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The Effect of Wrinkle Recovery Finishes on Shrinkage of Cotton Fabric for Different Finish Applying Techniques

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Abstract. This research study was conducted to make wrinkle free fabric by applying formaldehyde free anti-wrinkle finishes like Texicil DC, Knittex RCT, Arkofix NEC, Arkofix ELF. In this effort, various concentrations of these finishes were used by adopting three different finish applying techniques (pad-dry technique, pad-dry-cure technique and pad-flash-cure technique) on pure cotton fabric in order to optimize their application for best manufacturing results in sense of the shrinkage ability of the fabric. After making quality test of the resulting fabric it was depicted that pad dry method of applying finish proved itself better as compared to other techniques adopted in this research, while the finish Arkofix ELF and Arkofix NEC at concentration level of 120 g/L gave better results in respect of shrinkage of the fabric.

Keywords: non formaldehyde finishes, finishing techniques, cotton fabric, wrinkle free, fabric shrinkage

Introduction

Textile and clothing is one of the major sectors that have gained wide space in fashion industry of this age. The consumers like value added and ease caring products. Today the dresses do not stand only to cover the body but now clothing boosted up to wear a dress that has some unique properties in sense of protection, comfort, durability and many other aesthetic values like having wrinkle free properties. The ability of a dress to retain its ironed shape is the demand of the day. Wrinkle free characteristic is very demanding especially in garment industry.

During wearing and washing of the fabric the wrinkles are created in it. The wrinkle recovery of the fabric is highly dependent on the crosslinking property of the material. These crosslinks are the source of holding together the molecular chains due to which the fibre is pulled back to its original shape after getting bent and the wrinkles are prevented to be formed. In order to make cellulosic cotton fabric wrinkle resistant and create durable press property in it, there exists the use of permanent press finishes on these apparels. The conventionally used finishes for this purpose have serious health hazards in sense of having formaldehyde that has carcinogenic effect on human skin. So formaldehyde free finishes are highly recommended for creating special activities in the fabrics like wrinkle resistance ability (Sahin *et al*., 2009).

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During the finish applying process the cotton fabric undergoes the application of crosslinking agents in addition to adding suitable softener and catalyst. Then drying and heating process is carried out that supports the crosslinking reaction of the cellulose. It has been found that the finish concentration and use of softening agent have considerable changes in the ultimate quality parameters of the fabric (Frick *et al*., 1973). Today the demand of cotton fabric is on high peak. Hence, there is dire need of using wrinkle free finishes on these fabric to make it high valuable. This is the era of fashion and style and the people demand a dress having more and more value addition in order to create comfort ability, ease care, protection etc. to them. For the last five years this demand has gained high rank especially in the sense of having wrinkle free dressing. This demand is more focused for the cellulosic fabric. Hence, the use of wrinkle free finishes to create durable press ability among the fabric is increasing day by day. In every kind and style of clothes wrinkle free property is highly appreciated (Doshi, 2006).

The most commonly existing techniques that are being adopted by dye processing industry to apply finishes on the fabrics in order to create some special characteristic in the fabric are pad-dry method, pad-dry-cure method and pad-flash-cure method. But all these methods have variant impacts on fabric quality due to having process difference. Therefore, this research was taken to observe the ultimate impact of these different techniques for different concentrations of formaldehyde free anti-wrinkle finishes on the shrinkage of the fabric. Further, the selected variables were optimized to analyze their effect on the shrinkage property of the cotton fabric.

Materials and Methods

The present research study was conducted in Department of Fibre and Textile Technology, University of Agriculture Faisalabad with the collaboration of local textile mill of Faisalabad, Pakistan.

Phase wise categorization of this work is given below:

(1) Fabric testing in grey form, (2) Pretreatment processes of grey fabric, (3) Fabric dyeing after bleaching, (4) Application of wrinkle free finishes on the dyed fabric and (5) Statistical analysis of the quality parameter of the fabric in respect of its shrinkage.

Woven fabric made from pure cotton fibre was selected for this study. The fabric was taken in grey form with the following specifications:

No. of ends/inch 60; no. of picks/inch 60; warp yarn count (Ne) 20s; weft yarn count (Ne) 20s; fabric weight (g/m^2) 125.

Prior to dyeing and finishing this fabric was undergone following pretreatment processes:

Singeing. The fabrics made from cotton fibres have the problem of hairiness due to the protruding ends of the short fibres on the surface of the fabric. These fibres put negative impact on the appearance of the fabric and cause serious effects in dyeing stage in the form of shade difference. Hence, the removal of these fibres from the surface of the fabric is highly demanding. This is carried out by passing the fabric on the flame of specific intensity with specific speed. This process is known as singeing. In this study, the following singeing conditions were set:

Flame intensity (17 kW/m^2); temperature (125 °C); speed (80 m/min).

Desizing. In order to make yarn feasible for weaving process some strength is imparted to it by applying sizing material on it in the form of starch, poly vinyl alcohol (PVA) etc. (Madaras *et al*., 1993). But before dyeing this sizing material has to be removed from the surface of the fabric. This is called desizing process. Following recipe of desizing process was chosen for this study.

Desizer agent TS-10 (14 g/L); detergent (MRN) (10 g/L); wetting agent (4 g/L); PH (7.5); temperature (85 °C).

Scouring and bleaching. During weaving process many impurities attack on the fabric surface in the form of oil stains and some coloured material. Hence, before dyeing and finishing this fabric is needed to be cleaned from all kind of these stains. This is carried out by washing of fabric with some detergent and then bleaching it. For the present work, following are the details of the scouring and bleaching recipes.

For scouring. Scouring agent (caustic soda) (30 g/L); detergent (K-D) (5 g/L); squinting agent (Sacoron) (2 g/L); soda ash (4 g/L); temperature (95 °C).

For bleaching. Bleaching agent {H_2O_2 (50%)} (32 g/L); sodium hydroxide {NaOH (50%)} (13 g/L); wetting agent (PN) (3g/L); squinting agent (Sacoron) (2 g/L); stabilizer (SIFA) (12 g/ L); temperature (95 °C); steaming time (40 min.).

After the above mentioned pretreatments the fabric samples were dyed with reactive dyes using the dyeing recipe as given below:

Reactive dye 1, with drim blue shade (2.92 g/L); dye 2, with jack L yellow shade (1 g/L); antimigrating agent (25 g/L); dye leveling agent (20 g/L); urea (100 g/L); 1st washing (room temperature); 2nd washing (40 °C); 3rd washing (65 °C); 4th washing (at room temperature).

Dyeing. Continuous dyeing method was used to dye the prepared cotton fabric samples with reactive dyes. The fabric was padded at 30 °C. The dye bath was comprised with urea (100 g/L); drim blue (2.92 g/L); jack L yellow (1 g/L); anti-migrating agent (25 g/L). While a dye leveling agent (20 g/L) was also applied in dye bath. The use of the urea facilitates the dye diffusion in the sample by holding moisture on fabric at high temperature. It also helps in dye dissociation and swelling of fabric.

After this the fabric was dried immediately to avoid dye migration. The interaction between dye and fabric was created at 150 °C for 60 sec. Then washing and soaping of the material was done for removing the unfixed dye and to improve dye fastness.

Fabric finishing. For fabric finishing selected and concentrations are presented in Table 1.

Fabric shrinkage (%) (AATCC Test Method, 2003). ***Purpose and scope.*** This test method is planned to

Table 1. Variables for fabric finishing

Finishes (F)	Application methods (T)	Concentrations (g/L) (C)
F_1 = Texicil DC	T_1 = Pad-dry method	C_1 = 60
F_2 = Knittex RCT	T_2 = Pad-dry-cure method	C_2 = 80
F_3 = Arkofix NEC	T_3 = Pad-flash-cure method	C_3 = 100
F_4 = Arkofix ELF		C_4 = 120

resolve the dimensional changes in woven and knitted fabrics when subjected to repeated automatic laundering procedures.

Principle. The dimensional changes of fabric specimens subjected to procedures typical of home laundering and drying practices were measured using pairs of benchmarks applied to the fabric before laundering.

Apparatus and materials. Automatic washing machine; automatic tumble dryer; conditioning racks with perforated shelves; AATCC standard detergent; indelible ink marking pen; scale for measurement.

Measuring devices. Tape or ruled template in millimeters; tape or ruled template marked directly in percent dimensional change to 0.5%; scales with at least 5 kg capacity.

Test specimens. Three specimens of each sample to be tested are required to in wrinkle the precision of the average.

Marking of fabric. Test specimen (each 380×380 mm) were taken and marked with three 250 mm pairs of benchmarks parallel to the length of the fabric and three 250 mm pairs of benchmarks parallel to width of the fabric. Each benchmark must be at least 50 mm from all edges of the test specimen. Pairs of benchmarks in the same direction must be approximately 120 mm apart. Any alternate size specimens and benchmarks used must be indicated in report. Marks of 500 mm or 18 inches are commonly used to give better measurement precision. Sewing thread can be used to makes benchmarks.

To improve the accuracy and precision of the dimensional change calculations based on benchmarks applied to the fabric, measure and record the distance between each pair of bench marks with ruler. This is measurement (A) before washing.

Test procedure. ***Washing of fabric.*** Utilize specified water level, the special water temperature for the washing cycle and a rinse temperature of less than 29 °C. If this increased temperature is not attainable, verification available rinses temperature. Add 66±1 g of AATCC standard detergent. Add test specimens and enough ballast to make a 1.8±1 kg load can be used. Set the washer for the selected washing cycles and time.

Drying. Place the washed load (test specimen and ballast) in the tumble dryer, and set the temperature control to generate the correct exhaust temperature 160 °C. Operate the dryer until the total load is dry. Remove the load immediately after the machine stops.

Measurement. After ironing and conditioning, lay each test specimen without tension on a flat smooth, horizontal surface. Measure and record distance between each pair of bench marks to the nearest millimeter, tenth of an inch and smaller in wrinkle. This is measurement B.

Calculations and interpretation. After specified washing and drying, the dimensional changes are calculated as:

$$DC\ \% = 100\ (B-A)\ A$$

where:

DC = Dimensional change
A = Original dimension
B = Dimension after laundering

A final measurement smaller than the original measurement results in a negative dimension change that is shrinkage. A final measurement larger than the original measurement results in a positive dimensional change which is growth.

Atmospheric conditions. All tests were carried in labs maintaining standard lab conditions i.e., 65±5% relative humidity and 20±2 °C temperatures.

Statistical analysis. The collected data was analyzed by using SPSS software (Montgomery, 2009).

Results and Discussion

Fabric shrinkage % (warp wise). The collected data in respect of the fabric warp wise shrinkage was analyzed statistically to know the effects of selected variables i.e., 4 wrinkles free finishes, 4 concentration levels of these finishes and 3 different finish applying techniques. The results are depicted in Table 2. The results disclosed significant effect of finishes (F) on fabric shrinkage while, highly significant effect on fabric shrinkage was noted for various concentrations (C) of finishes and for different finish applying techniques (T).

The mean values of fabric shrinkage % (warp wise) for 4 types of finishes F_1 up to F_4 are given in Table 3. It shows a significant difference among the values. The minimum warp wise shrinkage is obtained for F_4 as 2.2380 (%), while the respective mean value of F_1, F_2 and F_3 are as 2.2613%, 2.2571% and 2.2474% as depicted from Fig. 1. It is inferred from these results that the finish F_4 showed less shrinkage and finish F_1 showed very high shrinkage than finish F_2 and F_3. These results are supported by the research findings that a good resin finish would stabilize the fabric and reduce the residual shrinkage to less than 2% (Tomasino, 1992). Similarly the crosslinking of cotton and viscose by a modified dimethyloldihydroxy ethylenecarbamid (DMDHEC) was found to have a long-lasting effect of wrinkled shrinkage (Lukanova and Ganchev, 2005).

The comparison of mean values of fabric warp wise shrinkage for varying concentrations C_1, C_2, C_3 and C_4 are tabulated in Table 3 and also illustrated graphically in Fig. 1. The results showed significant effect of concentration on cotton fabric warp wise shrinkage. The minimum warp wise shrinkage was obtained for C_4 as 2.1934% followed by C_1, C_2 and C_3 as 2.3069%, 2.2603% and 2.2432%, respectively. These results indicated that as the concentration of finishes increased, the warp wise shrinkage of cotton fabric decreased. C_1 showed more shrinkage percentage as compared to others. These results get support from the findings of Shih and Huang (2003) that an improvement in both the shrink-proof and antimicrobial properties of the fabric was observed with an increase in the temperature or duration of the heat treatment, as well as with an increase in the concentration of the processing agent.

Table 2. Analysis of variance for fabric warp wise shrinkage (%)

SOV	DF	SS	MS	F. value	Prob.
F	3	0.00391	0.00130	3.66	0.0320*
T	2	0.00624	0.00312	8.77	0.0022**
C	3	0.07909	0.02636	74.16	0.0000**
F×T	6	0.00104	0.00017	0.49	0.8099 NS
F×C	9	0.00280	0.00031	0.88	0.5628 NS
T×C	6	0.00309	0.00052	1.45	0.2502 NS
F×T×C	18	0.00874	0.00048	1.35	0.2951 NS
Error	18	0.00640	0.00036	-	-
Total	65	0.11131	-	-	-

C.V. = 0.84; * = significant; NS = non-significant; ** = highly significant.

Table 3. Individual comparisons of treatment mean values for warp wise shrinkage (%)

Finishes	Concentration	Application methods
F_1 = 2.2613^a	C_1 = 2.3069^a	T_1 = 2.2357^c
F_2 = 2.2571^b	C_2 = 2.2603^b	T_2 = 2.2541^b
F_3 = 2.2474^c	C_3 = 2.2432^c	T_3 = 2.2631^a
F_4 = 2.2380^d	C_4 = 2.1934^d	

Mean values having different letters differ significantly at 0.05% level of probability.

The mean values for fabric shrinkage (warp wise) for different finish applying methods i.e. T_1, T_2 and T_3 are compared and shown in Table 3 and illustrated in Fig. 1. There exists significant difference among these values. The minimum warp wise shrinkage was obtained for T_1 as 2.2357% followed by T_2 as 2.2541%, and T_3

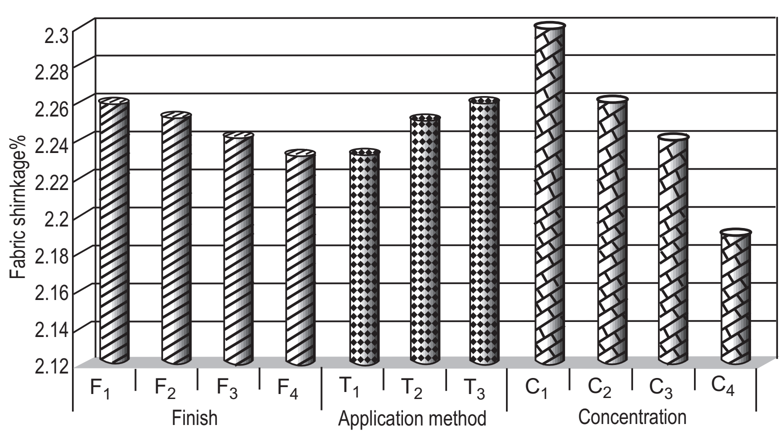

Fig. 1. Graphical representation individual mean values of fabric shrinkage (warp).

2.2631%, respectively. The application method T_3 has more shrinkage as compared to T_1 and T_2. These results also indicated that when the application method changed, the fabric shrinkage was also changed. The results are in line with the findings of Datta *et al*. (2010) that the treated samples produced by pad-flash-cure technique had even smaller bending length when compared to that of the fabric produced by pad-dry and pad-dry-cure techniques. The decrease in stiffness of the fabrics might be due to the reduction of cross-sectional area of the treated cotton fabric. Similarly in another study it was depicted that finishing improved the attractiveness or service-ability of a fabric, such as shrinkage control, wrinkle-resistance and soil release. It was also observed that resin treatment of a cellulosic fibre had the tendency that the increased amount of resin resulted in improved crease or shrink-proof properties of the fabric (Yanai *et al*., 2001).

Fabric shrinkage % (weft wise). The data related to the fabric weft wise shrinkage was analyzed statistically under the effect of four different wrinkle free finishes and four different concentrations of wrinkle recovery finishes were applied. Three application methods are presented in Table 4, which reveal that all the variables have highly significant effect on the weft wise fabric shrinkage while, all the possible interactions have non-significant effect except F×C that showed highly significant effect on weft wise fabric shrinkage.

The mean values so obtained were compared for 4 types of finishes (F_1 - F_4) and are summarised in Table 5 with further explanation graphically in Fig. 2. A significant difference among all values was noted. The minimum weft wise shrinkage was obtained for F_4 as 2.2367%, while the respective mean value of F_1, F_2 and F_3 were as 2.3015%, 2.2537% and 2.2518%. It is inferred that the finish F_4 showed less shrinkage and finish F_1 showed very high shrinkage than finish F_2 and F_3. These results correlate with the findings that a good resin finish would stabilize the fabric and reduce the residual shrinkage to less than 2%. Also the cotton and viscose fabrics cross-linked by a modified dimethyloldihydroxy ethylene-carbamid (DMDHEC) attained a long-lasting effect of wrinkled shrinkage (Lukanova and Ganchey, 2005; Tomasino, 1992).

The mean values of fabric weft wise shrinkage for various concentrations C_1, C_2, C_3 and C_4 were compared statistically and the results are given in Table 5 and also signified in Fig. 2, which showed their highly significant effect on cotton fabric weft wise shrinkage. The minimum

Table 4. Analysis of variance for weft wise shrinkage

SOV	DF	SS	MS	F. Value	Prob.
F	3	0.02844	0.00948	22.31	0.0000**
T	2	0.02126	0.01063	25.02	0.0000**
C	3	0.04087	0.01362	32.06	0.0000**
F×T	6	0.00356	0.00059	1.39	0.2702 NS
F×C	9	0.01408	0.00156	3.68	0.0090**
T×C	6	0.00508	0.00085	1.99	0.1202 NS
F×T×C	18	0.01156	0.00064	1.53	0.3542 NS
Error	18	0.00765	0.00042	-	-
Total	65	0.13253	-	-	-

C.V. = 0.91; * = significant; NS = non-significant; ** = highly significant.

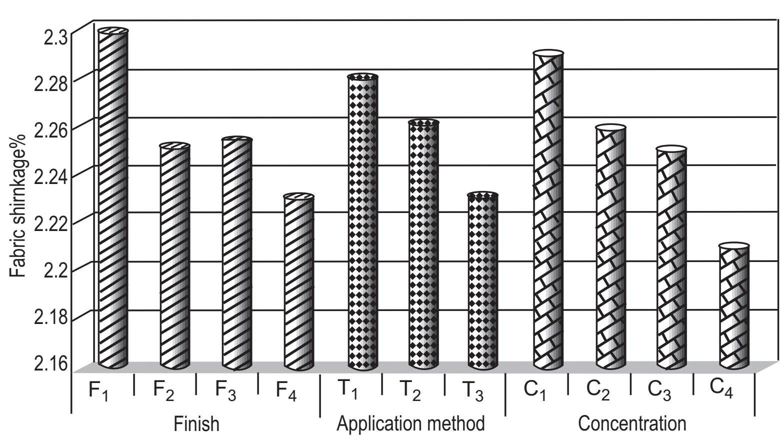

Fig. 2. Graphical representation individual mean values of fabric shrinkage (weft).

weft wise shrinkage was obtained for C_4 as 2.2181% followed by C_1, C_2 and C_3 as 2.2998%, 2.2678%, and 2.2579%, respectively. These results indicate that as the concentration of finishes increased the weft wise shrinkage of cotton fabric decreased. C_1 showed more shrinkage percentage as compared to other. These findings get confirmation from previous results that an improvement in both the shrink-proof and antimicrobial properties of the fabric with an increase in the temperature or duration of the heat treatment as well as with an increase in the concentration of the processing agent (Shih and Huang, 2003).

Comparison of mean values of fabric weft wise shrinkage for varying application methods T_1, T_2 and T_3 is presented in Table 5 and elaborated by Fig. 2. It is clear that all the values differ significantly with one another. The minimum weft wise shrinkage was obtained for T_3 as 2.2342% followed by T_1 and T_2 as 2.2856% and 2.2629%, respectively. The application method T_3 had more shrinkage as compared to T_2 and T_1. These results get support from the findings that the treated samples produced by pad-flash-cure technique had even smaller bending length when compared to that of the fabric produced by pad-dry and pad-dry-cure techniques. The decrease in stiffness of the fabrics might be due to the reduction of cross-sectional area of the treated cotton fabric and the crosslinking of cellulose was a crucial textile chemical process, and provided the textile manufacturer a multitude of commercially important textile products. The most commonly used crosslinking systems were based on N-methylol chemistry. These crosslinkers gave fabrics many desirable mechanical stability properties (e.g. crease resistance, anti-curl, shrinkage resistance, durable-press), but also imparted strength loss (Hauser *et al*., 2004).

Table 5. Individual comparisons of treatment mean values for weft wise shrinkage (%)

Finishes	Concentration	Application methods
$F_1 = 2.3015^a$	$C_1 = 2.2998^a$	$T_1 = 2.2856^a$
$F_2 = 2.2537^b$	$C_2 = 2.2678^b$	$T_2 = 2.2629^b$
$F_3 = 2.2518^b$	$C_3 = 2.2579^b$	$T_3 = 2.2342^c$
$F_4 = 2.2367^b$	$C_4 = 2.2181^c$	

Mean values having different letters differ significantly at 0.05% level of probability.

Conclusion

By applying the selected variables the following conclusions are drawn from the present study:

(i) Anti-wrinkle finishes of class Arkofix (ELF and NEC) were found better to improve shrinkage property of the fabric; (ii) 120 mg/L concentration of these finishes gave optimum results to improve shrinkage of cotton fabric and (iii) Finishes applied through Pad-flash-cure technique improved the shrinkage ability of the cotton fabric as compared to that of other techniques used in this study.

References

AATCC, 2003. Measurement of fabric properties. *AATCC Technical Manual*, *Test Method*, **135,** 128 pp.

Datta, C., Hansda, M., Behera, J., Haldar, S. 2010. Wrinkle recovery finishing for cellulosic fabric. [Online]. Available at http://www.Indiantextilejournal.com/articles/FAdetails.asp?id=2635. (Verified on 19-02-2015).

Doshi, G. 2006. Wrinkle free garments. [Online]. Available at http://www.ezinearticles.com. (Verified on 27-12-2014).

Frick, J.G., Gaytreaux, G.A., Pierce, A.G., Reeves, W.A. 1973. Wrinkle resistance finishes for cotton fabric using citric acid derivatives for soil release, U.S. Patent-3754860. [Online].

Hauser, P.J., Smith, C.B., Hashem, M.M. 2004. Ionic crosslinking of cotton. *Autex Research Journal*, **4:** 95-100.

Lukanova, V., Ganchev, V. 2005. A possibility for shrinkage decrease of textile fabrics made from cotton and viscose fibres. *Fiber and Textiles In Eastern Europe*, **13:** 51-53.

Madaras, G.W., Parish, G.J., Shore, J. (eds.). 1993. *Batch-wise Dyeing of Woven Cellulose Fabrics*: *A Practical Guide*, Published by Society of Dyers and Colourists, ISBN 10: 0901956554.

Montgomery, D.C. 2009. *Design and Analysis of Experiments*. Arizona State University, USA. ISBN: 978-0-470-12866-4.

Sahin, K.U., Gursoy, N.C., Hauser. P., Smith, B. 2009. Optimization of ionic crosslinking process: An alternative to conventional durable press finishing. *Textile Research Journal*, **79:** 744-752.

Shih, C.-Y., Huang, K.S. 2003. Synthesis of a polyurethane-chitosan blended polymer and a compound process for shrink-proof and antimicrobial woolen fabrics. *Journal of Applied Polymer Science*, **88:** 2356-2363.

Tomasino, D.C. 1992. Chemistry and technology of fabric preparation and finishing. [Online]. Available at www.uatf.com. (Verified on 23-02-2015).

Yanai, Y., Hirai, T., Oba, M, Ikeda, K., Takagi, Y., Ishikawa, T., Harada, K., Iida, H., Hasegawa, O., Ito, R. 2001. Shrink-proof treatment of cellulosic fiber textile, US Patent-6203577. [Online] Available at http://www.freepatentston.com (Verified on 23-02-2015).