Faculty of Engineering Department of Textile Engineering

Project (Thesis) Report on

Comparative Study on Dyeing Behavior of Different Shades of Reactive Dyes on Cotton Woven and Knit Fabrics

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A Thesis submitted in partial fulfillment of requirements for the degree of
Bachelor of Science in Textile Engineering

Major in Wet Processing Technology

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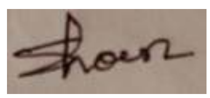
DECLARATION

I hereby announce that this Project (Thesis) report has been prepared by us under the supervision of **Md. Kamrul Islam**, Lecturer, Department of Textile Engineering, Faculty of Engineering, Daffodil International University. I also declare that either this report or any part of it has been submitted for the award of any degree.

Submitted By:



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LETTER OF APPROVAL

This Project (Thesis) report has been prepared by Md. Shoun Islam Badhon **(ID: 201-23-853)** has been partially approved to meet the requirements for the degree of **Bachelor of Science in Textile Engineering**. The mentioned students have completed their Project (Thesis) work under my supervision. During the research I found them sincere, hardworking and enthusiastic.

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ACKNOWLEDGEMENT

Firstly, I pay my gratitude to Almighty Allah, the most Beneficent, the most Merciful, whose heavenly blessings helped me throughout this Project (Thesis).

I would like to thank my Supervisor **Md. Kamrul Islam**, Lecturer, Department of Textile Engineering, Faculty of Engineering, Daffodil International University. Project (Thesis) work under supervision of my superior with strong passion and knowledge in textile dyeing and finishing taught us a lot and his unlimited patience, scholarly grilling, regular encouragement, dynamic supervision, constructive criticism, valuable counselling, lower reading. This Project (Thesis) is being graduated upon the basis of the Draft & Revised at all phases.

I want to acknowledge the most invaluable operand assistance of **Mr. Tanvir Ahmed Chowdhury**, Assistant Professor & Head, Department of Textile Engineering, Daffodil International University for his immense help at the conclusion of our Project (Thesis) report.

Abstract

The present study explores the dyeing behavior of cotton woven and knit fabrics using reactive dyes at 3 different percentages of shade: 0.5%, 1.5%, and 3.0%. Six samples were prepared by dyeing three woven and three knit fabric samples, using the same conditions. The research consists of a typology of critical parameters (fabric weight (GSM), wale per inch (WPI), course per inch (CPI), ends per inch (EPI), and picks per inch (PPI)) to investigate structural differences between woven and knit fabrics. Performance characteristics like continuous washing fastness, drapability, bursting strength and tensile strength were analyzed with respect to the dyeing behavior in terms of shade percentage and fabric construction. The results of dye uptake, fastness properties and mechanical performance were shown to have significant variation depending on fabric type and the shade depth. Knit fabrics were more flexible, but had a weaker bursting strength and lower tensile strength, while woven fabrics had a higher dimensional stability and tearing resistance and a higher tensile strength. The results exhibited dyeing behavior of woven and knit cotton fabrics and discussed the effect of fabric structure and depth of shade on physical and mechanical properties. The results can be applied to engineer dyeing processes and fabric selection for optimal performance in various applications.

Key words: Cotton woven, cotton knit, dyeing, drapability, fastness, bursting

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CHAPTER- 01
INTRODUCTION

1.1.Introduction

Reactive dyes belong to a class of dyes that, in contrast to direct dyes, chemically reacts to become attached to the fiber or (substrate) as a covalent bond. This reaction guarantees that the dye would remain attached to the fibers thus giving it great colorfastness and durability. For this reason, major textiles industry uses reactive dyes in dyeing of cellulose-based fibers (cotton).

1.2. Objectives of this research work:

- To Compare Fabric Structures:
  Analyze and discuss the impact of structural parameters including gsm, wpi, cpi, epi, and ppi of cotton woven and knit fabrics on their dyeing behavior.
- To Analyze Dyeing Behavior:
  Apply four of the most common fiber reactive dyes to both a woven and knit fabric to see how the depth of shade (0.5%, 1.5%, 3.0%) affects the fabrics.
- To Evaluate Mechanical Properties:
  Evaluate mechanical characteristics including tensile strength (warp and weft directions) and bursting strength for both kinds of fabric before and after dyeing.
- For Testing Fastness Properties:
  If reactive dyes are used on both woven & knit fabric then wash fastness can be done on both of these fabrics at different level of % shade.
- Examining Fabric Drape and Performance:
  Learning learning outcome: Analyse how dyeing impacts the aesthetic and functional performance of woven and knit fabrics by analysing drapability.
- To Provide Industry Insights:
  Give concrete advice for improving dyeing processes and choosing the right types of fabric based on end-use applications in textiles.

CHAPTER- 02
LITERATURE REVIEW

2.1. Reactive Dyes

Reactive dyes are a kind of synthetic dye used in staining applications, most commonly for cotton, wool, silk and other natural fibers. These are called 'reactive' dyes because chemical reactions form a covalent link between the dye and the fiber molecules. Reactive dyes are more stable (colorfast) to fading, washing, and exposure to light than other dyes as result of this chemical bond. Reactive dyes have reactive groups that can react chemically with functional groups of fibers (e.g., hydroxyl (-OH), amino ($-NH_2$), or sulfonate ($-SO_3H$) groups), forming covalent bonds. Reactive dying is a method that can be executed via exhaust dying, continuous dying or printing. Reactive dyes are the most widely used class of dyes in the textile industry because of their outstanding colorfastness, brilliant colors, and affinity for cellulosic fibers, thereby becoming the dye of choice for the dyeing of cotton and other natural textiles.

2.1.1.Structure of Reactive Dye

2.1.2. Properties of Reactive Dye

- Reactive dye is anionic in nature.
- Reactive dye is soluble in water.
- They establish a covalent connection with the textile material.
- For dying cellulosic textiles, reactive dyes are widely utilized.
- Additionally, they can be utilized to color protein fibers.
- They obtain a 6 grade for light fastness.
- Because they form a strong chemical bond with the fibers through a covalent bond, they have good wash fastness (graded 4-5).
- They rub fastness is moderate.
- Fixation and the dyeing process take place in an alkaline environment.
- The dyeing process requires a large amount of electrolyte.
- comparatively inexpensive.

2.3. Cotton Fabric

A flexible material is commonly constructed of yarn or thread to make a fabric, yarn is woven, knitted, matted or bonded together. It is a major fiber used in the manufacture of textiles that are used for clothing, upholstery, bedding, and industrial purposes.

2.3.1. There are many types of fabric

- Cotton woven
- Cotton knit

Cotton woven

Cotton woven: cotton fibers that are woven together in a weaving method. Weaving interlaces two sets of yarns the warp and weft at right angles to form strong and durable fabric. For shirts, trousers, and bedding we prefer Cotton woven fabrics.

Cotton Knit

Cotton knit is a term that can refer to fabrics created from cotton fibers knit together, generally from a single yarn. [How, Unlike Woven Fabrics in Which Yarn Is Interwoven at a Right Angle, Knitted Fabrics Are Made of Looping the Yarn in a Series of Interlocking Stitches.] It makes the cloth more elastic and moldable.

Knitted fabrics are used for clothing items such as t-shirts, sweaters, leggings, and other garments requiring comfort and elasticity. The knit structure and their knitted properties make them generally softener and breathable than woven fabrics.

There are two main types of knitting:

1. **Weft knitting**: Where the yarn runs horizontally and loops are formed in the direction of the fabric width. This is commonly used in t-shirts and sweaters.
2. **Warp knitting**: Where the yarn runs vertically, and the loops are made in the direction of the fabric length. This is typically used for more technical fabrics or industrial textiles.

2.4. Structure of Cotton Fiber

Cotton fibers are renowned for feeling smooth and comfortable on the skin. Since cotton fibers naturally have a smooth surface, its softness can be attributed to this feature.

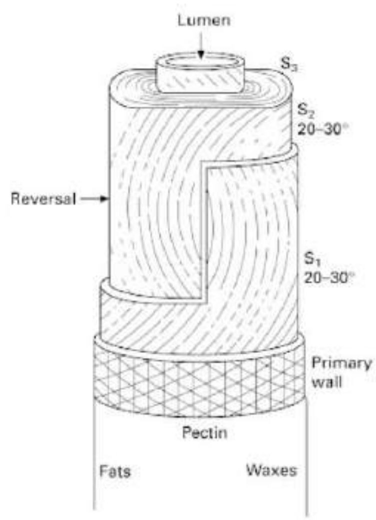


Fig. Structure of cotton fiber

2.5. Properties of Cotton Fiber

Physical Properties:

- **Elongation:** We cannot stretch Cotton so easily. Its elongation (5-10%).
- **Elasticity:** (2-5%)
- **Strength:** 6 CN/Tex
- **Effect of moisture:** It has a moisture regain of 8.5% & water absorbency (2527%).

Chemical Properties:

- **Effect of acid:** Cotton is highly affected by hot dilute acids.
- **Effect of alkalis:** Cotton has an excellent resistance to alkalis.
- **Effect of micro- organism:** Cotton gets attacked by fungi & bacteria.

2.6. Function of Dyestuffs & Chemicals used in this study

- **Reactive Dye:** The coloring substance used to produce color in cotton fabric. Two different shades of reactive dye (Novacron Blue) used in this study.

- **Levelling agent:** This type of chemical agent contributes to achieve even dyeing by causing the dyes to be distributed uniformly throughout the fibers.

- **Soda Ash (Na_2CO_3):** It is used to control the pH of reactive dyeing bath. Soda ash is also used in dyeing of cotton goods to fix dyes with the fiber by covalent bond formation.

- **Glauber Salt:** Used as an electrolyte in reactive dyeing to neutralize the negative charge of cotton fiber so that the affinity of reactive dye gets increased towards cotton fiber.

- **Sequestering agent**: To remove hardness of water.

CHAPTER- 03
MATERIALS AND METHODS

3.1. Materials used in this study

3.1.1. Fabric

Composition: 100% Cotton
Type: Knit
GSM: 187

Composition:100% Cotton
Type: Woven
GSM: 260

3.1.2. Dyes

In this Study, Novacron Blue reactive dye is used. For novacron dyes 0.5%,1.5% and 3.0% shade has been used for cotton (woven) & cotton(knit).

3.1.3. Chemicals & Auxiliaries

For Dyeing- Glauber Salt, Soda Ash, Wetting agent & Sequestering agent were used.

3.2. Machines used in this study

3.2.1. GSM Cutter

GSM indicates the measurement of fabric weight. GSM means gram per square meter. So, GSM indicates the weight of one square meter fabric in gram. By using GSM cutter, we can calculate the GSM of a given fabric.

Fig. 3.1. GSM Cutter

3.2.2. Electrical Balance

Electrical Balance were used to weigh the fabric, dyes, chemicals and auxiliaries in gm.

Fig. 3.2. Electrical Balance

3.2.3. Rapid dyeing Machine

Use for dyeing

Fig. 3.3. Rapid Dyeing Machine

3.2.4 Crock-meter

To measure the wet & dry rubbing fastness.

Fig. 3.4. Crock-meter

3.2.5. Universal Tensile Strength Testing Machine

Use for fabric strength test

Fig. 3.5. universal strength testing mc

3.3. Process Sequence of Dyeing

1. Fabric Preparation
2. Recipe Formulation
3. Stock Solution Preparation
4. Dyeing Bath Preparation
5. Dyeing
6. Washing
7. Drying

3.4. Pretreated Fabric Preparation for dyeing

take 3 sample cotton (woven) & 3 sample for cotton(knit) for Novacron Blue color

3.5. Recipe Formulation for Dyeing

Dyeing recipe for 100% cotton (Woven) & cotton(knit) sample fabric with reactive dye

Name of the dyes/chemicals	**Concentration**		
Novacron Blue	0.5%	1.5%	3.0%
Glauber Salt	20g/L	40g/L	60g/L
Soda Ash (Na_2CO_3)	5g/L	10g/L	15g/L
Temperature	60°C		
Time	60 minutes		
pH	10.5-11.5		
M:L	1:20		

3.6. Preparation for Dyeing

At first, all the required dyestuffs, chemicals & auxiliaries were taken in to the beaker according to the recipes. Then required amount of fresh water were added in the beaker according to the M:L followed by the immersion of pretreated fabric sample.

3.6.1. Dyeing

At first, according to the recipe calculations, the fresh water is taken at the dyeing beaker while keeping the liquor ratio of 1:20. Dyestuffs, chemicals & auxiliaries from the stock solution were added at 30°C. Fabric samples were put in the beaker and their pH was checked before dyed started. The beakers were then placed in the dyeing machine, and the temperature was increased to 60°C at 5°C/min in order to start the dyeing process. The dyeing process was continued for 60 minutes at 60°C. Then the beakers are cooled to room temperature and returned to their original temperature after 60 minutes. Following that, dyed samples are ready for washing once the dye liquor has been drained.

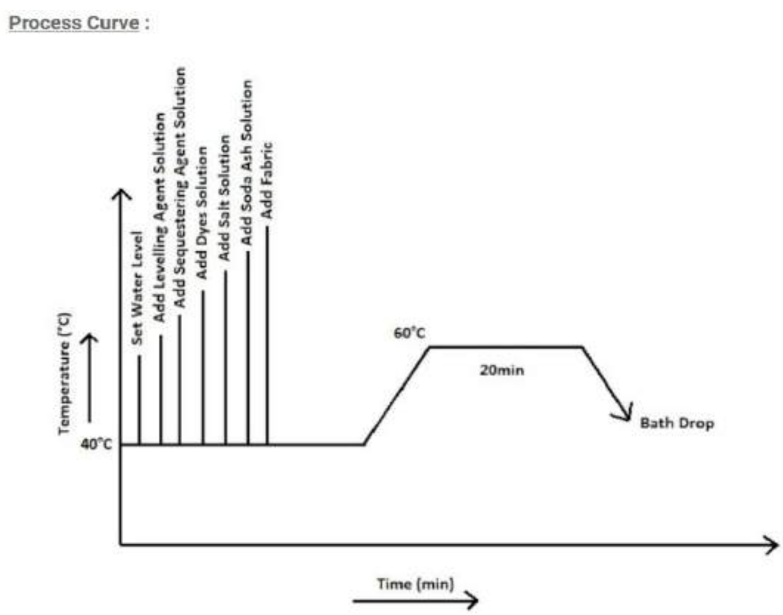


Fig. 3.1. Process Curve of Reactive Dyeing

3.7. Washing and Rinsing of dyed sample

dyed sample fabric was cold washed for 5 minutes. All the dyed samples were washed and rinsed with similar process.

3.8. Woven Fabric EPI, PPI Test Procedures

3.8.1. EPI Test

Apparatus:
1.counting glass
2.fabric sample

Working Procedure:

- **Prepare the Sample**: Take a piece of fabric and measure a known length, typically 1 inch or 10 cm (for higher precision).

- **Count the Warp Yarns**: Using a magnifying glass or under proper lighting, count the number of warp yarns (the yarns running vertically in the fabric) in the measured length.

- **Apply the Formula**: Use the formula above to calculate the EPI by dividing the total number of warp yarns in the sample by the length of the sample.

3.8.2. EPI Equation (Calculation)

The equation to calculate **EPI** is: Total Number of warp yarns / Length of fabric sample (inches)

3.8.3. PPI Test

Apparatus:
1.Counting glass
2.Fabric sample

Working procedure

- **Prepare the Sample**: Cut a piece of fabric from the weave, typically 1 inch or 10 cm in length, to accurately measure the weft yarns in that portion of fabric.

- **Count the Weft Yarns (Picks)**: Using a magnifying glass or under proper lighting, count the number of weft yarns (horizontal yarns) in the measured length of fabric.

- **Apply the Formula**: Divide the total number of weft yarns in the measured length by the length of the sample (in inches). This gives you the **PPI** of the fabric.

3.8.4. PPI Equation (Calculation)

The equation to calculate **PPI** is: Total number of weft yarns (picks) / Length of fabric sample(in inches)

3.9. Knit Fabric WPI, CPI Test

Apparatus:

- Counting glass
- Fabric sample

Working procedure

3.9.1. Count WPI

- Count the number of **wales** (vertical loops or columns) within the measured length of the fabric. Each vertical column of loops represents 1 wale.
- Divide the number of wales by the length of the fabric (in inches) to calculate the **WPI**.

3.9.2. Count CPI

- Count the number of **courses** (horizontal loops or rows) within the measured length of fabric. Each horizontal row of loops represents 1 course.
- Divide the number of courses by the length of the fabric (in inches) to calculate the **CPI**.

WPI (Wales Per Inch) Equation**: Total amount of wales / Length of fabric sample (in inches)**

CPI (Courses Per Inch) Equation**: Total amount of courses / Length of fabric sample (in inches)**

3.10. Drapability Test

Apparatus:

- **Bending Tester** (e.g., Shirley stiffness tester or similar apparatus).
- **Ruler or Scale** (for precise measurements).
- **Flat Surface** (for sample preparation).
- **Fabric Samples** (pre-conditioned to standard conditions).
- **Standard Atmosphere**: 21 ± 2°C and 65 ± 5% RH.

Working Procedure:

Set up the lester lay the fabric strip on flat surface of the tester horizontally.

- Position the Fabric: Let one edge of the fabric overhang the end of the test platform.
- Initiate Bending: Sweep the fabric strip forwards until it starts to buckle and its free end rests (normally at 41.5°) on a sloped plane.
- Measure the Vending Length: Determine the distance from the edge of the platform to where the fabric bends enough to touch the inclined plane.
- Change is the vending length.

3.11. Testing of Color Fastness

3.11.1. Color Fastness to Wash

Apparatus:

- Thermostatically controlled water bath (Rota Wash)
- Multifiber DW Fabric
- Dryer
- Grey Scale

Working Procedure:

- Make sure the specimen slice is 10 cm x 4 cm
- A 10 cm x 4 cm piece of multifiber fabric
- To fix the multifiber onto the specimen a price tag gun was used. Retain an unwashed piece of cloth for better analysis.
- Perform a sample wash using 25 steel balls in a 50 ml solution with 4 g/L ECE detergent and 1 g/L sodium perborate. Step: ISO C06 C2S for 30 Minutes at 60oC
- Followed care instructions to dry the Sample

3.11.2. Color Fastness to Rubbing

Apparatus:

- Crockmeter
- Crocking cloth
- Distilled water
- Grey Scale
- Light Box

Working Procedure:

- Rubbing Fastness: Rubbing Fastness is defined as how fast a colored sample changes its color after rubbing. There are two types of rubbing fastness test dry & wet.
- Dry rubbing test: After the specimen is prepared, the crockmeter's finger is inserted using a clip as a test agent on a white rubbing cotton cloth. After this, covered the finger over specimen and slide the finger to and fro for ten time in ten second.
- Wet rubbing test: The only distinction between wet rubbing test and the dry rubbing test is that in place of dry crocking cloth; a wet crocking cloth is used.

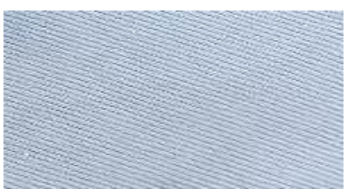
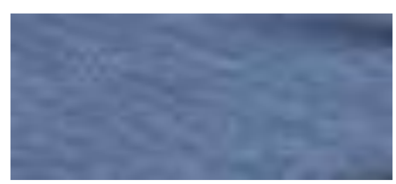
CHAPTER- 04
RESULTS & DISCUSSIONS

4.1. After GSM

1. Measure the GSM before and after dyeing for each sample.
2. Apply the formula to calculate the GSM change percentage for each fabric type and shade percentage.
3. Compare the results across woven and knit fabrics to analyze trends.

Fabric Type	Shade%	Before GSM	After dyeing GSM	GSM change%
Woven	0.5%	260	262	0.77%
	1.5%		264	1.53%
	3.0%		265	1.92%
Knit	0.5%	187	187	0%
	1.5%		189	1.05%
	3.0%		191	2.13%

4.2. Shade Variation of dyed Sample fabric

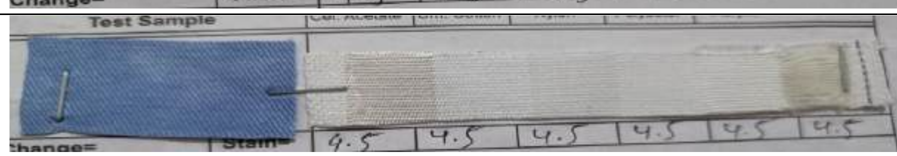
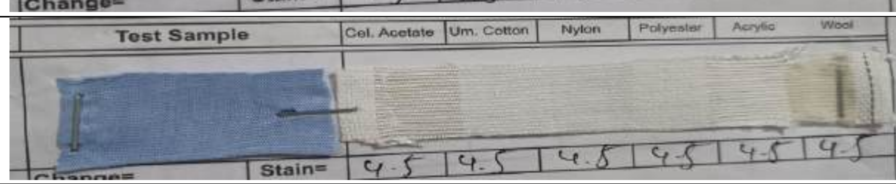
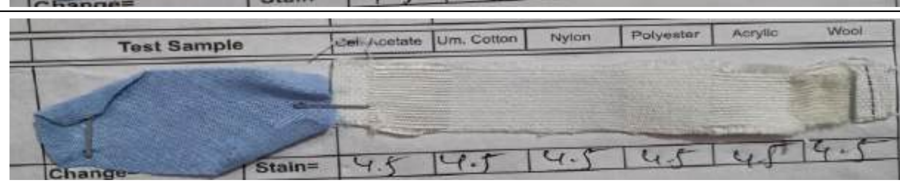
Shade %	**0.5% Novacron Blue**	**1.5% Novacron blue**	**3.0% Novacron blue**
Woven Fabric shade variation			
Knit Fabric shade variation			

4.2.1. Summary of Differences

Variation	% Difference in Shade	Visual Effect
0.5%	Very slight difference (lightest shade)	Almost uniform with faint tonal changes
1.5%	Noticeable difference (moderate shade)	Moderate contrast, adds depth and interest
3.0%	Significant difference (darkest shade)	Bold tonal shifts, dynamic contrast

4.3. Testing Sample Attachment

4.3.1. Wash Fastness test Sample

<table>
<tr><td rowspan="3">Woven fabric</td><td>0.5% shade</td><td>
</td></tr>
<tr><td>1.5% shade</td><td>
</td></tr>
<tr><td>3.0% shade</td><td>
</td></tr>
<tr><td rowspan="3">Knit fabric</td><td>0.5% shade</td><td>
</td></tr>
<tr><td>1.5% shade</td><td>
</td></tr>
<tr><td>3.0% shade</td><td>
</td></tr>
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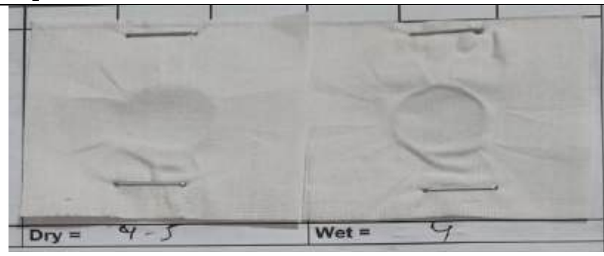
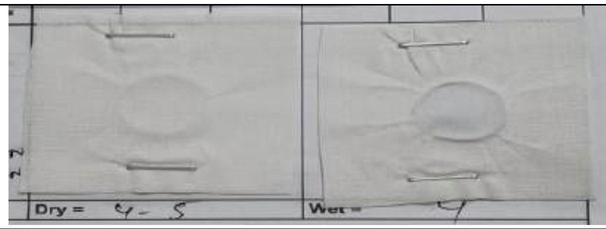
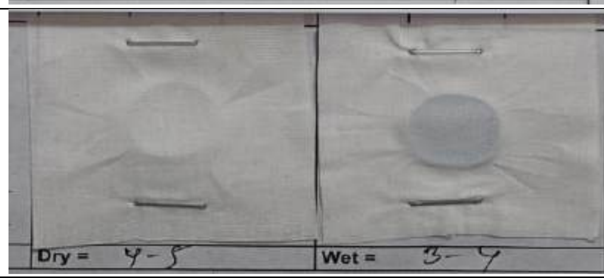
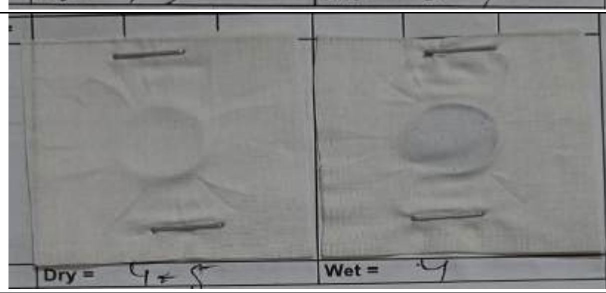
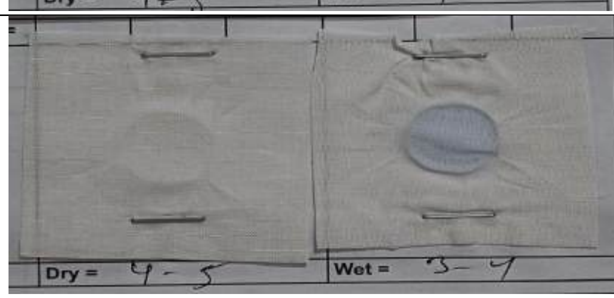
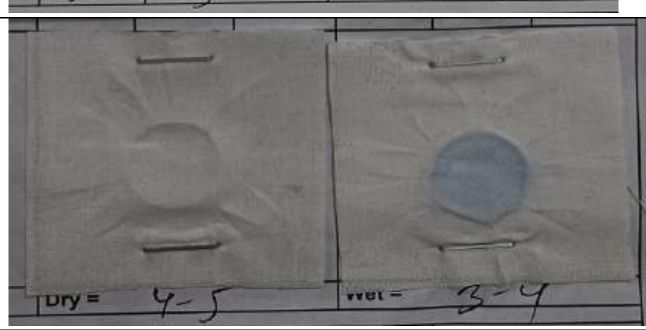
4.3.2. Rubbing Fastness test Sample

Rubbing Fastness test Sample:

Woven fabric	0.5%	
	1.5%	
	3.0%	
Knit fabric	0.5%	
	1.5%	
	3.0%	

4.3.3. Drapability Test result

Fabric Type	Shade%	Before Dyeing	After Dyeing
Woven	0.5%	1.0 inch	1.08 inch
	1.5%		1.09 inch
	3.0%		1.11 inch
Knit	0.5%	0.89 inch	0.94 inch
	1.5%		0.96 inch
	3.0%		0.98 inch

4.3.4. Woven fabric tensile test

For 0.5% Shade:

On the 0.5% shade, tensile strength results also show that for the warp direction, the tensile strength is higher at 312.60 N compared to the weft direction at 222.28 N which is expected due to hops; the warp direction is tighter woven than the weft direction. These results exemplify the underlying structural dissimilarities of yarn type and their ramifications toward the stress response of both weaves under tensile conditions.

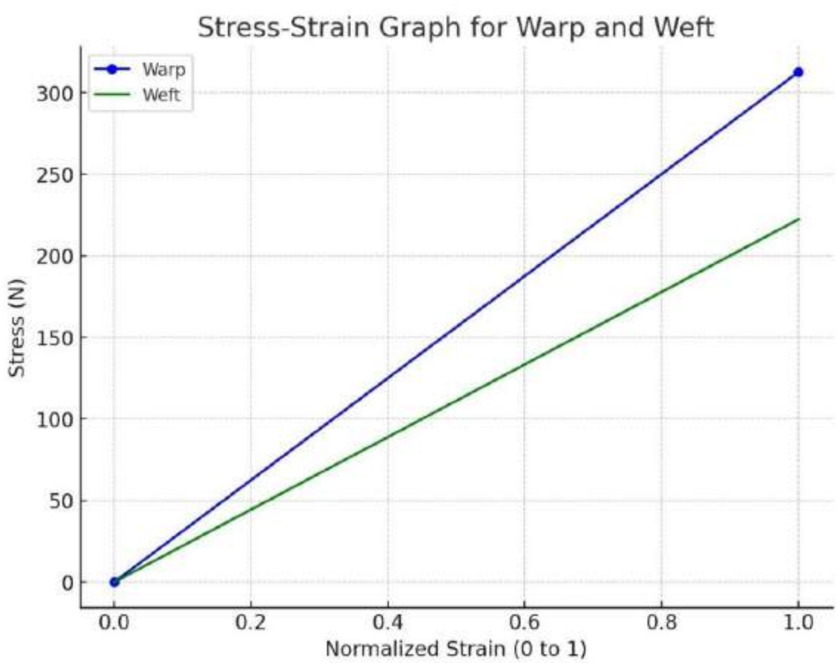


Fig. 4.1. stress-strain graph

For 1.5% Shade:

The tensile strength increases with variety 1.5% shade, as compared to variety 0.5% shade. The NST for warp and weft were observed to be 330.12 N and 246.32 N respectively, indicating improvement in tensile properties which may be attributed to stronger fiber-to-fiber bonds at higher dye concentration. The overall pattern, where warp strength was consistently greater than weft strength, is the indication of the structural integrity and compactness of warp yarns in the fabric.

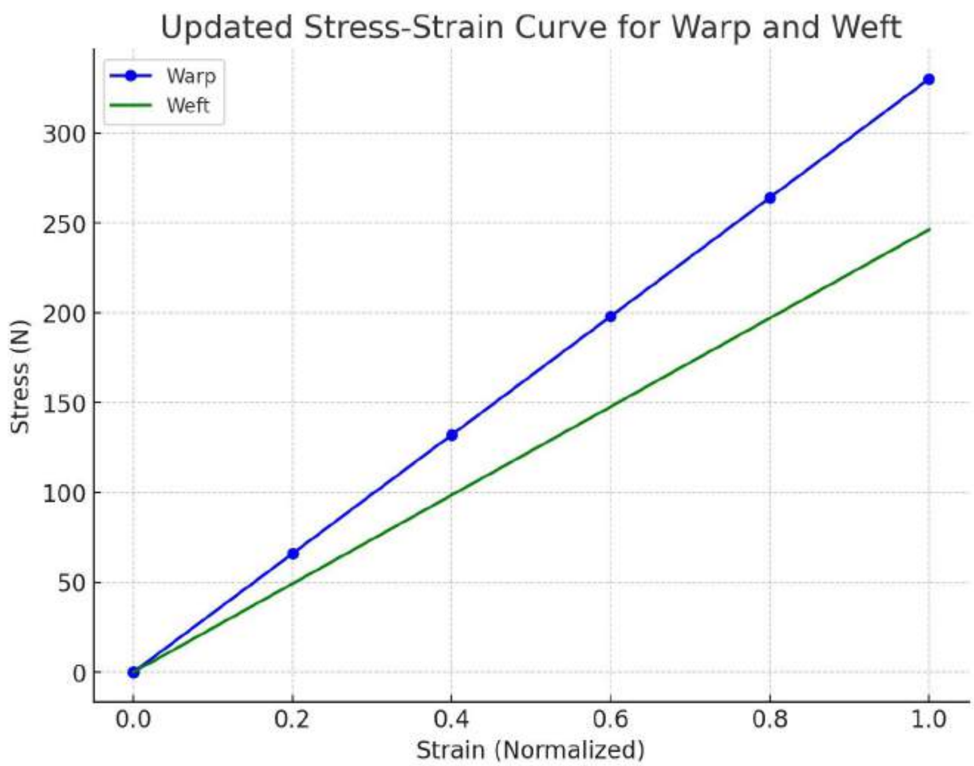


Fig. 4.2. stress-strain graph

For 3.0% Shade:

In the 3.0% shade, the warp tensile strength is 348.12 N and the weft tensile strength is 231.52 N. The warp strength is always greater than weft strength, which is consistent with the fabric's structure. The higher tensile strength at these dye concentrations suggests that weight percentage dyeing at this shade percentage could enhance fiber bonding and provide better integrity within the fabric, notably in the direction of the warp. The weft tensile strength, on the other hand is marginally reduced compared to the 1.5% shade indicating possible trade-offs at high dye concentrations.

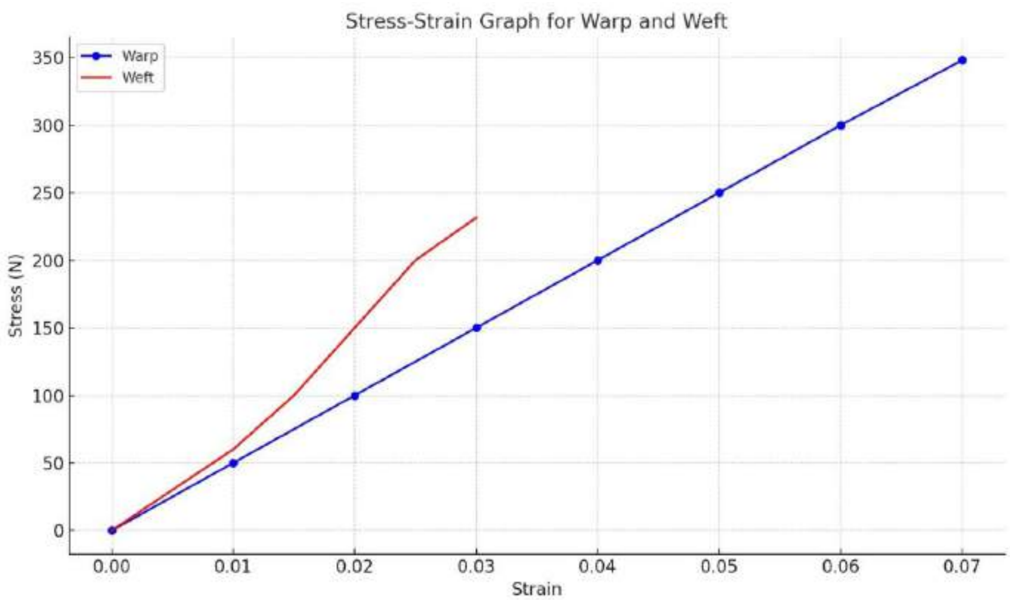


Fig. 4.3. stress-strain graph

4.4. Bursting strength test result for knit fabrics

The burst strength values for 0.5%, 1.5%, and 3.0% shades are 215.10 N, 211.20 N, and 209.31 N. These values showed a slight decreasing trend in bursting strength with increasing dye concentration. The decrease may be due to the effect of increased percentage of the dye on the flexibility of the fiber and the elasticity of the fabric which may slightly weaken the structure of the fabric. These results illustrate the required balance of dye concentration for retaining optimal fabric performance when subjected to multidirectional stress.

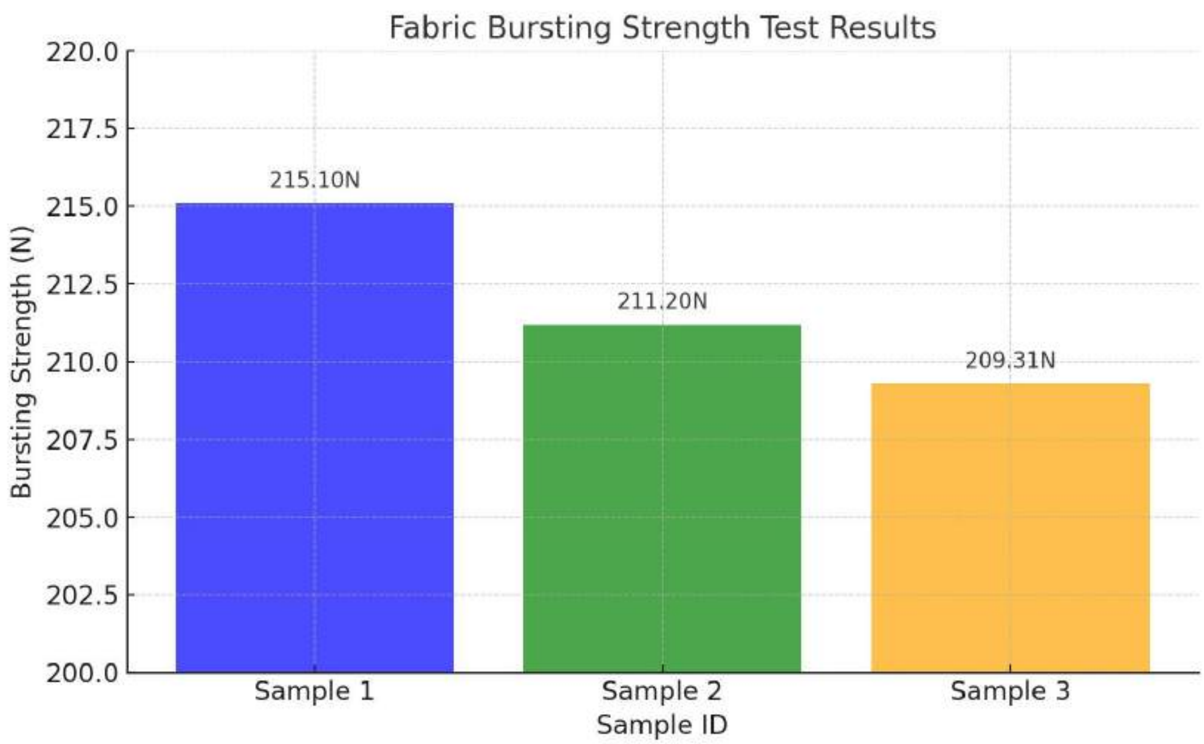


Fig. 4.4. Fabric bursting strength test result

CHAPTER- 05
CONCLUSION

5.1. Conclusion

This study reports on the dyeing behavior of reactive dyes on cotton woven and knit fabrics in three percentages of shade, namely: 0.5%, 1.5% and 3.0%. The performance of both fabric under these factors was analysed using several parameters like GSM, WPI, CPI, EPI, PPI, wash fastness, drapability, bursting strength and tensile strength. The results show that physical and mechanical properties depend on the fabric type and dye shade percentage. Woven fabrics possessed better tensile strength and dimensional stability, whereas knit fabrics had better drapability and flexibility. It was noted that the tensile strength in warp and weft directions increased with higher shade percentages, however a decrease in bursting strength was observed at higher dye concentrations. Wash fastness results were also consistent, showing good dye fixation across the shades. This work stresses the significant textile structure–dye concentration–performance relationship. The findings are paramount in enhancing dyeing processes and enabling the selection of appropriate types of fabric for varying applications available in the textile sector.

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