Effect of Multi Source Direct Dye Application and Important Process Variables on the Tensile Strength (Warp Wise& Fill Wise) of the Denim Fabric.

MUHAMMAD QAMAR TUSIEF, BABAR SHAHBAZ, SHEIKH MUHAMMAD NAWAZ* AND MUHAMMAD RASHID
Department of Fibre Technology, University of Agriculture Faisalabad, Pakistan.

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Summary: Dyes are intensively colored substances used for the coloration of various substrates. They are retained in these substances by physical adsorption or by the formation of covalent chemical bonds. The general reasons of using direct dyes for cellulosic fibers are their low costs and the simplicity of applications being water soluble. This paper endeavors to optimize the application of the direct black dyes, different dose levels, treatment temperatures and treatment time on the fabric for superlative results. The results revealed that all of the above variants had non significant affect on the tear strength (warp and fill wise) of the denim fabric.

Introduction

The general reasons of using direct dyes for cellulosic fibers are their low costs and the simplicity of applications being water soluble. But the washing fastness of direct dyes is not so good therefore these dyes are never preferred where the material is frequently washed and dried in the sunlight. However certain methods have been developed to overcome or at least to minimize these shortcomings. Direct dyes interact with cotton through relatively weak hydrogen bond having satisfactory fastness properties and direct colored cotton textile materials have only a moderate light fastness and poor washing fastness attributed to the good water solubility of direct dye molecules [1, 2].

The direct dye molecules contain some groups like amino [-NH2] group, which attach to the cellulose molecule and hydroxyl group by weak hydrogen bond. The size of the dye molecules is such that it can enter between the fiber molecules easily. When a cellulosic fiber is immersed in water, it carries a negative charge. On the other hand, when the direct dye is dissolved in the water it is ionized into dye anion (-ve) and sodium cat ions (+ve), as a result the negatively charged fiber surface repels the charged dye ions present in the dye bath. When salts are added in the dye bath, they also get ionized so the positive salt ions repel the dye anions present in the solution. Therefore the dye is easily attached to the fiber surface with in the range of bond formation between fiber and dye ions. The yarn dying process lies at the every function of denim fabric quality, if non- uniformities or inconsistencies in dye content or distribution exist at the yarn level, such flaws can become manifest as streaks or shade depth and unevenness in the laundered denim garment. These imperfections can appear even in denim that is stone washed or enzyme washed. The torsional properties of yarn have major industrial significance. They are directly related to the appearance of resulting knitted fabrics, woven cloth and carpets. [3, 4]. Temperature has a complex effect on dye uptake, affecting both the rate of dye uptake and the total amount of dye transferred during the dyeing. Further in mixture dyeing, temperature also effects the interaction between the dyes [5]. The influence of different dose level and treatment time on the quality parameters of the denim fabric has also been reported. How ever the manipulation of these factors on the Tear Strength of the Denim fabric has not been studied in Pakistan. This paper evaluates the performance of the application of direct black dye, different dose levels, treatment temperature and treatment time to optimize the quality of the denim fabric in respect of its tear strength.

Results and Discussion

Tensile Strength (Warp Wise)

The analysis of data (Table-1) under the effect of three types of direct black dyes, dose levels, temperatures and treatment times was observed and subjected to analysis of variances which reveals non significant effects of all sources of variances viz; dye brands (C), dose levels (D), temperatures (T) and times (t), and their all possible interactions, upon warp wise tensile strength.

*To whom all correspondence should be addressed.

Table-1: Analysis of variance for warp wise tensile strength

Source of variance	Degree of freedom	Sum of square	Mean sum of square	F. value
Dye (C)	2	2.719	1.360	0.0386 NS
Dose (D)	2	3.097	1.549	0.0439 NS
Temp (T)	2	10.221	5.111	0.1449 NS
Time (t)	2	0.427	0.214	0.0061 NS
C x D	4	4.277	1.069	0.0303 NS
C x T	4	70.762	17.690	0.5017 NS
C x t	4	2.016	0.504	0.0143 NS
D x T	4	40.841	10.210	0.2896 NS
D x t	4	7.697	1.924	0.0546 NS
T x t	4	2.604	0.651	0.0185 NS
C x D x T	8	38.712	4.839	0.1372 NS
C x D x t	8	30.611	3.826	0.1085 NS
C x T x t	8	11.239	1.405	0.0398 NS
D x T x t	8	36.311	4.539	0.1287 NS
C x D x T x t	16	83.458	5.216	0.1479 NS
Error	324	11424.712	35.261	
Total	404	11769.706		

NS = Non Significant

Table-2:0020Individual comparison of treatment means for warp wise tensile strength of fabric.

Dye	Tensile strength (Kg)	Dose	Tensile strength (Kg)	Temp	Tensile strength (Kg)	Time	Tensile strength (Kg)
C_1	108.67	D_1	108.36	T_1	108.45	t_1	108.73
C_2	108.40	D_2	108.98	T_2	108.85	t_2	108.59
C_3	108.92	D_3	108.95	T_3	108.95	t_3	108.67

Table-2 illustrates the comparison of individual means of warp wise tensile strength under the effect of dye brands, dose levels, dyeing temperatures, and times. The results shows that dye brand C3 recorded maximum tensile strength in warp direction with the mean value 108.92 Kg followed by C1 and C2 with their mean values 108.67 Kg and 108.40 Kg tensile strength respectively. However non- significant differences are recorded between all of these values.

Results pertaining to dose quantity inferred that the dose D2 (125 gm) recorded maximum warp wise tensile strength with the mean value 108.98 Kg followed by D3 (250 gm) and D1 (50 gm) with their mean values 108.95 Kg and 108.36 Kg respectively. All of these values differ non significantly from each other.

The tensile strength, tear strength and resistance to flex abrasion after each of stone washing, bleaching and automatic home laundering, the weakening effects of denim are found during stone washing and bleaching processes [6].

Anticipations attributing to treatment for temperature evident from Table-2 reveals that T3 (120 C) recorded maximum warp wise tensile strength with the mean value 108.95 Kg followed by T2 (100 C°) and T1 (80 C°) with their mean values 108.85 Kg and 108.45 Kg respectively. Non-significant differences are recorded between all values.

Regarding the effect of time (Table-2) it is found that t_1 (30 min) recorded maximum warp wise tensile strength with the mean value 108.73 Kg followed by t_2 (45 min) and t_3 (60 min) with their mean values as 108.59 Kg and 108.67 Kg respectively. These values have non-significant differences from each other.

Tensile Strength (Fill Wise)

The analysis of data under the effect of three types of direct black dyes, dose levels, temperatures and three treatment times was observed and subjected to analysis of variances (Table-3) which reveals non significant effects of all sources of variances viz, dye brands(C), dose levels (D), temperatures (T) and times (t), and their all possible interactions, on fill wise tensile strength.

Table-3: Analysis of variance for fill wise tensile strength

Source of variance	Degree of freedom	Sum of square	Mean sum of square	F. value
Dye (C)	2	20.817	10.408	0.4984 NS
Dose (D)	2	19.575	9.408	0.4687 NS
Temp (T)	2	4.698	2.349	0.1125 NS
Time (t)	2	4.530	2.265	0.1085 NS
C x D	4	12.933	3.233	0.1548 NS
C x T	4	4.756	1.189	0.0569 NS
C x t	4	13.874	3.468	0.1661 NS
D x T	4	17.927	4.482	0.2146 NS
D x t	4	2.641	0.660	0.0316 NS
T x t	4	13.324	3.331	0.1595 NS
C x D x T	8	29.776	3.722	0.1782 NS
C x D x t	8	12.615	1.577	0.0755 NS
C x T x t	8	15.500	1.938	0.0928 NS
D x T x t	8	58.305	7.288	0.3490 NS
C x D x T x t	16	99.583	6.224	0.2981 NS
Error	324	6765.810	20.882	
Total	404	7096.664		

NS = Non Significant

Table-4 illustrates the comparison of individual means of fill wise tensile strength due to dye brands, dye dose levels, dyeing temperatures, and dyeing times. The results show that dye brand C2 recorded maximum tensile strength in fill direction

Table-4: Individual comparison of treatment means for fill wise tensile strength of fabric.

Dye	Tensile strength (Kg)	Dose	Tensile strength (Kg)	Temp	Tensile strength (Kg)	Time	Tensile strength (Kg)
C_1	74.87	D_1	75.52	T_1	75.60	t_1	75.27
C_2	75.45	D_2	75.34	T_2	75.41	t_2	75.03
C_3	75.28	D_3	74.95	T_3	74.87	t_3	75.33

Dye Brand Name	Source
C_1=Direct Black-13	Personally Synthesized
C2=Sireus Black	Clarient Laboratories (Pak)
C3=Black NF 1200	Dye Star (American Base)

with the mean value 75.45 Kg followed by C3 and C1 with their mean values 75.28 Kg and 74.87 Kg respectively. Results pertaining to dose quantity inferred that the dose D1 (50 gm) recorded maximum fill Wise tensile strength with the mean value 75.52 Kg followed by D2 (125 gm) and D3 (250 gm) with their mean values 75.34 Kg and 74.95 Kg respectively. The direct dyes are attached to cellulose by hydrogen bonds indirectly through a layer of water i.e by forming hydrogen bonds with water molecules which in turn form hydrogen bonds with cellulose [7].

Anticipations attributing to treatment for temperature evident from Table-4 reveals that T_1 (80 ^{0}C) recorded maximum fill wise tensile strength with the mean value of 75.60 Kg followed by T_2 (100 ^{0}C) and T_3 (120 ^{0}C) with their mean values 75.41 Kg and 74.87 Kg respectively. All these values have non-significant differences from each other. These results find support from previous work of Anonymous (1979) who stated that surfactant and heat had little effect on the tensile properties [8].

Anticipations attributing to treatment to time inferred that t3 (60 min) recorded maximum fill wise tensile strength with the mean value 75.33 Kg followed by t1 (30 min) and t2 (45 min) with their mean values 75.27 Kg and 75.03 Kg respectively. These results show non significant effect on fill wise tensile strength.

Experimental

The research work was initiated in the Departments of Fibre Technology and Chemistry, University of Agriculture, Faisalabad, while the processing of samples was conducted at Crescent Bahuman Ltd. Pindi Bhattain, Distt. Hafizabad, Pakistan.

The study was carried out in five phases.
Phase-1: Synthesis of direct dye.
Phase-2: Desizing of the denim fabric.
Phase-3: Bleaching and antichloring of denim fabric.
Phase-4: dyeing of the denim fabric.
Phase-5: Determination of the tear strength of the fabric by Tensile tester (CRT Scott Model-J) according to ASTM standard techniques [8].
Following is the coding of variables for the current study.

Temperature	Time	Dose Level
T_1 = 80C°	t_1 = 30min	D_1 = 50gm
T_2 = 100C°	t_2 = 45min	D_2 = 125gm
T_3 = 120C°	t_3 = 60min	D_3 = 250gm

Statistical Evaluation of Data

The data obtained was analyzed statistically using Completely Randomized Design and M-Stat computer statistical program [9, 10].

Conclusion

The study revealed that different types of direct dyes, quantity of dose, dyeing temperature and treatment time, recorded non significant effects upon tensile properties of cotton denim fabric. Under all combinations fabric retained almost same strength.

The imported dye Black NF 1200 and locally produced direct black 13 showed equally good performance under moderate temperature and time. Therefore more emphases should be given to consume locally synthesized dyes in order to save the foreign exchanged of the country.

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