

## EFFECT OF LAUNDERINGS ON THE PILLING PROPERTIES OF COTTON AND POLYESTER WEFT KNITTED FABRICS

Noraqilah Mohd Azis<sup>1</sup>, Siti Farhanim Sarani<sup>1</sup>, Eryna Nasir<sup>2</sup>, Najua Tulos<sup>1</sup>

<sup>1</sup>*School of Industrial Technology, Faculty of Applied Sciences, Universiti Teknologi MARA, 40450 Shah Alam, Selangor*

<sup>2</sup>*School of Industrial Technology, Faculty of Applied Sciences, Universiti Teknologi MARA, Negeri Sembilan Branch, Kuala Pilah Campus, 72000, Kuala Pilah, Negeri Sembilan, Malaysia*

\*Corresponding author: [eryna@ns.uitm.edu.my](mailto:eryna@ns.uitm.edu.my)

### Abstract

Pilling is one of the fabric faults that originally found in knitted woolen goods especially made from soft twisted yarns. The rubbing action on loose fibres that is present on the fabric surface gives a high tendency to form pills which gives poor appearance to the fabric. This study was carried out to investigate the effect of repeated launderings on the propensity of pilling formation by using pill grade machine. The primary objective of this study was to determine the pilling behaviour of different types of weft knitted fabrics after a repeated number of laundering cycles. The study was conducted using two types of knitted fabrics; cotton and polyester with three types of knitted structures; interlock, 1x1 rib and plain jersey. The various number of laundering cycles were given on the fabrics and followed by 15,000 revolutions of ICI pilling box. The results showed that polyester fibre has better pilling resistance due to its exceptional strength, whilst in terms of fabric structure, plain jersey showed an excellent resistance. This is due to the higher density and compact structure that it possessed.

**Keywords:** knitted fabric, pilling, weft knit, laundering, textile surface appearance

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### Introduction

Knitted fabric has its own uniqueness that makes it suitable for certain end-uses which cannot be found in other forms of 2-dimensional textile materials. In general, knitted fabric has comfort properties, more elastic than woven or nonwoven, and has the ability to recover when being stretched. Commonly, knitted fabric is the most preferred material in daily activities due to their easy to care that remain relatively crease free. The elastic properties of knitted fabric are mainly influenced by its structure where the loop is the fundamental element in giving such characteristic. Besides, it is the basic element which allows the fabric to bend and flexible for body movement. The structures of the loop can trap more air, which suitable for sports garments application.

Different knitted structures of knitted fabric would give different results on physical and mechanical properties. Physical properties are usually referred to external testing, which used lighting cabinet to see the pilling performance on the fabric while the mechanical properties describe how it will react to physical forces such as elongation and strength. There is difference in knit stitches which depends on the use of different machine and parameter which will create different pattern and fabric types (Chen *et al.*, 1992).

Structures of knitted fabric can be divided into two basic types which are warp knit and weft knit fabric. Raschel crochet is the example of warp knit while plain jersey, interlock and 1x1 rib are examples of weft knit. Theoretically, warp knitted is more complicated on their structure and suitable for home furnishings and technical uses. On the other hand, weft knit fabric is used commonly for apparel and automotive. The end products of knitted fabric have their own unique characteristics, especially for their resiliency, stretchability, good drapability and comfort for easy body movement. However, there is a problem regarding to fabric appearance changes and dimensional stability that are associated with knitted fabric (Nasir *et al.*, 2014).

Fabric may lose its aesthetic appearance due to frequently worn, which are a combination of several factors such as abrasion, repeated laundering, the application of forces in dry and wet states from everyday use and service. Besides, pilling is one of serious problems that affect the aesthetic value of clothes which gives dissatisfaction to the wearer towards fabric manufacturers. Fabric pilling is a formation of small, fuzzy balls on the surface of the fabric. It happens when washing and wearing of the fabric cause the loose fabric to begin to push out from the surface of the fabric and abrasion causes the fibre to develop into a small spherical bundle. It can seriously compromise a textile's acceptability by consumers, in particular knitwear, which tends to pill more than woven fabrics (Wang and Qian, 2018).

Gykyte *et al.* (2002) stated that when the length of knitted fabric loop decreases and the surface density increases, it will result in pills to grow. Thus, it shows the density of fabric affected the pilling resistance of knitted fabrics. Moreover, Ucar *et al.* (2007) defined that the properties structure of knitted fabric such as twist, fuzzing, the quantity of fibres cross section are charger resistance to pilling. It means when the twist of yarn is higher, the fuzzing of fabric tends to be decreased. A factor of a particular range of tightness can influence the pilling formation, where the increased factor of tightness could decrease the number of pills. In other study, Shahid *et al* (2014) proved that compact yarn based single jersey knitted fabric exhibited better pilling resistance, higher bursting strength and better perspiration resistance than conventional ring spun yarn. Construction of the fabric as well as finishing treatment, spinning process and characteristic of fibre in the yarn are among the factors that affect pilling tendency in the knitted fabric which is applied before garment make-up process (Nasir *et al.*, 2014).

Washing or laundering is a part of fabric care activities that involves physical and mechanical actions towards the fabric, and many fabric impairs such as shrinkage and fading happened due to this process. Busilienne et al (2013) claimed that during washing, textile materials shrink and become more dense and rough, and their rigidity increases as well. In the different study conducted by Solaiman *et al* (2015), the garments washed by enzyme, silicone and softener formulation showed significant change in the shrinkage for certain type of structures. They also discovered that both dry and wet rubbing properties on most of the garments have improved. In relation to laundering as well, multiple washings caused an increase in pilling formation due to the intensive mechanical effect during laundering on bamboo knitted fabrics, and this pilling problem could be treated by the use of softener (Ozguney, 2016). Hence, this study was carried out in order to investigate whether laundering itself (without softener) would cause unpleasant appearance particularly pilling to knitted fabrics with different types of fibres.

## Methods

### Materials

Three types of knitted fabric which are cotton, polyester and blended of polyester 65% and cotton 35% were used as testing materials. Different knitted structures used namely; interlock, 1x1 rib and plain jersey. The three types of fabric structure, the fibres and their blend were selected due to their high degree of usage for clothing as pilling is one of the undesired properties to be appeared on any garments.

### Methods

Firstly, each of the fabrics was laundered repeatedly for five times; 10, 20, 30, 40 and 50 cycles. The fabrics were tested with some modifications of laundering for home laundering conditions (Chiweshe and Crews, 2000). Next, pilling test was conducted to determine the resistance to the formation of pills and other related surface changes of the fabric. Pilling testing was done by ICI pilling boxes and Pill Grade Machine.

#### *ICI Pilling Boxes*

Pilling testing can be done by ICI pilling-box according to standard BS 5811. The knitted fabric must be prepared into a tube form and need 4 samples and each sample size is 125 mm x 125mm. The tubes were placed inside the pilling boxes and allow them to tumble at 15,000 revolutions.

### *Pill Grade Machine*

Pill grade machine is an instrument to identify the pilling on the fabric. Pill grades machine detects, measure and grade the pill on the fabric by scanning. The height of each pill, fuzzing and the fabric pattern can be measured.

The assessment of pilling properties of cotton, polyester and polyester/cotton knitted fabrics were done to evaluate the pilling on the fabric. The assessment of objective method was done through Pill Grade machine. A pill was captured by using video rather than 2D photograph then the evaluation of pilling properties was automatically measured by the machine with the number of scale of the pilling. Pill Grade is a rating system where the fabric is graded from the lowest 1 (severe formation of pills) to 5 (no or very weak formation of pills).

## **Result and Discussion**

### **Physical Testing**

Three physical testings were conducted namely density, weight and thickness. All data were interpreted in Table 1 below.

**Table 1: Physical testing result**

<b>Physical Testing</b>		<b>1x1 Rib Cotton</b>	<b>1x1 Rib Poly/Cotton</b>	<b>Plain Jersey Cotton</b>	<b>Plain Jersey Polyester</b>	<b>Interlock Polyester</b>
<b>Density</b>	<b>Wales/inch</b>	26	12	24	23	12
	<b>Courses/inch</b>	36	16	47	13	21
<b>Weight (g/m<sup>2</sup>)</b>		166.5	254.8	185.2	278.6	110.9
<b>Thickness (mm)</b>		0.724	0.799	0.62	0.625	0.537

### **Pilling Evaluation**

#### *1x1 Rib Cotton*

Figure 1 shows pilling results for 1x1 rib cotton fabric. The pilling grade shows fluctuation trend from 0 cycle to 50 cycles. Pilling grade decreased significantly at first round of laundering, which the pill grade was 2.44. After 20 and 30 cycles of laundering, pilling grade increased to grade 2.78 and 3.15 and then dropped to grade 2.08 at 40 cycles. The pilling grade at 50 cycles was 3.76 which similar to the result at 0 cycle. By examining the appearance of fabric surface under naked eye, the fabric surface of 50 cycles was entirely covered by fuzz rather than fabric surface of 0 cycle. It may be occurred due to the falling off the pills due to many cycles of washings given to the fabric leaving fuzzy surface to be observed.

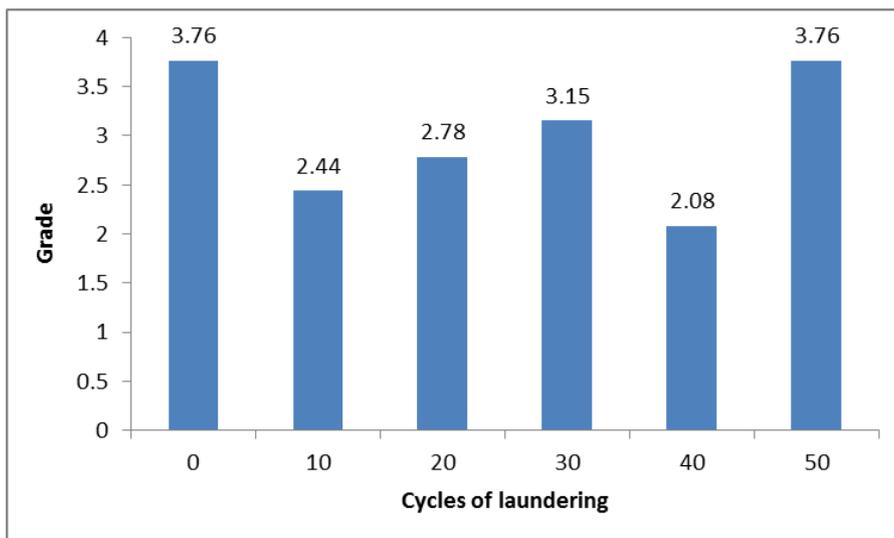


Figure 1. Objective Evaluation of 1x1 Rib Cotton

*1x1 Rib Poly/Cotton*

Based on the Figure 2, pilling grade of 1x1 rib poly/cotton before laundering was 1.29. It can be said that the pilling grade was poor where there were distinct fuzzing and pilling observed covering the whole of the fabric surface. After laundering, the pill grade was at grade 1 which was the lowest pilling standard evaluation. From the physical testing, 1x1 rib poly/cotton fabric was thicker which 8.9 mm with lower density, 12wpi x 16cpi respectively. Lower density refers to the loose fiber assemblies to interlooping and forming on the fabric surface tends to cause pill entanglements after undergoing mechanical action. Besides, the short staple of cotton fibres is one of the factors that contributes to the hairs to be formed on the surface of the fabric which later being gathered into little balls. Carr (1995) claimed that there is little or no tendency for the pills to wear off after further washing or use as polyester fibres anchors the pill to the fabric structure. Thus, the possible reason of 1x1 rib poly/cotton has a lower pilling resistance due to the cotton fibre blend.

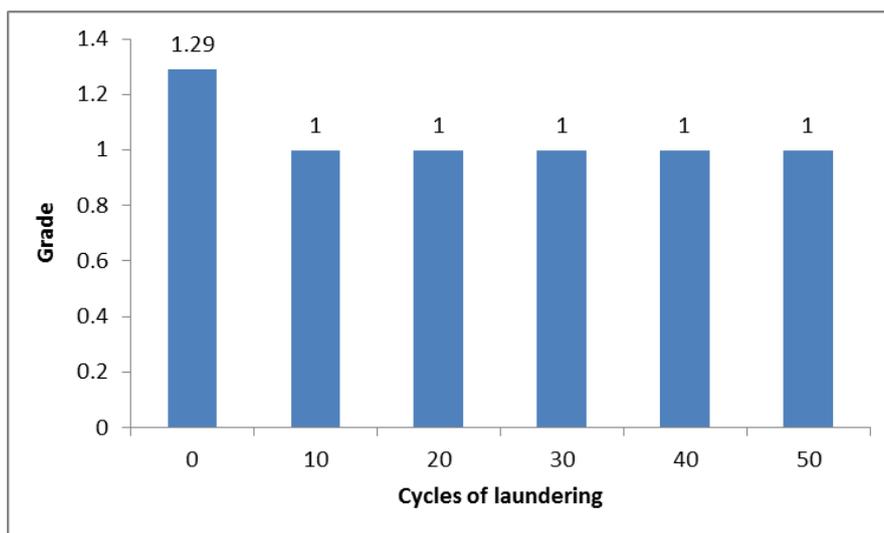


Figure 2. Objective Evaluation of 1x1 Rib Poly/Cotton

*Plain Jersey Cotton*

Figure 3 shows that the graph pattern was slightly decreased from 0 cycle to 40 cycles of laundering. The results approach to the grade 5 which are excellent pilling resistance. Then, pill grade of plain jersey cotton was considered as good as compared to other fabric samples. Besides, it can be said that there was slight pilling appearance on the fabric surface. Moreover, plain jersey cotton has a higher density than other fabric samples which the fabric structure is more compact and fewer tendencies for the pills to occur. The factor of certain rate of tightness can influence the increasing of pills but by increasing the factor of tightness can decrease the number of pills. The compactness of plain jersey structure make the fibers hold together and no gaps between them thus there has no path to migrate to the surface. The fibers remain in place and do not travel to the surface to form pills. As the results, the pills hard to form and the surface of the fabric looks nicer as compared to the 1x1 rib polyester.

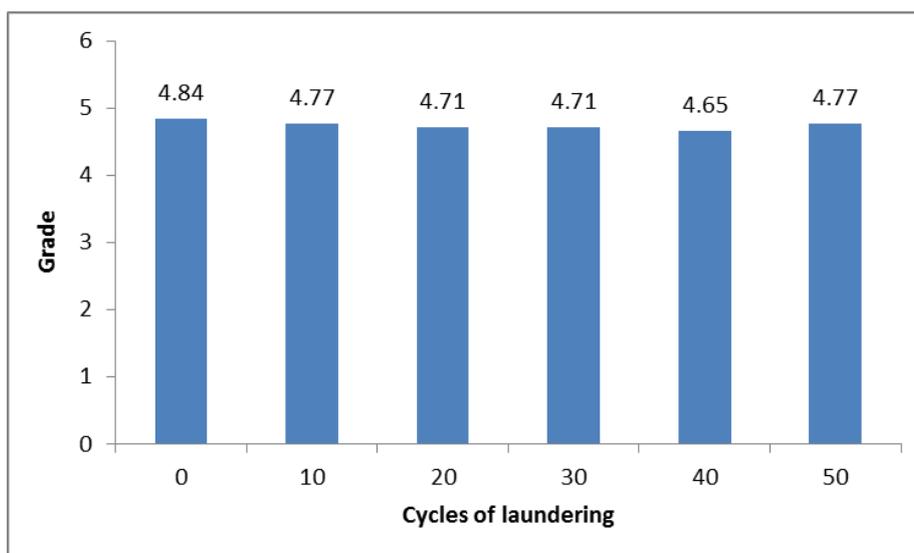


Figure 3. Objective Evaluation of Plain Jersey Cotton

*Plain jersey polyester*

The trend of pilling grade on plain jersey polyester shows a uniform mark grade which is 5, from 0 cycle until 40 cycles (Figure 4). However, at 50 cycles, the grade slightly reduced from grade 5 to grade 4.84. The surface of fabric was changed from no visual change to slightly fuzzing due to the long fibre of polyester and possibly the pills do not rub off. Besides, the possible reason for grade change was because of the repeated laundering and mechanical action which affected the pilling formation of these fabrics.

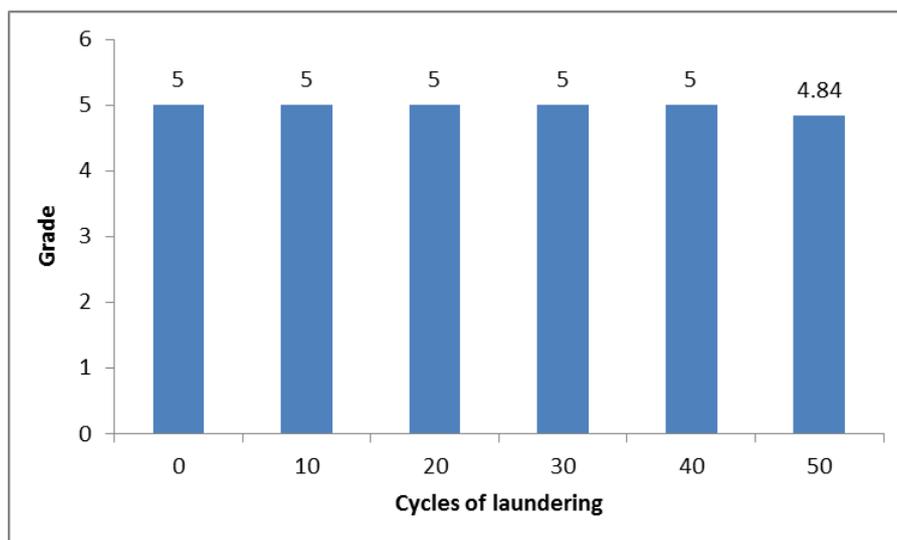


Figure 4. Objective Evaluation on Plain Jersey Polyester

*Interlock Polyester*

Based on Figure 5, interlock 100% polyester shows average pilling grade which is grade 4. The pilling grade decreased from 4.08 to grade 3.44 as the number of launderings increased. However, at 20 cycles the grade increased back to grade 3.93 and significantly increased at 30 cycles with grade 4.53. The pilling grade at 30 cycles was approaching to grade 5 where total pills on the fabric surface are fewer. Unfortunately, at 40 cycles the pilling grade decreased to grade 4.20 and continued to slightly reduce to grade 4.16 for 50 cycles. It shows different results of pilling grade between plain jersey and interlock although both fabrics were made up from the same types of fiber. Interlock has lower pilling resistance than plain jersey due to the compactness of the fabric structure and fabric weight. Interlock fabric has a lower density than plain jersey fabric where the fabric construction is loose and the fiber is easier to pull out on the fabric surface and cause pilling.

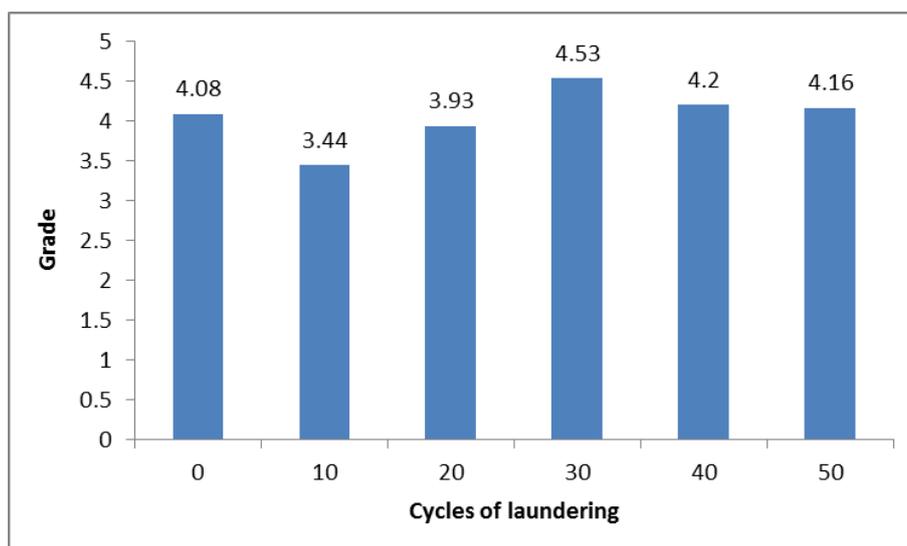


Figure 5. Objective Evaluation of Interlock Polyester

### Comparison of Pilling Evaluation on Different Knitted Structures

Plain jersey polyester showed excellent pilling resistance as compared to other fabric samples followed by plain jersey cotton (Figure 6). These two fabric samples have the same knitted structures which were plain jersey. The structure of plain jersey is extensible in both widthwise and lengthwise directions make the fabric to be flexible and stand under mechanical action.

While 1x1 rib poly/cotton was the lowest pilling resistance due to fibre content and their lower density. This fabric has loose construction where it tends to pill easily on the fabric surface due to pill entanglements after undergoing series of launderings.

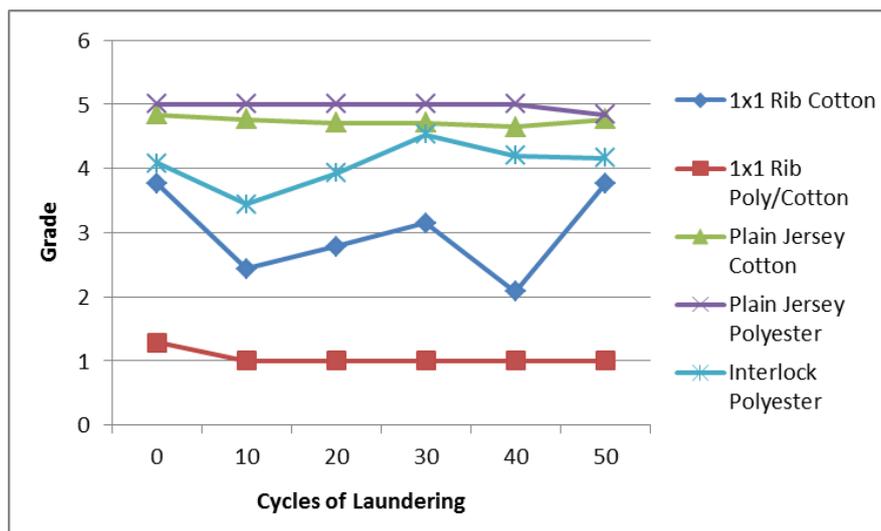


Figure 6. Graph of Pilling Grade against Cycles of Laundering

### Conclusion

The research was done to study the pilling properties of various weft knitted structures and the effect of repeated laundering on these fabrics. Pilling properties can be measured by using three types of parameters on this area of study which were types of knitted structures, type of fibres and number of laundering cycles. Plain jersey structure showed an excellent pilling resistance and followed by interlock structure that has intermediate of pilling grade and lastly is 1x1 rib structure with lower grade of pilling. The propensity of pilling formation on knitted fabric is dependent on the fabric construction. 1x1 Rib poly/cotton was the lowest pilling resistance because the construction of fabric is loose compared with other fabric. Loose fabric tends to make the fibres pulling out and entangled to form fuzzing and pill balls under mechanical action (washing). Fabrics with lower density have the highest pilling formation.

Besides, the pilling properties can be influenced by the types of fibre. In this research, polyester fibre indicated good pilling resistance because long filament fibre will reduce the loose fibres from being pulled out of the fabric surface. Thus, it minimises the pilling tendency to occur. The combination of polyester and cotton fibres make the fabric to pill more with the pills anchored to the structure with no significant appearance change after 50 launderings. This is due to the short staple characteristic of cotton and high strength nature of the polyester. Therefore, the right selection of fibres and the fabric structure must be taken into consideration before production to ensure a good appearance performance of the fabric to capture final users' preference.

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