Effect of Time on Dyeing Cotton Knitted Fabrics with Reactive Dyes

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Abstract

The effect of dyeing time has been studied on the colour strength and colour fastness properties of single jersey cotton knitted fabrics dyed with Novacron Red S-B reactive dye (1%) using conventional exhaust dyeing method. Same bath scouring and bleaching are done and conventional exhaust dyeing method employed by IR laboratory sample dyeing machine. Various dyeing time such as 40, 60 and 80 minutes are used and other parameters are kept fixed. The colour strength (K/S) and colour fastness to washing and rubbing are examined and evaluated. It is observed that the increase in dyeing time from 40 minutes to 60 minutes the value of K/S increases and then up to 80 minutes the value decreases. The overall colour fastness properties to washing and rubbing for the dyed samples range from good to excellent.

Keywords — *Dyeing time, cotton fabrics, reactive dye, colour strength, colour fastness.*

I. INTRODUCTION

Cotton is the king of fibre and it is the most used fibre all over the world. Cotton fibre has immense applications in textiles and garments industry. It is a seed fibre obtained from cotton plant by cultivation in the farmland. Major producing countries are USA, India, Brazil, Mexico, Egypt and China [1-4]. American cotton dominates world market. The chemical composition of dry cotton are cellulose (88–97%), protein (1–2%), oil and was (0.4–1.5%), pectins (0.4–1.5%), minerals (0.7–1.6%) and others (0.5–8.0%) [1]. Cotton is considered to be a relatively easy fibre to dye or print. The classes of dye which may be used to colour cotton are azoic, direct, reactive, sulphur and vat dyes. The ease with which cotton takes up dyes, and other colouring matter, is due to the polarity of its polymers and polymer system. This polarity will readily attract any polar dye molecules into the polymer system. In fact, dye molecules which can be dispersed in water will be absorbed by the polymer system of cotton [3]. Reactive dye is one of the popular and most used dye in textile dyeing industries for coloration of textile materials. The dye has a wide range of colour gamut, brightness of shade, excellent fastness properties, reasonable price and versatility of applications. For coloration of cotton it is the most suitable dyes [5-9]. Reactive dyes react chemically with the fibre polymer and the dye molecules form a covalent bond with the hydroxyl groups on the cotton polymers [3]. Many researchers have been studied the dyeing of cotton fabrics with reactive dyes [10-17]. Shahid et al. [10] observed the effect of different dyeing parameters on colour strength and fastness properties of cotton-elastane (CE) and lyocell-elastane (LE) knit fabrics. Various concentration of reactive dye such as 1, 3, 5, 7 and 9 %, salt (20, 30, 40g/l), and alkali (5, 8 and 10 g/l) are used. The temperature variation are 40, 60 and 80ºC, and 45 minutes constant dyeing time is kept. Khan et al. studied the dyeing of cotton fabrics with reactive dyes and their physico-chemical properties are assessed [11]. A. D. Broadbent et al. investigated the continuous dyeing of cotton with reactive dyes using infrared heat [12]. Mohsin et al. reviewed on developments in dyeing cotton fabrics with reactive dyes for minimizing effluent pollution [13]. Cotton is modified with hydrolysed sericin fraction of silk in the addition of trisodium citrate as the esterification catalyst by a pad–dry–cure method. The treatment of cotton fabric with 5% hydrolysed sericin in the addition of 7.5% catalyst followed by drying at 95°C for 5 minutes and curing at 140°C for 5 minutes given optimum results with respect to exhaustion and fixation of reactive dyes having chlorotriaznyle and vinyl sulphone reactive groups when dyeing is performed without salt. Colour fastness to wash, light and rubbing of cotton for the use of reactive dyes remain unchanged for such prior modification with hydrolysed sericin [14]. The influence of salt, alkali and dye on dyeing cotton knitted fabric by reactive dyes and the rubbing, ironing and dry cleaning fastness properties are studied by Iftikhar et al. [15]. Blackburn et al. reported the use of cationic fixing agents to cotton dyed with direct dyes under various alkaline conditions [16]. Tissera et al. experimented the ultrasound energy to increase dye uptake and dye–fibre interaction of reactive dye on knitted cotton fabric at low temperatures [17]. The present study deals with the dyeing of single jersey cotton knitted fabric with reactive dye with time variations and other parameters are kept fixed. The aim of this study is to examine the effects of dyeing time on the colour strength and colour fastness properties of the dyed fabrics. For this purpose, the colour strength and

colour fastness to washing and colour fastness to rubbing are tested and evaluated.

II. MATERIALS AND METHOD

A. Materials

100% cotton knitted fabric (single jersey, 180 GSM) is collected from local textile mill. Reactive dye (Novacron Red S-B), levelling agents, sequestering agent, electrolyte as Glauber's salt ($Na_2SO_4.10H_2O$), soaping agent (detergent) and acetic acid are used from the laboratory of the Department of Textile Engineering, MBSTU. All the chemicals are laboratory grade and used without any purification.

B. Methods

1) Conventional Exhaust Dyeing

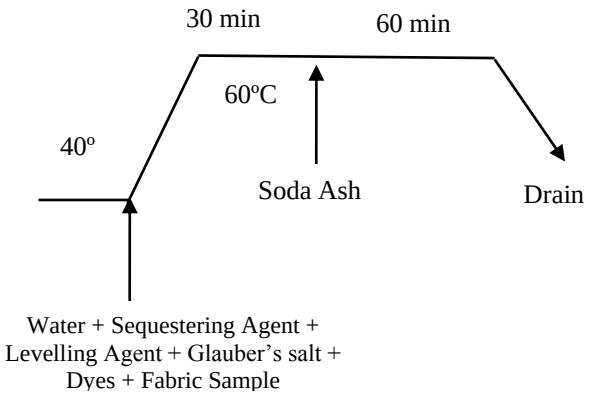

Fig 1: Conventional exhaust dyeing curve

Dyeing Process:

At first marked five dyeing pots for five samples
↓
Add required amount of water, sequestering agent, levelling agent, salt, dyes and fabric sample at room temperature
↓
Then raise the temperature at 60ºC at 2º/minute
↓
After 30 minutes, add soda by dosing and run 60 minutes at 60ºC
↓
Cooling at 40ºC and drain

After Treatment:

After drain, fabric is rinsed at 50ºC temperature for 10 minutes
↓
Neutralized with 1 g/l acetic acid solution at 45ºC for 10 minutes
↓
Soaping with 2 g/l detergent at 90ºC for 10 minutes
↓
Rinse with normal water for 10 minutes
↓
Drying

Time Variation:

The depth of shade and the reactivity of dye decide the time of dyeing. With the increasing of time dye fixation increases until the dye bath reached at equilibrium. After that point if continue the run time, dyes will be hydrolysed. The variation of dyeing time of 40, 60 and 80 minutes are taken and kept the other parameters fixed as below:

Novacron Red S-B	1%
Sequestering agent	1 g/l
Levelling agent	1 g/l
Glauber's salt	40 g/l
Soda ash	8 g/l
Sample weight	5 g
Liquor ratio	1:10
Temperature	60ºC
Acetic acid	1 g/l
Detergent	2g/l

2) Measurement of Colour Strength

The reflectance value of a specimen for the wave length of 400nm–700nm with 10 nm intervals is found using Datacolor® Spectrophotometer. By using this reflectance value into the Kubelka Munk's equation [18] colour strength (K/S) can be determined.

Colour Strength $(K/S) = (1-R)^2/2R$

Where,

R = Reflectance of an incident light from the dyed material,

K = Absorption, and

S = Scattering coefficient of the dyed fabric.

3) Measurement of Colour Fastness Properties

Colour fastness properties of all dyed specimens are determined by using the crock meter (Brand: SDL, Origin: UK) and multi-fibre. Colour fastness to washing and colour fastness to rubbing is assessed by using grey scale of colour change and staining according to ISO 105-C10:2006 and ISO 105-X12:1987 methods respectively.

III.RESULT AND DISCUSSION

A. Effect of Time on Colour Strength (K/S)

Figure 2 shows the effect of time variation on the colour strength of cotton fabrics dyed with Novacron Red S-B reactive dye. For time 40, 60 and 80 minutes the K/S value are found to be 0.030, 0.044 and 0.034 respectively. The colour strength increases up to 60 minutes then the value declines up to 80 minutes. The highest value of K/S is observed with

dyeing time of 60 minutes, and 40 and 80 minutes show the minimum K/S value for cotton fabrics which mean that this dyeing time has less impact at the values of dye uptake for fabrics. Hence, the optimum value of dyeing time used may be 60 minutes, which helps in saving water, salt and alkali. However, the effect of dyeing time on dye uptake is also affected by other factors such as dye, salt and alkali concentration, and dyeing temperature etc.

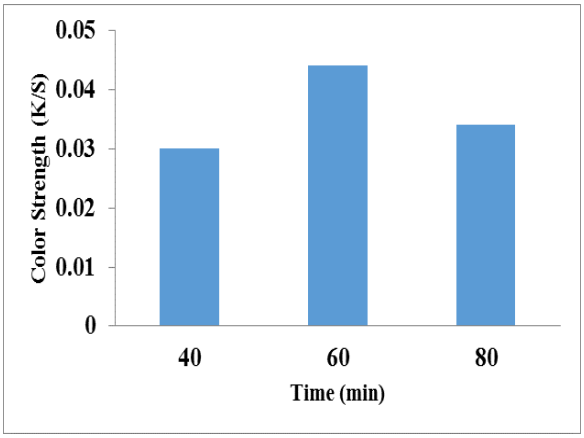

Fig 2: Colour Strength (K/S) Against 690 Nm for Different Time Variation.

B. Effect of Time on Colour Fastness to Washing

Table I-Colour Fastness To Washing For Different Time Variation

Time (min)	Change in colour	Colour staining on multi fibre					
		Wool	Acrylic	Polyester	Polyamide	Cotton	Acetate
40	3	5	5	4-5	5	3-4	4-5
60	4-5	5	5	5	5	4-5	5
80	3-4	5	5	3-4	5	3-4	5

Table I presents the colour fastness to washing for 40, 60 and 80 minutes of dyeing time of all the dyed samples. The overall results of colour fastness to washing of samples are good to excellent. Fabric dyed with 60 minutes of dyeing time displays excellent grade in colour change and staining. This is attributed to the very stable covalent bond that exists between the dye molecule and the cotton fibre polymer.

C. Colour Fastness to Rubbing for Time Variation

Table II-Colour Fastness To Rubbing For Different Time Variation

Time (min)	Staining on cotton	
	Dry condition	Wet condition
40	4	3
60	5	4.5
80	4.5	4

Rubbing fastness is performed both in dry and wet conditions. The higher the ratings of crocking colour fastness indicate the higher colour depth and strength onto the fabric. The grade of colour fastness to rubbing of the samples is evaluated and presented in the Table II. The overall results of colour fastness to rubbing of the samples are good to excellent. Wet rubbing properties are lower than dry rubbing. The minimum range for rubbing fastness is 3 and maximum range is 5. It is observed that the fabric sample dyed for 60 minutes exhibits good wet rubbing and excellent dry properties.

IV. CONCLUSION

The single jersey cotton knitted fabrics are dyed with 1% Novacron Red S-B reactive dye using same bath conventional exhaustion dyeing method by IR laboratory sample dyeing machine. All the parameters are kept fixed except dyeing time and the time varies from 40 minutes to 80 minutes for dyeing different samples. The better colour strength finds for 60 minutes and the colour fastness to washing and rubbing for the dyed fabrics are found to be good to excellent. Hence, the optimum value of dyeing time uses may be 60 minutes, which helps in saving water, salt and alkali for dyeing the cotton fabrics with reactive dyes.

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