6	2.2	2.5	2.3	2.5
4. 65% Cotton & 35% Polyester blended fabric	2.7	3.0	2.5	3.0	2.7	3.1	3.1	3.0