Faculty of Engineering

Department of Textile Engineering

Report on

STUDIES ON THE EFFECT OF DYEING POLYESTER FABRIC WITH DISPERSE DYE.

Course code: TE-4214   Course title: Project (Thesis)

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The project has submitted in partial fulfillment of the requirements for the degree of **Bachelor of Science in Textile Engineering**

DECLARATION

This study was completed under the direction of **Tanvir Ahmed Chowdhury**, Assistant Professor, Department of Textile Engineering, Faculty of Engineering, Daffodil International University. We further state that neither this project nor any part of it has been submitted to any other institution for the award of a degree or diploma.

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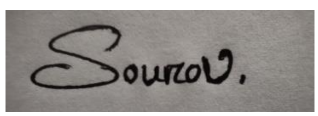

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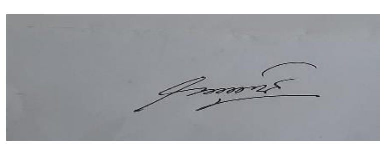
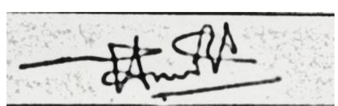


LETTER OF APPROVAL

This project report prepared by **Sourov Kumar Saha** (ID:181-23-5255) and **A.K.M. Mumeenul Huq** (ID:181-23-5310), is approved in Partial Fulfillment of the Requirement for the Degree of BACHELOR OF SCIENCE IN TEXTILE ENGINEERING. Under my direction, the aforementioned students completed their project work. I found them sincere, industrious, and eager during the research period.



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DEDICATION

This project is dedicated to our beloved parents.

ABSTRACT

The pH is a measure of how acidic/basic water is. The range of values is 0 to 14. 7 indicates neutral, below 7 indicates acidic, and over 7 indicates alkaline. Every chemical reaction works best at a specific pH, or acidity level. pH has a great effect on the dyeing process. The importance of pH control in textile wet processing cannot be overstated. Every phase of textile wet processing, such as pre-treatment, dyeing, printing, and finishing, is influenced by pH. The project has been done to find out the effects of pH variation on different types of Polyester fabrics where we used the same brand and same quantity of dyes and sold. Moreover, the ratio of water and fabric was similar for all of those experiments. Here we maintained 3 different pH, those values are 4.0, 4.5, and 5.0. For those experiments, we took 4 different types of fabrics and those are 1. Single Jersey Fabric, 2. 1x1 Rib Fabric, 3. Fleece Fabric, 4. Terry Fabric. As those fabrics' structures are very rare for 100% polyester that's why we took 65%/35% - PC (Polyester and Cotton blended) fabric. Most importantly, we took 3 pieces of fabric sample for every single fabric type. So that we can compare these after dyeing and easily make the variations noticeable. Those fabrics had dyeing by maintaining proper time and temperature. After dyeing, we have done different types of tested by following international rules to find out the variations. We used Spectrophotometer for the CMC test and also tested different types of colorfastness tests like Color Fastness to Rubbing, Color Fastness to Washing, Color Fastness to Water, and Color Fastness to Perspiration for both Acid and Alkali medium. After completing our project word we found out that a lot of changes can occur for pH variation so it's very important to maintain the pH level during the polyester fabric dyeing process.

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CHAPTER-1

INTRODUCTION

The fundamental goal of dyeing is to color the entire material such that the dye particles are entirely absorbed into the fiber and the visible surface is uniformly colored. The color development is the process of creating any color with ternary dyes while adhering to color mixing regulations. The goal of color matching is to replicate any target color. The ability to replicate the same color in a large number of batches is known as color reproducibility. In the dyeing industry, color reproducibility is critical. The dyed batch will be rejected if the intended shade cannot be reproduced completely in terms of color, even if the dying is excellent. As a result, it's critical to understand which factors influence color repeatability. Obviously, good color repeatability is due to dyeing control settings and the material itself. As a result, for polyester dyeing, temperature and time are critical considerations. The pH of disperse dyes is particularly crucial since disperse dyes are known to be unstable in alkali media. Polyester dyeing with dispersion dyes has a number of practical issues. When two polyester fabrics are dyed with the same dispersion dyes in the same shade %, the colors may not be identified only for a little variation of pH value. Because of their superior textile properties and chemical resilience, polyester textiles are the most extensively used synthetic materials. Polyester fabrics are used as dispersion dyes at high temperatures (typically in the range of 115–135°C) and high pressure due to their hydrophobic nature and highly compact structure. Disperse dyes are fundamentally non-ionic, have a low water solubility, and can be utilized in the form of water dispersion. The exhaustion procedure is used to dye polyester fabrics in a slightly acidic media in a water dye bath. Polyester fibers are resistant to dilute aqueous acids and alkaline solutions, and pH has no effect on the dyeing mechanism; however, if the pH is not controlled during aqueous dyeing, many disperse colors will degrade. Some disperse dyes have hydrolysable groups in their molecules, such as the ester group, which renders them particularly vulnerable to hydrolysis, particularly in alkaline environments. In comparison to hydrolyzed dye, the hydrolyzed form of dye may have a distinct color and, in some situations, a different affinity for polyester fibers. As a result, dyeing is done in a slightly acidic solution, usually in the pH range of 4.5–5.5, to reduce the risk of dye hydrolysis.[1] And, in our project word we maintained 3 different values within the pH range.

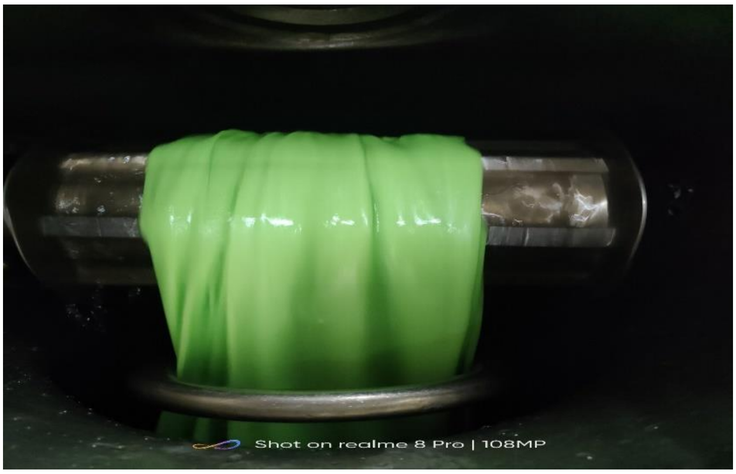


Figure 1.1: Polyester Fabric during Dyeing Process

Objectives:-

The project's main goal is to unveil the effects of pH variation on Polyester fabric's dyeing process. Also besides-

- To compare the shade variations after dyeing as the effect of pH variation.
- To check the color fastness properties after dyeing as the effect of pH variation.
- To find out the reason of uneven shade for pH variation.
- To check the effect of pH variation on fabric surface.
- To determine the most suitable pH value for polyester dyeing process.

CHAPTER – 2
LITERATURE REVIEW

2.1 Disperse dye

Disperse dye is a non-ionic dye. They are water-insoluble. Temperature and pH have a significant impact on dispersed dye. The dyeing parameters are a critical aspect when using Disperse dye. Uneven dyeing might occur if the dyeing parameters are not correctly maintained. It's possible that no dyeing will take place in some circumstances. The influence of temperature and pH on dispersed dye is the topic at hand. This dye is used in conjunction with a dispersing agent for Polyester fabric.

2.1.1 Properties of Disperse Dyes

Disperse dyes are non-ionic dyes. As a result, they are ionizing group-free. They are ready-to-use dyes that are either water insoluble or have a very low water solubility. They are organic coloring agents that can be used to dye hydrophobic fabrics. Man-made cellulose ester and synthetic fibers, particularly acetate and polyester fibers, as well as nylon and acrylic fibers, are dyed with disperse dyes. To dye with disperse dyes, you'll need a carrier or dispersing agent. Light fastness of disperse dyes ranges from fair to good, with a grade of roughly 4-5.

2.1.2 Dyeing Mechanism of Disperse Dye

Dyeing hydrophobic fibers such as polyester fibers using dispersion dyes can be thought of as a dye transfer procedure from a liquid solvent (water) to a solid organic solvent (fiber). To make an aqueous dispersion, disperse dyes are mixed with water and a surface active ingredient. Because disperse dyes are more tenacious to organic fiber than inorganic dye liquor, their insolubility allows them to escape the dye liquor. Heat enhances the energy of dye molecules in the dye liquid, which speeds up the dying of textile fibers. The fiber swells to some amount when the dye liquor heats up, making it easier for the dye to permeate the fiber polymer system. As a result, the dye molecule settles in the amorphous areas of the fiber. The dye molecules are maintained in place within the fiber polymer system by hydrogen bonds and Van Der Waals' force.

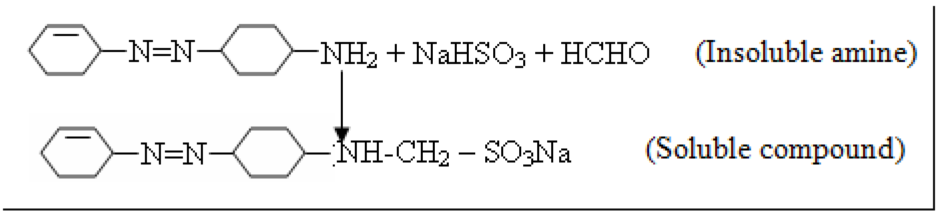


Figure 2.1: Dyeing Mechanism of Disperse Dye

2.2 Details Description of pH Scale:

The pH of water is a measurement of how acidic or basic it is. The scale ranging from 0 to 14, with 7 being the neutral value. Acidity is indicated by a pH less than 7, while a pH greater than 7 indicates a base. pH is a measurement of the proportion of free hydrogen and hydroxyl ions in water. Acidic water contains more free hydrogen ions, whereas basic water contains more free hydroxyl ions. pH is a significant indicator of water that is changing chemically because it is altered by chemicals in the water. The pH scale is measured in "logarithmic units." Each value signifies a 10-fold difference in the water's acidity/basicity. The acidity of water with a pH of five is ten times that of water with a pH of six. Acidic pH is less than 7, while alkaline pH is larger than 7.And, 7 show the neutral value of the solution. [2]

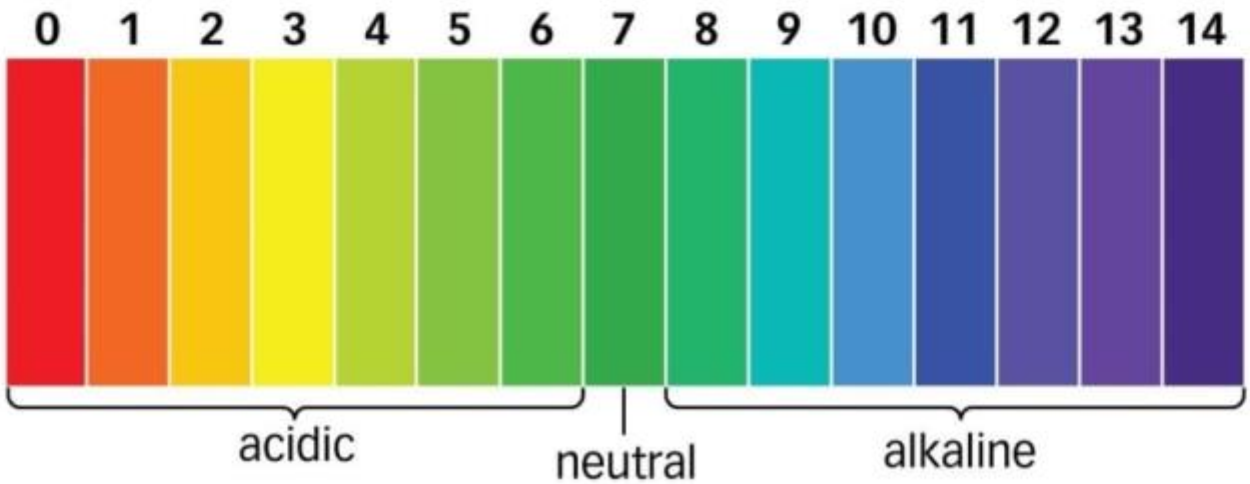


Figure 2.2: pH scale

2.3 Effect of pH in Textile Wet Processing:

Textile wet processing is a complex activity that includes several phenomena occurring at the same time. It includes chemistry, physics, mechanics, fluid mechanics, thermodynamics, and other fields of science. The importance of pH control in textile wet processing cannot be emphasized. Every phase of textile wet processing, such as pre-treatment, dyeing, printing, and finishing, is influenced by pH. In a pH-controlled process, the initial exhaustion value should be chosen so that the initial unleveled is no more than can be quickly remedied by dye migration. The dyeing process is highly influenced by pH. The uptake of basic dyes on polyacrylonitrile fibers, for example, increases when the pH rises. To ensure best stability of both dye and fiber, dyeing PAN fibers with cationic dyes is normally done at a pH of 4–5.5, which is frequently achieved using a buffer system.[3]

2.4 Effect of pH on Polyester Dyeing:

The dye bath should be acidic and the pH should be between 4.5 and 5.5 for disperse dyeing. Acetic acid is commonly used to maintain this pH. Dye exhaustion is satisfactory at this pH. Correct pH must be maintained during color formation; otherwise, color fastness will be compromised, and color will be unstable. The dyeing of polyester fabrics with disperse dyes at high temperatures without carriers and at various dyebath pH ranges was investigated. The nature and position of the dye's substituents were discovered to have a significant impact on the dye's behavior as well as the magnitude of dye uptake at various pH levels. In an acidic medium, substitutes that form lyonium ions produce higher dye uptake in an alkaline medium, while those that form lyate ions in an alkaline medium produce higher dye uptake in an acidic medium. Over a wide range of pH values, substitutes that cannot create lyonium ions or lyate ions provide almost identical dye absorption. For Polyester dyeing during dispersion, colors necessitate an acidic pH. The pH of the dyeing bath should be between 4.5 and 4.7 when the leveling chemicals are introduced. After adding the colors, the pH became 4.2-4.3.[4]

2.5 Shade Variation on Polyester Dyeing

When compared to the approved buyer or manufacturer color standard, to minimize shade variance within a garment and across garments. It is the obligation of the garment maker to guarantee that color consistency is maintained both within and between garments. During factory visits, the buyer may request and inspect continuity records. The following best practice is recommended for ensuring bulk dyeing consistency across fabric mills and garment producers.[5]

CHAPTER-3

EXPERIMENTAL DETAILS

3.1 Material

We collected 3 pieces of sample from every types of knitted fabric so that we could maintain 3 different pH for both of those. As a result we got the higher admissible result from this experiment. And most importantly, we maintained the all process and time during completing the process and until drying after washing the dyed sample by following the dyeing process.

Table 3.1: Specification of samples

Sample No.	Type of Fabric	GSM	Yarn Count
01-03	PC- Single Jersey	180	24
04-06	PC- 1X1 Rib	220	28
07-09	PC- Fleece	240	34
10-12	PC- Terry	200	30

3.2 Used Chemicals

3.2.1 Basic Chemicals:

1. Acetic Acid
2. Hydrochloric
3. Sulphuric Acid
4. Caustic soda
5. Formic acid
6. Hydrogen peroxide
7. Soda ash

3.2.2 Other Chemicals:

1. Leveling Agent
2. Fixing Agent
3. Stabilizer
4. Anti-creasing Agent
5. PH Controller
6. Enzyme
7. Salt[6]

Table 3.2: Chemicals & functions

Serial No.	Name of Chemical	Function
01	Acetic Acid	Acetic acid is commonly used to keep the pH of the solution in balance.
02	Enzyme	It's used to eliminate the hairiness on the fabric's surface.
03	Peroxide killer	Peroxide killer is used to remove any remaining peroxide from the fabric.
04	Anti-creasing Agent	This kind of chemical is used to prevent the cloth from creasing during the manufacturing process.
05	Neutralizing Agent	To adjust or raise the pH level to a more normal level, neutralizing chemicals are utilized.

3.3 Scouring & Bleaching Process[7]

3.3.1 Scouring Process:

The process is done before dyeing and it’s a part of pretreatment. It’s basically done for removing natural or added impurities from fabric like oil, wax, fat, dust, etc.

3.3.1 Bleaching Process:

Bleaching is also a pretreatment process. This process is done to remove natural color. After removing the gray color the fabric gets white effect.

3.4 Pre-treatment before Dyeing

The pre-treatment stage is referred to as the "Heart of Dyeing." The chemicals used to scour and bleach cotton or CVC fibers are generally the same. For each type of fabric, the dosage, temperature, and time are varied. Yarn-dyed fabrics, synthetic fiber-containing fabrics, very dark colors such as blacks and navy, and fabrics to be OBA whitened are pre-treated differently than the other varieties, with different chemicals and conditions to satisfy the demand. [8]

3.5 Objectives of Pre-treatment

1. To prepare for dyeing by remove the natural yellow or grey color.
2. Impurities such as knitting oil, spinning oil, rust, and dirt should just be removed.
3. To remove natural impurities like Pectin, Proteins, Wax, fat, etc.
4. To eliminate as many contaminants from the fiber as feasible, allowing all hydroxyl groups to react with dyes.
5. To keep hazardous inorganic salts from amassing.
6. To demineralize mineral salts.
7. To increase dye absorption and maximize absorbency.
8. To make the fabric ready for dyeing and get the proper shade.

3.6 After treatment Process

1. The fabric is cleaned and treated with a 1g/L soap solution, which removes the unfixed color from the fabric surface.
2. A hot water bath is used to clean the material.
3. A cold-water bath is used to cleanse the material.
4. The material would then be dried in a dryer.[9]

3.7 Polyester Dyeing Process

Dyeing is a step-by-step operation process. The flow chart for the polyester dyeing process after pre-treatment with disperse dyes is shown below: -

Runtime with Dyes
[135^0C – 40min]

↓

Unload and Cold Wash

↓

Reduction
[Caustic Soda -1.5 g/L and Hydrous – 1.5 g/L]

↓

Hot wash [95^0C – 20 min]

↓

Cold wash

↓

Acidic Acid

↓

Cold Wash

↓

Dryer

3.8 Process Curve of Polyester Dyeing [10]

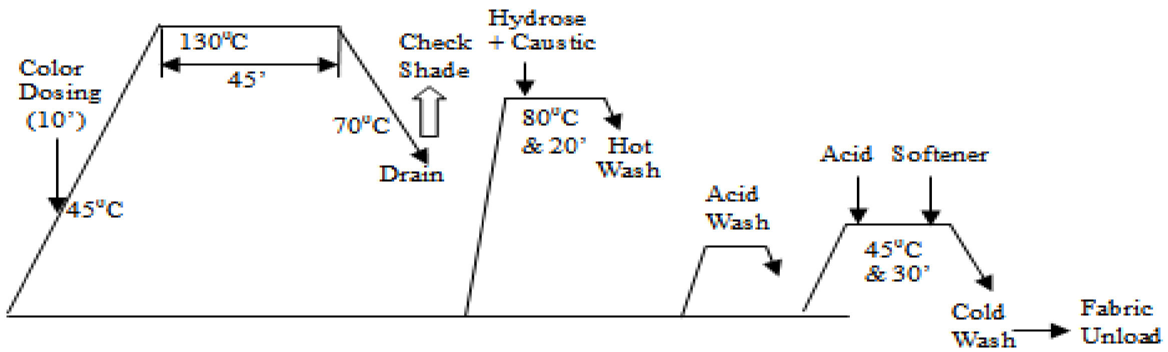


Figure 3.1: Polyester Dyeing Process Curve

3.9 Neutralization Process

Treatment with acetic acid is used to neutralize fabrics. This organic acid can be used to neutralize materials that will be dyed in medium or dark hues. Otherwise, early dyestuff hydrolysis will occur, resulting in uneven dyeing and lighter depths than previous batches, or, in other words, batch to batch fluctuation. The presence of core alkali in the fabric or yarn will have an unfavorable effect on the dyeing, resulting in spotty, uneven coloring. Deeper coloring is more likely to occur in areas where alkali residue is high.[11]

3.9.1 Peroxide Killer

It entails treating the cloth with the catalase enzyme to breakdown the troublesome remaining peroxide oxidant. After dying, this helps prevent blotches, shade or tonal changes, and dye waste.

3.10 Used Dyes and Instrument

Table 3.3: Used Dyes for This Experiment

Serial No.	Name of Dyes	% / g/L	Calculation
01	Dia- L/Yellow-S6G	0.0116%	1.16
02	Dia- Red-SBEL	0.044%	4.4
03	Dia-Blue-CC	0.298%	2.98

Table 3.4: Used Machines for This Experiment

Serial No.	Name of The Machine	Brand Name
01	Dyeing Machine (Lab)	Daelim Starlet - 3
02	Spectrophotometer	NetProfile ready (Color-Eye 70)
03	Light Box	VeriVide
04	Incubator	Lab. Companion
05	Rubbing Tester	Daelim Starlet (DL-2007)

Figure 3.2: Dyeing Machine for Lab

Figure 3.3: Spectrophotometer

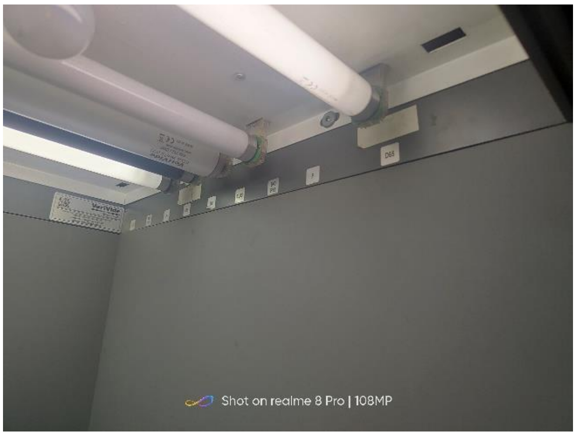


Figure 3.4: Light box

Figure 3.5: Rubbing Tester Machine

Figure 3.6: Incubator

We used Grey Scale for grading the dyed fabric. So that, we could easily find out results:

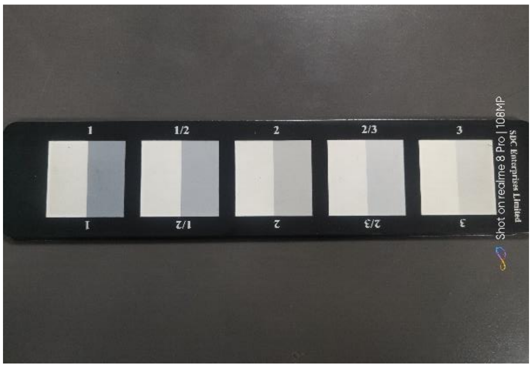


Figure 3.7: Grey Scale

3.11 Sample Attachment

Table 3.4: Sample of dyed S/J Fabric with pH value

1st Sample (pH-4)	2nd Sample (pH-4.5)	3rd Sample (pH-5)
		

Table 3.5: Sample of dyed 1X1 Rib Fabric with pH value

1st Sample (pH-4)	2nd Sample (pH-4.5)	3rd Sample (pH-5)
		

Table 3.6: Sample of dyed Fleece Fabric with pH value

1st Sample (pH-4)	2nd Sample (pH-4.5)	3rd Sample (pH-5)
		

Table 3.7: Sample of dyed Terry Fabric with pH value

1st Sample (pH-4)	2nd Sample (pH-4.5)	3rd Sample (pH-5)
		

CHAPTER – 4
DISCUSSION OF RESULT

4.1 Details Result about Dyed Polyester Fabric

After completing the dyeing process we have tested all of those dyed fabric by following the guideline of ISO. And also tried to compare the results to understand the impact of pH on dyeing process. For CMC (Color Matching Cabinet) test, we used Spectrophotometer. We got all of those CMC report under D-65 light source. For every types of fabric we had 3 samples those had dyed by maintaining 3 different pH. That's why, from every types of fabric we considered one as a standard. Specifically, from every fabric type we consider the sample as standard which one had been dyed by maintaining pH 4. So that, we can compare those 3 between one to another. Then, we tried to get fastness test result of those dyed sample. Here we have tested color fastness to rubbing, color fastness to washing, color fastness to water, color fastness to perspiration (Acid), color fastness to perspiration (Alkali).For those test we used Incubator and Rubbing machine. After that, we have graded those fastness quality by using Grey scale. The result is given below in details:

4.1.1 CMC Result

The CMC testing equipment can be utilized for a variety of test applications in order to meet color consistency and quality testing criteria. Multiple light sources or lamps are used to create diverse light patterns for the fabrics in order to detect the Metamerism problem. There are some parameters to compare the result.[8] Those are:

DE/ Delta E (Color Difference) = value; 0-1= Pass, Above 1 = Fail
DL / Delta L (Lightness or Darkness) = value; - (Deep) / + (Light)
Da / Delta a (Reddish ness or Greenish-ness) = value; - (Greenish) / + (Redish)
Db / Delta b (Yellow ness or Blueness) = value; - (Blush) / + (Yellowish)
DC (Chroma) = value; - (Dull) / + (Bright)
DH (All over view)
Metamerism
DEcmc (All over calculation)

All of those parameter has different tolerance value. After getting the value from dyed fabric it would compared with the tolerance value then the Spectrophotometer showed the DEcmc result; was it passed or Failed.

Table 4.1: CMC report of S/J dyed fabric

Sample No.	pH	DL*	Da*	Db*	DC*	DH*	DCcmc	MI-(1-2)	P/F DEcmc
01.	4	0.75 L	-0.14 G	0.39 D	-0.28 D	-0.12 G	-0.14 D	0.09	Passed
02.	4.5	-1.06 D	-0.04 G	0.49 D	-0.48 D	-0.05 G	-0.24 D	0.11	Passed
03.	5	0.58 L	-0.18 G	0.09 D	-0.08 D	-0.18 G	-0.04 D	0.01	Passed

Hare we can see the CMC report of 3 Single Jersey polyester dyed fabric. We considered the sample no. 1 as a standard sample then we got the value of all parameters and took 2 others value by Spectrophotometer. And after compare those values with the tolerance value we got the DEcmc result. And all of 3 are passed here. But the noticeable point is, for every sample all of those values are different.

Table 4.2: CMC report of 1X1 Rib dyed fabric

Sample No.	pH	DL*	Da*	Db*	DC*	DH*	DCcmc	MI-(1-2)	P/F DEcmc
04.	4	-0.27 D	0.22 R	-0.32 B	0.35 B	0.12 R	0.12 B	0.08	Passed
05.	4.5	-0.35 D	0.20 R	-0.18 B	0.18 B	0.20 R	0.09 B	0.01	Passed
06.	5	-0.02 D	0.26 R	-0.34 B	0.35 B	0.25 R	0.17 D	0.11	Passed

Hare we can see the CMC report of 3 1X1 Rib polyester dyed fabric. We considered the sample no. 04 as a standard sample. The compare all of 3 sample's value with the tolerance we got the DEcmc report. Though all of those parameter given different value but the final value of all 3 are passed.

Table 4.3: CMC report of Fleece dyed fabric

Sample No.	pH	DL*	Da*	Db*	DC*	DH*	DCcmc	MI-(1-2)	P/F DEcmc
07.	4	0.52 L	0.22 R	-0.28 B	0.56 D	0.24 R	0.22 B	0.11	Passed
08.	4.5	0.05 L	0.26 R	-0.37 B	0.35 D	0.27 R	0.18 B	0.07	Passed
09.	5	2.58 L	-1.30 G	1.32 Y	-1.26 D	-1.35 G	-0.62 D	0.29	Failed

Hare we can see the CMC report of 3 Fleece polyester dyed fabric. We considered the sample no. 07 as a standard which one have dyed by maintaining the pH value 4. Then we collected the value of all parameters and took 2 others value by Spectrophotometer. And after compare those values with the tolerance value we got the DEcmc result. Though 1st 2 are passed but the last one is failed. It's a huge point to notice from this experiment.

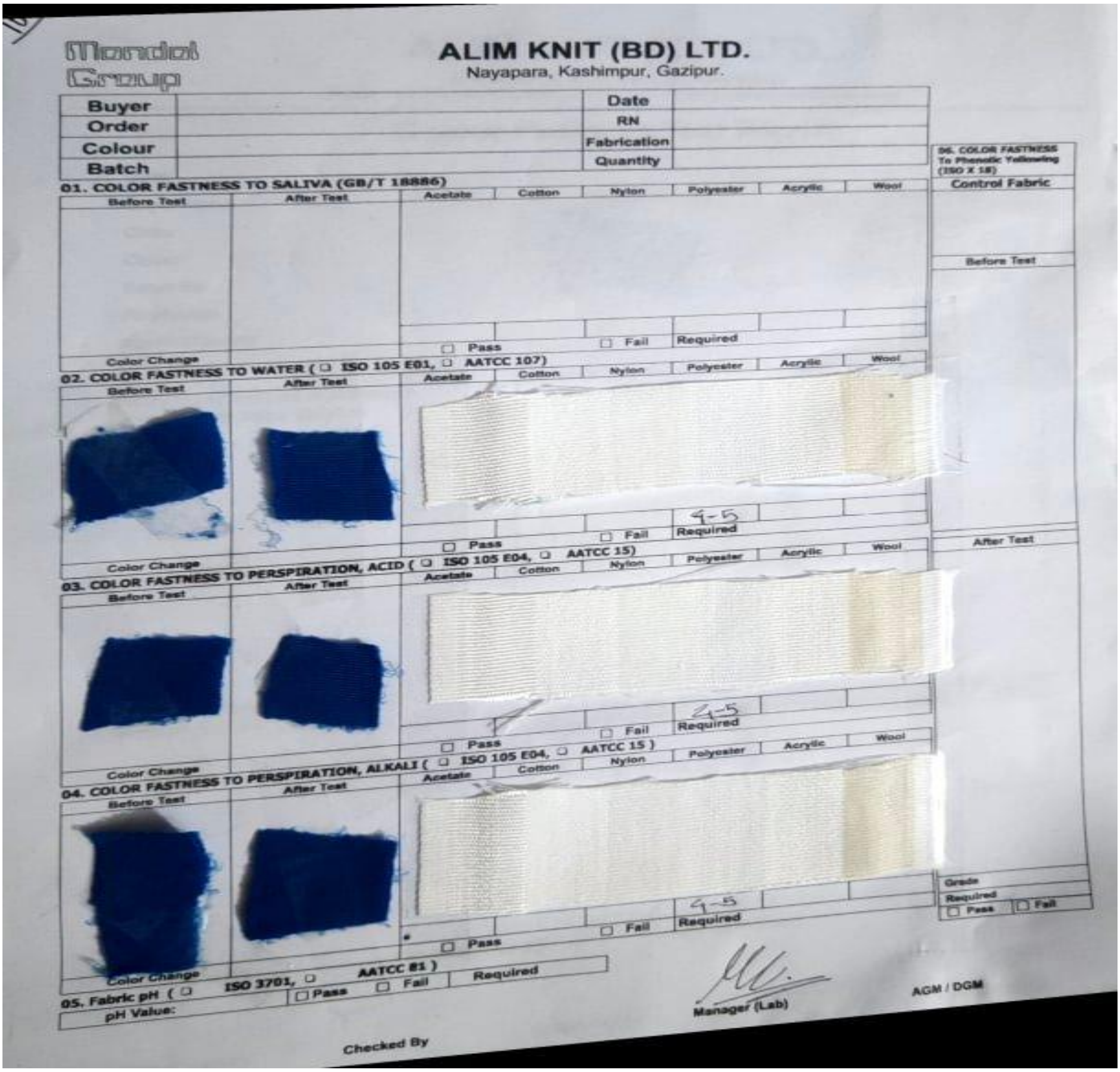
Table 4.4: CMC report of Terry dyed fabric

Sample No.	pH	DL*	Da*	Db*	DC*	DH*	DCcmc	MI-(1-2)	P/F DEcmc
10.	4	-0.47 D	0.40 R	-0.28 B	0.49 B	0.12 R	0.27 B	0.11	Passed
11.	4.5	-0.21 D	0.32 R	-0.65 B	0.65 B	0.32 R	0.32 B	0.13	Passed
12.	5	-0.68 D	0.52 R	0.04 Y	0.04 D	0.52 R	-0.02 D	0.10	Passed

Hare we can see the CMC report of 3 Terry polyester dyed fabric. We considered the sample no. 10 as a standard sample. By Spectrophotometer, all values with the tolerance value theses we got have compered. Then we got the DEcmc result for all of three. And all of 3 are passed here.

4.1.2 Color Fastness Test

The resistance of a fabric to changing its color properties or transferring its colorant(s) to adjacent materials is known as color fastness. Color fastness refers to a textile's resistance to fading or bleeding due to various agents such as light, wash, water, perspiration, rubbing, acid, alkali, hot pressing, bleaching, and so on. One of our fastness reports is given below:



Mondol Group

ALIM KNIT (BD) LTD.
Nayapara, Kashimpur, Gazipur.

Buyer		Date	
Order		RN	
Colour		Fabrication	
Batch		Quantity	

01. COLOR FASTNESS TO SALIVA (GB/T 18886)
Before Test | After Test | Acetate | Cotton | Nylon | Polyester | Acrylic | Wool
Color Change | ☐ Pass | ☐ Fail | Required

02. COLOR FASTNESS TO WATER (☐ ISO 105 E01, ☐ AATCC 107)
Before Test | After Test | Acetate | Cotton | Nylon | Polyester | Acrylic | Wool
4-5
Color Change | ☐ Pass | ☐ Fail | Required

03. COLOR FASTNESS TO PERSPIRATION, ACID (☐ ISO 105 E04, ☐ AATCC 15)
Before Test | After Test | Acetate | Cotton | Nylon | Polyester | Acrylic | Wool
4-5
Color Change | ☐ Pass | ☐ Fail | Required

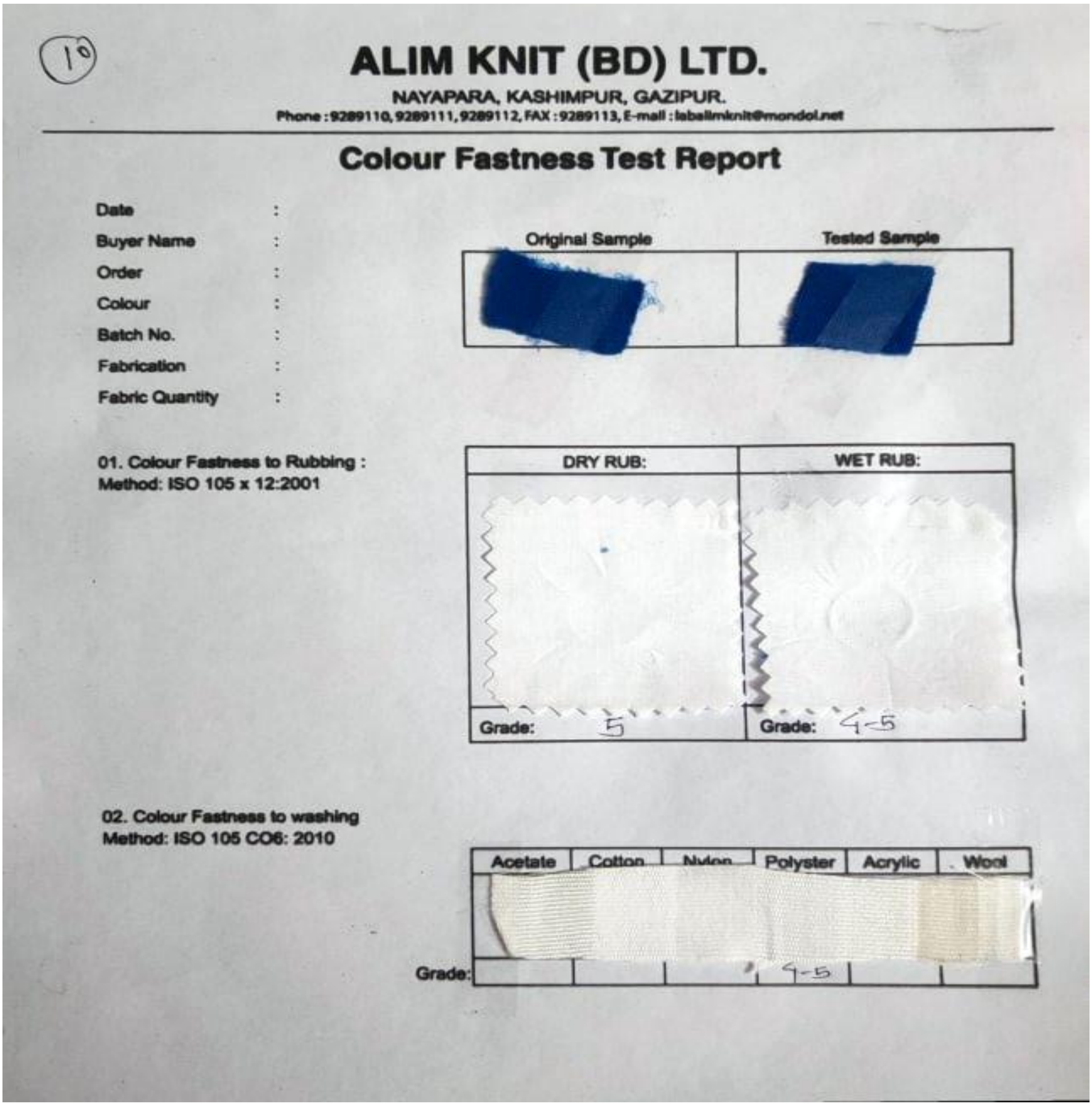
04. COLOR FASTNESS TO PERSPIRATION, ALKALI (☐ ISO 105 E04, ☐ AATCC 15)
Before Test | After Test | Acetate | Cotton | Nylon | Polyester | Acrylic | Wool
4-5
Color Change | ☐ Pass | ☐ Fail | Required

05. Fabric pH (☐ ISO 3701, ☐ AATCC 81) | Required
pH Value: | ☐ Pass | ☐ Fail

06. COLOR FASTNESS To Phenolic Yellowing (ISO X 18)
Control Fabric
Before Test
After Test
Grade
Required
☐ Pass ☐ Fail

Checked By | Manager (Lab) | AGM / DGM

Figure 4.1: Report of Color Fastness to Water and Perspiration for sample no. 10



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Colour Fastness Test Report

Date :
Buyer Name :
Order :
Colour :
Batch No. :
Fabrication :
Fabric Quantity :

Original Sample	Tested Sample

01. Colour Fastness to Rubbing :
Method: ISO 105 x 12:2001

DRY RUB:	WET RUB:
Grade: 5	Grade: 4-5

02. Colour Fastness to washing
Method: ISO 105 CO6: 2010

	Acetate	Cotton	Nylon	Polyster	Acrylic	Wool
Grade:				4-5		

Figure 4.2: Report of Color Fastness to Wash and Rubbing for sample no. 10

4.1.2.1 More Details about Color Fastness Report

To ensure consumer satisfaction with fabric products, color fastness validation is essential. One of the key concerns of textile importers is color fastness while washing. Throughout its existence, a textile item must be able to endure repeated washing without losing its color or staining other items washed with it. The crocking test evaluates a textile's resistance to rubbing off and staining other fabrics. The color fastness to perspiration test determines the resistance of textile colors to human perspiration. For Rubbing test, We have used sand paper and took 10 cycle on fabric and for other fastness test we have used Multifiber fabric. Then we have graded those by using Grey Scale.

Table 4.5: Fastness test report of Single Jersey polyester dyed fabric

Sample No.	pH	Color Fastness to Water	Color Fastness to Wash	Color Fastness to Rubbing	Color Fastness to Perspiration (Acid)	Color Fastness to Perspiration (Alkali)
01.	4	4-5	4-5	5	4-5	4-5
02.	4.5	4-5	4-5	5	4-5	4-5
03.	5	4-5	4-5	5	4-5	4-5

Color fastness of all single jersey fabrics are good enough. And there is nothing highlight able for pH variation.

Table 4.6: Fastness test report of 1X1 Rib polyester dyed fabric

Sample No.	pH	Color Fastness to Water	Color Fastness to Wash	Color Fastness to Rubbing	Color Fastness to Perspiration (Acid)	Color Fastness to Perspiration (Alkali)
04.	4	4-5	4-5	4-5	4-5	4-5
05.	4.5	4-5	4-5	4-5	4-5	4-5
06.	5	4-5	4-5	4-5	4-5	4-5

Color fastness properties are fine for all of those 1X1 Rib fabric when pH was different.

Table 4.7: Fastness test report of Fleece polyester dyed fabric

Sample No.	pH	Color Fastness to Water	Color Fastness to Wash	Color Fastness to Rubbing	Color Fastness to Perspiration (Acid)	Color Fastness to Perspiration (Alkali)
07.	4	4-5	4-5	4-5	4-5	4-5
08.	4.5	4-5	4-5	4-5	4-5	4-5
09.	5	4-5	4-5	4-5	4-5	4-5

All of those color fastness properties are well enough for Fleece fabric. All of those grade are 4-5.

Table 4.8: Fastness test report of Terry polyester dyed fabric

Sample No.	pH	Color Fastness to Water	Color Fastness to Wash	Color Fastness to Rubbing	Color Fastness to Perspiration (Acid)	Color Fastness to Perspiration (Alkali)
10.	4	4-5	4-5	4-5	4-5	4-5
11.	4.5	4-5	4-5	4-5	4-5	4-5
12.	5	4-5	4-5	4-5	4-5	4-5

For all of those three Terry dyed fabric's color fastness properties grade are 4-5. So, it's excellent.

4.2 Final Discussion on our experimental Result

Color fastness in textiles is one of the most fundamental tests that must be conducted on items to guarantee that their color is fast enough to withstand various processes like as rubbing, washing, and other conditions during use. The color of the fabric specimen after testing is compared to a "Grey Scale for Color Change" and a "Grey Scale for Staining" in most ISO and AATCC color fastness tests. On a scale of 1 (most change) to 5 (least change), the Grey Scale for Color Change rates the specimen's color fading (no change). From 1 (most color transfer) to 5 (least color transfer), the Grey Scale for Staining evaluates the staining of an undyed material tested with the specimen (no color transfer). After studies of those test result we can say all types of our tested Polyester fabrics has strong color fastness ability. But the point to highlight that due to pH variation CMC result can fluctuated and sometimes it can break the buyer's standardized limit like our 9th sample (Fleece Fabric- pH:5) .So a total shipment can get canceled ! So it's a big deal to maintain the actual pH during dyeing.

CHAPTER – 5
CONCLUSION

We learned a lot about dyeing polyester with disperse dyes as a result of this project. After dyeing process it's very important to test the dyeing properties and quality of dyed fabric. Without achieving the proper shade it's totally useless to do the process. After getting the shade there are many test to check the dyeing quality like color fastness to wash, color fastness to rubbing, color fastness to perspiration, CMC etc. Depending on the design and intended usage of your textile items, some color fastness tests may be more significant to you than others. But those fastness quality and better quality dyeing depends on some criteria. pH is one the most important thing for the perfect dyeing like the proper shade. Until end of the process, it's too important to maintain the pH value for every process. For Polyester dying process with disperse dyes requires an acidic pH. The range of pH value for perfect polyester dyeing is 4-5. The pH of the dyeing bath should be between 4.5 and 4.7 when the leveling chemicals are injected. After applying the dyes, the pH remained 4.2-4.3. More details about our dyed fabrics are given below: -

- As we have used 4 different types of fabric and took 3 samples from each type, and for every single sample we maintained 3 different pH value (4, 4.5, 5). So the shade weren't same for every types of fabric.
- During CMC test, we got different value for different samples, though the type of those samples were same. Such as, for S/J fabric; the DCcmc value of sample's 2 was -0.24 D and the maintained value for the sample dying process was 4.5. But for the sample type of fabric where we used the same quantity of dyes and just changed the pH value to 5; then the DCcmc value was -0.04 for the sample no. 3. So, it's a noticeable point of our project.
- From CMC test report, we got the final P/F DEcmc result. The result is given after verifying all of those parameter and those parameter has different tolerance value. Metamerism is one other most important parameter in this test. Highlighting point of the fleece dyed fabric is; the final CMC result of 8th and 9th sample is respectively Passed and Failed. For the 8th sample the maintained pH was 4.5 and for the 9th, the pH value was 5. So, we can say pH has directly impact on polyester fabric dyeing process.
- For the colorfastness test, we had to be more careful for grading. Basically, we have tested 5 different types of fastness test. And the tested results were almost same for all of those fabrics and all of those samples. But the fastness quality of S/J fabric was better than others fabric. Actually, Polyester fabric has better color fastness properties that's why it has shown the better quality fastness result. But it the pH would be higher than 5 or lower than 4 the result might be changed. Because pH really has huge impact on Polyester fabric dyeing process.

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Faculty of Engineering Department of Textile Engineering Report on STUDIES ON THE EFFECT OF DYEING POLYESTER FABRIC WITH DISPERSE DYE. Course code: TE-4214 Course title: Project (Thesis) Submitted by: Student's Name Student's ID Sourov Kumar Saha 181-23-5255 A.K.M. Mumeenul Huq 181-23-5310 Supervised by: Mr. Tanvir Ahmed Chowdhury Assistant Professor Department of Textile Engineering Daffodil International University The project has submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Textile Engineering DECLARATION This study was completed under the direction of Tanvir Ahmed Chowdhury, Assistant Professor, Department of Textile Engineering, Faculty of Engineering, Daffodil International University. We further state that neither this project nor any part of it has been submitted to any other institution for the award of a degree or diploma. Sourov Kumar Saha ID: 181-23-5255 Department of TE Daffodil International University A.K.M. Mumeenul Huq ID: 181-23-5310 Department of TE Daffodil International University ii LETTER OF APPROVAL This project report prepared by Sourov Kumar Saha (ID:181-23-5255) and A.K.M. Mumeenul Huq (ID:181-23-5310), is approved in Partial Fulfillment of the Requirement for the Degree of BACHELOR OF SCIENCE IN TEXTILE ENGINEERING. Under my direction, the aforementioned students completed their project work. I found them sincere, industrious, and eager during the research period.

MR. TANVIR AHMED CHOWDHURY ASSISTANT PROFESSOR DEPARTMENT OF TEXTILE ENGINEERING FACULTY OF ENGINEERING DAFFODIL INTERNATIONAL UNIVERSITY iii ACKNOWLEDGEMENT First of all, we are grateful to the Almighty for the good health and well-being that were necessary to complete this project. We are also thankful to our parents for their unceasing encouragement, support, and attention. They are bearing all of our study costs. I wish to express my sincere thanks to Dr. Md. Sabur Khan, Founder & Chairman, Daffodil Family. I place on record, my sincere thank you to Professor Dr. M. Lutfar Rahman, Vice- Chancellor of Daffodil International University (DIU), Dhaka. I would like to express my sincere thank you to Professor Dr. M. Shamsul Alam, Dean of The Engineering Faculty, for continuous encouragement. I take this opportunity to express gratitude to Md. Mominur Rahman, Head (In-Charge), and Assistant Proctor. We are grateful to our supervisor Mr. Tanvir Ahmed Chowdhury, Assistant Professor, Department of Textile Engineering, Faculty of Engineering, Daffodil International University. I wanna say thanks for his valuable and constructive suggestions during the planning and development of this research work. His willingness to give his time so generously has been very much appreciated. Special thanks to Omar Shakhawat (Sunny), Manager Fabric Processing, Alim Knit (BD) Ltd. He gave the opportunity to complete all of those dyeing and test in their lab. And, I also place on record, my sense of gratitude to one and all, who directly or indirectly, have lent their hand in this venture. Finally, thanks to all of our classmates for their mental support, strength, and assistance throughout writing the project report. iv DEDICATION This project is dedicated to our beloved parents. v ABSTRACT The pH is a measure of how acidic/basic water is. The range of values is 0 to 14. 7 indicates neutral, below 7 indicates acidic, and over 7 indicates alkaline. Every chemical reaction works best at a specific pH, or acidity level. pH has a great effect on the dyeing process. The importance of pH control in textile wet processing cannot be overstated. Every phase of textile wet processing, such as pre-treatment, dyeing, printing, and finishing, is influenced by pH. The project has been done to find out the effects of pH variation on different types of Polyester fabrics where we used the same brand and same quantity of dyes and sold. Moreover, the ratio of water and fabric was similar for all of those experiments. Here we maintained 3 different pH, those values are 4.0, 4.5, and 5.0. For those experiments, we took 4 different types of fabrics and those are 1. Single Jersey Fabric, 2. 1x1 Rib Fabric, 3. Fleece Fabric, 4. Terry Fabric. As those fabrics' structures are very rare for 100% polyester that's why we took 65%/35% - PC (Polyester and Cotton blended) fabric. Most importantly, we took 3 pieces of fabric sample for every single fabric type. So that we can compare these after dyeing and easily make the variations noticeable. Those fabrics had dyeing by maintaining proper time and temperature. After dyeing, we have done different types of tested by following international rules to find out the variations. We used Spectrophotometer for the CMC test and also tested different types of colorfastness tests like Color Fastness to Rubbing, Color Fastness to Washing, Color Fastness to Water, and Color Fastness to Perspiration for both Acid and Alkali medium. After completing our project word we found out that a lot of changes can occur for pH variation so it's very important to maintain the pH level during the polyester fabric dyeing process. vi Table of Contents

 CHAPTER-1 INTRODUCTION 1 The fundamental goal of dyeing is to color the entire material such that the dye particles are entirely absorbed into the fiber and the visible surface is uniformly colored. The color development is the process of creating any color with ternary dyes while adhering to color mixing regulations. The goal of color matching is to replicate any target color. The ability to replicate the same color in a large number of batches is known as color reproducibility. In the dyeing industry, color reproducibility is critical. The dyed batch will be rejected if the intended shade cannot be reproduced completely in terms of color, even if the dying is excellent. As a result, it's critical to understand which factors influence color repeatability. Obviously, good color repeatability is due to dyeing control settings and the material itself. As a result, for polyester dyeing, temperature and time are critical considerations. The pH of disperse dyes is particularly crucial since disperse dyes are known to be unstable in alkali media. Polyester dyeing with dispersion dyes has a number of practical issues. When two polyester fabrics are dyed with the same dispersion dyes in the same shade %, the colors may not be identified only for a little variation of pH value. Because of their superior textile properties and chemical resilience, polyester textiles are the most extensively used synthetic materials. Polyester fabrics are used as dispersion dyes at high temperatures (typically in the range of 115–135°C) and high pressure due to their hydrophobic nature and highly compact structure. Disperse dyes are fundamentally non-ionic, have a low water solubility, and can be utilized in the form of water dispersion. The exhaustion procedure is used to dye polyester fabrics in a slightly acidic media in a water dye bath. Polyester fibers are resistant to dilute aqueous acids and alkaline solutions, and pH has no effect on the dyeing mechanism; however, if the pH is not controlled during aqueous dyeing, many disperse colors will degrade. Some disperse dyes have hydrolysable groups in their molecules, such as the ester group, which renders them particularly vulnerable to hydrolysis, particularly in alkaline environments. In comparison to hydrolyzed dye, the hydrolyzed form of dye may have a distinct color and, in some situations, a different affinity for polyester fibers. As a result, dyeing is done in a slightly acidic solution, usually in the pH range of 4.5–5.5, to reduce the risk of dye hydrolysis.[1] And, in our project word we maintained 3 different values within the pH range. 2 Figure 1.1: Polyester Fabric during Dyeing Process Objectives:- The project's main goal is to unveil the effects of pH variation on Polyester fabric's dyeing process. Also besides- ? To compare the shade variations after dyeing as the effect of pH variation. ? To check the color fastness properties after dyeing as the effect of pH variation. ? To find out the reason of uneven shade for pH variation. ? To check the effect of pH variation on fabric surface. ? To determine the most suitable pH value for polyester dyeing process. 3 "©Daffodil International University" CHAPTER – 2 LITERATURE REVIEW 2.1 Disperse dye Disperse dye is a non-ionic dye. They are water-insoluble. Temperature and pH have a significant impact on dispersed dye. The dyeing parameters are a critical aspect when using Disperse dye. Uneven dyeing might occur if the dyeing parameters are not correctly maintained. It's possible that no dyeing will take place in some circumstances. The influence of temperature and pH on dispersed dye is the topic at hand. This dye is used in conjunction with a dispersing agent for Polyester fabric. 2.1.1 Properties of Disperse Dyes Disperse dyes are non-ionic dyes. As a result, they are ionizing group-free. They are ready-to-use dyes that are either water insoluble or have a very low water solubility. They are organic coloring agents that can be used to dye hydrophobic fabrics. Man-made cellulose ester and synthetic fibers, particularly acetate and polyester fibers, as well as nylon and acrylic fibers, are dyed with disperse dyes. To dye with disperse dyes, you'll need a carrier or dispersing agent. Light fastness of disperse dyes ranges from fair to good, with a grade of roughly 4-5. 2.1.2 Dyeing Mechanism of Disperse Dye Dyeing hydrophobic fibers such as polyester fibers using dispersion dyes can be thought of as a dye transfer procedure from a liquid solvent (water) to a solid organic solvent (fiber). To make an aqueous dispersion, disperse dyes are mixed with water and a surface active ingredient. Because disperse dyes are more tenacious to organic fiber than inorganic dye liquor, their insolubility allows them to escape the dye liquor. Heat enhances the energy of dye molecules in the dye liquid, which speeds up the dying of textile fibers. The fiber swells to some amount when the dye liquor heats up, making it easier for the dye to permeate the fiber polymer system. As a result, the dye molecule settles in the amorphous areas of the fiber. The dye molecules are maintained in place within the fiber polymer system by hydrogen bonds and Van Der Waals' force. Figure 2.1: Dyeing Mechanism of Disperse Dye 2.2 Details Description of pH Scale: The pH of water is a measurement of how acidic or basic it is. The scale ranging from 0 to 14, with 7 being the neutral value. Acidity is indicated by a pH less than 7, while a pH greater than 7 indicates a base. pH is a measurement of the proportion of free hydrogen and hydroxyl ions in water. Acidic water contains more free hydrogen ions, whereas basic water contains more free hydroxyl ions. pH is a significant indicator of water that is changing chemically because it is altered by chemicals in the water. The pH scale is measured in "logarithmic units." Each value signifies a 10-fold difference in the water's acidity/basicity. The acidity of water with a pH of five is ten times that of water with a pH of six. Acidic pH is less than 7, while alkaline pH is larger than 7.And, 7 show the neutral value of the solution. [2] Figure 2.2: pH scale 2.3 Effect of pH in Textile Wet Processing: Textile wet processing is a complex activity that includes several phenomena occurring at the same time. It includes chemistry, physics, mechanics, fluid mechanics, thermodynamics, and other fields of science. The importance of pH control in textile wet processing cannot be emphasized. Every phase of textile wet processing, such as pre-treatment, dyeing, printing, and finishing, is influenced by pH. In a pH-controlled process, the initial exhaustion value should be chosen so that the initial unleveled is no more than can be quickly remedied by dye migration. The dyeing process is highly influenced by pH. The uptake of basic dyes on polyacrylonitrile fibers, for example, increases when the pH rises. To ensure best stability of both dye and fiber, dyeing PAN fibers with cationic dyes is normally done at a pH of 4–5.5, which is frequently achieved using a buffer system.[3] 2.4 Effect of pH on Polyester Dyeing: The dye bath should be acidic and the pH should be between 4.5 and 5.5 for disperse dyeing. Acetic acid is commonly used to maintain this pH. Dye exhaustion is satisfactory at this pH. Correct pH must be maintained during color formation; otherwise, color fastness will be compromised, and color will be unstable. The dyeing of polyester fabrics with disperse dyes at high temperatures without carriers and at various dyebath pH ranges was investigated. The nature and position of the dye's substituents were discovered to have a significant impact on the dye's behavior as well as the magnitude of dye uptake at various pH levels. In an acidic medium, substitutes that form lyonium ions produce higher dye uptake in an alkaline medium, while those that form lyate ions in an alkaline medium produce higher dye uptake in an acidic medium. Over a wide range of pH values, substitutes that cannot create lyonium ions or lyate ions provide almost identical dye absorption. For Polyester dyeing during dispersion, colors necessitate an acidic pH. The pH of the dyeing bath should be between 4.5 and 4.7 when the leveling chemicals are introduced. After adding the colors, the pH became 4.2-4.3.[4] 2.5 Shade Variation on Polyester Dyeing When compared to the approved buyer or manufacturer color standard, to minimize shade variance within a garment and across garments. It is the obligation of the garment maker to guarantee that color consistency is maintained both within and between garments. During factory visits, the buyer may request and inspect continuity records. The following best practice is recommended for ensuring bulk dyeing consistency across fabric mills and garment producers.[5] CHAPTER-3 EXPERIMENTAL DETAILS 3.1 Material We collected 3 pieces of sample from every types of knitted fabric so that we could maintain 3 different pH for both of those. As a result we got the higher admissible result from this experiment. And most importantly, we maintained the all process and time during completing the process and until drying after washing the dyed sample by following the dyeing process. Table 3.1: Specification of samples Sample No. Type of Fabric GSM Yarn Count 01-03 PC- Single Jersey 180 24 04-06 PC- 1X1 Rib 220 28 07-09 PC- Fleece 240 34 10-12 PC- Terry 200 30 3.2 Used Chemicals 3.2.1 Basic Chemicals: 1. Acetic Acid 2. Hydrochloric 3. Sulphuric Acid 4. Caustic soda 5. Formic acid 6. Hydrogen peroxide 7. Soda ash 3.2.2 Other Chemicals: 1. Leveling Agent 2. Fixing Agent 3. Stabilizer 4. Anti-creasing Agent 5. PH Controller 6. Enzyme 7. Salt[6] Table 3.2: Chemicals & functions Serial No. Name of Chemical Function 01 Acetic Acid Acetic acid is commonly used to keep the pH of the solution in balance. 02 Enzyme It's used to eliminate the hairiness on the fabric's surface. 03 Peroxide killer Peroxide killer is used to remove any remaining peroxide from the fabric. 04 Anti-creasing Agent This kind of chemical is used to prevent the cloth from creasing during the manufacturing process. 05 Neutralizing Agent To adjust or raise the pH level to a more normal level, neutralizing chemicals are utilized. 3.3 Scouring & Bleaching Process[7] 3.3.1 Scouring Process: The process is done before dyeing and it’s a part of pretreatment. It’s basically done for removing natural or added impurities from fabric like oil, wax, fat, dust, etc. 3.3.1 Bleaching Process: Bleaching is also a pretreatment process. This process is done to remove natural color. After removing the gray color the fabric gets white effect. 3.4 Pre-treatment before Dyeing The pre-treatment stage is referred to as the "Heart of Dyeing." The chemicals used to scour and bleach cotton or CVC fibers are generally the same. For each type of fabric, the dosage, temperature, and time are varied. Yarn-dyed fabrics, synthetic fiber-containing fabrics, very dark colors such as blacks and navy, and fabrics to be OBA whitened are pre- treated differently than the other varieties, with different chemicals and conditions to satisfy the demand. [8] 3.5 Objectives of Pre-treatment 1. To prepare for dyeing by remove the natural yellow or grey color. 2. Impurities such as knitting oil, spinning oil, rust, and dirt should just be removed. 3. To remove natural impurities like Pectin, Proteins, Wax, fat, etc. 4. To eliminate as many contaminants from the fiber as feasible, allowing all hydroxyl groups to react with dyes. 5. To keep hazardous inorganic salts from amassing. 6. To demineralize mineral salts. 7. To increase dye absorption and maximize absorbency. 8. To make the fabric ready for dyeing and get the proper shade. 3.6 After treatment Process 1. The fabric is cleaned and treated with a 1g/L soap solution, which removes the unfixed color from the fabric surface. 2. A hot water bath is used to clean the material. 3. A cold-water bath is used to cleanse the material. 4. The material would then be dried in a dryer.[9] 3.7 Polyester Dyeing Process Dyeing is a step-by-step operation process. The flow chart for the polyester dyeing process after pre- treatment with disperse dyes is shown below: - Runtime with Dyes [1350C – 40min] Unload and Cold Wash Reduction [Caustic Soda -1.5 g/L and Hydrous – 1.5 g/L] Hot wash [950C – 20 min] “©Daffodil International University” Cold wash Acidic Acid Cold Wash Dryer 3.8 Process Curve of Polyester Dyeing [10] Figure 3.1: Polyester Dyeing Process Curve 3.9 Neutralization Process Treatment with acetic acid is used to neutralize fabrics. This organic acid can be used to neutralize materials that will be dyed in medium or dark hues. Otherwise, early dyestuff hydrolysis will occur, resulting in uneven dyeing and lighter depths than previous batches, or, in other words, batch to batch fluctuation. The presence of core alkali in the fabric or yarn will have an unfavorable effect on the dyeing, resulting in spotty, uneven coloring. Deeper coloring is more likely to occur in areas where alkali residue is high.[11] 3.9.1 Peroxide Killer It entails treating the cloth with the catalase enzyme to breakdown the troublesome remaining peroxide oxidant. After dying, this helps prevent blotches, shade or tonal changes, and dye waste. “©Daffodil International University” 3.10 Used Dyes and Instrument Table 3.3: Used Dyes for This Experiment Serial No. Name of Dyes % / g/L Calculation 01 Dia- L/Yellow-S6G 0.0116% 1.16 02 Dia- Red-SBEL 0.044% 4.4 03 Dia-Blue-CC 0.298% 2.98 Table 3.4: Used Machines for This Experiment Serial No. Name of The Machine Brand Name 01 Dyeing Machine (Lab) Daelim Starlet - 3 02 Spectrophotometer NetProfile ready (Color-Eye 70) 03 Light Box VeriVide 04 Incubator Lab. Companion 05 Rubbing Tester Daelim Starlet (DL-2007) Figure 3.2: Dyeing Machine for Lab Figure 3.3: Spectrophotometer “©Daffodil International University” Figure 3.4: Light box Figure 3.5: Rubbing Tester Machine Figure 3.6: Incubator We used Grey Scale for grading the dyed fabric. So that, we could easily find out results: Figure 3.7: Grey Scale “©Daffodil International University” 3.11 Sample Attachment Table 3.4: Sample of dyed S/J Fabric with pH value 1st Sample (pH-4) 2nd Sample (pH-4.5) 3rd Sample (pH-5) Table 3.5: Sample of dyed 1X1 Rib Fabric with pH value 1st Sample (pH-4) 2nd Sample (pH-4.5) 3rd Sample (pH-5) “©Daffodil International University” Table 3.6: Sample of dyed Fleece Fabric with pH value 1st Sample (pH-4) 2nd Sample (pH-4.5) 3rd Sample (pH-5) Table 3.7: Sample of dyed Terry Fabric with pH value 1st Sample (pH-4) 2nd Sample (pH-4.5) 3rd Sample (pH-5) "©Daffodil International University" CHAPTER – 4 DISCUSSION OF RESULT "©Daffodil International University" 4.1 Details Result about Dyed Polyester Fabric After completing the dyeing process we have tested all of those dyed fabric by following the guideline of ISO. And also tried to compare the results to understand the impact of pH on dyeing process. For CMC (Color Matching Cabinet) test, we used Spectrophotometer. We got all of those CMC report under D-65 light source. For every types of fabric we had 3 samples those had dyed by maintaining 3 different pH. That's why, from every types of fabric we considered one as a standard. Specifically, from every fabric type we consider the sample as standard which one had been dyed by maintaining pH 4. So that, we can compare those 3 between one to another. Then, we tried to get fastness test result of those dyed sample. Here we have tested color fastness to rubbing, color fastness to washing, color fastness to water, color fastness to perspiration (Acid), color fastness to perspiration (Alkali).For those test we used Incubator and Rubbing machine. After that, we have graded those fastness quality by using Grey scale. The result is given below in details: 4.1.1 CMC Result The CMC testing equipment can be utilized for a variety of test applications in order to meet color consistency and quality testing criteria. Multiple light sources or lamps are used to create diverse light patterns for the fabrics in order to detect the Metamerism problem. There are some parameters to compare the result.[8] Those are: DE/ Delta E (Color Difference) = value; 0-1= Pass, Above 1 = Fail DL / Delta L (Lightness or Darkness) = value; - (Deep) / + (Light) Da / Delta a (Reddish ness or Greenish-ness) = value; - (Greenish) / + (Redish) Db / Delta b (Yellow ness or Blueness) = value; - (Blush) / + (Yellowish) DC (Chroma) = value; - (Dull) / + (Bright) DH (All over view) Metamerism DEcmc (All over calculation) All of those parameter has different tolerance value. After getting the value from dyed fabric it would compared with the tolerance value then the Spectrophotometer showed the DEcmc result; was it passed or Failed. Table 4.1: CMC report of S/J dyed fabric Sample No. pH DL* Da* Db* DC* DH* DCcmc MI-(1-2) P/F DEcmc 01. 4 0.75 L -0.14 G 0.39 D -0.28 D -0.12 G -0.14 D 0.09 Passed 02. 4.5 -1.06 D -0.04 G 0.49 D -0.48 D -0.05 G -0.24 D 0.11 Passed 03. 5 0.58 L -0.18 G 0.09 D -0.08 D -0.18 G -0.04 D 0.01 Passed Hare we can see the CMC report of 3 Single Jersey polyester dyed fabric. We considered the sample no. 1 as a standard sample then we got the value of all parameters and took 2 others value by Spectrophotometer. And after compare those values with the tolerance value we got the DEcmc result. And all of 3 are passed here. But the noticeable point is, for every sample all of those values are different. "©Daffodil International University" Table 4.2: CMC report of 1X1 Rib dyed fabric Sample No. pH DL* Da* Db* DC* DH* DCcmc MI-(1-2) P/F DEcmc 04. 4 -0.27 D 0.22 R -0.32 B 0.35 B 0.12 R 0.12 B 0.08 Passed 05. 4.5 -0.35 D 0.20 R -0.18 B 0.18 B 0.20 R 0.09 B 0.01 Passed 06. 5 -0.02 D 0.26 R -0.34 B 0.35 B 0.25 R 0.17 D 0.11 Passed Hare we can see the CMC report of 3 1X1 Rib polyester dyed fabric. We considered the sample no. 04 as a standard sample. The compare all of 3 sample's value with the tolerance we got the DEcmc report. Though all of those parameter given different value but the final value of all 3 are passed. Table 4.3: CMC report of Fleece dyed fabric Sample No. pH DL* Da* Db* DC* DH* DCcmc MI-(1-2) P/F DEcmc 07. 4 0.52 L 0.22 R -0.28 B 0.56 D 0.24 R 0.22 B 0.11 Passed 08. 4.5 0.05 L 0.26 R -0.37 B 0.35 D 0.27 R 0.18 B 0.07 Passed 09. 5 2.58 L -1.30 G 1.32 Y -1.26 D -1.35 G -0.62 D 0.29 Failed Hare we can see the CMC report of 3 Fleece polyester dyed fabric. We considered the sample no. 07 as a standard which one have dyed by maintaining the pH value 4. Then we collected the value of all parameters and took 2 others value by Spectrophotometer. And after compare those values with the tolerance value we got the DEcmc result. Though 1st 2 are passed but the last one is failed. It's a huge point to notice from this experiment. Table 4.4: CMC report of Terry dyed fabric Sample No. pH DL* Da* Db* DC* DH* DCcmc MI-(1-2) P/F DEcmc 10. 4 -0.47 D 0.40 R -0.28 B 0.49 B 0.12 R 0.27 B 0.11 Passed 11. 4.5 -0.21 D 0.32 R -0.65 B 0.65 B 0.32 R 0.32 B 0.13 Passed 12. 5 -0.68 D 0.52 R 0.04 Y 0.04 D 0.52 R -0.02 D 0.10 Passed Hare we can see the CMC report of 3 Terry polyester dyed fabric. We considered the sample no. 10 as a standard sample. By Spectrophotometer, all values with the tolerance value theses we got have compered. Then we got the DEcmc result for all of three. And all of 3 are passed here. "©Daffodil International University" 4.1.2 Color Fastness Test The resistance of a fabric to changing its color properties or transferring its colorant(s) to adjacent materials is known as color fastness. Color fastness refers to a textile's resistance to fading or bleeding due to various agents such as light, wash, water, perspiration, rubbing, acid, alkali, hot pressing, bleaching, and so on. One of our fastness reports is given below: Figure 4.1: Report of Color Fastness to Water and Perspiration for sample no. 10 "©Daffodil International University" Figure 4.2: Report of Color Fastness to Wash and Rubbing for sample no. 10 "©Daffodil International University" 4.1.2.1 More Details about Color Fastness Report To ensure consumer satisfaction with fabric products, color fastness validation is essential. One of the key concerns of textile importers is color fastness while washing. Throughout its existence, a textile item must be able to endure repeated washing without losing its color or staining other items washed with it. The crocking test evaluates a textile's resistance to rubbing off and staining other fabrics. The color fastness to perspiration test determines the resistance of textile colors to human perspiration. For Rubbing test, We have used sand paper and took 10 cycle on fabric and for other fastness test we have used Multifiber fabric. Then we have graded those by using Grey Scale. Table 4.5: Fastness test report of Single Jersey polyester dyed fabric Sample No. pH Color Fastness to Water Color Fastness to Wash Color Fastness to Rubbing Color Fastness to Perspiration (Acid) Color Fastness to Perspiration (Alkali) 01. 4 4-5 4-5 5 4-5 4-5 02. 4.5 4-5 4-5 5 4-5 4-5 03. 5 4-5 4-5 5 4-5 4-5 Color fastness of all single jersey fabrics are good enough. And there is nothing highlight able for pH variation. Table 4.6: Fastness test report of 1X1 Rib polyester dyed fabric Sample No. pH Color Fastness to Water Color Fastness to Wash Color Fastness to Rubbing Color Fastness to Perspiration (Acid) Color Fastness to Perspiration (Alkali) 04. 4 4-5 4-5 4-5 4-5 4-5 05. 4.5 4-5 4-5 4-5 4-5 4-5 06. 5 4-5 4-5 4-5 4-5 4-5 Color fastness properties are fine for all of those 1X1 Rib fabric when pH was different. "©Daffodil International University" Table 4.7: Fastness test report of Fleece polyester dyed fabric Sample No. pH Color Fastness to Water Color Fastness to Wash Color Fastness to Rubbing Color Fastness to Perspiration (Acid) Color Fastness to Perspiration (Alkali) 07. 4 4-5 4-5 4-5 4-5 4-5 08. 4.5 4-5 4-5 4-5 4-5 4-5 09. 5 4-5 4-5 4-5 4-5 4-5 All of those color fastness properties are well enough for Fleece fabric. All of those grade are 4-5. Table 4.8: Fastness test report of Terry polyester dyed fabric Sample No. pH Color Fastness to Water Color Fastness to Wash Color Fastness to Rubbing Color Fastness to Perspiration (Acid) Color Fastness to Perspiration (Alkali) 10. 4 4-5 4-5 4-5 4-5 4-5 11. 4.5 4-5 4-5 4-5 4-5 4-5 12. 5 4-5 4-5 4-5 4-5 4-5 For all of those three Terry dyed fabric's color fastness properties grade are 4-5. So, it's excellent. 4.2 Final Discussion on our experimental Result Color fastness in textiles is one of the most fundamental tests that must be conducted on items to guarantee that their color is fast enough to withstand various processes like as rubbing, washing, and other conditions during use. The color of the fabric specimen after testing is compared to a "Grey Scale for Color Change" and a "Grey Scale for Staining" in most ISO and AATCC color fastness tests. On a scale of 1 (most change) to 5 (least change), the Grey Scale for Color Change rates the specimen's color fading (no change). From 1 (most color transfer) to 5 (least color transfer), the Grey Scale for Staining evaluates the staining of an undyed material tested with the specimen (no color transfer). After studies of those test result we can say all types of our tested Polyester fabrics has strong color fastness ability. But the point to highlight that due to pH variation CMC result can fluctuated and sometimes it can break the buyer's standardized limit like our 9th sample (Fleece Fabric- pH:5) .So a total shipment can get canceled ! So it's a big deal to maintain the actual pH during dyeing. 23 "©Daffodil International University" CHAPTER – 5 CONCLUSION "©Daffodil International University" We learned a lot about dyeing polyester with disperse dyes as a result of this project. After dyeing process it's very important to test the dyeing properties and quality of dyed fabric. Without achieving the proper shade it's totally useless to do the process. After getting the shade there are many test to check the dyeing quality like color fastness to wash, color fastness to rubbing, color fastness to perspiration, CMC etc. Depending on the design and intended usage of your textile items, some color fastness tests may be more significant to you than others. But those fastness quality and better quality dyeing depends on some criteria. pH is one the most important thing for the perfect dyeing like the proper shade. Until end of the process, it's too important to maintain the pH value for every process. For Polyester dying process with disperse dyes requires an acidic pH. The range of pH value for perfect polyester dyeing is 4-5. The pH of the dyeing bath should be between 4.5 and 4.7 when the leveling chemicals are injected. After applying the dyes, the pH remained 4.2-4.3. More details about our dyed fabrics are given below: - ‣ As we have used 4 different types of fabric and took 3 samples from each type, and for every single sample we maintained 3 different pH value (4, 4.5, 5). So the shade weren't same for every types of fabric. ‣ During CMC test, we got different value for different samples, though the type of those samples were same. Such as, for S/J fabric; the DCcmc value of sample's 2 was -0.24 D and the maintained value for the sample dying process was 4.5. But for the sample type of fabric where we used the same quantity of dyes and just changed the pH value to 5; then the DCcmc value was -0.04 for the sample no. 3. So, it's a noticeable point of our project. ‣ From CMC test report, we got the final P/F DEcmc result. The result is given after verifying all of those parameter and those parameter has different tolerance value. Metamerism is one other most important parameter in this test. Highlighting point of the fleece dyed fabric is; the final CMC result of 8th and 9th sample is respectively Passed and Failed. For the 8th sample the maintained pH was 4.5 and for the 9th, the pH value was 5. So, we can say pH has directly impact on polyester fabric dyeing process. ‣ For the colorfastness test, we had to be more careful for grading. Basically, we have tested 5 different types of fastness test. And the tested results were almost same for all of those fabrics and all of those samples. But the fastness quality of S/J fabric was better than others fabric. Actually, Polyester fabric has better color fastness properties that's why it has shown the better quality fastness result. But it the pH would be higher than 5 or lower than 4 the result might be changed. Because pH really has huge impact on Polyester fabric dyeing process. 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