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# Investigating the effect of fabric design on properties of different weft knit fabrics

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## Abstract

Fabric structure exhibits a significant impact on the various properties of weft knitted fabric if processing variables such as yarn count, stitch length, machine diameter, and needle gauge are modified. In this study, weft knitted constructions such plain jersey, Lacoste, waffle, fleece, and rib are evaluated in relation to a number of attributes, including dimensional stability, fabric breadth, spirality and bursting strength. According to the study, lengthwise shrinkage reduces as tuck stitch and spirality grow, however widthwise shrinkage rises. The experiment also revealed that weft knit fabric's bursting strength is less affected by variations in fabric structure.

**Keywords:** Fabric design; Weft knit fabrics; Spirality; Bursting strength

## 1 Introduction

Row after row of intermeshed loops provide the foundation of knitted constructions. The interconnectedness of each stitch to its neighbors on each side, above, and below it, determines many of a knitted structure's characteristics [1]. Knit textiles have a variety of properties since they are made on multiple machines under varying circumstances to generate various types of fabric [2]. Knitted fabric structures and finishing techniques have an impact on the physical characteristics of knit garments and are linked to their wear-abilities [3]. Dimensional stability is crucial for preserving the elegance of knitted textiles at the consumer level. The dimensional features of knitted textiles are influenced by several factors, including fiber qualities, yarn parameters, and machine settings [4]. Fabric shrinkage, which results from dimensional changes in the fabric, is a major issue. When knitting, yarn is subjected to a variety of tensions, and as it relaxes, the knitted fabric's dimensions are altered [5]. There hasn't been enough research done on how knit structures affect fabric shrinkage [6].

A significant knitting criterion to satisfy customer demands is GSM (Gram per Square Meter). It is a crucial aspect in pricing negotiations as opposed to taking the fabric's overall weight into account. When knitting, factors such as yarn count, machine gauge, and stitch density are taken into account. GSM will be lower with a longer loop length and higher with a shorter loop length [7].Fabric structure with the higher depth demonstrated greater bursting strength [8]. When there are more tuck stitches applied to a certain structure than to another with less tuck stitches, the bursting strength varies [9]. One of the main issues with knit materials generated by circular knitting machines is spirality. Dimensional distortions and instability in knitted loop structures are brought on by the relaxation of torsional tensions. Some studies have examined the impact of machine gauge, yarn, and fabric characteristics on the spirality of single jersey knit textiles [10], [11], [12].

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## 2 Material and methods

### 2.1 Materials

Different weft knit fabric structures like GSM, CPI & WPI were employed.

**Table 1** Testable Fabrics

| Sample No. | CPI | WPI | Yarn count | Stitch length | Composition | Finish Type | GSM (gm/sq.mtrs) |
|---|---|---|---|---|---|---|---|
| 1 | 52 | 38 | 24/1 Ne | 2.85 | 100% Cotton | Single jersey | 180 |
| 2 | 50 | 36 | 24/1 Ne | 2.80 | 100% Cotton | Pointal s/jersey | 170 |
| 3 | 51 | 36 | 20/1 Ne | 2.75 | 100% Cotton | Single Lacoste | 230 |
| 4 | 52 | 37 | 24/1 Ne | 2.80 | 100% Cotton | Double Lacoste | 220 |
| 5 | 48 | 28 | 34/1 Ne | 2.90 | 100% Cotton | 4x2 Rib | 190 |
| 6 | 46 | 26 | 34/1 Ne | 2.85 | 100% Cotton | 14x5 Rib | 185 |
| 7 | 47 | 28 | 28/1 Ne | 2.85+2.35 | 100% Cotton | Waffle | 220 |
| 8 | 44 | 26 | 30/1 Ne | 2.80+2.30 | 100% Cotton | Tuck Waffle | 200 |
| 9 | 48 | 28 | 34/1+75d+12/1 | 44+29+17 | 80% Cotton 20% poly | Normal Fleece | 280 |
| 10 | 46 | 27 | 34/1+75d+12/1 | 44+29.5+17.5 | 80% Cotton 20% poly | Diagonal Fleece | 300 |
| 11 | 50 | 29 | 30/1+75d+12/1 | 44+29.5+18.5 | 80% Cotton 20% poly | Baby Fleece | 320 |

#### *2.1.1 Fabric specification*

- Fabric Data: Plain Single Jersey
- M/C: Dia-30x24
- Finished Dia- 64
- Stitch length- 2.85
- Yarn count-24/1 Ne
- Manufacturing Process-Knitting, Dyeing, Finishing

**Figure 1** Plain Single Jersey

- Fabric Data: Pointal Single Jersey
- M/C: Dia-30x24
- Finished Dia- 66
- Stitch length- 2.80
- Yarn count-24/1 Ne
- Manufacturing Process-Knitting, Dyeing, Finishing

**Figure 2** Pointal Single Jersey

- Fabric Data: Single Lacoste
- M/C: Dia-30x24
- Finished Dia - 80
- Stitch length- 2.75
- Yarn count-20/1 Ne
- Manufacturing Process-Knitting, Dyeing, Finishing

**Figure 3** Single Lacoste

- Fabric Data: Double Lacoste
- M/C: Dia-30x24
- Finished Dia - 75
- Stitch length- 2.80
- Yarn count-24/1 Ne
- Manufacturing Process-Knitting, Dyeing, Finishing

**Figure 4** Double Lacoste

- Fabric Data: (4x2) Rib
- M/C: Dia-36x18
- Finished Dia - 64
- Stitch length- 2.90

- Yarn count-34/1 Ne
- Manufacturing Process-Knitting, Dyeing, Finishing

**Figure 5** (4x2) Rib

- Fabric Data: (14x5) Rib
- M/C: Dia-36x18
- Finished Dia - 66
- Stitch length- 2.85
- Yarn count-34/1 Ne
- Manufacturing Process-Knitting, Dyeing, Finishing

**Figure 6** (14x5) Rib

- Fabric Data: Waffle
- M/C: Dia-36x18
- Finished Dia - 54
- Stitch length- 2.85 + 2.35
- Yarn count-34/1 Ne
- Manufacturing Process-Knitting, Dyeing, Finishing
- Note: Knit Cam Miss Cam.

**Figure 7** Waffle

- Fabric Data: Tuck Waffle
- M/C: Dia-36x18
- Finished Dia - 56
- Stitch length- 2.80 + 2.30
- Yarn count-30/1 Ne
- Manufacturing Process-Knitting, Dyeing, Finishing
- Note: Tuck Cam Miss Cam

**Figure 8** Tuck Waffle

- Fabric Data: Normal Fleece
- M/C: Dia-30x20
- Finished Dia - 62
- Stitch length- 4.40 +2.90 + 1.70
- Yarn count-34/1 Ne + 75D + 12/1 Ne
- Manufacturing Process-Knitting, Dyeing, Finishing

**Figure 9** Normal Fleece

- Fabric Data: Diagonal Fleece
- M/C: Dia-30x20
- Finished Dia - 64
- Stitch length- 4.40 + 2.95 + 1.75
- Yarn count-34/1 Ne + 75D + 12/1 Ne
- Manufacturing Process-Knitting, Dyeing, Finishing

**Figure 10** Diagonal Fleece

- Fabric Data: Baby Fleece (Inside Sweet Brush)
- M/C: Dia-30x20
- Finished Dia - 60
- Stitch length- 4.40 + 2.95 + 1.85
- Yarn count-30/1 Ne + 75D + 12/1 Ne
- Manufacturing Process-Knitting, Dyeing, Brushing, Finishing

**Figure 11** Baby Fleece(Inside Sweet Brush)

## 2.2 Methods

### *2.2.1 ShrinkageTest*

A sample test specimen of 24 inches x 24 inches istaken and 20 inches x 20 inches is marked with various colored sewing thread. The specimen sample is exposed to the usual testing environment (65% R.H & 68$^0$F) at least for 18 hourswhile lying flat and without tension on a smooth level surface.

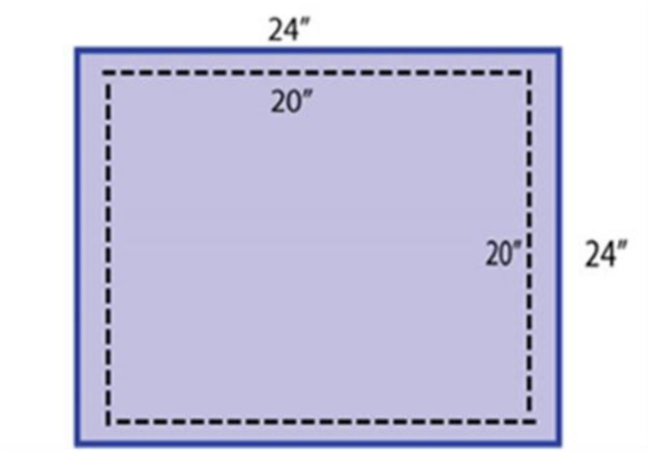


**Figure 12** Test Sample

After that, the test specimen is put to the washing machine. Temperature is set to the $38^0$ C. To create a solution with 0.1% of each ingredient, Sodium Carbonate and neutral wetting agent is added in the appropriate amounts. A specimen cannot weigh more than 0.5 pounds per gallon of washing fluid. The washing machine was started and kept running continuously until the specimen has been thoroughly washed and rinsed. The washing fluid must be emptied out after the machine has operated for 15 minutes. The specimen must then be cleaned three times for five minutes each at$38^0$C.

The sample was removed from the washing machine, folded into an 8-layer pad, and placed against the hydro-extractor machine's side. To get rid of surplus water from the specimen, a 10-minute hydro-extraction was done. The specimen is removed from the hydro-extractor and left out for a little while to evenly distribute any leftover water in the sample.The specimen is then placed flat on the pressing table without stretching, pressed for 30 to 40 seconds with a hot iron, moved to an adjacent spot without sliding, and repeated until the entire specimen is dry. After pressing, the sample is cleaned up, and measurements need to be collected [13].

### *2.2.2 Spirality Test*

AATCC Test method 179 -2004

By repeatedly subjecting woven and knitted materials to automatic laundry techniques that are often used at home, this test method can assess how skewness or twist in clothing changes. Fabrics or garments that are deformed in their unwashed condition as a result of improper fabric finishing or improper garment assembly may provide misleading results when washed using any method [14].The measurement of spirality in the garment is shown at Fig 13.

In order for the second leg of a right angle marking device to be perpendicular to the first leg from point "B," it needs to be placed along Line YZ. On line YZ, a benchmark is drawn along the perpendicular. Figure 13 shows point A' as the location of the bench mark and line YZ's junction. An appropriate tape or ruler is used to measure and record the length of lines AA' and AB to the nearest millimeter, tenth of an inch, or smaller increment. Depending on the spiral's orientation, point A can be moved either left or right [15].

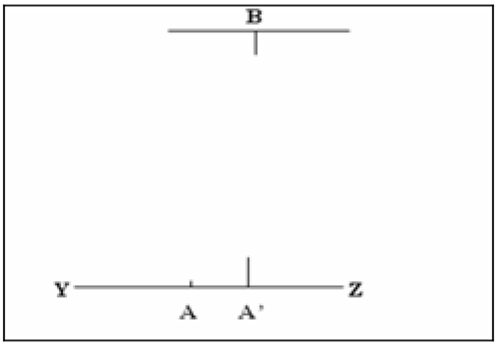


**Figure 13** Measurement of Spirality

## 2.3 Bursting Test

### *2.3.1 Bursting Strength of Fabrics*

It is defined as the force necessary to rupture a woven / knitted fabric under normal conditions by dilating it with a force applied perpendicular to the plane of the sample. The equipment utilized for this test technique operates on the Constant Rate of Elongation concept (CRE). Without any stress on the ball burst attachment, the sample is firmly secured to the machine. A polished, hardened steel ball is used to apply force to a fabric sample until rupture occurs. The bursting strength tester is used to determine the maximum amount of force necessary to collapse a material when a force is given to it by placing it on a rubber diaphragm.

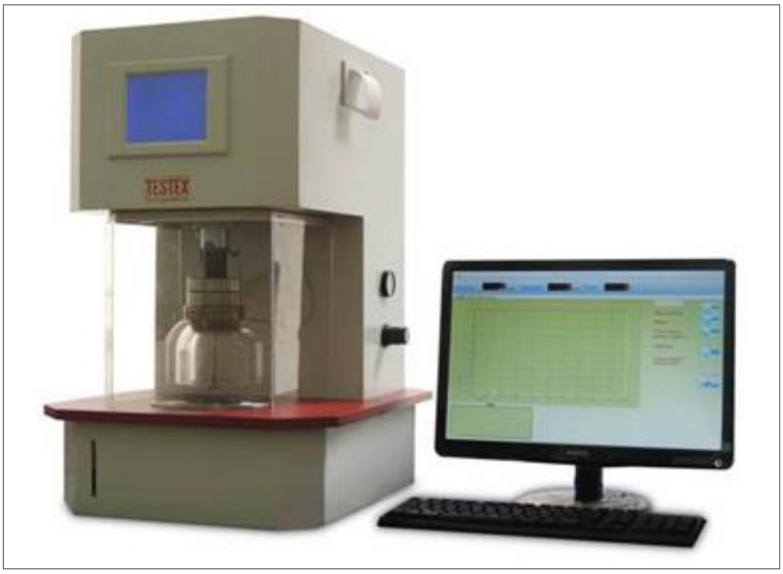


**Figure 14** Bursting Strength Tester

### 2.4 Determination of Bursting Strength of the Fabric Samples

The bursting strength of a fabric sample is tested using this approach by applying regulated hydrostatic pressure using a rubber diaphragm. A test specimen is held under appropriate pressure between two annular clamps to minimize slippage. The upper clamping surface features a continuous spiral groove in contact with the test specimen, while the bottom clamping surface contains a number of concentric grooves. A circular diaphragm of pure gum rubber is clamped between the lower clamping plate and a pressure cylinder such that the center of its top surface is below the plane of the clamping surface before it is stretched by pressure beneath it. A test specimen of 90 × 90 mm isput on the bottom clamp with the region to be tested in the center, and the machine is operated until the test sample ruptures. The pressure indicator determines the pressure necessary to rupture the sample[16].

## 3 Results and discussion

### 3.1 Sample Measurement after the Experiment

**Table 2** Single Jersey and Pointal Single Jersey

| Sample name | Length (cm) | | Width (cm) | |
|---|---|---|---|---|
| | Before | After | Before | After |
| Single Jersey | 35 | 34 | 35 | 33.5 |
| Pointal S/Jersey | 35 | 33.5 | 35 | 32.5 |

**Table 3** Difference

| Sample name | Length (cm) | Width (cm) |
|---|---|---|
| Single Jersey | 1.0 | 1.5 |
| Pointal S/Jersey | 1.5 | 2.5 |

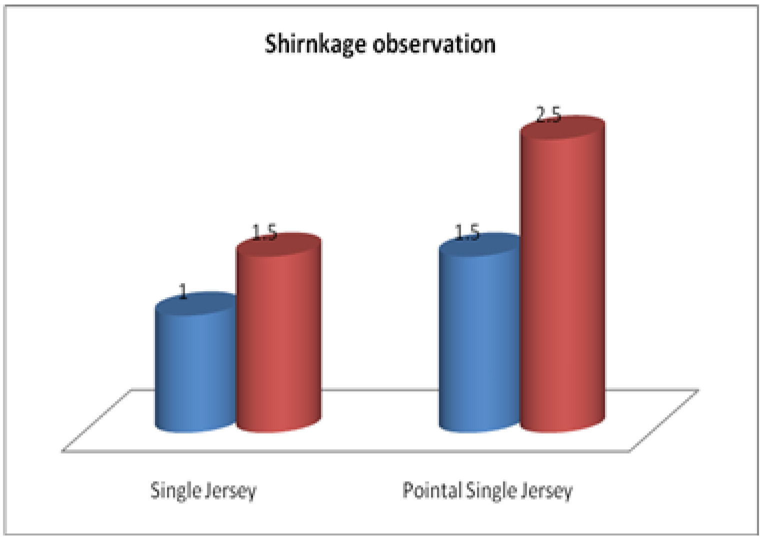


**Figure 15** Shirnkage level of Single Jersey and Pointal Single Jersey

**Table 4** (4x2) Rib and (14x5) Rib

| Sample name | Length (cm) | | Width (cm) | |
|---|---|---|---|---|
| | Before | After | Before | After |
| (4x2) Rib | 35 | 33 | 35 | 32 |
| (14x5) Rib | 35 | 32.5 | 35 | 31 |

**Table 5** Difference

| Sample name | Length (cm) | Width (cm) |
|---|---|---|
| (4x2) Rib | 2.0 | 3.0 |
| (14x5) Rib | 2.5 | 4.0 |

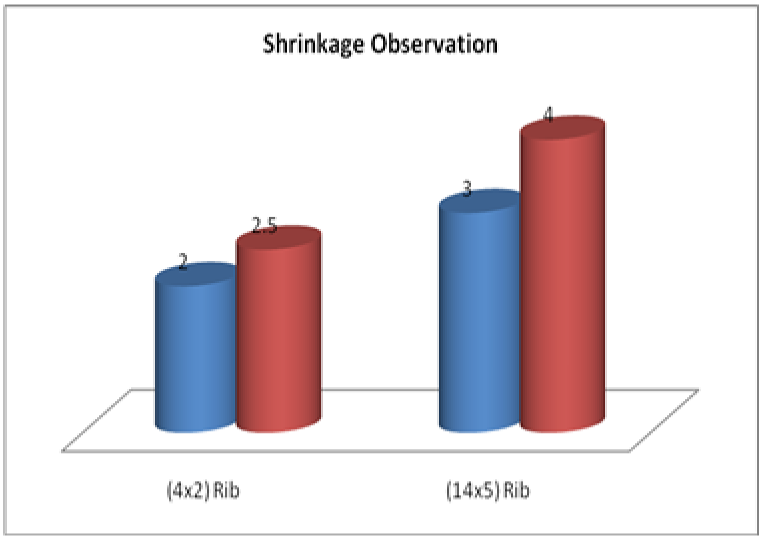


**Figure 16** Shirnkage level of (4x2) Rib and (14x5) Rib

**Table 5** Waffle and Tuck Waffle

| Sample name | Length (cm) | | Width (cm) | |
|---|---|---|---|---|
| | **Before** | **After** | **Before** | **After** |
| Waffle | 35 | 33.5 | 35 | 33 |
| Tuck Waffle | 35 | 33 | 35 | 32.5 |

**Table 6** Difference

| Sample name | Length (cm) | Width (cm) |
|---|---|---|
| Waffle | 1.5 | 2.0 |
| Tuck Waffle | 2.0 | 2.5 |

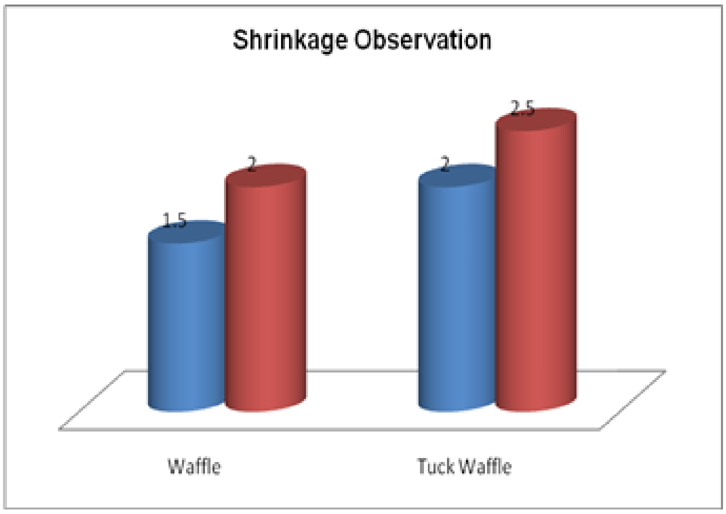


**Figure 17** Shirnkage level of Waffle and Tuck Waffle

**Table 7** Normal Fleece, Diagonal Fleece and Baby Fleece (Brush)

| Sample name | Length (cm) | | Width (cm) | |
|---|---|---|---|---|
| | **Before** | **After** | **Before** | **After** |
| Normal Fleece | 35 | 34 | 35 | 33.5 |
| Diagonal Fleece | 35 | 34 | 35 | 34 |
| Baby Fleece (Brush) | 35 | 34 | 35 | 34.5 |

**Table 8** Difference

| Sample name | Length (cm) | Width (cm) |
|---|---|---|
| Normal Fleece | 1.0 | 1.5 |
| Diagonal Fleece | 1.0 | 1.0 |
| Baby Fleece (Brush) | 1.0 | 0.5 |

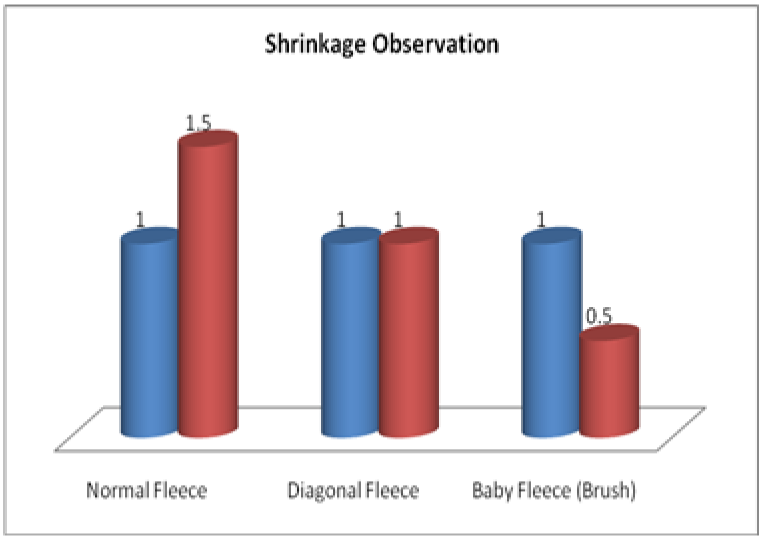


**Figure 18** Shirnkage level of Normal Fleece, Diagonal Fleece and Baby Fleece (Brush)

### 3.2 Shrinkage Percentage Calculation

The formula applied for the calculation of Shrinkage percentage is as follows-

$$\text{Shrinkage} = \frac{(Orginal\ measurement - Final\ measurement)}{Orginal\ measurement} \times 100\%$$

$$\text{Single Jersey, Shrinkage} = [\frac{(35-33.5)}{35}] \times 100$$

So, for single jersey, Shrinkage = 4.28%

Spirality % - 1%

$$\text{PointalSingle Jersey, Shrinkage} = [\frac{(35-32.5)}{35}] \times 100$$

So, for pointal single jersey, Shrinkage = 7.14%

Spirality % - 2.5%

$$\text{(4x2) Rib, Shrinkage} = [\frac{(35-32)}{35}] \times 100$$

So, for (4x2) rib, Shrinkage = 8.5%

Spirality % - 3.0%

$$\text{(14x5) Rib, Shrinkage} = [\frac{(35-31)}{35}] \times 100$$

So, for (14x5) rib, Shrinkage = 11.00%

Spirality % - 3.5%

$$\text{Waffle, Shrinkage} = [\frac{(35-33)}{35}] \times 100$$

So, for waffle, Shrinkage =5.71%

Spirality % - 4%

Tuck Waffle, Shrinkage $= [\frac{(35-32.5)}{35}] \times 100$

So, for tuck waffle, Shrinkage =7.14%

Spirality % - 4.5%

Normal Fleece, Shrinkage $= [\frac{(35-33.5)}{35}] \times 100$

So, for normal fleece, Shrinkage =4.28%

Spirality % - 1.5%

Diagonal Fleece, Shrinkage $= [\frac{(35-34)}{35}] \times 100$

So, for diagonal fleece, Shrinkage =2.85%

Spirality % - 1%

Baby Fleece (Brush), Shrinkage $= [\frac{(35-34.5)}{35}] \times 100$

So, for baby fleece (brush), Shrinkage =1.42%

Spirality % - .5%

### 3.3 Discussion onFabric Shrinkage

When the result and shrinkage % are compared, it is obvious that cotton and lycra blended fabric has a greater shrinkage behavior than synthetic fiber thermal fabric. After exposing them to thermal shrinkage, the thermal shrinkage behavior of polyester yarn and plain knitted fabric produced of the identical yarns was investigated. The heat effects on yarns, yarns in textiles, and wale and course densities were studied. Thermal shrinkage in the direction of travel is closely connected to width-wise extension.

### 3.4 Discussion onFabric Bursting Strength

After the experiment bursting strength result is accumulated on Table 9.

**Table 9** Result of Bursting (ISO 13938-2) Strength

| Sl. No. | Fabric Type | Bursting strength (kPa) |
|---|---|---|
| 1 | Single Jersey | 525 kPa |
| 2 | Pointal single jersey | 578kPa |
| 3 | Single lacoste | 529kPa |
| 4 | Double lacoste | 500kPa |
| 5 | (4x2) Rib | 438kPa |
| 6 | (14x5) Rib | 279kPa |
| 7 | Waffle | 488kPa |
| 8 | Tuck Waffle | 287kPa |
| 9 | Normal Fleece | 275kPa |
| 10 | Diagonal Fleece | 537kPa |
| 11 | Baby Fleece | 420kPa |

By studying the results and bursting strength, it is noticeable that single jersey fabric (Ex-single jersey, pointal jersey lacoste) and double jersey fabric (4x2 rib, 14x5 rib) has a strong bursting strength. Again, bursting strength is 525kPa for single jersey fabric and 438 kPa for 4x2 rib.Then, three different types of fleece cloth were tested for bursting strength. Normal fleece had a bursting strength of 275 kPa, whereas diagonal fleece had a bursting strength of 537 kPa and baby fleece had a higher strength than normal fleece.That is the range of different sorts of knit fabric. As a result, different varieties of knit fabric clarified the influence of bursting strength.

## 4 Conclusion

It was observed that the bursting strength of various knitted textiles was affected by a variety of circumstances. In this study, it was found that the fabric strength of knitted textiles is affected by fabric architectures, fiber kinds and mixes, and yearns.Tuck stitches, according to this study, have an important impact in the bursting strength and thickness of weft knitted materials. GSM and strength increase as stitch length decreases. The fabric breadth was wider on the Double Lacoste structure and narrower on the simple structure. This article will assist researchers who want to do additional research on this topic, as well as people who are interested in the correlation between structural and performance aspects in terms of comfort.

## Compliance with ethical standards

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### *Disclosure of conflict of interest*

The authors have no conflicts of interest to declare. All co-authors have seen and agreed with the contents of the manuscript and there is no financial interest to report. We certify that the submission is original work and is not under review at any other publication.

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