The Impact of Enzyme Concentration (%) on Different Properties of Knitted Fabric During Bio-polishing and Their Technical Relationship

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Abstract— soft handle and clean surface of fabric without any protruding fiber is mostly desired. Bio-polishing technique for removing protruding fiber from cotton knitted fabric surface is well established and most commonly used by the textile factory. We have been considered Single jersey, Rib (2*2), Interlock, Fleece and Pique fabrics for our project work. Pre-treatment process (Bio-polishing, Scouring & Bleaching) and dyeing is carried out by using sample dyeing machine. Enzyme shows various effects on different types of fabrics but those effects mainly based on Whiteness, Reflectance and GSM. We have been used different percentages of enzyme on different types of knitted fabric but the percentage of enzyme have been used (0.25%, 0.30%,0. 40%).After enzyme treatment we have been found the relation among concentration of enzyme, whiteness value, reflectance value, GSM and process loss. The aim of this study includes; determination of the effect of enzyme concentration on various knitted fabrics such as determination of whiteness, reflectance value of treated & untreated knitted fabrics by spectrophotometer. Determination of the process loss (%) in after treatment, Determination of relation among enzyme concentration, whiteness index, reflectance value and GSM. After the study we come to a conclusion i.e. with the increase of enzyme concentration Whiteness value, Reflectance value and Process loss of the different knitted fabric increase, at the same time GSM, Strength of the fabric decrease whilst the fastness properties remain similar.

Index Terms— Enzyme, Bio-polishing, knitted fabric, Whiteness Index, GSM, Strength, Process loss.

1 Introduction

THE dramatic increase in the popularity of knitted fabrics during the last three decades provides a vivid example of the interrelationships between lifestyle, technology and fashion. The high degree of stretch and comfort that knit cloth brings to close-fitting garments, coupled with excellent wrinkle resistance, makes them demands.'Eminently suitable to the modern consumer [1]. The surface of knitted fabric is not smooth as compare to woven fabric. It is due to its construction technology. Knitted fabric is made by suing loops, and there is quite uneven surface. Moreover, protruding fibers (fiber ends) are also present on the surface of knitted fabric [2]. Abrasion of the surface tends to texture the protruding fiber ends, causing them to form into tiny balls, are also known as pilling [3].Pilling is a serious defect for textile fabrics which adversely affects the fabric aesthetic, hand, and service life of a garment, and is a major source of fabric attrition, principally for knitted fabrics rather than woven ones [4].There are two different ways to minimize pill formation: reducing fuzz density and fuzz formation by fixing fibers more tightly in the yarn and fabric, thereby preventing pill formation; or weakening protruding fibers, resulting in the pills breaking off more easily [5].The process of eliminating the surface fibers by treatment with cellulose enzyme is well established.

The treatment with cellulase enzyme is carried out under mild conditions so as to minimize the degradation of the fabric. This process of eliminating surface fibers is also known as bio-polishing [6]. The major constituents of cellulase are the washing are the important parameters influencing -1, 4-gluconases. It actually consists of a complex cloth shade and the garments mechanical properties. Mixture of acting enzymes. The (1-4) linkages between The application of these treatments and their succession adjacent repeat units in cellulase polymer chain are the in finishing garments is advisable to have more and more sites for catalytic hydrolysis by cellulase. They catalyze increased whiteness. Nevertheless, all these treatments the primary reaction of hydrolytically splitting the -1, 4- that cause a more worn appearance and aged look for glycosidic linkages in cellulase chain molecule [7]. Due to the un-optimized cellulose composition and high dosages, significant weight (GSM) and strength losses can occur [8].In this study, an attempt has been made to study the effect of enzymes during bio-polishing on 100% cotton weft-knitted Single jersey, Rib (2*2), Interlock, Fleece and Pique fabric. The effect of enzyme concentration (%) on different properties i.e. GSM, Whiteness value, Reflectance value and Process loss also investigated. The fastness properties & strength of a dyed single jersey knitted also measured to investigate the effect of enzyme on these properties.

2 Experimental

2.1 Raw Maerials

Different types of cotton knitted fabrics were used in this study (see Table 1). For each types of fabric sample weight taken was 5kg. All of the knitted fabrics used were collected from the Dird Composite Textile Ltd, Gazipur, Bangladesh. All the reagents used (wetting agent, sequestering agent, anti-creasing agent, leveling agent, Caustic soda (NaOH), hydrogen peroxide (H_2O_2), enzyme, reactive dye, soda ash and glauber salt) were collected from Dird Composite Textile Ltd.

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TABLE 1
DIFFERENT TYPES OF KNITTED FABRIC USED

Types	GSM	Count
Single jersey	141	30/1s
Rib(2*2)	286	30/1s
Interlock	161	44/1s
Fleece	222	34/1s
Pique	207	28/1s

2.2 Instruments

Scouring, bleaching, bio-polishing and dyeing were performed in a sample dyeing machine (Fong's, Hong Kong, capacity: 10kg). Whiteness Index (%) and reflectance value of the fabric were collected from spectrophotometer (Data color 650 TM). The GSM of the fabric measured by using GSM cutter & electric balance. Color fastness of the dyed sample (single jersey) was measured by using Gyro Wash (James Heal, UK). The Rubbing fastness measure by using crock master (James Heal, UK). Bursting strength measured by using PnuBurst™ (SDL Atlas, USA).

2.3 Scouring and Bleaching of different knitted fabrics

The scouring and bleaching of different knitted fabrics i.e. Single jersey, Rib (2*2), Interlock, Fleece and Pique fabrics were performed by using following recipe .

Wetting agent: 0.5gram/L
Sequestering agent: 0.2gram /L
Anti-creasing agent: 0.5 gram/L
Caustic soda (NaOH): 0.5 gram/L
Stabilizer: 0.3gram /L
Hydrogen peroxide (50%) (H2O2):0.5 gram/L
PH: 10:5
M: L = 1:10
Temperature: 98° C
Time: 60 min

2.4 Bio-polishing of different knitted fabrics

The scouring and bleaching of different knitted fabrics i.e. Single jersey, Rib (2*2), Interlock, Fleece and Pique fabrics were performed by using following recipe.
Enzyme: 0.25% / 0.30% / 0.40%
PH: 4.5
M: L=1:10
Temperature: 55° C
Time: 60 min

2.4 Dyeing of Single Jersey knitted fabric

The following recipe was followed for dyeing of single jersey knitted fabric.

Super yellow-0.28%
Deep Red CD-2.3%
Navy blue GG-0.15%
Glauber salt-60gram/L
Soda ash-2.25gram/L
Levelling Agent-0.6gram/L
Sequestering Agent-0.5gram/L
PH 10-11
M:L = 1:6
Temperatures 60°C
Time 60min

3 METHODOLOGY

Five different types of kntted fabric i.e. single jersey, Rib (2*2), Interlock, Fleece and Pique were taken for this study. Scouring, bleaching and bio-polishing of these fabrics were carried out in a sample dyeing machine. Whiteness Index (%) and reflectance values were measured by using spectrophotometer. GSM and process loss also measured. The single jersey knitted fabric was dyed with reactive dyes.Color fastness of the dyed fabric was also measured (method followed; ISO 105:CO3). Rubbing fastness of the dyed fabric was also measured (method followed; ISO 105: X12). Bursting strength was measured and method followed was ASTM D3786.

4 RESULT AND DISCUSSION

4.1 Effect of Enzyme Concentration (%) on Fabric GSM

The different concentration of enzyme greatly influence the gsm (gram per square meter) of the cotton knitted fabric. Table 2 represents the effect on enzyme concentration on the gsm of different knitted fabric.

TABLE 2
EFFECT OF ENZYME CONCENTRATION (%) ON GSM

Fabric type	Grey GSM	GSM After Enzyme		
		Sample-1 (0.25%)	Sample-2 (0.30%)	Sample-3 (0.40%)
Single Jersey	141	123	120	116
Rib(2*2)	286	273	269	265
Interlock	161	150	147	142
Fleece	222	204	200	197
Pique	207	181	178	174

For all kinds of cotton knitted fabric gsm tends to decrease with the increase in enzyme concentration (%) (See Fig. 1)

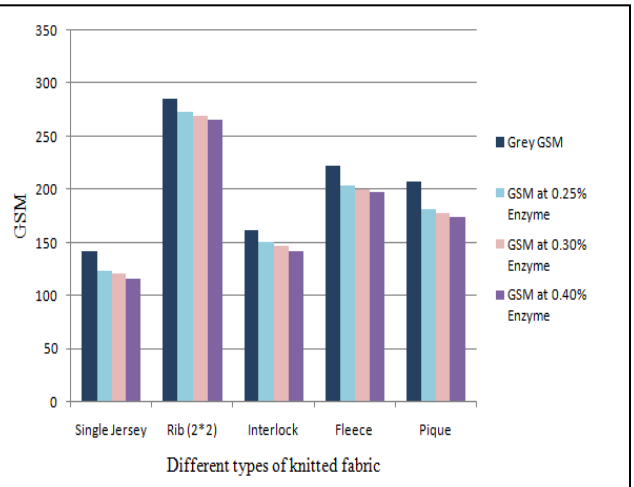

Fig. 1. Changes of GSM of different knitted fabrics.

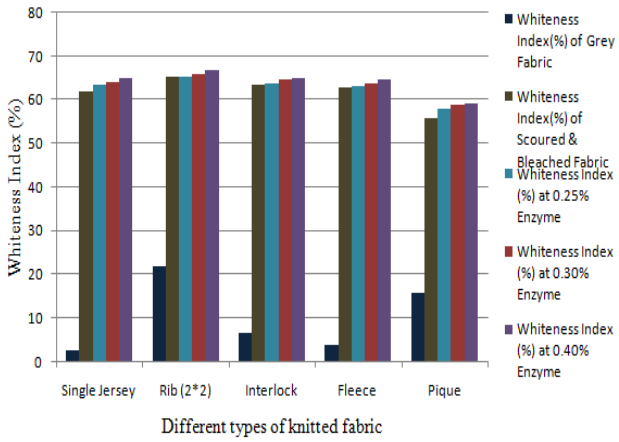

Fig. 2. Changes of Whiteness Index (%)of different knitted fabrics.

A great difference observed in between the grey gsm and the gsm after enzyme treatment. Grey gsm of the fabric tends to decrease in enzyme treatment. For example grey gsm of single jersey knitted fabric was 141 and after bio-polishing with enzyme of different concentration (0.25%, 0.30% and 0.40%) the gsm of the same fabric found were 123, 120 and 116 respectively. This phenomenon has also been observed for all the other 4 kinds of fabrics (rib (2*2), interlock, fleece and pique).

4.2 Effect of Enzyme Concentration (%) on Whiteness Index (%)

Whiteness is an attribute by which an object is judged to approach the preferred white. The enzyme concentration (%) has a certain impact over the whiteness value (%) of the different fabrics (see Table 3).

TABLE 3
EFFECT OF ENZYME CONCENTRATION (%) ON WHITENESS INDEX (%)

Fabric type	Grey	After Scouring & Bleaching	After Enzyme		
			Sample-1 (0.25%)	Sample-2 (0.30%)	Sample-3 (0.40%)
Single Jersey	2.32%	62.01%	63.59%	64.02%	64.85%
Rib(2*2)	21.62%	65.20%	65.40%	65.92%	66.92%
Interlock	6.29%	63.30%	63.84%	64.66%	65.13%
Fleece	3.64%	62.86%	63.05%	63.90%	64.75%
Pique	15.58%	55.70%	57.86%	58.87%	59.05%

Whiteness Index (%) in grey state exhibit a very poor value because it grey states the fabric contains its natural grey color. After the scouring, bleaching and bio-polishing the whiteness index (%) of the different farics improved significantly (see Fig. 2).

The lowest whiteness index (2.32%) was observed for single jersey in grey state among all the other types of knitted fabric. At scouring-bleaching it improved significantly to 62.01% .This improvement of whiteness index (%) also carried out by bio-polishing treatment. Whitess index (%) for single jersey knitted fabric was found 63.59%, 64.02% and 64.85% for 0.25%, 0.30% and 0.40% enzyme repectively. Similar types of incidents observed for other types of fabrics also.

4.3 Effect of Enzyme Concentration (%) on Reflectance value.

The different concentration of enzyme also influence the reflectance value of different knitted fabric.Table 4 shows the reflectance value of different cotton knitted fabric at scouring-bleaching and bio-polishing with different enzyme concentration (%).

TABLE 4
EFFECT OF ENZYME CONCENTRATION (%) ON REFLECTANCE VALUE

Fabric type	After Scouring & Bleaching	After Enzyme		
		Sample-1 (0.25%)	Sample-2 (0.30%)	Sample-3 (0.40%)
Single Jersey	86.82	86.59	87.19	87.40
Rib(2*2)	86.50	86.39	86.63	86.88
Interlock	86.15	86.83	86.77	87.05
Fleece	87.28	87.67	87.68	87.87
Pique	84.97	85.70	86.32	86.59

The highest reflectance value found 87.28 for fleece fabric after scouring and bleaching while interlock fabric showed lowest reflectance value 86.15. Further imporvent of reflectance value of different knitted fabric observed after bio-polishing with different enzyme concentration (%). The following figure (see Fig 3.) shows the change in reflectance value of different knitted fabrics.

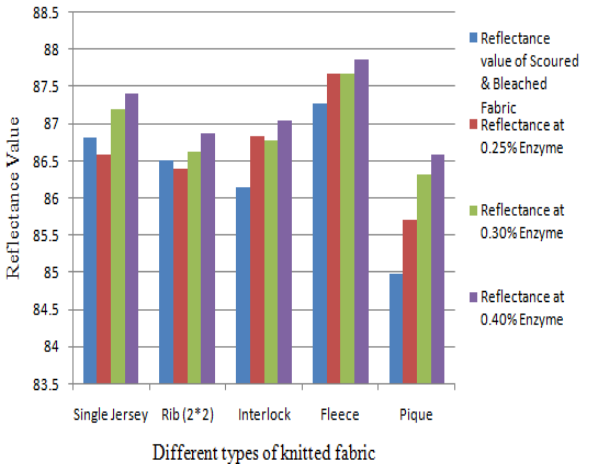

Fig. 3. Changes of Reflectance Value of different knitted fabrics.

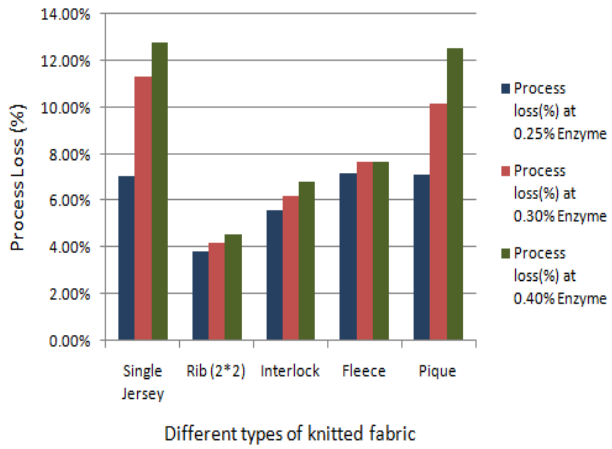

Fig. 4. Process loss (%) of different knitted fabrics.

The increase in the concentration of enzyme during bio-polishing lead to the increase in reflectance value. For all kinds of knitted fabrics reflectance value increased along with the increase in enzyme concentration (%). For example reflectance value 86.59, 87.19 and 87.40 were observed for single jersery fabric with 0.25%, 0.30% and 0.40% enzyme repectively.

4.4 Effect of Enzyme Concentration (%) on the Process Loss (%)

The weight loss/process loss (%) of different knitted fabrics during bio-polishing with enzyme of different concentration was measured (see Table 5)

TABLE 5
EFFECT OF ENZYME CONCENTRATION (%) ON PROCESS LOSS(%)

Fabric Types	Process Loss (%)		
	Enzyme (0.25%)	Enzyme (0.30%)	Enzyme (0.40%)
Single Jersey	7.09%	11.34%	12.76%
Rib (2*2)	3.84%	4.19%	4.54%
Interlock	5.59%	6.21%	6.83%
Fleece	7.20%	7.65%	7.66%
Pique	7.14%	10.14%	12.56%

The concentration of enzyme greatly influences the process loss (%) different types of knitted fabric. With the increase inenzyme concentration process loss (%) of different fabrics also increase (see Fig. 4).

Single jersey knitted fabric showed maximum process loss (12.76%) at 0.40% enzyme during bio-polishing. Among all of the different knitted fabrics rib (2*2) showed lowest process loss (4.54%) at 0.40% enzyme.

4.5 Color fastness to Wash for single jersey knitted fabric.

Single jersey cotton knitted fabrics were dyed using reactive dye. ISO105:CO3 method was followed for measurement of color fastness and ISO grey scale was used for assessment. Wash fastness properties of enzyme treated fabric and untreated fabric were compared (see Table 6).

TABLE 6
COMPARISON OF WASH FASTNESS PROPERTIES OF UNTREATED AND ENZYME TREATED SINGLE JERSEY KNITTED FABRIC

Sample (Untreated)	Rating		Sample (Enzyme Treated)	Rating	
	Color Change	Color Staining		Color Change	Color Staining
Sample-1*	4-5	4-5	Sample-1	4-5	4-5
Sample-2*	4-5	4-5	Sample-2	4-5	4-5
Sample-3*	4-5	4-5	Sample-3	4-5	4-5

There was no significant change in the fastness properties of the single jersey knitted observed for both untreated (sample 1*, 2*, 3*) and enzyme treated [sampe-1 (0.25%), sample-2(0.30%), sample-3(0.40%)] fabric. In both case wash fastness rating was good (4) to excellent (5). So, it could be said that enzyme has no influence over the wash fastness properties of different types of cotton knitted fabric.

4.6 Color fastness to Rubbing for single jersey knitted fabric.

For the measurement of rubbing fastness of single jersey knitted fabric ISO 105: X12 method was followed. ISO grey scale

for staining was used for the assessment of rubbing fastness. Color fastness to rubbing properties of enzyme treated fabric and untreated fabric were compared (see Table 7).

TABLE 7
COMPARISON OF RUBBING FASTNESS PROPERTIES OF UNTREATED AND ENZYME TREATED SINGLE JERSEY KNITTED FABRIC

Sample (Untreated)	Rating		Sample (Enzyme Treated)	Rating	
	Dry Rub	Wet Rub		Dry Rub	Wet Rub
Sample-1*	4	3	Sample-1	4	3
Sample-2*	4	3	Sample-2	4	3
Sample-3*	4	3	Sample-2	4	3

There was no significant change observed in rubbing fastness properties of untreated and enzyme treated single jersey knitted fabrics. In the both cases of untreated and enzyme treated fabric colorfastness to dry rubbing was good (4) and colorfastness to wet rubbing was fair (3).

4.7 Bursting Strength of single jersey knitted fabric.

Bursting strength of the knitted single jersey fabric was measured before and after bio-polishing. For the measurement of bursting strength method followed was ASTM D3786.With the increase of enzyme concentration strength of fabric decreased considerably. Average strength of the fabric in grey state found 68.63 Kpa and after enzyme treatment it has been decreased and found about 62 Kpa.

5. Conclusion

Bio-polishing is a very promising method for lowering the consumption of chemicals specially in wet finishing where plenty of these compounds are used. Bio-polishing may be having some adverse effect on some selective properties of knitted fabric. In this study we have tried to find out the effect of different enzyme concentration on different types of knitted fabric. The results demonstrate that Whiteness value, Reflectance value and process loss (%) increase of the knitted fabric increase with the increase in enzyme concentration. GSM, strength of the fabric decreases when the enzyme concentration is higher and the fastness properties of the fabric remain similar in each concentration. Since the enzyme at low concentration may not bring the desired surface cleaning effect and less whiteness value & less reflectance value. So, the optimum concentration of enzyme should be used during bio-polishing for avoiding the problem associated with the high concentration of enzyme such as low GSM and high process loss (%).

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