

# Sulpher Black Dyeing of Raw White Stretch Denim Fabrics Using Continuous Mercerizing Machine

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**Abstract**— A new method of dyeing raw white stretch denim fabrics using continuous mercerizing range was developed. An un-pretreated raw white denim fabric of 8.25 oz/yd<sup>2</sup> weight having construction of (10s OE+12s Ring Slub+12s OE) ×150L70D/75×60 was selected as experimental fabric. The fabric was firstly mercerized at 20 Baume caustic soda concentrations and then dyed in 4 dip 4 nip sulphur black dye bath of 2.5 g/l concentration with a redox value/ millivolt value of -(700-710) followed by 2 step washing, neutralization and steam drying continuously. Color fastness to wash of the dyed fabric was found grade 4.5 and cross-staining grade to acetate, cotton, nylon, polyester, acrylic and wool was 4.5. Dry rubbing and wet rubbing grade in both warp and weft direction was found 3.4 and 2.3 respectively. Tensile strength in warp and weft was found 84.7 kg and 44.2 kg respectively. Length and width shrinkage was 3% and 14.5% respectively with a skew displacement of 2%. The method is a novel approach, rapid, innovative and time saving as well.

**Index Terms**— color fastness, mercerizing, raw white stretch denim, sulphur dye

## I. INTRODUCTION

In recent decades, denim has become a synonym of fashion and an indispensable part of the textile industry. The evaluation and the supply curve of denim fabric in the market moves to the side of visual variety in a globalizing world. Considering the developments, designing and production of value-added products has unavoidable demands, cater to fast-growing current fashion [1-2]. In Bangladesh, Denim industries are the top growing sector because of continuous demand in the world market. New industries are establishing to meet this remarkable demand with new concept on their product.

In addition, with the production of different colored denim using indigo and sulphur dye at yarn stage ( continuous sheet form/ slasher dyeing range), raw denim fabrics without dyeing in sheet form are also producing, which will be dyed in garments form using denim washing machine [3-4]. The apparel producers just buy these raw white fabrics, produce garments and then wash in washing machine with different color as per buyer required shade. If denim fabric producers

can dye these raw white denims in their own factory, they will be able to sell their products at a high unit price than that of raw white denim. But most of denim fabric producers do not have their own washing plant to dye their fabrics. In our experiment, we have taken an approach to dye these raw white denim fabrics using continuous mercerizing range. A continuous mercerizing machine is must for any denim manufacturer to mercerize their fabrics in order meet buyer requirement. Also there is some idle time of mercerizing machine in denim factory as all denim fabrics don't need to mercerize as stated in buyer proforma invoice of product. If it can be established successfully every denim fabric producer will be able to use their mercerizing machine to meet fabric dyeing function in continuous process [5-6]. They don't need any other dyeing machine to dye their white fabrics and idle time of mercerizing machine will be reduced.

## II. MATERIALS AND METHOD

### A. Fabric profile

10 Ne –open end, 12 Ne-ring slub and 12 Ne-open end yarn was used as warp yarn. 150 denier intermingled polyester with 70 denier polyurethane filament core was used as weft. Warp beam ratio was 4:4:4. Grey ends/inch: 75 and grey picks/inch: 60. Fabric width: 50 inch. Total ends of fabric: 3750. i.e, each warp beam contains 313 warp yarns. Total number of 10 Ne –open end: 1252, 12 Ne-ring slub: 1252 and 12 Ne-open end: 1252. Type of weave was 3/1 Right hand twill.

### B. Dyes and chemicals used

- i. Liquid sulphur dye ( Asutex, Spain)
- ii. Hydrose ( Asutex, Spain)
- iii. Sodium sulphide ( Unichem, China)
- iv. Sodium hydroxide ( Unichem, China)
- v. acetic acid ( Unichem, China)

### C. Experimental procedure

- a) Singeing of grey fabric

Fabric was singed in both side using 80% flame efficiency at 100 meter/min speed in gas singeing unit of Cibitex Denim Line finishing machine.

- b) Dyeing in mercerizing machine
- c)
- i. Caustic soda bath preparation

Caustic soda bath was prepared maintaining 20 baume concentration in a 700 liter bath. Concentration of caustic soda was measured using Baume meter.

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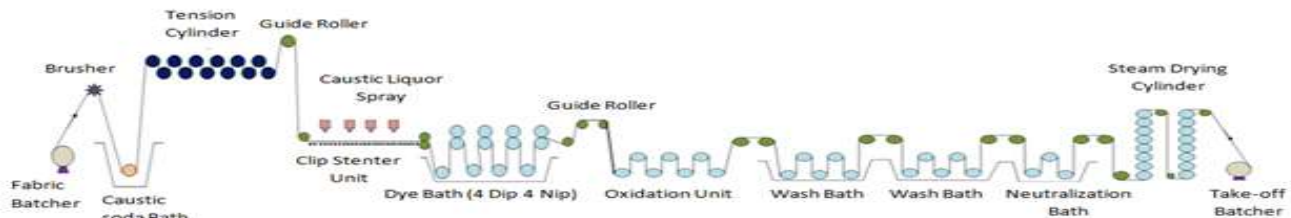


Fig.1: Schematic diagram of mercerizing machine used for dyeing

### ii. Dosing caustic soda bath preparation

As the fabric will be processed in continuous sheet form, bath concentration will be decreased time to time. In order to assure accurate bath concentration during whole processing time, a dosing caustic soda bath was prepared. The bath was prepared using 100 g/l caustic soda in 500 liter bath. The dosing rate was adjusted to 3 liter/min.

### iii. Dye bath preparation

A dye bath of 700 liter volume capacity was prepared using following recipe:

Dyes and Chemicals	Amount	Processing Temp
Sulpher Dye	2.5 g/l	85°C
Hydrose	20 g/l	
Sodium Sulphide	5 g/l	
Sodium hydroxide	20 g/l	

### iv. Dosing dye bath preparation

In order to maintain accurate 2.5 g/l dye bath concentration for whole processing time, dye dosing bath was prepared using following recipe:

Dyes and Chemical	Amount	Dosing rate
Sulpher Dye	2.5 g/l	3 liter/min
Hydrose	20 g/l	
Sodium Sulphide	5 g/l	
Sodium hydroxide	20 g/l	

### v. Wash bath preparation

Two wash bath containing only water of 90 °C temperature heated by steam injection was prepared.

### vi. Neutralization bath preparation

Neutralization bath contains 4 g/l acetic acid (H<sub>3</sub>C-COOH) at normal temperature.

### vii. Dyeing

The singed raw white fabric was firstly feed at 20 m/min speed into the brushing unit of continuous mercerizing machine to brush out burned out fibers adheres into the fabric

surface (Fig.1). Then the fabric was immersed into the caustic soda bath, passed through 6 pairs of tension rollers and then enters into the width control clip stenter unit. The caustic soda liquors obtained from squeezing of fabric at caustic soda bath was collected into another bath which was then sprayed over the fabric in clip stenter unit. From clip stenter unit the fabric enters into the dye bath of 4 dip 4 nip system. The dyed fabric was then enters into the roller arrangement to provide sufficient oxidation time for dye fixation. These rollers are so arranged that 8 meters of fabric remains in open air for oxidation. The oxidized fabric was then enters into the 1<sup>st</sup> and then in 2<sup>nd</sup> washing bath containing hot water of 90 °C temperature. After wash bath fabric enters into the neutralization bath containing acetic acid. The neutralized fabric was then enters over the steam heated drying cylinders and finally come out from the machine.

### viii. Finishing of fabric

The dyed fabric was finished using CibiTex Denim Line finishing machine consisting of 7 processing unit namely-brushing, chemical padding, anti-skew roller, predryer, mini stenter, sanforizing unit and calendaring unit.

## III. RESULTS AND DISCUSSION

### A. Color fastness test

Color fastness to washing and rubbing of the dyed fabric was tested using BSEN ISO-105-C06 (30 mins mechanical wash at 40 °C in 0.4 % ECE phosphate detergent, 0.1 % sodium perborate solution and rpm 40 with 10 steel balls) and BSEN ISO-105×12 standard respectively [7-8]. Fastness grading is given in Table-I and Table- II.

Table I  
Test results of color fastness to washing

Color fastness	Fastness grading
Wash fastness	4-5
Staining on-Acetate	4-5
Cotton	4-5
Nylon	4-5
Polyester	4-5
Acrylic	4-5
Wool	4-5

Table II  
Test results of color fastness to washing

Fastness	Warp/Lengthwise	Weft/Widthwise
Dry Rubbing	3-4	3-4
Wet Rubbing	2-3	2-3

### B. Tensile strength test

Tensile strength of dyed fabric was tested using BSEN ISO 13934-2(Grab method) standard [9]. Tensile strength values are given in Table-III.

Table-III  
Tensile strength test results

Tensile Strength	Values (Kg)
Warp	84.7
Weft	44.2

### C. Shrinkage and spirality test

Shrinkage value in warp and weft direction and skew displacement(%) was tested using ISO-6330-2012( wascator washing machine, front loading horizontal rotating type, test program 4N at 40 °C, 2 kg load, in ECE reference detergent, sodium perborate and bleaching activator taed, tumble dry low) and ISO-16322-2 (procedure A, machine wash at 40°C, tumble dry low) standard respectively [10-11]. Results are given in Table-IV.

Table-IV  
Shrinkage and spirality test results

Shrinkage	Value (%)	Skew displacement (%)
Warp	3	2
Weft	14.4	

As our experimental fabric was a raw (un-scoured) fabric, it was a challenge to achieve adequate color fastness grade. The caustic soda bath at the entry of the mercerizing machine was utilized to give fabric some absorption capacity which does not provide actual scouring purpose of fabric [12]. Achieved wash fastness grade 4.5 meet AATCC standards requirement though it may vary from buyer to buyer [13]. Also there was a possibility of strength fall of fabric as the fabric was immersed in caustic soda bath and then directly enters in highly tensioned into the tension cylinders and in clip stenter unit. Again the fabric was immersed into the dye bath which also contains concentrated caustic soda.

In slasher denim dyeing process, dyeing with black color involve 3-4 dye bath depending on the depth of shade and proper oxidation chamber placed over each dye bath [12]. But in mercerizing machine we have dyed our fabric using only

one bath and there was no oxidation chamber above the dye bath. Only rollers are used to keep the dyed fabric in open air for oxidation. Also 5 step washing is the industrial practice used for sulphur dyeing to achieve superior fastness grade [12]. .But we have used only 2 steps washing after dyeing So these may be the causes of somewhat low rubbing fastness. Shrinkage value in weft direction for 150L70D core spun yarn normally ranges from 14-18% depending on fabric construction. Length shrinkage obtained +2.5 % whereas acceptable range in  $\pm 3$  % [10]. Though in case of mercerized fabric, fabric finishing department sometimes face difficulties to maintain acceptable length shrinkage

## IV. CONCLUSION

Modification of mercerizing machine through installing oxidation chamber after dye bath and addition of 2-3 dye bath and 4-5 wash bath may provide the dyed fabric a considerable increase in fastness properties. If the experimental fabric was pretreated (scoured and bleached) there was a possibility to achieve more acceptable test results.

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