Effect of 1×1, 2×1, 2×2, 3×1 and 3×3 Knit Structure on Different Properties of Rib Knitted Fabric

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Abstract This study investigates the effect of different knit structure on various properties of rib knitted fabric. The acrylic yarns were used to make 1×1, 2×1, 2×2, 3×1 and 3×3 rib structured fabrics using manual V-bed knitting machine in this research work. The effects of knit structure were measured concerning drape co-efficient percentage, bending length, flexural rigidity and tightness factor. The results disclosed that the fabric properties are greatly influenced by knit structures. 1×1 rib knit fabric showed the lowest value for all tested properties and 3×3 rib knit fabric showed the highest value except drape co-efficient. The bending length and flexural rigidity was investigated in both wale and course direction. At the same time, surface and back sides bending length were also calculated. It has been identified from the test results that the effect of knit structure on flexural rigidity in both wale and course direction were influenced in a same chronological way.

Keywords Knitted Fabric, Drape Co-efficient, Bending Length, Flexural Rigidity, Tightness Factor

1. Introduction

Knit wear industry is rising at a faster rate over the globe and technological advancements contribute a lot in the success of industry. Knit wear fabrics are popular on account of their excellent properties of comfort, softness, sweat absorption, durability and softness. Quality of the fabric is of prime concern in placement of new ties between buyers and manufacturers. Consumers, now days, are becoming more and more concerned and aware of fabric quality and accept higher quality standards than any time in recent years [1-4]. Knit fabrics provide outstanding comfort qualities and have long been preferred as fabrics in many kinds of clothing. Knit fabrics are produced on different machines with different knit stitches and conditions to create different patterns and fabric types. The knitted fabrics have more stretchable property compared to

the woven fabrics [5-7]. The commercial design of knitted garments is a process that shares many important characteristics with other types of aesthetic design and engineering [8, 9]. Rib is a more costly and heavier structured fabric to produce than plain fabric [10]. The main utilization of knitted rib structures are in providing welts, cuffs, and collars for garments with plain-knitted bodies and sleeves. Moreover, the knitted rib structures are also widely used in body lengths for outerwear [11].

Fabric drape is defined as the ability of a fabric to deform when suspended under its own weight in specified conditions [12, 13]. Drape is a unique property that allows a fabric to be bent in more than one direction describing a sense of graceful appearance. Drape is a complex property and it is an essential parameter to decide both appearance and handle of fabrics [14]. The role of drape in a garment is an important aspect of aesthetics. It is also one of many factors that influence the aesthetic appearance of a fabric and has an outstanding effect on the formal beauty of the cloth [15-17]. The drape is characterized by drape coefficient (DC). The drape coefficient is the widely used parameter to describe fabric drape. A low drape coefficient indicates easy deformation of a fabric and a high drape coefficient indicates less deformation [18, 19]. The drape co-efficient of knitted fabric have been examined by many researchers [12, 20-26].

The bending length is very important factor which determines the flexibility of the fabric. The bending length in both the warp and weft direction of the fabric is important in calculating the flexibility of the fabric. Fabrics with high bending length are stiffer and these are not used as suitable aesthetic fabrics. The bending length of knit and woven fabric has been studied by some researchers [6, 27-29].

Fabric bending rigidity, also called flexural rigidity, is one of the most important factors of fabric which has affect on handling and comfort of apparel. It is a key component in deciding fabric handle and drape. It is an important contributor to fabric's formability, buckling behavior, wrinkle-resistance and crease resistance. A lower value of

bending rigidity supports the positive impression of sensorial comfort, and is at the same time a feature of fabrics which are susceptible to the formation of pleats. The importance of bending rigidity are the estimating the technological usefulness and usability of fabrics. The bending rigidity or flexural rigidity of fabric has been observed by many researchers [27, 30-32].

Fabric tightness implies the looseness and tightness of knitted fabrics. When the stitch length is big, the fabrics become slack and when the loops are small, the fabric is tighter [33, 34]. Tightness factor of fabric has examined by several researchers [35-38]. Tightness factor significantly influences the properties of knitted fabrics.

The goals of this study were to disclose the effect of 1×1, 2×1, 2×2, 3×1 and 3×3 knit Structure on various properties of knitted fabric such as drape co-efficient percentage, bending length, flexural rigidity and tightness factor.

Figure 1. Rib knitted structure [1]

2. Experimental

2.1. Materials

The acrylic yarns were collected from local market of Dhaka, Bangladesh. Different rib structured fabrics like 1×1 rib, 2×1 rib, 2×2 rib, 3×1 rib and 3×3 rib were knitted with manual V-bed knitting machine using full needle bed length, 3.5 machine gauge and Single ended latch needle at fabric manufacturing and technology lab of Ahsanullah University of Science and Technology, Dhaka, Bangladesh. The wales per inch (WPI), course per inch (CPI) and stitch length of the samples are mentioned in the figures 2, 3 and 4 respectively.

Figure 2. WPI of the samples

Figure 3. CPI of the samples

Figure 4. Stitch length of the samples

2.2. Methods

2.2.1. Sampling

The samples are categorized as accordingly as stated table 1.

2.2.2. Sample Testing

The specimens were held in standard conditions (RH = 65% ±2%, T = 20 °C ±2 °C) according to the requirements of ISO 139:2005 before the investigation carried out [39].

2.2.3. Measurement of WPI, CPI & Stitch Length

The wales per inch (WPI) and course per inch (CPI) were measured by counting glass [40]. Stitch length was determined by HATRA Course Length Tester (SDL International Ltd., England).

Table 1. Fabric structures, identification code and knitting notation

Fabric structure	Identification Code	Knitting notation
1×1 rib	R11
2×1 rib	R21
2×2 rib	R22
3×1 rib	R31
3×3 rib	R33

2.2.4. Measurement of Drape Co-efficient

The appropriate diameter of the template and corresponding size of paper ring was 30 cm. Firstly, the test sample was calendared and conditioned in standard atmosphere. The selected template (30 cm) was placed on the specimen and marked round it. Then a pin was pushed through the template center in order to make a small hole in the middle of specimen. After cutting the specimen it was placed on the disc (18 cm) of Cusick drape tester and the lid was covered. A paper ring was placed on the lid around the locating disc. After that the light of the drape tester was switched on. A shadow of the specimen was found on the paper. Then the shadow was drawn on the paper. Drape co-efficient of fabrics were calculated using the following formula (i) [22, 24].

$$DC = \frac{W_s - W_d}{W_D - W_d} \times 100\% \quad (1)$$

Where,

DC= Drape Co-efficient.

W_D = Weight of the paper whose area is equal to the area of the specimen.

W_d = Weight of the paper whose area is equal to the area of the supporting disc.

W_s = Weight of the paper whose area is equal to the projected area of the specimen.

2.2.5. Determination of Bending Length

Fabric bending length for each direction (course and wale directions) was measured five times using the

cantilever method. Fabric bending length (c), a measure of the interaction between the fabric bending rigidity and weight, is defined as following formula (ii) [6, 28].

$$c = l f_1(\theta) \quad (2)$$

$$\text{Where, } f_1(\theta) = \left(\frac{\cos \frac{1}{2} \theta}{8 \tan \theta} \right)^{\frac{1}{3}}$$

l = Cantilever length

θ = Deflection angle

2.2.6. Determination of Flexural Rigidity

Flexural rigidity (G) is identified as the force couple required to bend a non-rigid structure to a unit curvature. This is a measure of stiffness associated with handle. Any formula from (iii) and (iv) can be used to measure the fabric flexural rigidity.

$$G = 3.39 w_1 c^3 \text{ mg.cm} \quad (3)$$

$$\text{or } G = w_2 c^3 \times 10^3 \text{ mg.cm} \quad (4)$$

Where, c = Bending length

w_1 = Cloth weight in ounces per square yard

w_2 = Cloth weight in gram per square centimeter

2.2.7. Determination of Tightness Factor

The tightness factor is the measurement of level of fabric density [36, 37]. The tightness factor was calculated by using formula (v).

$$T.F = \frac{\sqrt{T}}{L} \quad (5)$$

Where, T.F = Tightness Factor

T = The linear density of yarn in Tex

L = Stitch length or loop length in cm

3. Results and Discussion

3.1. Drape of Co-efficient

The figure 5 illustrates the effect of fabric structures on drape of co-efficient of rib fabric. It is clearly evident from the figure 5 that the drape co-efficient really affected by fabric structures. The orders of the samples depending on drape of co-efficient percentage value were found as $R22 > R33 > R31 > R21 > R11$. The drape co-efficient percentage among different structures, it is seen that 1×1 rib possesses the lowest value and 2×2 rib possesses the highest value. The figure 5 also showed that the drape co-efficient were 3.59%, 12.50%, 4.11% and 10.62% higher for the samples R21, R22, R31 and R33 respectively compared to the sample R11.

Figure 5. Effect of fabric structure on drape co-efficient

3.2. Bending Length

The figures 6 and 7 demonstrate the effect of fabric structures on bending length of rib fabric. The figure 6 is responsible for bending length in wale direction and the figure 7 is responsible for bending length in course direction. The bending length in both sides (surface and back) of the fabric has calculated for both directions (wale and course) of the fabric. In wale direction, the highest bending length was recorded in surface side of 3×3 rib and lowest value was observed in back side of 3×1 rib. In the other hand, in course direction, the highest bending length was recorded in surface side of 3×3 rib and lowest value was observed in same side of 1×1 rib. It is also clearly evident from the figure 6, the bending length of back side showed lower than surface side except 2×1 and 2×2 rib and from the figure 7, the bending length of back side explained higher than surface side except 3×1 and 3×3 rib.

Figure 6. Effect of fabric structure on bending length in wale direction

Figure 7. Effect of fabric structure on bending length in course direction

3.3. Flexural Rigidity

The figures 8 and 9 reveal the effect of fabric structures on flexural rigidity of tested specimen. The flexural rigidity in wale and course direction were measured and plotted in the figures 8 and 9. It is clearly evident from the figures 8 and 9 that the flexural rigidity in wale direction is higher than the flexural rigidity in course direction. The flexural rigidity among different structures, it is seen that 1×1 rib possesses the lowest value and 3×3 rib possesses the highest value both in wale and course direction. Regarding flexural rigidity in wale direction, the orders of the samples were found as R11> R21> R31> R22> R33. The flexural rigidity were 34.29%, 64.93%, 48.41% and 405.39% higher for the samples R21, R22, R31 and R33 respectively compared to the sample R11 in wale direction. Concerning flexural rigidity in course direction, the orders of the samples were found as R11> R21> R31> R22> R33 as like as wale direction. The flexural rigidity were 64.49%, 107.51%, 96.83% and 365.94% higher for the samples R21, R22, R31 and R33 respectively compared to the sample R11 in course direction.

Figure 8. Effect of fabric structure on flexural rigidity in wale direction

Figure 9. Effect of fabric structure on flexural rigidity in course direction

3.4. Tightness Factor

The outcomes of tightness factor of different structures of rib fabric are shown in the figure 10. The orders of the samples were found as $R11 > R21 > R22 > R31 > R33$ depending on the value of tightness factor. The lowest value was identified for 1×1 rib and highest value for 3×3 rib. The tightness factor were 0.90%, 1.80%, 2.70% and 8.11% higher for the samples R21, R22, R31 and R33 respectively compared to the sample R11.

Figure 10. Effect of fabric structure on tightness factor

4. Conclusions

It has been established that properties of the knitted fabrics are related to the knitting structure. The effect of 1×1 , 2×1 , 2×2 , 3×1 and 3×3 knit structure on different properties viz. drape co-efficient, bending length, flexural rigidity and tightness factor of rib knitted fabric has carried out in this work. The results disclosed that the fabric properties greatly influenced by knit structures. 1×1 rib knit structured fabric showed the lowest value for all tested properties and 3×3 rib knit structured fabric showed the highest value except drape co-efficient. 2×2 rib knit fabric possessed the highest drape co-efficient percentage. The bending length and flexural rigidity was investigated in both wale and course direction. At the same time, surface and back sides bending length were also calculated. From

the above mentioned data it has been identified that the effect of knit structure on flexural rigidity in both wale and course direction were influenced in a same chronological way ($1 \times 1 < 2 \times 1 < 3 \times 1 < 2 \times 2 < 3 \times 3$). The tightness factor was observed as orderly as $1 \times 1 < 2 \times 1 < 2 \times 2 < 3 \times 1 < 3 \times 3$. The effects of other knit structures on the all other features of fabrics will be evaluated in further works. The variety of knitted fabrics with natural and synthetic fibre and/or blend of natural and synthetic fibre will also be used in future for characterizing the effects of knit structures.

Author Contributions

The objectives and methodology of this works were proposed by Md. Reazuddin Repon and Md. Nura Alam Shiddique. The specimen fabrication, characterization and data treatment also carried out by Md. Reazuddin Repon and Md. Nura Alam Shiddique. The article was written by Md. Reazuddin Repon and revised by all authors.

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Conflicts of Interest

The authors declare no conflict of interest.

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