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Scope of Polyester Cotton Blended Single Jersey Knit Fabric Finishing Without Heat Setting

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Abstract: ***The present paper elucidates the study on finishing of single jersey PC fabric devoid of heat setting. 140 grams per square meters (GSM) single jersey PC (65% cotton and 35% polyester) blended knit fabric was prepared by circular knitting machine and divided into two categories. The processing and finishing of one group of fabric samples was carried out by heat setting and another one was performed without heat setting. The bursting strength of without heat set fabric was slightly higher than the heat set polyester cotton blended fabric. However, the pilling of polyester cotton blended fabric was faintly better in case of heat set samples. Although, heat set fabric exhibited better outcomes for shrinkage and spirality compared to non heat set fabric, still both results were within the acceptable limit (±5%). Furthermore, it can be seen from the revealed data that the washing fastness and rubbing fastness properties were not significantly influenced by the heat set process on finished fabric. No distinction was noticed in hand feeling for both types of fabrics.***

Keywords: knit fabric, heat setting, polyester cotton blend, dimensional stability.

1. Introduction

Textile fabrics, for wearable purpose, are mainly prepared from cellulosic fibers such as cotton which provides desirable properties like high absorbency, breathability, softness and comfort all kind of people all over the world[1,2]. Despite the aforementioned advantages, there are also some unexpected properties such as easy wrinkling, easy soiling, susceptibility to microbial attack, supporting the growth of micro organisms, low UV-protection as well as low strength [3,4]. On the other hand, textile fabrics based on polyester fibers generally are strong, wrinkle resistant, more resistant to microbial attacks by microorganisms and dirt resistant[5]. However, they certainly lack the comfort properties as well as low absorbency [6].Therefore, blending of cellulosic cotton and polyester fibers along with the used novel finishes and innovative technologies can economically extend the functional and performance properties as well as values of textile processing and products, to cope with the increasing consumer's demand for innovative multifunctional materials[7,8,9].This blend is perfect for clothing as it outcomes both the benefits of the two types of fibers together. The fabric thus remains light and cool for the presence of cotton and at the same time polyester gives the strength and durability. This blend is usually comfortable by combining the natural effects of cotton for softness and moisture absorption with the no iron crispness of polyester. The most common polyester cotton blend is found as 65% polyester and 35% cotton. Other combination of polyester cotton blended fabrics are 50% polyester and 50% cotton, 70% polyester and 30% cotton, 80% polyester and 20% cotton etc.

Heat setting needs to be applied on polyester or polyester cotton blend fabric prior to dyeing process to alter the physical properties of polyester fabric resulting more stable polyester fiber. This system, applied in industry, includes dry air contact heating elements, water vapor, liquid baths etc[10]. It is one of the major influencing parameters to process the polyester cotton blend fabric. Basically heat setting is a heat treatment by which shape retention, crease resistance, resilience and elasticity are imparted to the fibers. It also brings changes in strength, stretchability, softness, dyeability. All these changes are connected with the structural and chemical modifications occurring in the fiber. The importance of heat setting as a means of optimizing the structure and performance of oriented films and fibers has been well recognized.

In the different textile dyeing industries in Bangladesh, heat setting is done on polyester cotton blended fabric before dyeing. However, for heat setting, utility cost, manpower cost and other costs are involved which ultimately increases the production cost of fabric. This cost can be reduced by avoiding heat setting process prior to dyeing of polyester cotton blended fabric. In this case, fabric quality will be a vital issue to avoid this process from this type of blended fabric finishing. If heat setting could be avoided without compromising the quality of polyester cotton blended fabric, production cost and process duration will be reduced to a great extent. In this study, the properties of polyester cotton blended fabric such as bursting strength, dimensional stability, pilling and also various color fastnesses properties of dyed PC fabric were compared after finishing by heat setting and without heat setting to predict wheather is it feasible to omit heat set prior to dyeing or not.

2. Experimental

2.1 Materials

Single jersey polyster cotton blended fabric was used to perform the experimental works. The fabirc was formed with 65% polyester and 35% cotton where yarn count was 30^s. The pretreatment i.e. scouring and bleaching was carried out by using the chemicals - Wetting agent (Imeron PCLF) and Peroxide stabilizer (Stabilizer SOF liquid) from Clariant, Bangladesh; Hydrogen Peroxide (H_2O_2), Acetic acid (CH_3COOH), and Caustic soda (NaOH) from Merck, India; Sequestering agent from Dysin, Bangladesh. The dyeing of fabric was carried out by using three commercial reactive dyes Novacron Yellow FN2R, Novacron Red FN2BL and Novacron Blue FNR from Swiss Colours BD Ltd., Bangladesh. Auxiliary chemicals like-Leveling agent (Drimagen E3R) from Clariant, Bangladesh; Glauber's salt ($Na_2SO_4.10H_2O$) and Soda ash (Na_2CO_3) were collected from Merck, India. The finishing was performed by using softening agent (Cepreton- UNP) brought from Clariant, Bangladesh. All the chemicals applied in the fabric processing were of analytical grade and used as received.

2.2 Equipments

The knitting of fabric was done by circular knitting machine of Mayer & Cie from Germany. The pretreatment and dyeing of fabric was carried out by sample dyeing machine from Fongs, Taiwan.The dyed fabric samples were finished by keeping the same parameters. Slitting machine (Bianco from Italy) was used for squeezing and opening the fabric. Stenter machine (Brukner from Germany) was employed to heat set and dry the fabric. Moreover, compacting of the fabric was done by open compactor machine (Lafer from Italy). The performance of the finished fabric i.e. bursting strength and pilling was measured by hydraulic bursting strength tester (Tru Burst from James H. Heal & Co, UK) and ICI Pilling Box (Tex care industries from India) respectively. The washing and drying of the fabric for the testing of shrinkage and spirality were executed by washing machine (Gyro wash from James H. Heal & Co, UK) and Tumble dryer (Accu-Dry from U.K)**.** Colorfastness to washing and rubbing of dyed fabric was also assessed. Wash fastness tester (Gyro wash model no: 415/8), rubbing fastness tester (Crock meter, model no: 670) from James H. Heal & Co, UK were used for the respective fastness testing.

Table: 1 Single bath scouring bleaching recipe for all test samples

Ingredients	Wetting agent g/l	Sequestering agent g/l	Hydrogen peroxide g/l	Stabilizer g/l	Caustic soda g/l	M:L*
Amount	0.4	0.3	2.5	0.5	4.0	1:10

*Material liquor ratio

Table 2: Dye bath recipe for all test samples

Ingredients	Dyes (%)	Glauber salt g/l	Soda ash g/l	Wetting agent g/l	Leveling agent g/l	M:L*
Amount	1.0	50.0	12.0	1.0	1.0	1:10

*Material liquor ratio

2.3 Methods

2.3.1 Fabric formation

The formation of fabric was performed by circular knitting machine at 24 gauge, dia 34 inch and stitch length 2.57 mm through which 140 GSM fabric was produced. Maintaining the same production parameters the manufactured fabrics were divided into two groups. Each group is divided into three fractions where 15 Kg of fabric was used in each fraction. The processing and finishing of one group of fabric samples was carried out by heat setting and another group was performed without heat setting. For the ease of identification, the heat set couples were denoted by H1, H2, and H3 and without heat set couples were W1, W2, and W3.

2.3.2 Heat setting of fabric

The heat setting of fabric was carried out in Stenter machine at 190^0C in dry condition. During heat setting 20% over feeding of fabric was maintained throughout the process.

2.3.3 Processing of fabric

The processing of fabric i.e. pretreatment and dyeing was performed after knitting and heatsetting. The pretreatment (scouring and bleaching) of fabric samples both heat set and without heat set was carried out by exhaust method at 100 °C temperature for 45 minutes. The single bath scouring and bleaching recipe and process curve are given in Table 1 & Figure 1.The pretreated fabric was then dyed in the same bath of scouring and bleaching. Only cotton part of the blended fabric was dyed in batch process with medium brand reactive dyes at 60^0C temperature for 60 minutes. All the parameters were remained constant for both the types of fabrics. Dyeing recipe and process curve are shown in Table 2 & Figure 2

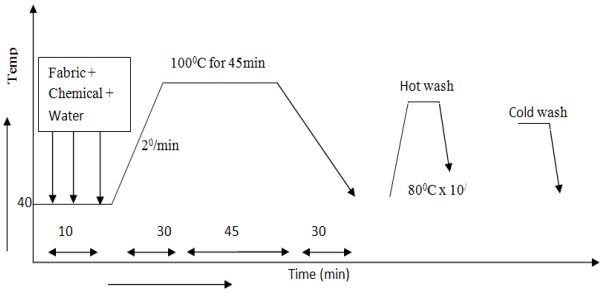

Figure 1: Single bath scouring bleaching procedure of cotton fib

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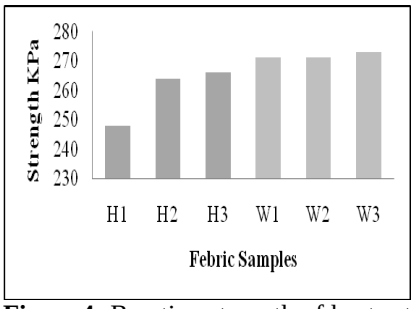

Figure 4: Bursting strength of heat set and without heat set fabric samples after finishing

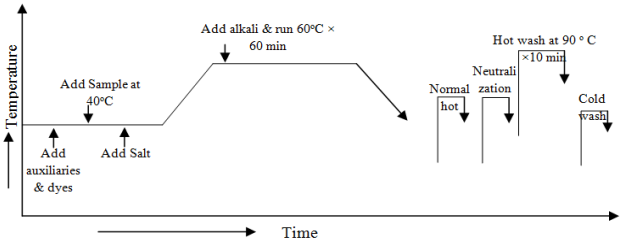

Figure 2: Dyeing procedure of cotton part of PC fabric using reactive dye

2.3.4 Finishing of fabric

The dyed fabric samples were finished maintaining the same process parameters . The drying of fabric was done by Stenter machine at 140℃ temperature and then compacted by using compactor machine followed by opening and squeezing by slitting machine.

2.3.5 Evaluation of fabric performance

The bursting strength and pilling of fabric was determined according to BS EN ISO 13938-2 and BS EN ISO 12945-1:2000 respectively. The pilling of fabric was examined visually after comparing it with the standard sample by the use of a written scale of severity[11]. The shrinkage and spirality of fabric was measured after washing. The washing of fabric was conducted according to**:** ISO-6330. After washing and drying the lengthwise and widthwise shrinkages were calculated according to ISO-3759 by using following formula:

Length wise Shrinkage $= \frac{L_1 - L_2}{L_1} \times 100$ Width wise Shrinkage $= \frac{W_1 - W_2}{W_1} \times 100$

Where, L_1= Length of fabric before wash, L_2= Length of fabric after wash, W_1= Width of fabric before wash and W_2= Width of fabric after wash. The spirality of fabric was calculated by using the following formula from Figure -3.

Spirality % $= \frac{\left(\frac{CC_1}{AC_1} \times 100 + \frac{DD_1}{BD_1} \times 100\right)}{2}$

The fastness properties of dyed fabrics i.e. color fastness to washing and rubbing were assessed according to ISO 105C03 and ISO 105x12 method respectively.

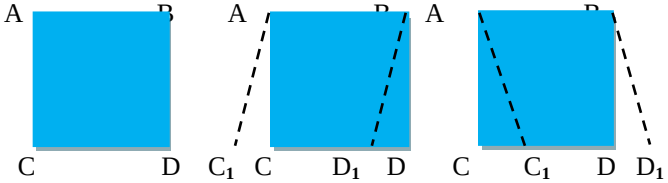

Figure 3. Measurement of spirality of PC blend fabric after finishing

3. Results and discussions

3.1 Measurement of Bursting Strength of fabric

Bursting strength is a method in which the material is stressed in all directions at the same time. This method is applicable for knitted fabrics where maximum strength is not found at any distinct direction[11]. This strength of the sample knitted fabric was measured by hydraulic diaphragm method and the results of heat set (H1, H2 and H3) and without heat set (W1, W2 and W3) fabrics are represented in the Figure 4. From figure 4 it has been found that, the fabric samples of without heat set exhibit higher bursting strength than the heat set fabrics. In case of without heat set, the strength of fabric was 271, 270 & 273 KPa respectively. However, the strength of heat set fabrics was lower than that of the without heat set fabric samples and the values varied from 248 KPa to 266 KPa. The decrease in strength of fabric is due to the loss of strength of polyester fiber after heat setting. Because heat setting was carried out at 190^0C in dry condition and polyester fiber losses its strength above 150^0C[12] which results in lower bursting strength of fabric after heat setting.

3.2 Pilling of Fabric Surface

Pilling is a phenomenon that arises in wear due to the formation of little 'pills'. Pills are entangled fiber clinging to the fabric surface giving it an unsightly appearance. The tendency of pill formation is greater in case of blended fabric such as polyester/cotton[13].

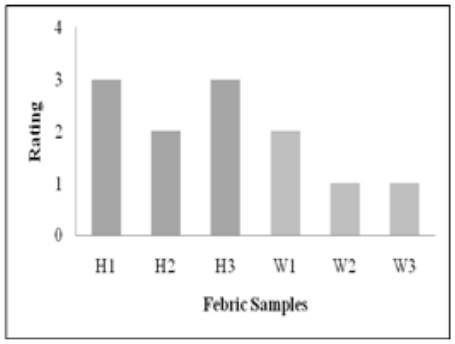

Figure 5. Rating of pilling of heat set and without heat set fabric surface

Figure 5 represents that, the average pilling rating of without heat set fabric is 1-2 i.e. dense surface fuzzing or severe pilling[11]. But the fabric samples of heat set exhibit higher pilling rating. Because, heat setting can improve the pilling performance of fabrics containing thermoplastic fibers such as polyester, nylon etc[13]. Since heat setting of fabric was performed in dry condition at high temperature 190^0C. High temperature can enhance the pilling performance of PC fabric due to high heat shrinkage combined with low flex life where the fabric appears to be pill free.

Table 3**:** Shrinkage percentage of heat set and without heat set fabric after finishing

Fabric samples	H1	H2	H3	W1	W2	W3
Lengthwise shrinkage (%)	+1.00	+1.0	+1.0	-0.30	-0.33	-0.33
Widthwise shrinkage(%)	-1.86	-1.82	-1.84	-2.87	-2.84	-2.83

Table 3 shows the lengthwise and widthwise shrinkages of fabric (heat set and without heat set) after finishing. Though the fabrics, heat set and without heat set shrink after finishing, but the values found in case of both samples were remained within the recommended range (±5% of shrinkage) of commercial purpose. However, the widthwise shrinkage of heat set fabric is comparatively less than without heat set fabric. Since, heat setting was carried out at 190^0C which stabilizes the polyester fibers results in control the residual shrinkage of PC fabric[15]. Moreover, heat setting changes the morphology of the polyester fibers and improves the dimensional stability of the fabric[16]. As a consequence, the development of dimensional stability heat set fabric exhibits less shrinkage than without heat set fabric. Again, the lengthwise extension of heat set fabric is due to the 20% over feeding of fabric during heat setting. This overfeeding compresses the knitted loop axially and after finishing these loops is retained at their original shape, resulting positive lengthwise shrinkage of fabric.

3.3. Determination of fabric Spirality

Spirality is a common problem in single jersey knit structure and it may be developed in grey, washed or finished state of fabric. It influences the aesthetic and functional performance of knitwear **.**

Table 4**:** Spirality percentage of heat set and without heat set fabric after finishing.

Fabric	H1	H2	H3	W1	W2	W3
Spirality	0%	0%	0%	2%	2.03%	2.05%

The practical problems arising out of the loop spirality in knitted garments are: displacement or shifting of seams, mismatched patterns and sewing difficulties. These problems can be minimized by heat setting in case of 100% polyester or PC fabric. The spirality of PC fabric after heat setting and without setting is given in Table 4. The dimensional distortions and instability in the knitted loop construction is experienced due to the relaxation of torsional stresses[17]. This leads to the appearance of spirality in the single jersey knitted fabrics especially in case of PC fabric. This tendency of deformation and unsteadiness of knitted loop of PC fabric is reduced by heat setting. Due to the improvement of dimensional stability after heat setting[18]. The spirality of fabric was found 0% which is shown in Table 4. However, the fabric without heat setting exhibit spirality is about 2%. Though the spirality of fabric is increased by 2% of without heat set fabric but this value is quite satisfactory in case of commercial application where generally ±5% spirality is acceptable.

3.4 Assessment of color fastness

The color fastness properties of dyed PC fabric i.e. fastness to washing and rubbing were analyzed. Color fastness to washing was assessed in respect of color change and color staining. The staining of color was examined by multifiber fabric (acetate, cotton, nylon, polyester, acrylic, wool). Rubbing fastness was evaluated in dry and wet condition. Fastness ratings of different types of dyed samples are furnished in the Table 5.

Table 5. Color fastness to washing (color change and staining) and rubbing of heat set

Fabric samples	Rubbing Fastness		Washing Fastness						
			Color change	Color staining					
	Dr	We		Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
H1	4/5	4	3/4	4/5	4/5	4/5	4/5	4	4/5
H2	4/5	4	4	4/5	4/5	4/5	4/5	4	4/5
H3	4/5	4	3/4	4/5	4/5	4/5	4/5	4	4/5
W1	4/5	4	3/4	4/5	4/5	4/5	4/5	4	4/5
W2	4/5	4	3/4	4/5	4/5	4/5	4/5	4	4/5
W3	4/5	4	4	4/5	4/5	4/5	4/5	4	4/5

From Table 5 it has been found that, the fabrics of heat set and without heat set demonstrate almost similar ratings in case of both color fastness to washing and rubbing. Heat setting affects the dyeability of polyester fiber and the dye uptake of this fiber is influenced by the time and temperature of heat setting[18]. Since, only cotton part of the PC fabric was dyed and there is no effect of heat setting on the dye absorption of the cotton fiber, so the depth of shades of colored fabric was also similar. As a consequence of similar depth of shade, same fabric and same dyestuff the fastness rating will be also similar.

4. Conclusion

In this study, the properties of polyester cotton blended fabric were compared after finishing with heat setting and without heat setting. The bursting strength of without heat set fabric was slightly higher than the heat set polyester cotton blended fabric. However, the pilling of polyester cotton blended fabric was slightly better when dyed and finished after heat setting than non heat set fabric. Although, heat set fabric shown the better shrinkage and spirality compared to non heat set fabric, the both results were within the acceptable limit of different buyers. Moreover, it can be seen from the result that the washing fastness and rubbing fastness did not influenced by the heat set process on finished fabric remarkable. No difference was found in hand felling of both fabric practically. Therefore, the findings of this work suggest that, single jersey PC fabric could be finished of that composition without heat set process to save time and utility cost as well as to increase production in a dyeing finishing unit.

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