Effect of Textile Auxiliaries at Various Stages of Processing and Its Impact on Tensile Strength

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Summary: An experimental investigation has been undertaken for the determination of tensile strength of cotton fabric, which undergoes to the various textile chemical- processing operations of pre-treatment, dyeing and finishing. Two different commercial products for each chemical treatment at three different concentrations were examined. The method of percentage dropage was used in bleaching process for the determination of stabilizer efficiency and loss of strength. Increase in weight after using stiff finish at different concentration is also analysed.

Introduction

Cellulose is the most abundant of all naturally occurring organic polymers, thousands of millions of tones being produced by photosynthesis annually throughout the world [1]. An industrially important feature of cellulosic fibers is chemical stability, enab-ling them to with stand degradation with its conesq-uential loss of tensile strength under normal condi-tions of use. Even slight degradation during proce-ssing, however, may be accompanied by unaccept-able loss of strength and other undesireable affects. The study of degradation is therefore impor-tant implication for satisfactory dyeing and finishing. In chemical degradation six different depredating agen-cies have been identified, which are acids, alkalis, oxidizing agents, enzymes, heat and radiations [2]. Under certain circumstances cellulose can also be degraded mechanically in industrial processing. Ultimately the complete degradation of cellulose yields carbon dioxide and water. However, it is the early stages of partial degradation that are important in textile point of view [3]. Only slight changes in composition of different chemical auxiliaries, con-centration of chemicals and processing parameters may affect the physical properties of cellulose. In textile work the strength of a fabric is taken to mean the load, which is required to break it. It does not follow that the breaking load correctly represents the working strength of the fabric during manufacture and in actual use as this working strength depends upon other factors such as elasticity and resistance to friction, but the breaking load has for so long been the most convenient test for strength that the two terms have becomes synonymous. It is obvious that a strength-testing instrument should break the speci-men in a manner, which has a fairly close resem-blance to that in which it would be broken in actual use [4].

The present research shows a comparative study of tensile strength after desizing, scouring, bleaching, dyeing and finishing processes of cotton fabric. The data were collected by using textile auxi-liaries of different manufacturers, the finding are then discussed by varying concentration of auxiliaries and processing conditions.

Results and Discussion

The tensile strength of the cellulosic fabric during various processes was measured by the ASTM, D -5035 standard test procedure [5]. In desi-zing process the action of enzymes is to split off size. They react very sensitively towards any change in their surroundings, due to that pH, temperature, degree of water hardness and electrolytes also effect on the process. Certain amount of Calcium and Magnesium, which are present in water, also promo-tes the desizing efficiency; they are deposited on the fabric during the dwelling period (8-12 hours) and will degrade the fabric. If damp cotton is exposed to air, mildew may gradually develop on it, accom-panied by staining that is difficult or impossible to remove. Prolonged exposure also causes a serious loss of tensile strength [6].

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Table- 1: Tensile strength loss in warp and weft direction of treated fabric during various processes.

S/No.	Process	Warp Fabric Force in (N)						Weft Fabric Force in (N)					
1	Grey Fabric				410 N			402 N					
2	Desizing	Desizer JRL-40			Desizer -3C			Desizer JRL-40			Desizer -3C		
		6 g/l	8 g/l	10 g/l	6 g/l	8 g/l	10 g/l	6 g/l	8 g/l	10 g/l	6 g/l	8 g/l	10 g/l
		389.1	386.2	384.2	386.3	385.6	381.3	380.2	378.3	376.5	371.1	376.2	369.7
3	Scouring	NaOH 70°C			NaOH 80°C			NaOH 70°C			NaOH 80°C		
		50g/l	60g/l	70g/l	50g/l	60g/l	70g/l	50 g/l	60 g/l	70g/l	50 g/l	60g/l	70g/l
		358.2	357.6	356.2	353.2	353.8	354.3	349.3	348.7	348.1	348.2	347.8	347.1
4	Bleaching	Stablizer Contavan Gal			Stablizer CWP 200			Stablizer Contavan Gal			Stablizer CWP 200		
		4 g/l	6 g/l	10 g/l	4 g/l	6g/l	10 g/l	4 g/l	6 g/l	10 g/l	4g/l	6g/l	10 g/l
		331.5	333.2	330.4	330.3	331.6	331.2	325.6	327.8	324.6	321.4	325.2	324.6
5	Dyeing	Yellow 145			Red 195			Yellow 145			Red 195		
		10 g/l	20 g/l	30 g/l	10 g/l	20 g/l	30 g/l	10 g/l	20 g/l	30 g/l	10 g/l	20 g/l	30 g/l
		332.2	332.5	332.8	332.1	332.2	332.1	327.2	327.3	326.9	325.8	326.2	325.9
6	Soft finish	SM 3909 Amino silicon emulsion			HI soft CH Paste			SM 3909 Amino silicon emulsion			Hi soft CH paste		
		20g/l	40 g/l	60 g/l	20 g/l	40 g/l	60 g/l	20 g/l	40 g/l	60 g/l	20 g/l	40 g/l	60 g/l
		336.8	337.6	335.2	335.1	336.5	334.5	329.5	330.2	328.3	328.4	328.5	327.4
7	Stiff finish	Appereton EMD			Resin M3TP			Appereton EMD			Resin M3TP		
		20g/l	40 g/l	60 g/l	20 g/l	40 g/l	60g/l	20 g/l	40 g/l	60 g/l	20 g/l	40 g/l	60 g/l
		337.1	337.7	338.5	334.2	334.8	335.2	330.2	331.3	331.1	329.1	330.6	329.6

In desizing process, the desizer JRL-40 gives optimum results at 6g/ l concentration with 7-8 Tegawa (Table- 3). By increasing the concentration of desizer *i.e* 8 g/ l, the degree of desizing remains same i.e 7-8 Tegawa but a slight decrease in tensile strength is observed. (Table- 1).

Cellulose contains about 8-10 % of natural impurities, while most of the sizing material is removed during desizing. When cellulose material is treated with strong alkaline like caustic soda at elevated temperature, oils and fats are converted to soap and proteins are broken up into the sodium salts of simple amino acids [7]. As a result a correspon-ding loss of weight (0.965 %) is observed. When the fabric was scoured at different temperature with different concentration of sodium hydroxide, it was observed that at low temperature and high concen-tration a considerable change in elongation occur, [8] which ultimately results in loss of tensile strength (Table-1). Fabric absorbency at 70 g/ l of sodium hydroxide also supports the results.

In bleaching process the stabilizers acts as chelating agents for nascent oxygen and mainly depends on high pH and temperature, leads to decom-position of peroxide bleaching liquor which results in cellulose degradation [9]. Besides the concentration of liquor, another danger of the bleaching process is due to metal ions (rust). These metal ions react with peroxide in the fibre and leads to extreme damage to the fabric. The role of stablizer is simply to control or regulate these effects by multiplicity of function. We use two different stablizers at different concentration, one is hydroxy carbonic acid and other is silicate based. From the results given in the Table-1 it was observed that the Berger whiteness considerably decreases by increase-ing the concentration of stabli-zer (Table-3). At a concentration of 6g/ l the stablizer control the decomposition of H_2O_2, which results in lowering in the degree of whiteness and we get minimum loss in tensile strength (Table-1).

These results can be explained in terms of percentage dropage. Percent dropage is important in the bleaching process because the stabilizers chelate the nascent oxygen and when time and temperature increase during bleaching process the concentration of peroxide anion also increases and they act upon cellulose by the formation of pinholes *i.e* loss in tensile strength of the fabric when cellulose substrate is bleach with a silicate based stablizer, it must be washed off in soft neutral boiling water in order to prevent problems caused by insoluble silicates or silicic acid [10]. Silicates are deposited on the fabric and reduce the strength of fabric. From the results given in Table-2, it was observed that % dropage by using stablizer Contavan GAL at a concentration of 4 gm/ L is 28.4 while at 10 gm/ L is 9.6. From practical point of view we can say that at 10 gm/ L Contavan GAL gives best results but from economical point of view at this

Table-2: % dropage after using stabilizer at different concentration.

Time	Stablizer Contavan Gal			Stablizer CWP 200		
	4g/l	6g/l	10g/l	4g/l	6g/l	10g/l
	Volume of $KMnO_4$ Used			Volume of $KMnO_4$ Used		
Initial	8.8ml	8.83ml	8.85ml	8.8ml	8.83ml	8.85ml
5min	8.2ml	8.6ml	8.70ml	8.1ml	8.5ml	8.7ml
10min	8.0ml	8.4ml	8.5ml	7.8ml	8.2ml	8.4ml
15min	7.8ml	8.1ml	8.5ml	7.6ml	8.0ml	8.2ml
20min	7.4ml	8.0ml	8.2ml	7.2ml	7.9ml	8.2ml
25min	6.8ml	8.0ml	8.2ml	6.5ml	7.8ml	8.1ml
30min	6.3ml	7.8ml	8.0ml	6.0ml	7.4ml	7.8ml
%Dropage	28.40%	11.66%	9.60%	31.81%	16.19%	11.86%

concentration the process cost also increase. Hence we conclude that at 6 gm/ L both the stablizers give optimum results.

It was also observed that there is no consider-able loss of tensile strength after dyeing [11]. For all the dyes the value of K/S increases as the dye con-centration increases which shows a good build up developing. The function of softener is to crosslink the cellulose macromolecules. The type of silicone group, viscosity of the emulsion, adsorption mechan-ism of the softener as well as treatment condition such as curing temperature are crucial factors effect-ing the properties of the treated fabric. The formation of elàstic silicone polymer network, which entraps the fibres with in its matrix, there by improving the strength ability [12,13]. In our study we use non-ionic softener and cationic softener. By treating with silicone softener (non-ionic) there is no considerable strength loss (Table-1), while loss is observed when cationic softener was applied. In processing lack of general compatibility with certain processing chemicals is the for most disadvantage of cationic softeners. We used anionic detergents throughout the whole processing. These anionic detergents form complexes with cationic softener and gives precipi-tate. These precipitates prevent the softener to cross link the cellulose macromolecule.

Stiffness of cotton ·fabric could be achieved by the application of commercially available synthetic or natural polymer based products. They are usually applied with pad-dry technique. The fabric may be padded with a suitable diluted dispersion at 25-30 °C with 60~70 % expression. The fabric is then dried at 120 °C for few min. In the present research work we used two different types of stiff finish *i.e* Appereton EMD which is polyvinyle acetate based and the other one is Resin M3TP which is melamine resin based product. The dispersion of these products crosslinked with cotton and make a tough and transparent film with ultimately increases its tensile strength. As the concentration of stiff finishing agent increases i.e from 20 to 60g/ l the thickness of treated fabric also increases due to the % gain in weight of the fabric. This ultimately results in minimum loss of tensile strength.

Table-3 Pretreatment, Dyeing and Finishing performance at various concentrations.

S/No.	Process/ Properties	Recipe/ Results					
	Desizing	Desizer JRL-40			Desizer-3C		
1.	Degree of desizing	6 g/l	8 g/l	10 g/l	6 g/l	8 g/l	10 g/l
	(Tegawa)	7-8	7-8	8-9	6- 7	6-7	7-8
		NaOH 70°C			NaOH 80°C		
2.	Scouring	50g/l	60g/l	70g/l	50g/l	60g/l	70g/l
	Absorbency	2cm	3cm	3cm	2.5cm	3cm	3cm
	Bleaching	Stablizer Contavan Gal			Stablizer CWP 200		
	Berger	4 g/l	6 g/l	10 g/l	4 g/l	6g/l	10 g/l
	Whiteness	88.34	74.68	68.01	89.04	78.81	72.23
3.	Absorbency	5.8cm	6cm	5.4cm	6cm	5.8cm	5.5cm
		Yellow 145			Red 195		
4.	Dyeing	10 g/l	20 g/l	30 g/l	10 g/l	20 g/l	30 g/l
	K/S	4.6	6.5	7.4	4.6	7	7.9
		SM 3909 Amino silicon emulsion			HI soft CH Paste		
5.	Soft finish	20g/l	40 g/l	60 g/l	20 g/l	40 g/l	60 g/l
	Softness (Hand Feel)	Poor	Excellent	Excellent	Poor	Good	Excellent
	Stiff finish	Appereton EMD			Resin M3TP		
6.	Thickness	20g/l	40 g/l	60 g/l	20 g/l	40 g/l	60g/l
		0.015mm	0.037mm	0.091mm	0.013mm	0.035mm	0.087mm
	% Gain in weight	0.192gm	0.319gm	0.607gm	0.027gm	0.182gm	0.449gm

Experimental

Materials

Fabric

Grey woven fabric 100 % cotton having G. S. M· 118 g/ m^2, 1/ 1 plain weave was used throughout the experiment.

Dyes and chemicals

Commercial sample of bi functional reactive dyes C.I Yellow 145 and C.I Red 195 were used. Enzymatic desizer JRL-40 and Desizer-3c were used for desizing, Sandozin MRN is wetting agent, which is a polyglycol ether derivative. Sandozin N.I extra is scouring agent, which contain alkylene oxide. Stabili-zer Contavan GAL is silicate free and stabilizer CWP 200 is silicate based. For soft finish we used SM3909 amino silicon emulsion, which is non-ionic softener and Hisoft CH paste, is cationic softener. For stiff finish we use Appreton–EMD which is polyvinyl acetate dispersion containing plasticizer and resin while M3TP, which is also stiff finish, contain Melamine Resin. These chemicals were purchased from the local market. Sodium Hydroxide flakes, Hydrogen peroxide liquid 35 %, Urea, Sodium sulphate decahydrated, Sodium bicarbonate and acetic acid are AR grade chemicals.

Equipment

Dyeings were carried out by using a laboratory scale vertical Padder .The samples were cured on curing machine (Rapid). The tensile strength of the fabric was done on LF plus tensile strength tester. Thickness of the treated fabric was determined by thickness tester (Mesdan). The Berger whiteness of treated fabric was determined by SF 650 plus data color spectrophotometer.

Fabric processing

Conventional types of fabric processing methods were adopted on laboratory scale in the following sequence.

Desizing

The fabric was desized by using concentration 6g/l, 8g/l, 10g/l of enzymatic desizer, 2~4g/l wetting agent with 0.1~0.3g/ l acetic acid to maintain the pH range 6.0~7.5 at 75 °C to 85 °C liquor temperature, the reaction time on exhaust method is 5min. Fabric was then batched up to 8~12 hrs and covered by a plastic sheet. After batching the fabric was washed with hot water and then with cold water.

Scouring

Scouring process was carried out by using 50g/ l, 60g/ l, 70g/ l caustic soda solid, 5g/ l emulsifying agent, 2g/ l detergent, scouring solution were prepared in distilled water at 70 °C and 80 °C for 30 min process time.

Bleaching

Bleaching process was carried out by using 4g/ l, 6g/ l, 10g/ l stabilizer concentration, 30g/ l H_2O_2 50 %, 4g / l wetting agent and 20 g/ l caustic soda solid. Bleaching solution is prepared in distilled water at 98 °C for 30 min process time. When bleach-ing was completed the fabric was washed with hot water and cold water, then neutralized the fabric with acetic acid and again wash with hot water and cold water. % dropage of stabilizer can be determined by the following method.

During bleaching process 2 ml of bleaching solution was taken in conical flask and 10 ml of 10 % H_2SO_4 was added and titrate with standard solution of $KMnO_4$ 0.1N. This test is performed after every 5 min.

$$\text{\% Dropage of stabilizer} = \frac{\text{Initial Reading} - \text{Final Reading}}{\text{Initial Reading}} \times 100$$

Dyeing

Dyeing process was carried out by using 10 g/ l, 20g/ l, 30 g/ l, dyes concentration, 20g/ l soda ash, 200 g/l urea and 200 g/ l sodium alginate was 3 % concentration, at 70 % pick up. When dyeing was completed the fabric was dried at 120 °C for 1 min 20 sec then cured at 155 °C for 5min.

Finishing

Finally the fabric was finished by applying concentration (20 g/ l, 40 g/ l, 60 g/ l) of soft and stiff finish, solution is prepared with distill water. In soft finish we used 0.05 % acetic acid, the liquor pick is 80 % in padding machine. When finishing was completed then fabric was dried at 120 °C for 1 min 20 sec. The weight gain is analyzed before and after application of stiff finish.

Conclusions

In the present work studies have been made on various operations of textile processing by the use of auxiliaries of different manufacturers. By the above investigations the following conclusions have been drawn.

By increasing the concentration of desizer a slight decrease in tensile strength is observed. When the fabric was scoured at different temperature with different concentration, it was observed that at low temperature and high concentration a considerable change in elongation is occurred which untimely results in loss of tensile strength.

When cellulose substrate is bleached with a silicate based stablizer, it must be washed off in soft natural boiling water in order to prevent problem caused by silicates or silicic acid. It was observed that % dropage by using stablizer Contavan GAL at a concentration of 4 gm/ L is 28.4 while at 10 gm/ L is 9.6. From practical point of view we can say that at 10 gm/ L Contavan GAL gives best results but from economical point of view at this concentration the process cost also increase. Hence we conclude that at 6 gm/ L both the stablizers give optimum results.

If parameters are controlled there is no considerable loss of tensile strength after dyeing. A good built up developing is observed at high concentration. By treating with silicon softener (non-ionic) there is no considerable loss in strength. While some loss of strength is observed when cationic softener was applied. Optimum value was achieved at a concentration 40 g/ l. By increasing the concentration of stiff finish % Gain in weight is also observed which is due to film formation on the fabric surface, which ultimately results in least loss in tensile strength.

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