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Studying the Effect of Polyester Fiber Blend Ratio and Pilling Cycle on Blended Knit Fabrics

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Abstract

Pilling is a severe concern for blended fabrics. The aesthetic look and smoothness are the buyers' prime requirements. The main focus of the study was to see the pilling behavior from various percentages of polyester fiber blend ratio as well as the different pilling cycles on blended fabrics. The cotton, polyester, and elastane prepared the study fabrics. These fabrics are (90% Cotton/5% Polyester/5% Elastane, 90% Cotton/6% Polyester/4% Elastane, 90% Cotton/7% Polyester/3% Elastane, 90% Cotton/8% Polyester/2% Elastane, and 90% Cotton/9% Polyester/1% Elastane, 85% Cotton/10% Polyester/5% Elastane, 85% Cotton/11% Polyester/4% Elastane, 85% Cotton/12% Polyester/3% Elastane, 85% Cotton/13% Polyester/2% Elastane, and 85% Cotton/14% Polyester/1% Elastane, 80% Cotton/15% Polyester/5% Elastane, 80% Cotton/16% Polyester/4% Elastane, 80% Cotton/17% Polyester/3% Elastane, 80% Cotton/18% Polyester/2% Elastane, and 80% Cotton/19% Polyester/1% Elastane). The selected polyester blend ratios were 5%, 6%, 7%, 8%, 9%, 10%, 11%, 12%, 13%, 14%, 15%, 16%, 17%, 18% and 19% respectively. The study used the Martindale pilling tester with 2000, 5000, and 7000 cycles, respectively. The evaluation followed the ISO 12945-2:2000. The study findings are that the polyester fiber blend ratio did not influence the pilling grade on blended fabrics for pilling cycles 2000, and the pilling grade remained constant at 4 - 5. The pilling grade started to deteriorate in pilling cycle 5000 for the fabrics 85%C/10%P/5%E, 85%C/11%P/4%E, 85%C/12%P/3%E, 85%C/13%P/2%E, 85%C/14%P/1%E showed the pilling grade 4, and the fabrics made from 80%C/15%P/5%E, 80%C/16%P/4%E, 80%C/17%P/3%E, 80%C/18%P/2%E, 80%C/19%P/1%E showed the pilling grade 4, 3, 3, 3, and 3 respectively. For the pilling cycles 7000, the pilling grade further deteriorated for the fabrics 80%C/15%P/5%E, 80%C/16%P/4%E, 80%C/17%P/3%E, 80%C/18%P/2%E, 80%C/19%P/1%E showed the pilling grade 3, 3, 2, 2, and 2 respectively. The study finds the dominance of polyester fiber throughout the experiment. The author hopes this study's outcome will help new researchers, advanced researchers, and the textile industry's sustainable development research and development team.

Keywords

Pilling, Cotton, Polyester, Elastane, Blended, Knit, Fabric

1. Introduction

Resistance to pilling is a critical quality parameter of fabric and garments. Pilling concerns textile and apparel manufacturers and consumers, because it affects fabric aesthetics and appearance. The acceptability of textile or garment shipment depends on the appearance of the garments. The study concentrated on the effect of the pilling behavior of blended weft knitted fabric using cotton, polyester, and elastane with varying percentages of blend ratio of cotton, polyester, and elastane. The literature survey found that many researchers studied the pilling behavior of textile fabrics, especially on two-fiber blends. Various previous researchers found that heat setting, singeing, and cropping can improve the pilling performance for polyester/wool blends [1]. A linen/silk blend study found that the printed fabric showed better pilling performance for both with and without singeing [2]. In the case of the viscose/polyester blend, the pilling phenomenon after garment dyeing was better [3]. In a study to improve the pilling performance of wool/acrylic blend, a neural network strategy positively impacted wool/acrylic blend weft knitted fabrics [4]. One study found that fibrous composition, softener, laundering, and material thickness influence the pilling behavior of knitted fabrics [5]. This study is a new and original research work. This research uses three types of textile fibers, cotton, polyester, and elastane, with varying percentages of the blend ratio. The study findings are helpful to the fabric manufacturers and buyers who decide the ratio of fiber blend in terms of the pilling behavior of knit fabrics. The blend ratio percentage of polyester changed in ascending order from 5% to 19%. The actual objective of the study was:

1) To see the effect of polyester fiber blend ratio on blended knit fabrics and whether any change of pilling grade (increase or decrease).

2) To see the effect of pilling cycles (2000, 5000, and 7000) on blended knit fabrics and whether any change of pilling grade (increase or decrease).

3) The weight of elastane is heavy. Polyester is lightweight and also has good stretchability, like elastane. The price of polyester fiber is also lower compared to elastane (almost four times cheaper). The purpose of blending is to improve the existing quality as well as to reduce cost. The price of elastane is very high compared to cotton and polyester fiber. Besides this, the price of polyester is much lower than cotton.

Bio-polishing enzyme incorporated in the dyeing process. It removes pills and fuzz from the fabric surface [6]. Cellulase hydrolyzes the cellulose microfibrils

(Those projected from the fabric surface). This enzyme softens the fabric's hand feel and reduces pilling to a significant level. Fabric softeners can reduce fiber-to-fiber friction by which the pilling tendency decreases. Softeners create a lubricating layer on the fibers, significantly reducing pilling on the fabric surface. The selection of softener depends on fiber, yarn, and fabric types. The Tubingal 9270 is a softener used in the finishing process. Due to mobility and flexibility, the slippery effect appears on the surface of fabrics, which tends to cause less pilling.

The latest model NU Martindale Pilling tester (1316 ORBITOR) conducted the pilling test. The Martindale pilling tester follows the Lissajous pattern of motion. The French physicist Jules A. Lissajous named this figure and initiated a Lissajous figure. A Lissajous figure is generated by transformations, beginning with a circle and progressing to progressively smaller ellipses and then to a straight line [7]. **Figure 1** represents the Lissajous pattern of movement of the Martindale Pilling Tester.

1.1. Mechanism of Pilling

According to W.D. Cook, the pilling and pill formation has a mechanism or system. The pilling formation consists of the well-known six stages, and these are:

1) The establishment of high fuzz density in a particular area of fabric.

2) The development of loose entanglement of that particular area.

3) The tightening of the entangled area.

4) The pulling out of anchor fibers to mobile pills.

5) The breakdown of certain fibers is due to the movement of pills.

6) The breakdown of the remaining fibers and, finally, the wear off or loss of the pills [8].

Figure 2 represents the pill formation in sequential order.

1.2. Factors Responsible for Pilling

1.2.1. Effect of Fiber

Polyamide and polyester fibers are the most severe for pill formation, while

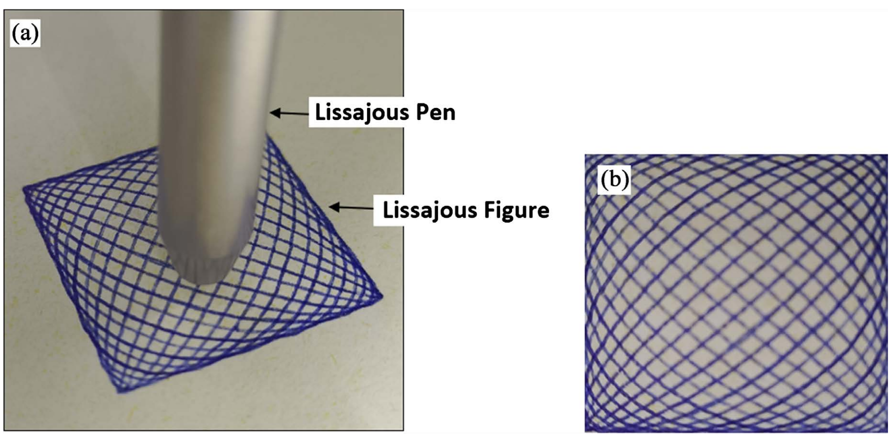

Figure 1. (a) the Lissajous figure with Pen and (b) the Lissajous Figure from Martindale Tester.

acetate and wool are the least affected. The coarser fibers have fewer tendencies to the pill because they are stiff. A circular cross-section with a smooth surface of the fiber allows the fiber to come to the surface of a fabric and form pills. Irregular cross-sections, such as star-shaped sections and a rough surface, reduce pilling. Fibers with short-staple lengths tend to have more pilling and fibers with high extensibility generate more pills. Fiber-to-fiber friction tends to fuzz formation, entangling adjacent fibers and forming pills. During the testing operation, hairy fibers broke due to friction and the applied pressure of the Martindale tester [9]. The immediate entanglement occurred between broken cotton hairy fibers with polyester fibers and formed pills and fuzziness. With the increase in the pilling cycle and the polyester fiber blend ratio, the frequency and quantity of pills increase.

1.2.2. Effect of Yarn Parameters

Ring-spun yarn is generally more pilling-resistant than open-end spun yarn. Regarding yarn count, the knitted fabrics having finer counts suffered from less pilling. The higher the twist in the tale, the less the pilling because of the yarn's compactness and less protruding fiber. The doubled yarn gives less pilling than single yarn for the same reason. Blended material has more tendency to generate pills than single fiber. Applying a heat setting reduces the pilling tendency. Due to heat setting, the bending stiffness of fiber increases, which leads to reduced pilling grade [10].

1.2.3. Effect of Fabric Parameters

Knitted fabrics tend to pill more readily than woven fabrics. Since knitted constructions are composed of loops, a tremendous amount of yarn surface area is exposed, making them more susceptible to abrasion in the movement of fibers on the fabric surface, and the knitting structure is responsible for pill formation [11]. The higher the stitch density, the higher the pilling tendency. Fabric cover factor and short fiber content are also accountable for fabric pilling [12]. The linear and fabric density (stitch density) influence the pilling behavior. The fabric produced from carded yarn tends to be more pill formation than the combed ring spinning process [13].

1.2.4. Effect of Dyeing and Finishing

The dyeing and finishing technique and different finishes affect pilling resistance,

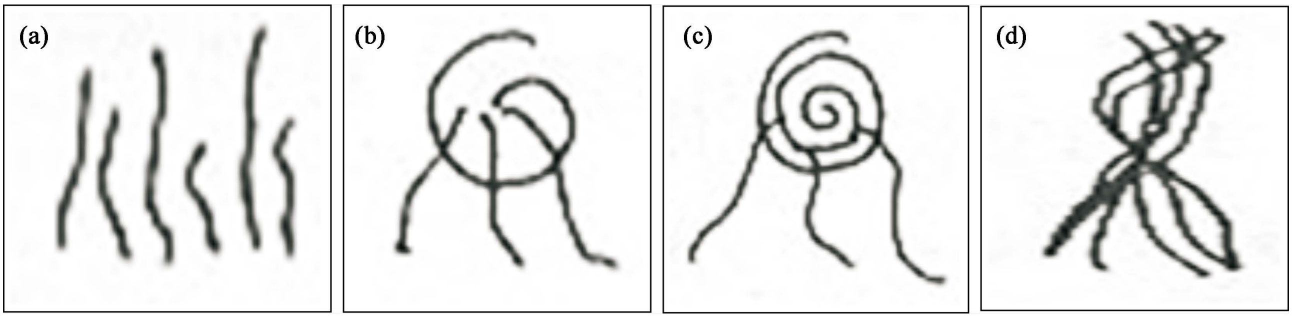

Figure 2. (a) fuzz, (b) a pill with loose entanglement, (c) a pill with tight entanglement, and (d) a pill with spiral entanglement.

such as singeing reduces the pilling tendency to a great extent. Heat setting at a higher temperature for a suitable duration reduces pilling. The cellulosic material is super steam and reduces pilling. The pilling results of the dyed fabrics are better than grey fabrics. Similarly, pigment-printed fabrics' pilling performance is better than reactive-printed fabrics. An anti-pilling agent can reduce the pilling tendency [14]. During dyeing and finishing, the fiber-fiber friction tends to be higher due to swelling in water. The mechanical washing process tends to form pills due to the vigorous movement of cloth inside the washing machine. The dyes do not affect pilling performance [15].

2. Materials & Methods

2.1. Materials

2.1.1. Blended Fabrics

The study used single jersey blended weft knitted fabrics with three different fibers: cotton, polyester, and elastane, with varying percentages of blend ratios. The yarn count and fabric weight were 34/1 ring-spun and 180 GSM (Gram per square meter). Table 1 shows the sampling plan and the decided pilling cycle.

2.1.2. Preparatory Process Involved in the Study

1) Fiber Stage

The yarn had been produced from BCI (Better Cotton Initiative) U.S. Upland cotton, virgin staple polyester, and elastane. USTER HVI 100 ensures raw cotton

Table 1. Sampling plan.

Fabric Composition	Pilling Cycle for test
Cotton 90%, Polyester 5%, Elastane, 5%	2000, 5000, and 7000
Cotton 90%, Polyester 6%, Elastane, 4%	2000, 5000, and 7000
Cotton 90%, Polyester 7%, Elastane, 3%	2000, 5000, and 7000
Cotton 90%, Polyester 8%, Elastane, 2%	2000, 5000, and 7000
Cotton 90%, Polyester 9%, Elastane, 1%	2000, 5000, and 7000
Cotton 85%, Polyester 10%, Elastane, 5%	2000, 5000, and 7000
Cotton 85%, Polyester 11%, Elastane, 4%	2000, 5000, and 7000
Cotton 85%, Polyester 12%, Elastane, 3%	2000, 5000, and 7000
Cotton 85%, Polyester 13%, Elastane, 2%	2000, 5000, and 7000
Cotton 85%, Polyester 14%, Elastane, 1%	2000, 5000, and 7000
Cotton 80%, Polyester 15%, Elastane, 5%	2000, 5000, and 7000
Cotton 80%, Polyester 16%, Elastane, 4%	2000, 5000, and 7000
Cotton 80%, Polyester 17%, Elastane, 3%	2000, 5000, and 7000
Cotton 80%, Polyester 18%, Elastane, 2%	2000, 5000, and 7000
Cotton 80%, Polyester 19%, Elastane, 1%	2000, 5000, and 7000

parameters like spinning consistency index S.C.I. (138), maturity index, uniformity ratio index, strength, elongation%, Rd (71.0), +b (9.8), upland grading (42-1), short fiber content S.F.C. (243), trash grade (4).

2) Yarn Stage

The state-of-the-art spinning machine used for producing quality yarn. The count of the yarn was 34/1 Ne. The produced yarn was the ring spun yarn. The yarn manufacturing followed the basic spinning flow chart, as shown in **Figure 3**.

3) Knitting Stage

The latest model knitting machine (Terrot, Germany) knitted the grey fabrics. The fundamental knitting parameters were 32-inch diameter, 24 machine gauge, stitch length of 29.0 mm, yarn linear density (34/1 Ne), grey GSM (190), and finished GSM (180).

4) Dyeing Stage

The bio-polishing enzyme "Cellusoft Combi9800L" improved pilling test results or pilling grade. The excellent brand dyes from B.E.Z.E.M.A., Germany, and disperse dyes from Taiwan, and suitable brand auxiliaries treated the fabrics as usual. Two dye-stuff types (reactive and dispersed dyes) dyed the blended fabrics.

5) Finishing Stage

The Stenter (Monfortis, Germany) and Compactor (Lafer, Italy) machines finished the study samples. For further improvement of pilling and hand feel issues, softener "Tubingal 9270" (brand) processed the fabrics.

2.2. Method

2.2.1. Test Standard

The international test standard ISO 12945-2:2000-Textiles-Determination of fabric propensity to surface pilling and pilling—Part 2: Modified Martindale

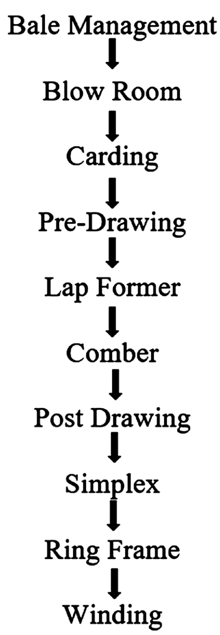

Figure 3. Flow chart of spinning.

Method [16].

2.2.2. Test Equipment & Apparatus

The pilling resistance test used the Martindale Pilling and Abrasion Tester (James Heal, UK) and the Piliscope. Figure 4 shows a pilling Testing machine.

2.2.3. Test Procedure

The sample cutter, with a diameter of 140±5 mm, was used for cutting the samples for testing. The specimens were conditioned for 16 hours (ISO 139:2005) [17]. The selected pilling cycles were 2000, 5000, and 7000. The method followed was to take three specimens from each category of fabric type. After completing the cycle, the specimens were removed from the machine and made ready for assessment. The assessment of pilling concentrated on two types: pilling and fuzzing. The evaluation was done in a dark room, using a philosophy supported by a pilling replica. Table 2 describes the pilling grade. Figure 5 shows the different stages of pilling testing.

3. Results and Discussion

3.1. Fabric Pilling Data Analysis for 2000 Cycles

Table 3 represents the pilling grade found against the pilling cycle 2000 cycles.

Figure 4. Martindale pilling and abrasion tester.

Table 2. Pilling grade description.

Pilling Grade	Description
5	No change.
4	Slight surface fuzzing and formed pills
3	Moderate surface fuzzing and moderate pilling. Pills of varying size density partially cover the specimen surface.
2	Distinct surface fuzzing and or distinct pilling. Pills of varying size density partially cover a large portion of the specimen surface.
1	Dense surface fuzzing and severe pilling. No change. Pills of varying size density partially cover a large portion of the specimen.

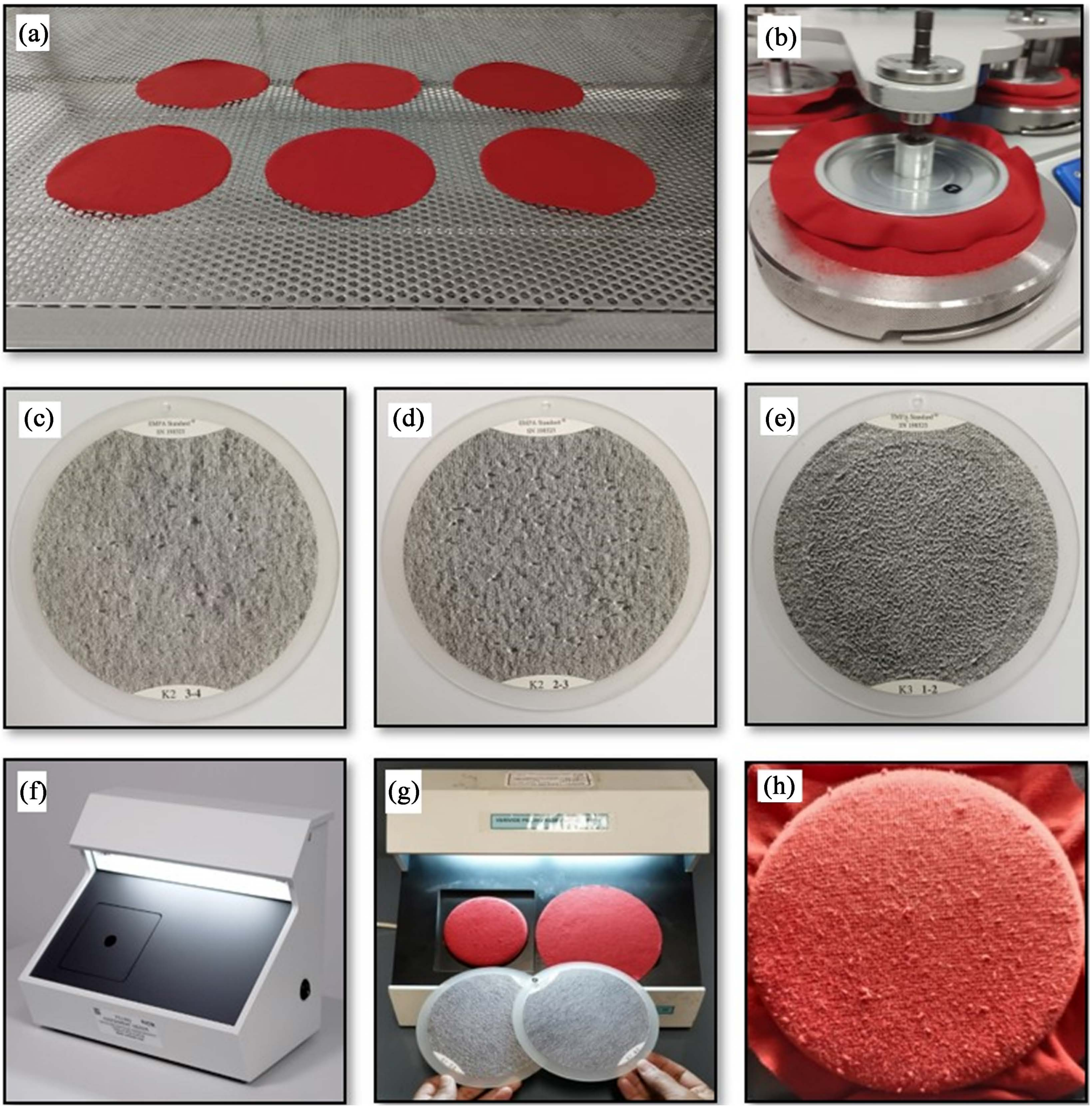

Figure 5. (a) the specimens for conditioning, (b) the pilling test is in action, (c) a Replica of pilling grade 3 - 4, (d) a Replica of pilling grade 2 - 3, (e) a Replica of pilling grade 1 - 2, (f) a Piliscope for assessment, (g) the assessment of pilling grade, (h) the tested specimen.

The x-axis indicates the pilling process for types of blended fabrics, and the y-axis shows the pilling grade obtained from the test results. The pilling grade was 4 - 5 against the 2000 cycles for all the fabric. Figure 6 shows the pilling grade for 2000 cycles.

3.2. Fabric Pilling Data Analysis for 5000 Cycles

Table 4 represents the pilling grade found against the pilling cycle 5000. The

Table 3. Fabric pilling grade summary for 2000 Cycles.

Fabric Composition	Pilling grade from 2000 cycles
Cotton 90%, Polyester 5%, Elastane, 5%	4 - 5
Cotton 90%, Polyester 6%, Elastane, 4%	4 - 5
Cotton 90%, Polyester 7%, Elastane, 3%	4 - 5
Cotton 90%, Polyester 8%, Elastane, 2%	4 - 5
Cotton 90%, Polyester 9%, Elastane, 1%	4 - 5
Cotton 85%, Polyester 10%, Elastane, 5%	4 - 5
Cotton 85%, Polyester 11%, Elastane, 4%	4 - 5
Cotton 85%, Polyester 12%, Elastane, 3%	4 - 5
Cotton 85%, Polyester 13%, Elastane, 2%	4 - 5
Cotton 85%, Polyester 14%, Elastane, 1%	4 - 5
Cotton 80%, Polyester 15%, Elastane, 5%	4 - 5
Cotton 80%, Polyester 16%, Elastane, 4%	4 - 5
Cotton 80%, Polyester 17%, Elastane, 3%	4 - 5
Cotton 80%, Polyester 18%, Elastane, 2%	4 - 5
Cotton 80%, Polyester 19%, Elastane, 1%	4 - 5

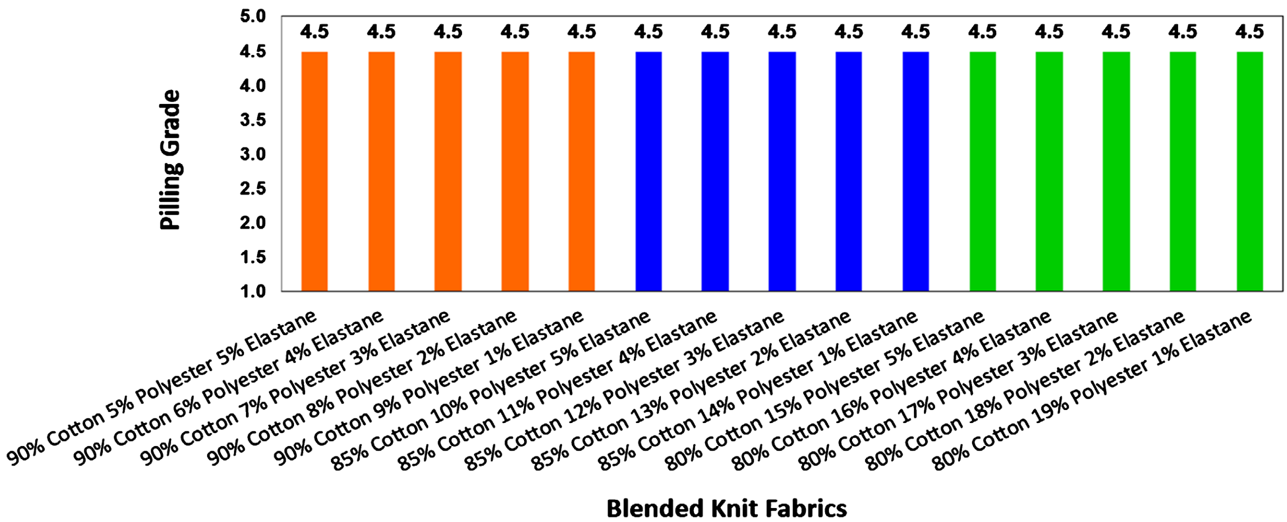

Figure 6. The pilling grade against the different polyester fiber blend ratios on blended knit fabrics for 2000 cycles.

x-axis indicates the pilling process for types of blended fabrics, and the y-axis shows the pilling grade obtained from the test results. The pilling grade obtained from the fabric C90%P5%E5%, C90%P6%E4%, C90%P7%E3%, C90%P8%E2%, C90%P9%E1%, are 4 - 5. The pilling grade obtained from the fabric C85%P10% E5%, C85%P11%E4%, C85%P12%E3%, C85%P13%E2%, C85%P14%E1%, are 4. The pilling grade obtained from the fabric C80%P15%E5%, C80%P16%E4%, C80%P17%E3%, C80%P18%E2%, C80%P19%E1%, are 4. 3, 3, 3, and 3 respectively. The trend line goes downward, indicating worsening pilling grade with increased polyester fiber blend ratio and pilling cycles. **Figure 7** shows the pilling grade for 5000 cycles.

3.3. Fabric Pilling Data Analysis for 7000 Cycles

Table 5 represents the pilling grade found against the pilling cycle 7000. The x-axis indicates the pilling process for types of blended fabrics, and the y-axis

Table 4. Fabric pilling grade summary for 5000 cycles.

Fabric Composition	Pilling grade from 5000 cycles
Cotton 90%, Polyester 5%, Elastane, 5%	4 - 5
Cotton 90%, Polyester 6%, Elastane, 4%	4 - 5
Cotton 90%, Polyester 7%, Elastane, 3%	4 - 5
Cotton 90%, Polyester 8%, Elastane, 2%	4 - 5
Cotton 90%, Polyester 9%, Elastane, 1%	4 - 5
Cotton 85%, Polyester 10%, Elastane, 5%	4
Cotton 85%, Polyester 11%, Elastane, 4%	4
Cotton 85%, Polyester 12%, Elastane, 3%	4
Cotton 85%, Polyester 13%, Elastane, 2%	4
Cotton 85%, Polyester 14%, Elastane, 1%	4
Cotton 80%, Polyester 15%, Elastane, 5%	4
Cotton 80%, Polyester 16%, Elastane, 4%	3
Cotton 80%, Polyester 17%, Elastane, 3%	3
Cotton 80%, Polyester 18%, Elastane, 2%	3
Cotton 80%, Polyester 19%, Elastane, 1%	3

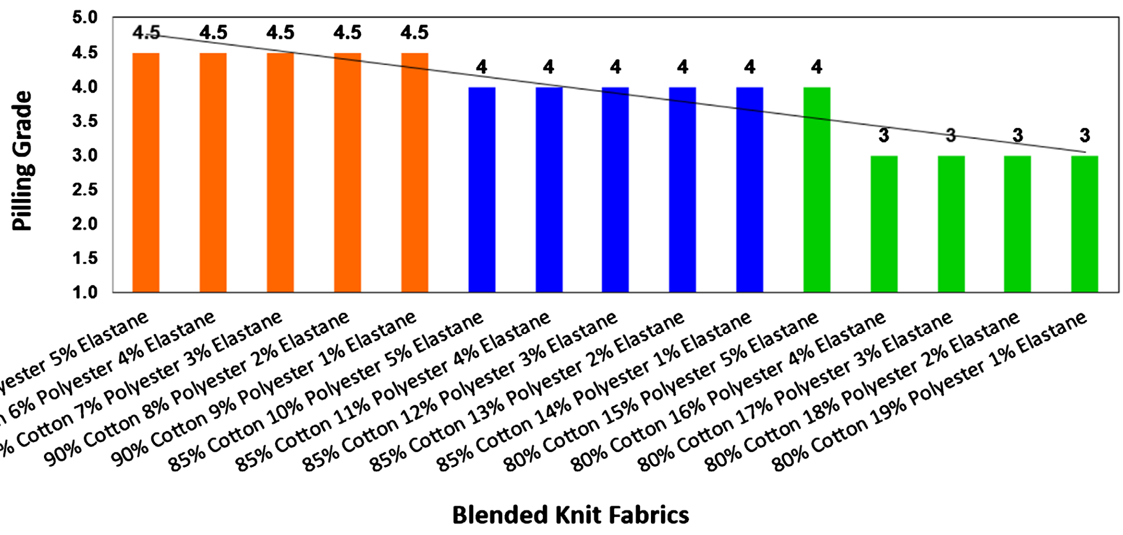

Figure 7. The pilling grade against the different polyester fiber blend ratios on blended knit fabrics for 5000 cycles.

Table 5. Fabric pilling grade summary for 7000 cycles.

Fabric Composition	Pilling grade from 7000 cycles
Cotton 90%, Polyester 5%, Elastane, 5%	4 - 5
Cotton 90%, Polyester 6%, Elastane, 4%	4 - 5
Cotton 90%, Polyester 7%, Elastane, 3%	4 - 5
Cotton 90%, Polyester 8%, Elastane, 2%	4 - 5
Cotton 90%, Polyester 9%, Elastane, 1%	4 - 5
Cotton 85%, Polyester 10%, Elastane, 5%	4
Cotton 85%, Polyester 11%, Elastane, 4%	4
Cotton 85%, Polyester 12%, Elastane, 3%	4
Cotton 85%, Polyester 13%, Elastane, 2%	4
Cotton 85%, Polyester 14%, Elastane, 1%	4
Cotton 80%, Polyester 15%, Elastane, 5%	3
Cotton 80%, Polyester 16%, Elastane, 4%	3
Cotton 80%, Polyester 17%, Elastane, 3%	2
Cotton 80%, Polyester 18%, Elastane, 2%	2
Cotton 80%, Polyester 19%, Elastane, 1%	2

shows the pilling grade obtained from the test results. The pilling grade obtained from the fabric C90%P5%E5%, C90%P6%E4%, C90%P7%E3%, C90%P8%E2%, C90%P9%E1%, are 4 - 5. The pilling grade obtained from the fabric C85%P10% E5%, C85%P11%E4%, C85%P12%E3%, C85%P13%E2%, C85%P14%E1%, are 4. The pilling grade obtained from the fabric C80%P15%E5%, C80%P16%E4%, C80%P17%E3%, C80%P18%E2%, C80%P19%E1%, are 3.3, 2, 2, and 2 respectively. The trend line goes downward, indicating worsening pilling grade with increased polyester fiber blend ratio and pilling cycles. Figure 8 shows the pilling grade for 7000 cycles.

3.4. Reason for Change of Pilling Grade

During the testing operation, the pattern of movement of the pilling zone in the Martindale pilling tester is one reason for pill formation and fuzziness on the fabric surface. This movement goes as per the Lissajous pattern throughout the testing operation. It follows a swivel pattern of motion during the operational condition. The face-to-face close touch of test specimens and pressure (9 kPa) tend to cause severe pilling.

The pilling tendency of 100% single fiber differs from blended fibers. Usually, the 100% single polyester fiber tends to generate fewer pills than 100% cotton, but the scenario is severe when these fibers are in blends. In this study, the lengths of polyester and cotton are 38.0 mm and 28.0 mm, respectively. The length of the elastane is continuous. When these fibers are combined, the fibers with comparatively shorter lengths start to untwist and then wrap around the polyester fibers. The polyester also starts to untwist but slowly compared to cotton. After that, polyester and cotton create entanglement among them. In this stage, polyester, cotton, and elastane make entanglement. The entanglement frequency and pill formation tend to be the severity with the gradual increase of the percentage of polyester.

The frictional resistance of these three fibers is different. The applied pressure from the Martindale pilling tester (9 kPa) enhances the fiber-to-fiber frictional force and tends to pill formation. This pill formation starts to increase with the billing cycle. With pilling cycle 2000, the grade was found satisfactory but deteriorated with pilling cycles 5000 and 7000.

3.5. Statistical Significance Test by ANOVA

The one-way analysis of variance (ANOVA) conducted the statistical significance test for all fabric pilling grade data obtained from pilling cycles 2000, 5000, and 7000. The one-way ANOVA test confirmed the statistical significance [18]. The H0 and Ha represent the null hypothesis and alternative hypothesis, respectively. Table 6 shows the analysis of variance data for pilling grades or the pilling test results.

H0: There are no significant differences in pilling grade from different polyester fiber blend ratios and pilling cycles.

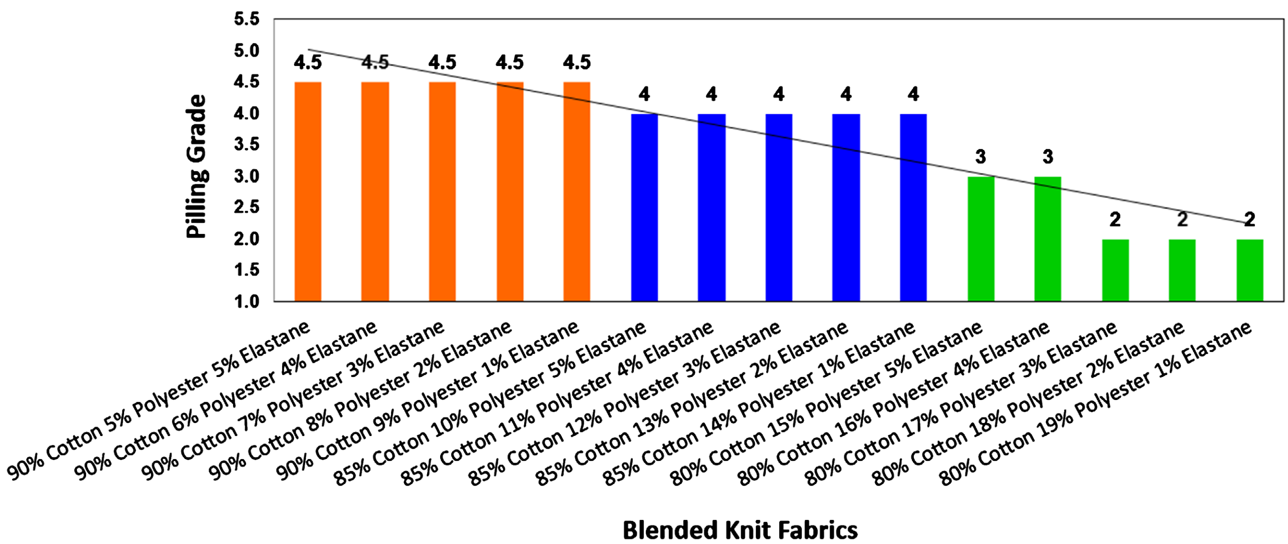

Figure 8. The pilling grade against the different polyester fiber blend ratios on blended knit fabrics for 7000 cycles.

Table 6. One-Way ANOVA Table.

Source	S.S.	Df	MS	F	F critical	P-value
Between	5.9111	2	2.9556	6.7709	3.2899	0.002826
Within	18.3333	42	0.4365			
Total	24.2445	44	0.551			

Ha: There are significant differences in pilling grade from different polyester fiber blend ratios and pilling cycles.

The level of significance, Alpha, α (0.05) > p-value (0.002826), the one-way ANOVA rejected the null hypothesis. The average pilling grades among different pilling grades are unequal, *i.e.*, significant differences exist among all blended knit fabrics. In other words, there are significant differences in pilling grade from different polyester fiber blend ratios and pilling cycles.

3.6. Correlation Analysis

1) Statistical Analysis by Pearson Correlation (2000 cycles)

Pearson correlation conducted the statistical significance test [19]. For 2000 cycles, the graph (**Figure 9**) shows a "No correlation", meaning that the pilling grade did not deteriorate with the increase in polyester fiber blend ratio.

2) Statistical Analysis by Pearson Correlation (5000 cycles)

For 5000 cycles, the graph (**Figure 10**) shows a "Negative correlation", meaning that the pilling grade started to deteriorate with the increase in polyester fiber blend ratios as well as the increase in pilling cycles (5000 cycles). The Pearson correlation coefficient is -0.913. It is a strong negative correlation. The polyester blend ratio and the pilling grade were negatively correlated. The p-value (0.00001) is less than the significance level, alpha, α (0.05). This statistical test is significant.

3) Statistical Analysis by Pearson Correlation (7000 cycles)

For 7000 cycles, the graph (**Figure 11**) shows a "Negative correlation", meaning that the pilling grade started to deteriorate with the increase in polyester fiber blend ratios as well as the increase in pilling cycles (7000 cycles). The Pearson correlation coefficient is −0.9118. It is a strong negative correlation. The polyester blend ratio and the pilling grade were negatively correlated. The p-value (0.00001) is less than the significance level, alpha, α (0.05). This statistical test is significant.

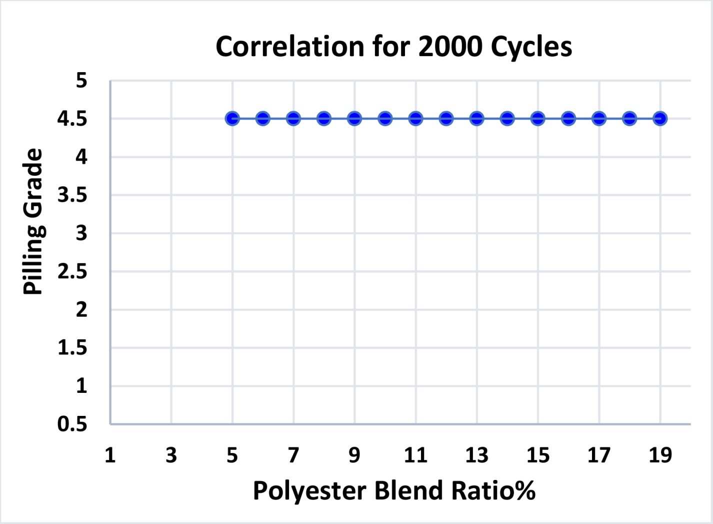

Figure 9. The correlation between the Polyester blend ratio and pilling grade for 2000 pilling cycles.

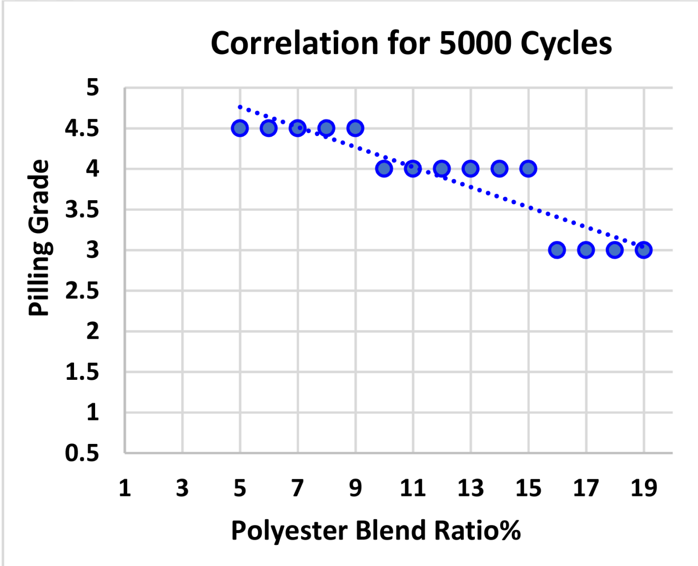

Figure 10. Pearson correlation between polyester blend ratio and pilling grade for 5000 pilling cycles

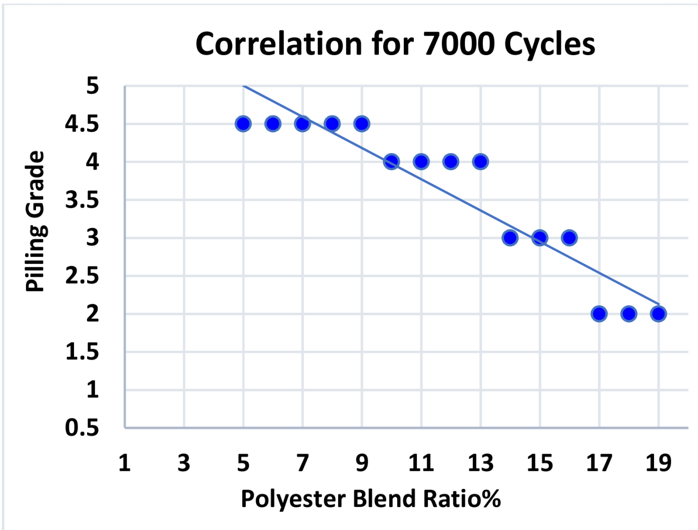

Figure 11. Pearson correlation between polyester blend ratio and pilling grade for 7000 pilling cycles.

3.7. Causes of Variation in Pilling due to Cotton Fiber

The 100% single cotton fiber has little tendency to develop pills compared to synthetic fibers. The tenacity and length of the used cotton were 31.8 g/tex and 28.0 mm, 4.24 Micronaire (fineness) values, respectively. The higher the tenacity and length of the fiber, the lower the tendency of pill formation. The fiber with a higher Micronaire (fineness) value tends to reduce pill formation. The weaker fiber will rupture while mixing cotton with polyester and finally form a pill.

3.8. Causes of Variation in Pilling due to Polyester Fiber

Polyester fiber tends to develop pills more than cotton and natural fibers but in blended condition. The tenacity and length of the used polyester were 56.7 g/tex and 38.0 mm, respectively. The fabric blend with a higher percentage of polyester tends to lower pilling grade [20]. One fiber is usually more substantial once the fibers are in the cotton/polyester blend. The weaker fiber will break, create entanglement, and knot around to the stronger fiber, forming a pill. Polyester tends to be more pilling [21].

3.9. Causes of Variation in Pilling due to Elastane Fiber

Elastane is a synthetic fiber that tends to form pills entangled with other fibers. The tenacity of elastane is significantly less. Elastane has two main segments. One portion is soft and rubbery, and the other is rigid. The increase in the pilling cycle tends to deteriorate the pilling grade. The chemical structure of elastane is responsible for creating pills due to its soft, rubbery segment [22].

4. Conclusions

Pilling is a real-life unpleasant, unwanted, and inevitable phenomenon in textiles. Below is a brief conclusion based on the discussion and evidence mentioned in this study.

1) The novelty of this research is to add different percentages of polyester fiber into the blends of cotton, polyester, and elastane. The polyester fiber blend ratios incorporated into the blend are 5%, 6%, 7%, 8%, 9%, 10%, 11%, 12%, 13%, 14%, 15%, 16%, 17%, 18%, and 19% respectively so that the textile manufacturers can easily choose the polyester fiber blend ratio according to their requirement. This addition of polyester would reduce the manufacturing cost in the textile industry.

2) The gradual increase of polyester fiber percentage in the blend influenced the pilling grade. The pilling cycles also influenced the formation of pills. The study observed the deterioration of the pilling grade from the pilling cycle 5000; more deterioration occurred with the pilling cycle 7000.

3) The polyester fibers in the blends dominated the pilling behavior. The clear message to the fabric manufacturer is to incorporate a certain percentage of polyester fiber in the blend, as the price of polyester fiber is much lower than elastane fiber.

4) The soft rubbery segments of elastane polymer assisted in pill formation and entanglement with polyester and cotton. The severity increases with the increase of the polyester fiber blend ratio. The study used cotton, polyester, and elastane, but future research could explore other fibers.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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