

Evaluation of Impact of Yarn Count and Stitch Length on Pilling, Abrasion, Shrinkage and Tightness Factor of 1 $\,\times\,$ 1 Rib Cotton Knitted Fabrics

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Abstract

This study investigates the impact of yarn count and stitch length of 100% cotton knitted fabrics. 1×1 ribs structured fabrics were used in this research work. The stitch length 2.50 mm, 2.52 mm, 2.60 mm, 2.70 mm, 2.80 mm and 2.96 mm were used of the yarn count of 26Ne, 28Ne and 36Ne. The areal densities of the grey fabrics were in various amounts. The impacts of yarn count and stitch length were measured concerning pilling resistance, abrasion resistance, and shrinkage and tightness factor. The result showed that the fabric pilling grade decreased while number of cycle increased. Abrasion resistance decreased but length wise shrinkage increased despite the fact that the stitch length increased. The results also exposed that the tightness factor of the fabric increased with the increase of the stitch length in both dyeing and washing state and finished state compared to grey state for the yarn count 26Ne and homogeneous result not found for yarn count 28Ne and 36 Ne.

Keywords: Rib fabric; Yarn count; Stitch length; Pilling resistance; Abrasion resistance; Shrinkage; Tightness factor

Introduction

The most widely used fabric forming method is knitting and its principles is divided into two major sections namely warp and weft knitting [1]. In general, the knitted fabrics have more stretchable property compared to the woven fabrics [2,3]. Rib is a more costly and heavier structured fabric to produce than plain fabric [4]. The main utilization of knitted rib structures are in providing welts, cuffs, and collars for garments with plain-knitted bodies and sleeves [5]. Moreover, the knitted rib structures are also widely used in body lengths for outerwear.

The impact of different factors such as yarn count, twist, stitch length, various processing stage such as dyeing, finishing and washing process on the dimensional and physical properties such as pilling resistance, abrasion resistance, shrinkage and tightness factor of knitted fabric have been examined by many researchers.

Pilling is a surface defect and it's a noteworthy problem for textile manufacturers. The fabric quality considerably decreases and a negative influence on the user's comfort observed due to pilling [6]. The pilling is noticed as small fiber balls or group consisting of intervened fibers during wear and washing [7]. The fabric of compact construction shows less pills and opposite phenomenon for loosely knitted or woven fabric. Many scientists have investigated the factors affecting the pilling performance [8-12]. Pilling attitude is prejudiced by fiber properties, e.g. tensile strength, percent elongation, bending rigidity, shape of fiber cross-section and friction and structure of the yarn and fabric [13,14].

Physical damage of textile materials like fibres, yarns, and fabrics has made due to abrasion and abrasion occurs during wearing and washing. Abrasion ultimately results in the loss of performance characteristics, such as strength, but it also affects the appearance of the fabric [15]. The service life of the garment seriously depends on its end use. Abrasion is a serious problem for home textiles like as carpets and upholstery fabrics, socks and technical textiles as well [16,17]. The abrasion property of textile materials is effected by many factors (e.g. fibre fineness, yarn count, yarn type, weave etc.) in a very complex manner [18].

Many researchers have investigated the influence of raw material, yarn production technology, yarn twist and chemical treatment on the abrasion resistance property [12,13,18-21].

Fabric shrinkage is a serious problem for knitwear, which originates from dimensional changes in the fabric and it is a combined effect of number of factors such as relaxation, finishing, dyeing, and effects of machinery [22,23]. Shrinkage is very important to maintain the aesthetics of knitted products in the user ends. Different factors such as fiber characteristics, yarn parameters, Stitch length, yarn count, structure of fabric, machine parameters influence the dimensional characteristics of knitted fabrics [24,25]. The significance of shrinkage was investigated by many researchers [8,13,14,26-31].

Fabric tightness implies the looseness and tightness and it varies with the stitch length of knitted fabrics. When the stitch length is big, the fabrics become slack and when the loops are small, the fabric is tighter [32,33]. Fabric area shrinkage is lower with a lower tightness factor and increases with the twist factor of the yarn. Tightness factor significantly influences the dimensional changes of knitted fabrics. Fabric tightness factor has examined by several researchers [34-36].

The objectives of this study were to disclose the effect of yarn count and stitch length on various fabric properties such as pilling resistance, abrasion resistance, and shrinkage and tightness factor (Figures 1-4).

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Figure 4: 1×1 Rib structure [1].

Experimental

Materials

The fabrics were collected from "DIVINE GROUP LIMITED", kaliakoir, Gazipur, Bangladesh [5]. The areal density, average course per inch (CPI) and wales per inch (WPI) of the grey samples are mentioned in the Figures 5-7 respectively.



Methods

Sampling: The samples are categorized as accordingly as stated Table 1.

	Sample types	Identification	
Count	Stitch Length (mm)	Identification	
	2.70	A	
26 No	2.80	В	
20116	2.96	С	
	2.50	D	
32 No	2.60	E	
52 NE	2.70	F	
	2.52	G	
36 No	2.60	Н	
00116	2.70	I	

Table 1: Sample Identification.

Sample testing: The specimens were held in standard conditions (RH = $65\% \pm 2\%$, T = $20^{\circ}C \pm 2^{\circ}C$) according to the requirements of ISO 139:2005 before the investigation carried out [37-39].

Determination of pilling: Pilling test was done according to ISO 12945-2 test method by using Martindale Pilling Tester (SDL International, England) [40]. The samples were assessed for 125, 500 and 2000 cycles. The grading system for visual pilling assessment authorized by ISO is given in Table 2.

Determination of abrasion resistance: By using the Martindale abrasion tester ISO 12947-1:1998 test method the abrasion resistance property was tested [41]. The samples are assumed for 500 cycles (Table 3 and Figures 5-8).

Grade	Description
5	No change.
4	Slight surface fuzzing and/or partially form pills.
3	Moderate surface fuzzing and/or moderate pilling. Pills of varying size and density partially covering the specimen surface.
2	Distinct surface fuzzing and/or distinct pilling. Pills of varying size and density covering a large proportion of the specimen surface.
1	Dense surface fuzzing and/or severe pilling. Pills of varying size and density covering the whole of the specimen surface.

 Table 2: Assessment of pilling [12].

Series of experiment	Abrasion cycles at the breakage of the sample	Abrasion cycles for determination of weight loss
а	≤ 1000	100,250,500,750,1000(1250)
b	> 1000 ≤ 5000	500,750,1000,2500,5000 (7500)
С	> 5000 ≤ 10000	1000,2500,5000,7500,10000(15000)
d	> 10000≤ 25000	5000,7500,10000,15000,25000,(40000)
е	> 25000 ≤ 50000	10000,15000,25000,40000,50000,(75 000)
f	> 50000 ≤ 100000	10000,15000,25000,40000,50000,75000, 100000,(125000)
g	> 100000	25000,40000,50000,75000,100000,(12 5000)

Table 3: Intervals for measuring weight loss [12].



Figure 8: Martindale abrasion testing apparatus.

Determination of shrinkage: ISO 6330 test method was used to measure the shrinkage. Distance of points (which was marked in $35 \times 35 \text{ cm}^2$ before wash) was measured in both lengthwise and width wise direction. The following formulas (1) and (2) were used to calculate the shrinkage percentage.

Length Wise Shrinkage = (Before wash Length-After wash Length)/ (Before wash Length)×100% (1)

Width Wise Shrinkage = (Before wash Width-After wash Width)/ (Before wash Width)×100% (2)

Determination of tightness factor: The tightness factor is the measurement of level of fabric density [35,36]. The tightness factor was calculated by using equation 3 (Tables 4-6).

 $T.F = \sqrt{T/L}$ (3)

Where, T.F = Tightness Factor

T = The linear density of yarn in Tex

L = Stitch length or loop length in cm

S. No.	Parameters	Specification/ Description
1	Brand name	Pailung
2	Model number	PL-KDCS6U, PL-XR2B/CE
3	Manufacturer	Pailung Machinery mill co. Itd
4	Origin	Taiwan
5	Machine Diameter	36", 30", 34"
6	Machine Gauge	18G
7	Number of Needle	3384, 4040, 5088
8	Number of Feeder	54, 60, 72
9	Feeding System	Positive

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Table 4: Knitting machine specification.

SI. No.	Parameters	Specification/Description
1	Brand name	THIES
2	Model number	D-48653coesfeld
3	Temperature	100°C
4	Time	60 minutes
5	Origin	Germany

Table 5: Dyeing machine specification.

S. No.	Parameters	Specification/ Description
1	Machine name	STENTER
2	Manufacturer	Uni-tech S.P.A Textile machinery
3	Model number	A512-0463
4	Temperature	200°C (Highest)
5	Width	220"
6	Feeding system	Over & under feed
7	Origin	Italy

Table 6: Finishing machine specification.

Results and Discussion

Fabric pilling

The Figures 9-11 illustrates the results of fabric pilling resistance. It is clearly evident from the figures that the pilling grade remarkably affected by number of cycles. For constant yarn count, the stitch length has no significant effect on the pill formations. The result showed that the fabric pilling grade deteriorated whilst the number of cycle increased. The lowest grade of pilling 2-3 is reported in the all samples except A and E for 2000 cycles. No pill formation or excellent pilling resistance is observed in the sample A for 125 cycles.

Abrasion resistance

The Figures 12-14 demonstrates the fabric abrasion resistance. In abrasion resistance test, the weight loss percentage was recorded. The







weight loss percentage increased with the increase of stitch length when yarn count was kept in constant. But opposite scenario was observed for the sample H. During increasing stitch length from 2.52 mm to 2.60 mm for 36 Ne yarn, the weight loss percentage was decreased. It is clearly evident from the Figures 12-14 that the abrasion resistance is higher for lower stitch length.

Shrinkage

Fabric shrinkage is the most common problem of knitted fabrics. The good serviceable fabric should have least shrinkage. Figures 15-17 exhibits the outcome of fabric shrinkage. The length wise and width wise shrinkage were measured and plotted in the Figures 15-17. It is clearly evident from the figures that the width wise shrinkage is lower





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Figure 14: Effect of count (36 Ne) and stitch length on abrasion resistance.



Figure 15: Effect of count (26 Ne) and stitch length on shrinkage.







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than the length wise shrinkage except for the sample B. All samples showed positive shrinkage in both length wise and width wise direction while only sample F showed negative shrinkage in width wise direction. The highest shrinkage 10.29% is found in length direction for the sample of F and lowest shrinkage -2% is found for same sample in width wise direction.

Tightness factor

Figures 18-20 represents the impact of parameters which are taken in the consideration in this work on fabric tightness factor. Tightness factors were measured in various processing stages. From the Figure 18, it is observed that the tightness factor of the fabric increased with the increase of the stitch length in both dyeing and washing state and finished state compared to grey state. The tightness factor were increased as 2.26%, 4.12% and 9.92% at dyeing and washing state and 7.91%, 10% and 14.91% at finished state accordingly for the samples A, B and C as compared to grey state (Figure 18).



From the Figure 19, it is identified that the tightness factor of the fabric increased with the increase of the stitch length in dyeing and washing state and decreased in finished state compared to grey state. The tightness factor were increased as 0.58%, 0.61% and 3.14% at dyeing and washing state for the samples D, E and F as compared to grey state. In finished state, the tightness factors were increased as 2.33% and 5.45% for the sample D and E and 1.89% decreased for the sample F as compared to grey state (Figure 19).



It is clearly evident from the Figure 20 that with the increasing of the stitch length, the tightness factor of the fabric has increased in dyeing and washing state and finished state compared to grey state except for the sample F in the finished state. The tightness factor were increased as 5.59%, 1.92% and 2.68% accordingly for the samples G, B, H and I at dyeing and washing state compared to grey state. On the other hand, the tightness factor were decreased 3.73% for the sample G and increased 1.28 % and 10.07% for the samples H and I at finished state compared to grey state.



Conclusion

1.8

1.7 1.6 17

In this work, an attempt has been carried out to determine the physical characteristics such as pilling resistance, abrasion resistance and shrinkage of 1×1 rib structured 100% cotton knitted fabrics. The tightness factor was also investigated in different processing stages. Here, impacts of some controlling parameters like yarn count and stitch length were disclosed. From the above mentioned data it has been identified that the pilling resistance decreased when the number of cycle increased. Alternatively, abrasion resistance decreased while stitch length increased. The unveiled data has also indicated that the length wise shrinkage is higher than width wise shrinkage. The highest tightness factor was observed 1.91 for the sample of 2.70 mm stitch length of 26 Ne yarn at finished state.

Author Contributions

The objectives and methodology of this works were proposed by N.A.S. and R.U.R. The specimen fabrication, characterization and data treatment carried out by R.U.R. and N.A.S. with the help of N. A. The article was written by R.U.R. and. M.S.I. and revised by N.A.S., D.P., R.A.M., N. A. and S.S.

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Conflicts of Interest

The authors declare no conflict of interest.

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