

A Study on Abrasion Characteristics and Pilling Performance of Socks

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Abstract:

This research concerns the effects of fiber type, yarn count (for single and ply yarn), to the abrasion resistance and pilling performance of socks. Seven different types of socks were selected from Egyptian market. Specimens were subjected to Martindale apparatus and Roll Box to measure abrasion resistance and pilling performance, according to the "ASTM". It was found that the abrasion resistance value of socks can be increased by a number of measures; use of thicker yarns, adding PA to the structure, adding elastic yarns to the structure. It was also found that the use of coarse yarns, addition of polyester, polyamide fibers or elastane filaments to the structure and application increase the abrasion resistance of the socks.

Keywords:

Abrasion; Pilling, Socks industry; Wear resistance; Testing Instruments.

1.Introduction:

1.1 Sock:

A sock is an item of clothing worn on the feet. The name is derived from the loose-fitting slipper, called a *soccus* in Latin, worn by Roman comic actors. [9]

Socks come in a variety of fibers and fiber combinations. Commonly used fibers include cotton, wool, nylon, acrylic, polyester, olefin, and spandex. Occasionally, luxury fibers such as silk, linen, cashmere, or mohair will be blended for softness, but this adds to the cost. Socks are knitted, giving them stretch and the ability to conform to the foot and leg. [6]

Socks, which are a necessary item of clothing, need to be comfortable, affordable. They should retain their quality throughout their life. The span life of the socks is shorter than other textile materials because of higher abrasion within the shoes, slippers or even the ground during usage. Abrasion usually occurs on the heel, sole and toes of the socks. The socks rub within the shoes, slippers or even the ground. The life of sock becomes shorter with the changing in mechanical properties and decreasing in quality due to abrasion. This can greatly reduce the material's life. To determine the parameters affecting the sock abrasion will be useful both for producer and for consumer.

A number of studies have investigated the abrasion resistance of terry socks. Miajewska and Kazmierczak (1983), and Wisniak (1987) of abrasion resistance of seven different types of socks consisting of different rates of Co-PA.

In their study carried out in 1981 Sivakumar and Pillay defined the pilling as a phenomenon exhibited by fabrics formed from staple spun yarns. Pills are masses of tangled fibers that appear on fabric surfaces during wear or laundering, resulting in an unsightly appearance and an unpleasant handle. [12] While Sridharan (1982) defined pilling as a physical process appearing on the surface of a garment, taking the form of small balls made up of fibers, sometimes with contaminants. These fibers give a bad appearance to the garment. [14]

In Baussan *et al* study (2013) six types of cotton-made athletic socks were studied in order to evaluate the influence of the knitted structure on the sock-to-skin friction, he found that a plain jersey knitted with two yarns, were found to be most suitable for running socks. [4]

A further study was carried out by KM Herring and DH Richie Jr, where, they studied Two different socks were tested, One test sock was composed of 100% acrylic fibers, and the other test sock was composed of 100% natural cotton fibers. The results showed that acrylic fiber socks were associated with fewer blistering events and smaller blisters (mm²), when compared directly to cotton fiber socks. [8]

1.2 Socks Constructions:

Socks are knitted, giving them stretch and the ability to conform to the foot and leg. Knit structures used in socks must be in adequate elasticity and fit to feet and legs. Generally, a rib or jersey knit structures is generally used for legs and foot top. stockinette or plain knit stitch

is used in the foot area and a rib stitch is used in the leg area (though some socks are made totally of rib stitch). The rib stitch is very stretchy, with the ability to return to shape. As both the stockinette and rib stitches are simple knit constructions, the stitch can ravel out if a yarn is broke and when a thread broke, ladder can occur starting from that part.

Look carefully at socks for loose threads, broken yarns, or holes that could start to run or ravel with wear. Also, look for evenly knitted stitches on socks and a flat seam at the toe. Toe seams placed high over the toe are usually more comfortable than those at the end of the toe. Both the toe and heel areas should be smooth; otherwise irritation could occur during wear. Heel shape in a sock is equally important to comfort. A square heel gives the best fit. A small, curved heel tends to slip under the foot easily and bunch in the shoe. Toe and heel reinforcements are important features. [13]

However they are preferred for they are elastic and have ability of coming back to their old form. The rubber part knitted on the top section of socks to prevent socket socks from sliding downward is made of elastic threads. For rubber part of socks, wide ribbed band supported with Spandex (lycra) is preferred.

1.3 Abrasion resistance:

Abrasion resistance is the ability of a fabric to resist surface wear caused by flat rubbing contact with another fabric. Abrasion resistance of the textile materials is very complex phenomenon and affected by many factors, mainly classified as follows: Fiber, yarn, fabric properties and finishing processes. Some of these parameters affect fabric surface whereas some of them has an influence on internal structure of the fabrics. [10]

Abrasion occurs during wearing, using, cleaning or washing process and this may distort the fabric, cause fibers or yarns to be pulled out or remove fiber ends from the surface. The first stage of abrasion is small balls entanglement because of the loose fibers unravels from the fabric surface during usage and washing. Eventually the fibers which bind the balls to the surface breakdown and a hole occur. If the sock consists of synthetic fibers with natural fibers, during rubbing action natural fibers, which give the desirable properties of the sock, move away, only synthetic fibers remain. This gives the sock undesirable appearance and decrease the overall fabric thickness. [7]

The initial effect of abrasion on the surface of a fabric is the formation of fuzz as the result of two processes, the brushing up of free fiber ends not enclosed within the yarn structure and the conversion of fiber loops into free fiber ends by the pulling out of one of the two ends of the loop. Gintis and Mead consider that the fuzz formation must reach a critical height, which is dependent on fiber characteristics, before pill formation can occur. [5]

Abrasion resistance and pilling performance are two of the most important mechanical characteristics of fabrics. The resistance of a fabric against the force of friction is known as the abrasion resistance. In general, pilling is a fabric defect observed as small fiber balls or a group consisting of intervened fibers that are attached to the fabric surface by one or more fibers. [11]

1.4 Pilling performance:

Ever since the invention of the loom, fabric producers have observed the phenomenon known as fabric "Pilling," a process that results in the formation of small fuzzy balls or "pills" on the fabric surface. In the short term, pilling may lead to unattractive "fuzzy" fabric; over time, especially with natural fabrics, it can lead to a complete wear-through of the fabric.

Although pilling has been with us for some time, it wasn't a significant problem with wool and cotton fibers. With the invention of synthetic fibers, how-ever, consumers and manufacturers began to take note of the undesirable pilling syndrome. The pilling of textile fabrics is a very complex property because it is affected by many factors that include: type of fiber or blends, fiber dimensions, yarn and fabric construction, and fabric finishing treatments.

Pilling is a condition that arises in wear due to the formation of little 'pills' of entangled fiber clinging to the fabric surface giving it an unsightly appearance. Pills are formed by a rubbing action on loose fibers which are present on the fabric surface. Pilling was originally a fault found mainly in knitted woolen goods made from soft twisted yarns. The introduction of man-made fibers into clothing has aggravated its seriousness. The explanation for this is that these fibers are stronger than wool so that the pills remain attached to the fabric surface rather than breaking away as would be the case with wool. The more usual way of evaluation is to access the pilling subjectively by comparing it

with a written scale of severity. Most scales are divided into five grades and run from grade 5, no pilling, to grade 1, very severe pilling. [3]

1.5 Tools:

1.5.1 Martindale abrasion resistance tester

In Martindale abrasion resistance tester (Figure 1), circular specimens are abraded under known pressure against a standard fabric. Abrasion resistance is measured by subjecting the specimen to rubbing motion in the form of a geometric figure. The advantage of the Martindale abrasion test is that the fabric sample gets abrasion in all directions. Stress develops along the fiber from the force acting transverse to the fiber axis as a result of surface friction; the magnitude of surface friction developed is directly related to the harshness of standard worsted fabric abradant. [1-15]

1.5.2 Roll Box instrument for pilling test

This test method covers the determination of the resistance to the formation of pills and other surface distortions such as fuzzing of textile fabrics (Figure 2).

The degree of fabric pilling is evaluated by

comparing the tested specimens with visual standards, which may be actual fabrics or photographs of fabrics, showing a range of pilling resistance. The observed resistance to pilling is reported on an arbitrary scale ranging from 5 (no pilling) to 1 (very severe pilling). [2]

2. Research Questions:

- 1- What is the type of socks that has the highest abrasion resistance (the heel and the bottom)?
- 2- What is the type of socks that has the highest resistance to pilling performance (the heel and the bottom)?

3. Materials and Methods:

3.1 Materials:

100% Cotton, Cotton/polyester, 100% Acrylic, and Cotton/Polyamide fibers are mostly used in socks. So in this research, the effect of commonly used fibers to abrasion resistance and pilling resistance were investigated. For this purpose the specifications of selected specimens shows in Table (1). The socks were knitted in a single jersey structure using suitable hosiery machines.

Table (1): represents specifications of socks specimens

Materials	Yarn Count	Twist Coefficient
100% Cotton	20/1	4.3
70% Cotton-30% Polyester	20/1	3.9
50% Cotton-50% Polyester	20/1	4.0
100% Polyamide	150x2	-
50% Cotton-50% Polyamide	20/1+150x2	4.0
75% Cotton-25% Polyamide	20/1+150x2	4.2
100% Acrylic	16/1	104.9

3.2 Methods:

There are two different methods commonly used to test abrasion, referred to as Wyzenbeek and Martindale, in this study, abrasion resistance values are measured on Martindale instrument Figure (1), and Roll Box instrument for pilling test Figure (2).



Fig. (1): Martindale Apparatus

For each sock, four samples (three from heel-

three from sole) are taken and the average abrasion resistance values were calculated. The endpoint was determined according to a hole which usually develops when one thread is broken causing a hole to appear. At this point the number of rubs which represent abrasion resistance is recorded. This assessment criteria was used all types of socks.



Fig.(2): Roll Box Instrument



Fig. (3): Specimen In Martindale holder



Fig. (4): Specimen in Roll Box instrument

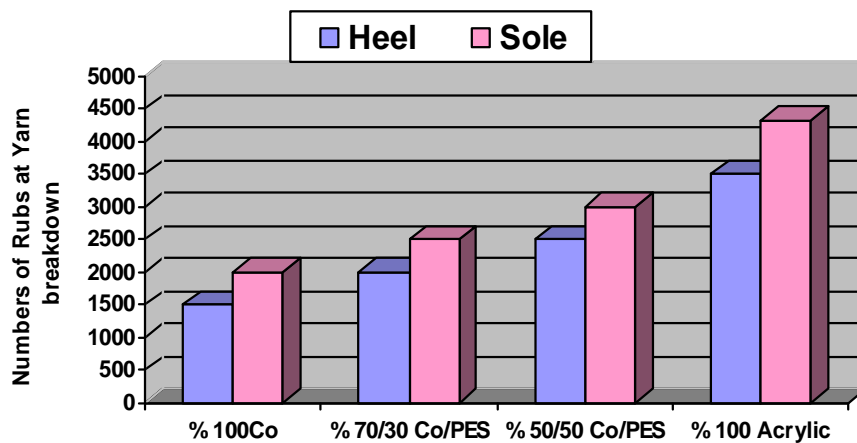


Fig. (5): The abrasion resistance of socks knitted with 100%Co – Co/PES blends

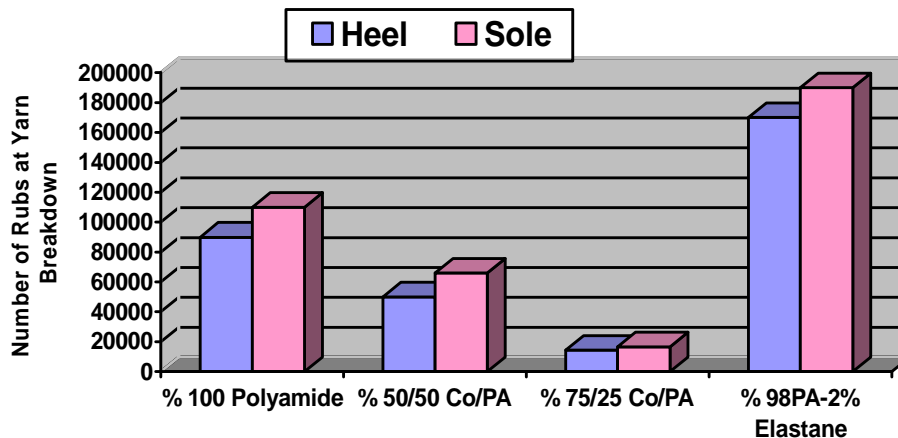


Fig.(6): The abrasion resistance of socks knitted with 100% PA- Co/PA blends and PA/Elastane.

4. Results and Discussion:

Following figures represent the results of experimental work were carried out on the employed specimens as Y axe represents the number of rubs at yarn breakdown and X axe represents specimen (heel & sole values).

After comparing the statistics results of abrasion and pilling socks tests, we can notice from the above figures which represent the results of the experimental part of this work.

It was found that the number of rubs for a hole

and the abrasion resistance values increase when coarser yarns are used. With the presence of plied yarns, these values increase also, because plied yarns are coarser. Discussions of results as followed:

Effects of blend ratio of Co/PES

(Cotton/Polyester) on abrasion resistance

In this study, different blend ratios of Co-PES yarns, which are mostly used in the sock industry, were tested and the results are given in fig. (5). the number of rubs where one thread is

broken causing a hole, was taken as the end point of the test.

The results showed that the abrasion resistance significantly increases when the PES ratio increases because of the higher tensile strength and bending resistance of PES fibers. So, it was found that 50/50 Cotton/Polyester blend has the higher abrasion resistance in both (heel and sole) than other cotton/polyester blends.

Effects of blend ratio of Co/PA (Cotton/Polyamide) on abrasion resistance

In this study, different blend ratios of Co-PA yarns were also tested and the results are given in fig. (6).

According to results and statistical evaluation, the abrasion resistance increases as the polyamide filament ratio increases and this relation is statistically significant. The results show that by using elastic yarn the abrasion resistance of the socks tested increased by almost 80 percent. The analysis of variance indicated that the effect of elastic yarn on abrasion values is statistically significant.

So, 100% polyamide has more resistance to abrasion in both (heel and sole) than cotton/polyamide blends and 100% acrylic, but the highest resistance sock to abrasion of all 7 kinds was 98% polyamide/2% elastane. That's answer the first research question.

The percentage of weight loss in grams for number of revolutions. In 100% cotton socks breaking occurs in the first 5,000 rubs; in Co/PA blend socks because of the affect of cotton yarn, loss weight in grams was obtained within the first 10,000 rubs.

The weight loss with each rub decreases in proportion to the amount of PA used. The weight loss is minimum in (98%PA / 2%elastane) socks, Medium in (100%PA) and maximum in percent (75% Co/ 25% PA) socks.

Effect of yarns and filaments on pilling performance

Socks made from PES is of a very high quality and resistance to pilling, polyamide resistance to pilling is different, it is evaluated by grade 4, socks made from cotton is of similar resistance to pilling grade 3. That's answer the second research question.

5. Conclusions:

The study showed that the abrasion resistance value of socks can be increased by a number of measures; use of thicker yarns, adding PA to the structure, adding elastic yarns to the structure,

increasing the PES ratio in Co/PES yarns, increasing the PA ratio in Co/PA blends. The effect of the spinning process on abrasion resistance of socks is not significant statistically. In the end, it is obvious from the results of the tests and the answers of research questions that: The results reported the classification of types of socks to abrasion resistance which reflects the utilization of yarns in the treatment of some weak abrasion resistance and raising their efficiency.

Also, the results declared the classification of types of socks to pilling performance which reflects the utilization of yarns in the treatment of some weak pilling resistance and raising their efficiency.

6. Acknowledgment:

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