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Comparison of Physical Properties between Grey and Dyed Knitted Fabric

Nusrath Jahan Khanam
Sushama Saha Swati
Mayesha Maliha
Nadvi Mamun Pritha
Department of Textile Engineering, Primeasia University, Bangladesh
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Abstract

This paper focuses on the changes in the fabric's physical properties like GSM, bursting strength, pilling, extension, and residual extension in both grey and dyed stage. Moreover, this investigation also shows the relationship between bursting strength, pilling, extension, and residual extension with GSM. Furthermore, from grey to dyed stage, a visible change in GSM occurred and the influence of GSM in different physical properties also appeared significantly. A strong relationship of bursting strength, extension, and residual extension with GSM change of 100% cotton single jersey fabric was found, but pilling shows very negligible change in relation to GSM. Physically, after dyeing, changes were visible in case of GSM and pilling. With the change of fabric condition, i.e., grey and dyed stage fabric, the physical properties shows significant changes in terms of characteristics. In comparison to different physical properties of fabric in grey and dyed stage, the analysis has shown that the value of GSM was increased gradually after dyeing. Bursting strength, extension, and residual extension was decreased from grey to dyed stage. Overall pilling rate was observed and it was found to improve after dyeing.

Keywords: GSM (Gram per square meter), Bursting Strength, Pilling, Extension, Residual

Introduction

Knit fabric plays an important role in textile industry. In knit fabric, there are so many parameters involved which highly influence the fabric end use behavior. Among them GSM, bursting strength, pilling, extension, and residual extension are few of the most important fundamental physical parameters. With the variation in fabric GSM and the condition of testing (i.e., grey stage and dyed stage), fabric properties like bursting strength, pilling, extension, and residual extension shows phenomenal change. The goal of this paper is to portrait the change in different physical properties like GSM, bursting strength, pilling, extension, and residual extension in grey and dyed stage as well as built a relationship of GSM with other physical properties. GSM is an important parameter of knit fabric which means gram per square meter, and it is used to determine whether the fabric is heavier or lighter in weight (Faridul Hasan, 2015). GSM has severe impact on different physical properties of knit fabric. Bursting strength, which is a mechanical property of knitted fabric, is determined by the application of multi-directional force to find out the ultimate performance. Due to the diverse structural features of knit fabric, tensile and tear strength is not appropriate to perform but bursting strength can give a definite result of strength (Hafsa Jamshaid, 2012). Bursting strength of knit fabric significantly varies while passing through the process of grey stage to finished stage (Tufail Hassan, 2020). Bursting strength has greater influence on all other performances and it is essential to consider the strength of fabric before selecting it for appropriate end use (Mohammad Mobarak Hossain, 2018). Pilling occurs as a consequence of mechanical action during washing or wear. Due to rubbing or friction (i.e., different mechanical action), loose fibers that protrude from the fabric surface entangle and form pills (Mahbubul Haque, 2017). From the analysis of influence of fabric structure to pilling of knitted fabric, it was demarcated that single jersey knitted fabrics are more prone to pilling compared to other structures (Gykytė, 2002; Mikučionienė, 2009; Candan, 2002; Abramavičiūtė, 2011; Emirhanova, 2008). Extension is one of the most important functional properties of apparel clothing. However, knitted fabric with elastane can have greater extension and be recovered to its original shape when relaxed, but knitted fabric has always shows elastic properties even without elastane (Selin Hanife Eryuruk, 2016). Elastic recovery is the term used when the fabric can be recovered to its original state after the removal of applied load. Fabric with less elastic recovery shows more residual extension after the removal of the applied load. In addition, the fabric is not able to turn back to its original shape completely due to the occurence of residual extension. Residual extension of knit fabric

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depends on the yarn composition and structure, the knitted fabric structure and properties, the tension, the atmosphere, etc.

Methods

Sample Specification

For this work, grey and pretreated dyed single jersey and 100% cotton knit fabric was used primarily. The study was carried out mainly to determine the physical properties like GSM, bursting strength, pilling, extension, and residual extension of 100% cotton single jersey grey and pretreated dyed fabric with different types of machines. Grey fabric of GSM (Gram per square meter) 140, 160, and 180 was taken to determine the physical properties of which GSM changed respectively after dyeing.

Chemical Specification

Dyeing process was done for producing a combine shade of black color with reactive dyes named Yellow 3RX, Red 3BX, and Black B. Auxiliaries and others chemicals required for dyeing like glauber's salt ($Na_2SO_4.10\ H_2O$), Soda Ash (Na_2CO_3), caustic soda (NaOH), sequestering agent Complexant P-H/C, and Dynotex MH_1D wetting agent were collected from Huntsman (America).

Machine Specification

For dyeing of fabric sample, dyeing machine which was utilized originated in Germany. Grey and pretreated dyed fabrics GSM, bursting strength, pilling, extension, and residual extension were carried out by GSM cutter, Tru Burst3, Nu-Martindale, and Titan2 machines correspondingly. Machines used for physical testing was manufactured by James Heal which originated in UK.

Dyeing Process

Dyeing of pretreated fabrics of GSM 140, 160, and 180 was carried out for 4.5% shade with reactive dyes. The dyeing process with three reactive dyes was done in sample dyeing machine. Recipe which was used in dyeing are stipulated in Table 1.

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Table 1. Dyeing Recipe with Reactive Dyes

Dye Concentration (%)	4.5
Fabric weight (gram)	10
Glauber salt (gram/litre)	85
Soda ash (gram/litre)	20
*Sequestering agent (cc/litre)	1
**Wetting agent (cc/litre)	1
Dyeing temperature (°C)	60
Dyeing time (min)	60
Liquor ratio	1:10

*Complexant P-H/C,** Dynotex MH_1D

After Treatment of Dyed Fabric and Sample Collection Process

The dyeing process of cotton sample was carried out at 60^0C for 60 minutes with reactive dyes. Colored cotton samples were neutralized by acid wash later in where 1 ml/litre of acetic acid was used at room temperature and continued for 10 minutes. After that, hot wash was given on the neutralized samples with l gram/litre of soaping agent at 70°C temperature for 15 minutes. Sequentially, fixation process was carried out at 40°C for 10 minutes exactly with 1 gram/litre of cationic dye fixing agent in which pH is kept between 5.0 and 6.0 with the addition of 0.5 g/l of acetic acid. Finally, samples were dried at 105°C temperature for 10 minutes with the help of a sample dryer. Sample was collected in two stages i.e., in grey stage and dyed stage for the purpose of GSM, bursting strength, pilling, extension, and residual extension test.

Methods of Assessment

Assessment of GSM

ISO 3801-1977 (E) test method was selected for the assessment of GSM. GSM of fabric was measured with the help of GSM cutter. The specimen was cut with the help of GSM cutter and weighted, and the mass per unit area was calculated. The GSM was measured and stipulated in Table 2.

Assessment of Bursting Strength of Fabric

ISO:13938-2:1999 test method was selected for the assessment of bursting strength of knit fabric in both grey and dyed condition. According to this method, test specimen clamped over an expansive diaphragm by means of a circular clamping ring. Increasing compressed air pressure is applied to the underside of the diaphragm, thereby causing distension of the diaphragm and the fabric. The pressure is increased smoothly until the test specimen bursts.

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The bursting strength were determined and stipulated in Table 2.

Assessment of Pilling of Fabric

ISO:12945-2 test method was used for the assessment of pilling of knit fabric in both grey and dyed stages. By following this method, a circular test specimen is passed over a friction surface comprising the same fabric at a defined force in the form of Lissajous figure, with the test specimen able to rotate easily around an axis through its center, which is perpendicular to the plane of the test specimen.
Pilling was assessed visually after different stages of rub test and grading as noted in Table 2.

Assessment of Extension and Residual Extension

BS EN 14704-1:2005 test method was used for the assessment of extension and residual extension of fabric in both grey and dyed stages. A fabric test specimen of specified dimensions is extended at a constant rate to either a specified force or elongation for an agreed number of cycles, and its elasticity is determined by measuring certain characteristics. The value of extension and residual extension was calculated and recorded in Table 2.

Results and Discussion

Bursting strength, pilling, extension, and residual extension at different GSM of 100% cotton single jersey grey and dyed fabric was measured with different types of testing machines and the results are provided as follows in Table 2.

Table 2. Ratings of Bursting Strength, Pilling, Extension and Residual Extension at Different GSM of 100% Cotton Single Jersey Grey and Dyed Fabric

Sample No.	GSM		Bursting Strength (KPa)		Pilling (Grade)								Extension% (Lengthwise)		Extension% (Widthwise)		Residual extension% (Lengthwise)		Residual extension% (Widthwise)	
					500 rev.		1000 rev.		1500 rev.		2000 rev.									
	Grey	Dyed	Grey	Dyed	Grey	Dyed	Grey	Dyed	Grey	Dyed	Grey	Dyed	Grey	Dyed	Grey	Dyed	Grey	Dyed	Grey	Dyed
01	140	157	238.9	170.3	3-4	4-5	3-4	4	3	4	3	4	60.91	31.13	70.19	60.49	11.62	5.75	15.83	14.25
02	160	178	256.0	183.9	3-4	4-5	3-4	4-5	3-4	4	3	4	64.87	34.31	71.09	61.15	13.33	6.25	17.50	17.08
03	180	202	299.1	209.3	4-5	4-5	4	4-5	3-4	4-5	3-4	4	71.41	40.42	76.25	71.08	14.50	7.96	18.00	19.75

Assessments of GSM of grey and dyed fabric

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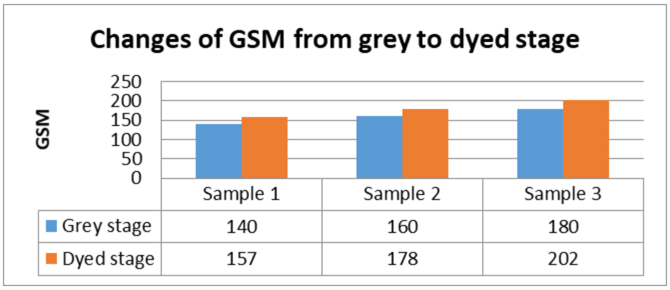

Figure 1. Changes of GSM from Grey to Dyed Stage

Figure 1 represents values of GSM of grey and dyed fabric. After dyeing, the GSM of dyed fabric increased due to application of dyes, chemicals, and auxiliaries. The GSM of knit fabric increases gradually after dyeing (Faridul Hasan, 2015). Due to chemical treatment as the indirect yarn count value (Ne) of fabric decrease and the yarn become coarser, so also the GSM increases. Moreover, during dyeing, as stitch length of fabric decrease and the stitch density increase, so the GSM also increase (Mohammad Hosain Reza, 2015). In grey stage, the fabric GSM was found in the range from 140 to 180, and after dyeing, the GSM value increase in the range from 157 to 202.

Assessments of Bursting Strength of Grey and Dyed Fabric

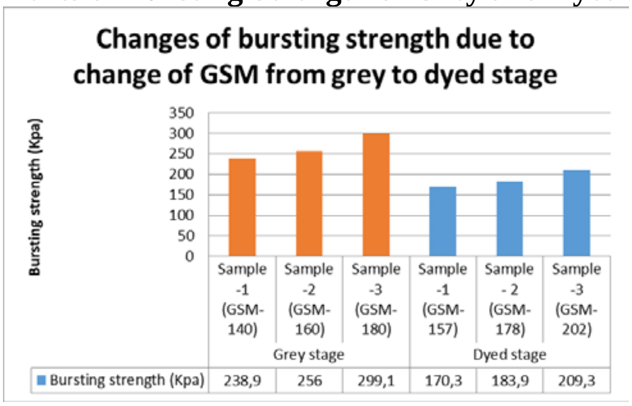

Figure 2. Changes of Bursting Strength due to Change of GSM from Grey to Dyed Stage

Figure 2 represents values of bursting strength of grey and dyed fabric. In case the grey fabric strength was increased, the GSM increased respectively. After dyeing as the GSM increases, the bursting strength of knit fabric increased gradually. However, the overall range of bursting strength was decreased after dyeing. After dyeing, the GSM increases due to application of dyes, chemicals, and auxiliaries, but the actual structure of fabric is hampered and losses its strength. In the stage after dyeing, strength of dyed fabric decreases but in response to the GSM, the

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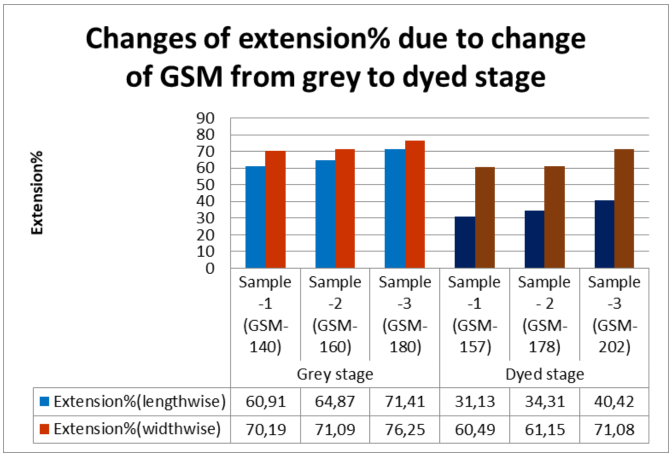
strength also increases respectively. At grey and dyed stages, the total experimental data of bursting strength was found in the range from 170.3 KPa to 299.1 KPa. For grey stage and dyed stage respectively, maximum fabric strength was recorded to be 299.1 KPa at GSM 180 and 209.3 KPa at 202 GSM. Minimum values of fabric bursting strength was stipulated to be 238.9 KPa at GSM 140 and 170.3 KPa at GSM 157 respectively for grey and dyed fabric. By analyzing the data of bursting strength, it was observed that the maximum value was 299.1 KPa at GSM 202 of grey fabric and the minimum value was 170.3 KPa at GSM 157 of dyed fabric.

Assessments of Pilling of Grey and Dyed Fabric

Grading of pilling of grey and dyed fabric was shown in Table 2. In grey fabric and dyed fabric, the range of grade found is almost the same for all GSM fabric both after grey and dyed stage. Pilling rate was decreased in dyed fabric compared to grey fabric. Before dyeing due to the presence of short fiber, surface pilling grade were found in the range from 3 to 4 which indicates light to medium pilling for number of revolutions of 500,1000,1500, and 2000. After dyeing, due to biopolishing, the pilling grade improve to 4, 4-5 which indicates light pilling for all number of revolutions. With the increase in the number of revolution as the friction between fabric surface and the base fabric increases, it enhances the chance of entanglement of the loose fibers that protrude from the fabric surface. As the number of revolution increase from 500 to 2000, the rate of pilling also increases.

Assessments of Extension and Residual Extension of Grey and Dyed Fabric



*****grey and dyed stage of sample indicated respectively by light and dark tone of same color in the figure.***

Figure 3. Changes of Extension% due to Change of GSM from Grey to Dyed Stage

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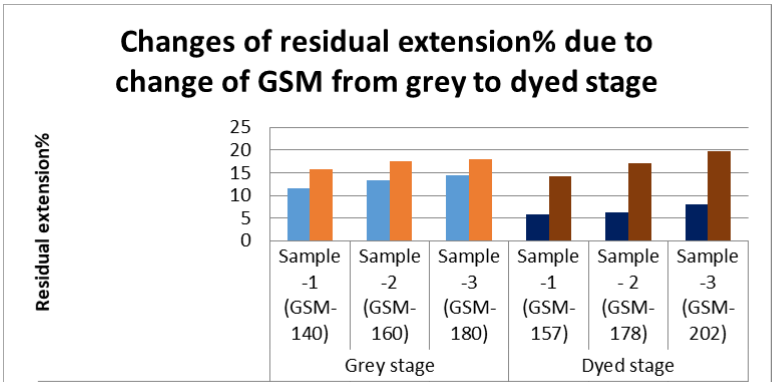

	Sample -1 (GSM-140)	Sample -2 (GSM-160)	Sample -3 (GSM-180)	Sample -1 (GSM-157)	Sample - 2 (GSM-178)	Sample -3 (GSM-202)
Residual extension%(lengthwise)	11,62	13,33	14,5	5,75	6,25	7,96
Reidual extension%(widthwise)	15,83	17,5	18	14,25	17,08	19,75

****grey and dyed stage of sample indicated respectively by light and dark tone of same color in the figure.***

Figure 4. Changes of Residual Extension% due to Change of GSM from Grey to Dyed Stage

Figure 3 and 4 represents respectively the values of extension and residual extension of grey and dyed fabric. In case of grey fabric, as the GSM increases, the extension and residual extension percentage increases also for both length and widthwise direction. After dyeing, with the increase of GSM, both the extension and residual in length and widthwise direction of knit fabric increased. After dyeing, as the GSM increases due to application of dyes, chemicals and auxiliaries, the crystalline region of the dyed fabric increase and porosity decrease. As the porosity decrease, the extension and residual extension of dyed fabric also decrease both for length and widthwise direction. At grey and dyed stages, the total experimental data lengthwise extension was found in the range from 31.13% to 71.41%, and widthwise extension was found in the range from 60.49 % to 76.25%. For grey stage and dyed stage respectively, maximum lengthwise fabric was recorded at 71.41% at GSM 180 and 40.42% at GSM 202 . For grey stage and dyed stage respectively, maximum widthwise fabric was recorded at 76.25% at GSM 180 and 71.08% at GSM 202. Minimum values of lengthwise fabric extension was stipulated at 60.91% at GSM 140 and 31.13% at GSM 157 respectively for grey and dyed fabric. Minimum values of widthwise fabric extension was stipulated at 70.19% at GSM 140 and 60.49% at GSM 157 respectively for grey and dyed fabric.

At grey and dyed stages, the total experimental data lengthwise residual extension was found in the range from 5.75% to 14.50% and widthwise extension was found in the range from 14.25 % to 18.00%. For grey

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stage and dyed stage respectively, maximum lengthwise fabric was recorded at 14.50% at GSM 180 and 7.96% at GSM 202. Minimum values of lengthwise fabric extension was stipulated at 11.62% at GSM 140 and 5.75% at GSM 157 respectively for grey and dyed fabric. For grey stage and dyed stage respectively, maximum widthwise fabric was recorded at 18.00% at GSM 180 and 19.75% at GSM 202. Minimum values of widthwise fabric extension was stipulated at 15.83% at GSM 140 and 14.25% at GSM 157 respectively for grey and dyed fabric.

In grey stage, the extension and residual extension of GSM 140, 160, and 180 increases respectively. Consequently, the range of extension and residual extension decrease significantly after dyeing. However, after dyeing, the value of extension and residual extension of GSM 157, 178, and 202 increase gradually.

Conclusion

In this paper, some fundamental physical properties of knit fabric were examined to analyze the variation found in grey and dyed stage and for variation found in fabric GSM. Thus, such, tremendous changes in other properties was also observed. Normally, GSM of knitted fabric was significantly changed after dyeing due to exhaustion of dyes, chemicals, and auxiliaries. Bursting strength of single jersey knitted fabric decreased after dyeing the morphological structure of fabric changes, and as a result it losses strength. In addition, with the higher value of GSM, bursting strength of fabric increase for both grey and dyed condition. Single Jersey knitted fabric has no significant influence on pilling for change in GSM. However, after dyeing, the pilling property of fabric has improved as biopolishing has reduced the protruded fiber from the fabric surface. Extension percentage of single jersey knit fabric is more in widthwise direction compared to lengthwise direction, and with the increase of GSM, extension percentage increases both in length and widthwise direction. Although after dyeing extension occurred, the value of fabric extension has decreased phenomenally in both directions. After dyeing due to application of dyes, chemicals and auxiliaries, the crystalline region of the dyed fabric increase and porosity decrease. The extension and residual extension of dyed fabric also decrease both for length and widthwise direction as the porosity decrease. Residual extension has shown similar characteristics as fabric extension where widthwise residual extension was more compared to lengthwise direction, and with the increase of GSM, residual extension percentage increases both in length and widthwise direction. Additionally, after dyeing, the value of fabric residual extension decreased compared to grey fabric residual extension.

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