Note

(Received May 6, 1993)

Wash and Wear Finishing of Cotton Fabrics by Loop Transfer Applicator

Shizuo Kubota ^{*1} and Robert J. Harper, Jr. ^{*2}

^{*1} Industrial Technology Center of Wakayama Prefecture, 60, Ogura, Wakayama-city, 649-62 Japan

^{*2} Southern Regional Research Center, 1100, Robert E. Lee Blvd., P.O. Box 19687, New Orleans, 70179 U. S. A.

Abstract : Cotton fabrics were wash and wear finished with a loop transfer applicator, one of low wet pick-up finishing apparatus. A resin solution was applied evenly to the fabrics at a low pick-up, where no resin migration occurred on drying, so that the reduction of strength might be lessened and the durable press properties and the wrinkle recovery might be enhanced. As a crosslinking agent, dimethyloldihydroxyethyleneurea, and as acidic catalyst, $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ and glycolic acid were used and the add-on (pick-up) of the resin solution was adjusted to about 30%. In comparison to the ordinary finishing, the reduction of the strength in tensile and tearing in the low wet pick-up finishing was lower for any of the finished fabrics, at the same level of the durable press properties. The pretreatment with thermoplastic resins prevented the reduction of the tensile strength.

1. Introduction

The easy-care finishing of cotton fabrics always reduces their strengths. Various finishing methods for preventing the reduction of the strengths have been investigated [1]. It is supposed that the causes of the strength reduction lie in the distortion of cotton fibers by crosslinking [2], the formation of a surface-resin due to migration on drying, the degradation of cellulose with acid catalysts, and so forth.

In this study, a resin solution was applied evenly to fabrics at a wet pick-up of 40% and lower, where no migration of the resin occurs on drying [3], so that the reduction of strength might be depressed and the durable press properties (the smoothness of a fabric at the surface after washing, hereinafter abbreviated as DP) might be enhanced. The low wet pick-up finishing contributes to the saving of chemicals and energy.

As apparatus for the low wet pick-up finishing, lick rollers, spray applicators, liquor metering by engraved or spiraled rollers, foam applicators, loop transfer applicators, vacuum slot extractors, curved blade applicators, and so forth are useful [3,4]. In the investigation by Harper, a sheeting was finished with a loop transfer applicator in order to depress the reduction of abrasion re-

sistance [5].

In this study, cotton fibers were wash and wear finished with a loop transfer applicator. The finished fabrics exhibited less reductions in tensile and tearing strengths and good hand.

2. Experimental

2.1 Materials

Fabrics finished : For thin cotton fabrics, were used ammonia - mercerized sheetings (137.52 g/m^2), scoured, bleached print cloths (114.11 g/m^2) and scoured, bleached, sodium hydroxide - mercerized print cloths (121.76 g/m^2), and for thick ones, scoured, bleached twill (219.92 g/m^2) and scoured, bleached, sodium hydroxide - mercerized twill (232.39 g/m^2).

The following agents were used : Dimethyloldihydroxyethyleneurea (DMDHEU)(National Starch & Chemical Corp., Hylite LF, 40%), $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ crystal (J. T. Barker Inc.), glycolic acid (Eastman, 70%), a polyethylene softener (Alkalil Chem. Inc., Velvetol 17%), a silicone softener (Sandoz Chemicals Corp., Sandopern FE Liquid 50% ; Dow Corp., Dow Corning 1111 emulsion 38% used with TL -41), and a nonionic wetting agent (Conoco Petrochemicals, Continental Oil Co., Aifonic 1012-60). As a thermoplastic resin, Hystretch V-29

(BF Goodrich Co., poly(acrylonitrile-butadiene) elastomer emulsion, 44.5%), and Airfix Copolymer Emulsion TL-41 (Air Products & Chemicals, Inc., polyacrylic ester, $T_g = -15^\circ\text{C}$, 50%) were used.

The concentrations of the finishing agents listed in the tables are expressed in W/W%.

2.2 Finishing

The loop transfer applicator is shown in Fig. 1. The loop was made of cotton knitting. The amount of pick-up was controlled by changing the pressure between rolls 2 and 3, at constant pressure of 4.2 kg/cm^2 between 1 and 2. Moreover, for finishing, the time by which the fabric was passed through between the rolls was changed to adjust the pick-up to ca. 30%. Thereafter, the fabric was preliminarily dried at 60°C for 7 min, steam pressed,

Fig. 1 Loop transfer applicator.

cured at 160°C , washed one time with a Kenmore washing machine, tumble-dried for 30 min, and let to stand for 12 h. Then, the add-on, the DP properties and so forth of the fabric were determined. For comparison, the ordinary finishing [6] was carried out; the resin solution was applied by two dips-two nips method (squeezing at 3.5 kg/cm^2), preliminarily dried and cured under the same conditions as described above.

2.3 Physical Properties

The tensile strength was determined by the grab method with a Scott tester, the tearing strength by the Elmendorf method, and the wrinkle recovery by the Monsanto method. The DP degree was evaluated by using AATCC TM 124 replicas.

3. Results and Discussion

As thin cotton fabrics, ammonia-mercerized sheetings, scoured, bleached print cloths and scoured, bleached, sodium hydroxide-mercerized print cloths were wash and wear finished by using DMDHEU with the loop transfer applicator.

As seen in Tables 1, 2 and 3, the DP of the ammonia-mercerized and not finished sheeting was suitable, whose value was 2.4. The sodium hydroxide-mercerized fabrics had higher tensile strengths than those of the fabrics not sodium hydroxide-mercerized. The low wet pick-up finished fabrics showed a less reductions in tensile and

Table 1 Finishing of NH_3 -Mercerized Cotton Sheeting^{a)}

DMDHEU	Catalyst	Softener		Wetting agent		Pick-up	Add-on	DP	WRA	Tensile	Tearing
(%)	(%)	(%)		(%)	(%)	(%)	(degree)	(W+F,degree)	conditioned strength	(kgf)	strength (gf)
Untreated fabrics								2.4	250	31.8	770
4.5 ^{b)}	MgCl ₂	1.35	—	0.1	71.2	0.6	3.7	282	19.0	560	
12	⋈	3.6	—	—	30.8	1.9	3.9	294	21.1	627	
12	⋈	3.6	—	0.2	30.6	1.4	4.4	283	18.3	573	
12	⋈	3.6	Polyethylene	0.5	30.0	1.2	4.3	290	17.7	620	
12	⋈	3.6	Silicone	0.5	30.1	1.7	4.2	289	18.9	707	
10 ^{c)}	⋈	3.0	Polyethylene	0.5	22.7	4.0	3.7	294	20.1	613	
20 ^{d)}	⋈	6.0	⋈	0.5	22.1	5.9	4.3	310	18.8	587	
10 ^{e)}	⋈	3.0	—	0.2	31.8	4.8	4.0	295	19.6	707	
12	Glycolic acid	5.0	Polyethylene	0.5	28.7	1.8	3.8	297	19.9	820	

a) Curing $160^\circ\text{C} \times 3\text{ min}$. b) Finishing with ordinary method (pad-dry-cure). c) Hystretch V-29, 6%, wetting agent, 0.1%: 2 dips: 2 nips (3.5 kg/cm^2): predry, $60^\circ\text{C} \times 7\text{ min}$: add-on, 2.3%. d) Same as above: add-on, 1.2%. e) Air fix TL-41, 5%: silicone, 1%: wetting agent, 0.1%: 2 dips: 2 nips (3.5 kg/cm^2): pick-up, 68.1%: add-on, 2.4%.

Table 2 Finishing of Scoured and Bleached Cotton Print Cloth^{a)}

DMDHEU	Catalyst	Softener	Wetting agent	Pick-up	Add-on	DP	WRA conditioned	Tensile strength	Tearing strength
(%)	(%)	(%)	(%)	(%)	(%)	(degree)	(W + F, degree)	(kgf)	(gf)
Untreated fabrics						1.5	189	32.3	870
4.5 ^{b)}	MgCl ₂	1.35	—	0.1	85.3	1.2	4.0	252	14.9
12	〃	3.6	—	—	32.0	1.7	4.3	267	16.1
12	〃	3.6	—	0.2	30.2	1.2	4.6	251	16.0
12	〃	3.6	Polyethylene	0.5	0.2	29.5	1.1	4.6	263
12	〃	3.6	Silicone	0.5	0.2	30.5	1.4	4.4	264
12	Glycolic acid	5.0	Polyethylene	0.5	0.2	27.4	1.7	4.3	268

a) Curing 160 °C × 3 min. b) Finishing with ordinary method (pad-dry-cure).

Table 3 Finishing of Scoured, Bleached and NaOH-Mercerized Cotton Print Cloth^{a)}

DMDHEU	Catalyst	Softener		Wetting agent	Pick-up	Add-on	DP	WRA	Tensile	Tearing
(%)	(%)	(%)		(%)	(%)	(%)	(degree)	conditioned (W+F,degree)	strength (kgf)	strength (gf)
Untreated fabrics							1.4	196	33.8	874
4.5 ^{b)}	MgCl ₂	1.35	—	0.1	80.3	0.4	3.9	259	20.2	620
12	〃	3.6	—	—	31.3	1.3	4.2	268	21.5	644
12	〃	3.6	—	0.2	29.6	1.0	4.3	262	21.6	647
12	〃	3.6	Polyethylene	0.5	0.2	29.3	0.7	264	19.4	800
12	〃	3.6	Silicone	0.5	0.2	29.3	1.2	273	20.5	873
10 ^{c)}	〃	3.0	—	0.2	31.3	4.9	3.6	299	23.4	967
12	Glycolic acid	5.0	Polyethylene	0.5	0.2	27.6	1.1	266	22.3	917

a) Curing 160 °C × 3 min. b) Finishing with ordinary method (pad-dry-cure). c) Air fiex TL-41, 5% : silicone, 1% : wetting agent, 0.1% : 2 dips : 2nips (3.5 kg/cm²) : pick-up, 78.2% : add-on, 1.4%.**Table 4** Finishing of Thick Cotton Fabrics^{a)}

Fabrics	DMDHEU	MgCl ₂	Wetting agent	Pick-up	Add-on	DP	WRA	Tensile strength	Tearing strength
	(%)	(%)	(%)	(%)	(%)	(degree)	conditioned (W+F,degree)	(kgf)	(gf)
Scoured,bleached cotton twill						1.5	138	70.9	3,800
	6 ^{b)}	2.0	0.1	67.0	0.8	3.4	229	37.2	1,333
	14	4.2	0.2	33.7	0.7	3.8	230	39.4	1,217
NaOH-mercerized cotton twill						1.4	173	73.3	2,333
	6 ^{b)}	2.0	0.1	65.0	0.4	3.1	249	41.1	1,159
	14	4.2	0.2	29.1	0.4	3.7	254	42.4	1,100

a) Curing 160 °C × 4 min. b) Finishing with ordinary method (pad-dry-cure).

tearing strengths than the ordinarily finished fabrics of the same DP value, for all the kinds of the fabrics. For the low wet pick-up fabrics having a considerably high DP, the tensile strength was significantly lower than that of the ordinarily finished fabrics. However, considering

the increase of the DP, the reduction of the tensile strength was relatively small. With the co-use of the softeners, the reduction of the tearing strength was remarkably prevented. For some finished fabrics, the tearing strengths were higher than those of the unfinished

fabrics. The silicone softener was more effective in preventing the reduction of the tearing strengths than the polyethylene softener. The pretreatment of the fabrics with a thermoplastic resin prevented the reduction of the tensile strengths. In the case of glycolic acid (HOCH_2COOH) as catalyst, the reductions in tensile and tearing strengths were low, as compared with the case of magnesium chloride as catalyst. The low wet pick-up finishing rendered higher DP properties and wrinkle recovery and better hand to the fabrics than the ordinary finishing.

The thick cotton fabrics, that is, the scoured, bleached twill and the scoured, bleached, sodium hydroxide-mercerized twill were finished next with DMDHEU by means of the loop transfer applicator.

As seen in Table 4, the tensile strength of the scoured, bleached, sodium hydroxide-mercerized twill was higher than that of the scoured, bleached twill. By the low wet pick-up finishing at a pick-up of ca. 30%, the reduction of the tensile strength was less than that by the ordinary finishing. Considering the high DP, the reduction of the tearing strength was small. The low wet pick-up finishing gave higher DP degree and crease recovery.

As described above, the low wet pick-up finishing was effective in depressing the reductions of the tensile and tearing strengths, giving high DP and wrinkle recovery properties and good hand of the fabrics. This is presumably a result of no migration of the resin during the drying, that is, the absence of the resin at the surface, and the uniformity in the applied resin and the crosslinking distribution.

It is speculated that, generally, the tearing strength of finished fabrics, which is often an important factor in their practical use, is substantially proportional to the product of the resistance of the spun yarns to impact and

the deformation capability of the fabrics for the impact [7]. Accordingly, the cause of the softeners increases the deformation capability of the fabrics against impact, leading to the less reduction of the tearing strength.

As for the catalysts, glycolic acid was more effective in depressing the reductions of the tensile and tearing strengths than magnesium chloride. For this reason, it is supposed that the cellulose was hydrolyzed to a less degree. The sodium hydroxide-mercerized fabrics exhibited a higher tensile strength due to the less distortion of cotton fibers.

It is needless to say that the low wet pick-up finishing contributes to energy-saving. The crosslinking agent is evenly distributed to improve the DP and the wrinkle recovery. Accordingly, the amount of a resin used in the low wet pick-up finishing can be considerably saved as compared with the ordinary finishing, provided that the DP's and the wrinkle recoveries are the same.

References

1. a) T. Hongu, "New Technology of Textile Finishing" (I. Hashimoto and H. Yokoyama, Eds.), The Textile Machinery Society of Japan, p. 56 (1973); b) K. Yamataka, "New Course of Dyeing and Finishing - Finishing", Vol. 11, No.1 (H. Tonami and H. Sanuki, Eds.), Kyoritsu Shuppan, p.73 (1972); c) T. Masuda and K. Shiozawa, "Technology of Textile Finishing", Chijin Shokan, p.9, p.72 (1976).
2. J. G. Frick, Jr., B. A. K. Andrew, and J. D. Raid, *Text. Res. J.*, **29**, 314 (1959).
3. R. D. Leah, *J. Soc. Dyers Colour.*, **98**, 422 (1982).
4. S. Kubota, *Sen'i Kako*, **34**, 379; 438 (1982).
5. R. J. Harper, Jr., *Text. Chem. Color.*, **11**, 125 (1979).
6. 1. b), p. 60.
7. R. Steele, *Am. Dyest. Rep.*, **46**, 329 (1957).