# The Effect of Different Weft Yarn Production Technique on the Pilling Property of Jeans Fabrics.

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**Abstract:**
The main purpose of this study is to investigate the relationship between using three different types of weft yarns with different counts and their effect on the pilling properties of jeans fabric. These three types are namely: core spun yarn, dual core spun yarn with welding, and dual core spun yarn without welding. The dual core yarns are produced by using three different textile materials, which connected to each other in the spinning process to form the final yarn. The advantages of dual core yarns are having the benefits of each type of textile materials. Martindale pilling and abrasion tester was used to evaluate pilling property for tested samples by comparing with standard sample. Results have indicated that the best results for fabric pilling property are both dual core yarn types with higher yarn count.

**Keywords:**
***Core Spun Yarn***
***Dual Core Yarn***
***Jeans Fabric***
***Pilling Property***
***Weft Yarn Count***

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## 1- Introduction

Jeans fabric is considered among the most popular fabrics for clothing in general. One of the most important differences of jean fabric from other fabrics is that its warp is dyed. Today jeans fabrics are categorized under two groups as men’s clothing and women’s clothing; the fabrics preferred in women’s clothing generally have a weft-resembling elasticity (stretch, super stretch), and those utilized in men’s clothing are rigid (non-elastic) and comfort (low elasticity).
The common construction used in the jeans weaves is Twill 3/1Z, 3/1S, 2/1Z, and satin4. Fabrics are manufactured mostly within the weights of 4-16 Oz/yd². Warp density and warp thread count are usually higher compared to the weft; cotton being in the first material place, such materials as viscose, tensile, etc. could be used in the warp (the reason there is not a variety of raw materials is that the warp dyeing process can be applied to only cellulosic fibers).
Weft compositions are various; cotton being in the first place again, such materials as polyester, elastane, linen, viscose, tensil, etc. and their mixtures could be utilized. In the finishing procedures, different levels of caustification, softening, desizing, resin, fixing, coating, etc. processes are applied. With the stretch fabrics, the threads used in the weft have the property to give elasticity to the fabric. These threads are manufactured by using elastane (Lycra®, creora® etc.), PBT, and T400. T400 and PBT have low elasticity values, and are used on their own, whereas the thread made of elastane that could elongate up to 4–6 times compared to their own length should have been manufactured with the core-spun technique, or twisted with other threads, or produced with intermingling process.
The core-spun thread is generally manufactured by placing elastane to the center while thread is being produced out of cotton (other staple fibers could be used as well).
In the case of the “Dual-core” thread used in this study, two core threads are fed into the center. While the Dual-core thread is manufactured through the ring-spinning machine, previously combined of two threads could simultaneously be fed into the center together, or the core threads could separately be fed into the center. Core-spun threads with threads in 3-4-5 centers could also be manufactured.
This research presents a practical study of the influence of using different techniques of yarn spinning in the weft to improve the properties of jeans fabrics by making a comparison between two types of dual core yarns and a conventional core spun.

### 1.1. Jeans Fabrics

The story of jeans begins in the mid- 19th century simultaneously in the European cities:
In France, where the fabric itself was created, the so-called “Serge de Nimes” was used, then that led to the name of “denim”.
Genoa in Italy, where the color comes from, called in French “Bleu de Genes” which led to the

expression "blue jeans".

The fabric and color come together to become the jeans. In these two cities, the strong and resistant fabric started being used to produce work wear, especially for sailors and dockworkers. This blue fabric, which was going to replace the classical brown and beige work wear, established itself many kilometers away from Europe, in the United States of America.

A young immigrant from Germany, called Levi Strauss, started marketing the new garment with riveted copper buttons, which considerably reinforced pockets. Jeans became more and more popular in the 1920s and 1930s and consolidated their reputation as a common work garment. Little by little, an industry was established and it returned to Europe in the form of some newly founded brands (such as Morris Cooper Overall, later called Lee Cooper).

Like in the USA, the first European jeans were intended for the labor market. In the 1950s, jeans entered a new phase in the USA as an article of fashion. They gained ground due to their appearance in Hollywood films where popular actors such as James Dean, Marlon Brando or Marilyn Monroe wore them. By this way jeans very quickly became an object of many young people's desire.

This new fashion trend came after World War II to Europe, not without difficulties, which were due to the economic and trade problems of the time. In the 1960s brands, such as the American Levi's or Wrangler, established their first outlets in Europe in response to the steady increase in demand. Later, others such as Lee started flocking in. Until then dyeing and production of jeans was an exceedingly laborious and not very productive task.

However, in the 1960s, new dyeing systems were introduced and the production of the denim fabric increased and was optimized. Slowly, the first European jeans brands appeared Carrera in Italy, Lois in Spain, or Chi pie in France. Although quite popular, jeans were not able to gain adequate recognition in the fashion industry. Nevertheless, at the beginning of the 1970s new brands appeared. They put emphasis on sales strategies that were completely different from those established so far and provided the denim fashion with a definite impulse. It was consolidated in the 1980s with the creation of brands such as Goldie, Diesel, Replay and others. At present jeans is not just a garment, but also an entire lifestyle. Nowadays brands make clear their commitment on the protection of the environment. The use of organic cotton and chemical products with low environmental impact is becoming usual as well as industrial processes, which minimizes consumption both of water and of residues generated during the entire process. Comfortable, risky, adventurous, relaxing, glamorous, attractive, aggressive, smart, casual, funny, dynamic, energetic, fashionable, practical, creative… universal. All these adjectives define denim not only as a style in fashion but also as something more: a lifestyle. [1]

### 1.2. Yarn Classification

Generally, in textile, there are so many types of yarns and it can be classified in so many ways but we are going to classify them in groups and sub group. The groups are four, which are continuous filament, staple spun, composite, and plied yarns. These groups are divided, with the final column giving the commonly used names for yarns, and are based largely on the method or technique used to produce the yarn. Generally, a technique produces a yarn structure that differs from those of other techniques.

Continuous filament (CF) yarns are basically unbroken lengths of filaments, which include natural silk and filaments extruded from synthetic polymers (e.g., polyester, nylon, polypropylene, acrylics) and from modified natural polymers (e.g., viscose rayon). Such filaments are twisted or entangled to produce a CF yarn.CF yarns can be subdivided into un-textured (i.e., flat) and textured yarns. The more commonly used are false-twist textured and air-jet textured yarns.

For the former, extruded filaments are stretched, then simultaneously heated, twisted, and untwisted, and subsequently cooled to give each filament constituting the yarn a crimped shape and thereby a greater volume or bulk to the yarn.

Alternatively, groups of filaments forming the yarn can be fed at different speeds into a compressed-air stream (i.e., an air-jet), producing a profusion of entangled loops at the surface and along the yarn length. These processes are known as texturing or texturizing. Continuous filaments can be chopped into discrete lengths, comparable to the lengths of natural plant and animal fibers. Both manufactured fibers and natural fibers can be assembled and twisted together to form staple-spun yarns. [2]

### 1.3. Production of Dual Core Yarn

With the stretch fabrics, the threads used in the weft have the property to give elasticity to the fabric. These threads are manufactured by using Elastane (Lycra®, creora® etc.), PBT, and T400. T400 and PBT have low elasticity values, and are used on their own whereas the thread made out of elastane that could elongate up to 4–6 times compared to their own length should have definitely been manufactured with the core-spun technique, or twisted with other threads, or produced with intermingling process. The core-spun thread is generally manufactured by placing elastane to the center while thread is being produced out of cotton (other staple fibers could be used as well).

Two core threads will be feed into the center. While the Dual-core thread manufacturing through the ring-spinning machine, previously combined two threads could simultaneously be fed into the center together, or the core threads could separately be fed into the center. Core-spun threads with threads in 3-4-5 centers could also be manufactured. [3]

**1.3.1. Types of Dual Core yarns**

- Dual Core with welding.
- Dual Core without welding.

**1.3.2. Steps of Dual Core yarns formation**For Dual Core with welding, both of synthetic fibers and spandex must be welding in a SSM machine (texturizing machine) with different draft for both, then the final cone takes a place in ring spinning machine with the cotton roving to pass through the usual path of spinning through the drafting roller to the ring area and Compaction thread into the bobbins. The machine, which used in the study is from Rieter as shown in Fig (1).

Dual Core without welding there is no need to weld two core before spinning because the spinning machine is already suitable for holding and merging the cores and the cotton roving together to form the final dual core yarn as core spun yarn with additional place for synthetic fibers bobbins. The size of synthetic fibers bobbins is the same size of the cotton roving size. The machine, which used in the study is from Zensir as shown in Fig (2), [4]

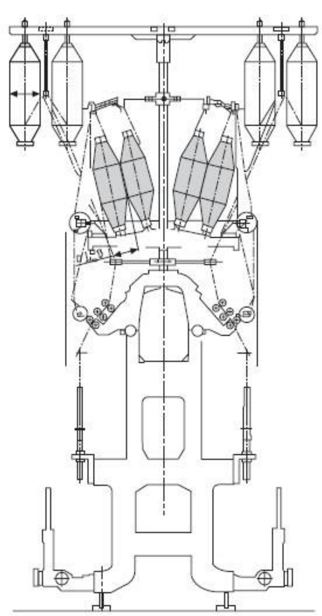

Fig (1): Formation of dual core yarn with welding.

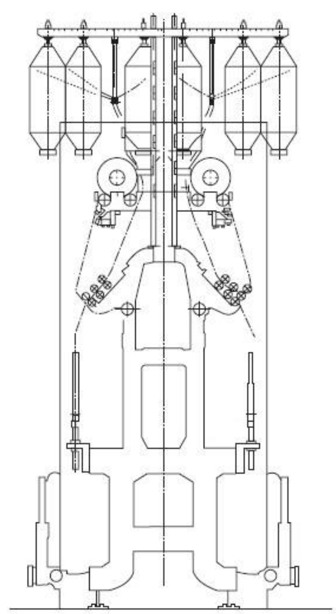

Fig (2): Formation of dual core yarn without welding.

**1.4. Yarn Properties**

The properties includes "breaking strength; tensile strength – tenacity – elongation - elastic recovery".

**1.4.1.Breakingstrength; tensile strength**this is the maximum tensile force recorded in extending a test piece to breaking point. The figure is generally referred to as strength. The force at which a specimen breaks is directly proportional to its cross-sectional area, therefore when comparing the strengths of different fibers yarns and fabrics allowances have to be made for this.

**1.4.2. Tenacity** is defined as the specific stress corresponding with the maximum force on a force/extension curve. The nominal denier or Tex of the yarn or fiber is the figure used in the calculation; no allowance is made for any thinning of the specimen as it elongates.

**1.4.3. Elongation**is the increase in length of the specimen from its starting length expressed in units of length. The distance that a material will extend under a given force is proportional to its original length therefore; elongation is usually quoted as strain or percentage extension. The elongation at the maximum force is the figure most often quoted.

**1.4.4. Elastic recovery**when forces are below the level of their breaking strength and allow them to recover stretch textile materials, they do not immediately return to their original length. How much of the original length they recover depends on the force used the length of time the force is applied for and the length of time allowed for the recovery. [5]

**1.5. Jeans fabric properties**

The properties includes "tensile strength – tear strength – fabric stretch - fabric abrasion resistance - fabric pilling".

**1.5.1. Tensile strength**measurement of tensile stress–strain properties is the most common mechanical measurement on fabrics. It is used to determine the behavior of a sample while under an axial stretching load. From this, the breaking load and elongation can be obtained. The principle of the tensile strength test is simple: a test piece is held in two or more places and extended until it breaks. The tensile properties measured are generally considered arbitrary rather than absolute. Results depend on specimen geometry, the fiber type and arrangement, as well as the fabric structure.

**1.5.2. Tear strength**tearing of a fabric can occur in a wide range of products and is involved in fatigue and abrasion processes as well as the catastrophic growth of a cut on application of a force. Tear strength is the tensile force required to start, continue, or propagate a tear in a fabric under specified conditions. A tear strength test is often required for woven fabrics used for applications including army clothing, tenting, sails, umbrellas, and hammocks. It may also be used for coated fabrics to evaluate brittleness and serviceability.[6]

**1.5.3. Fabric stretch properties**these properties are particularly important for elastic fabric and stretch fabric. Elastic or elastomeric fabric is made from an elastomer either alone or in combination with other textile material. Elastomers include polymers such as rubber, polybutadiene. Polyisobutylene and polyurethanes. Because the glass transition temperature of these polymers is below room temperature, these materials are soft or rubbery at room temperature and can easily return to their original shape after stretching. Due to the nature of these materials, they do not always return to their original shape after prolonged deformation. Tests should measure size change (kickback) after long periods of extension. The tension to stretch an elastic material and the percentage stretch achievable are also important variables to be measured.

Stretch fabric is usually accomplished by incorporating a small percentage of elastomeric fibers or filaments into a conventional woven or knitted textile fabric. Stretch fabric can also be achieved without elastomeric fibers by fabric construction or yarn selection. There are two types of stretch fabrics: comfort stretch (5–30%) and power stretch (30–50%). Comfort stretch fabrics are designed for low loads, and power stretch for considerably higher loads. Stretch is important in sportswear such as swimwear or other active sports clothing, which is required to be a close fit to the body. The stretch requirements of a fabric can be gauged from the typical values of stretch that are encountered during the actions of sitting, bending, or flexing of knees and elbows. Both elastic fabric and stretch fabric require good elasticity; consequently, fabric tends to recover its original size and shape immediately after removal of the force causing deformation. The three main factors of interest when testing a fabric with recoverable elongation are elongation at load, force for elongation, and recovery after load.

- Elongation at load is the amount that a fabric stretches in length from its original length after a fixed load is applied. This is commonly used to define the level of stretch within the fabric. Woven fabrics have much less stretch than knitted fabrics.
- Force for elongation defines the amount of force required to extend a fabric a certain distance in elongation. It can be called power or tension of the fabric at elongation and is important for comfort factors in garment design.
- Recovery after load is the amount a fabric returns to its original dimensions after the elongation load is released.

Recovery is possibly the most important factor as it defines whether a fabric is stretch or not. Fabrics without elastic properties are often tested for stretch and recovery to quantify the effect of stretching the fabric in use. A 100% cotton single jersey fabric will generally stretch significantly when a load is applied; however, its recovery after stretch is poor. The addition of an elastomeric fiber will increase the level of recovery, which can then define this fabric as a stretch fabric.

Recovery is often measured after a long period of load. Elastomers can break down when loaded for a long time. This is observed as a loss in fabric recovery or tension at load. This type of test is often used for elastic tapes or fabrics where the tension is an integral part of the garment design. An example is underwear where the product is rendered useless if the elastic waistband no longer holds the garment in place.

There are two main ways by which fabrics are measured for stretch and recovery. These are dynamic and static measurements. In dynamic measurement, the fabric is applied with a fixed load or a fixed extension at a controlled rate of extension. Dynamic measurements can be cycled through a series of extensions before the results are taken. The CRE machine is an example of a machine used for dynamic testing. Dynamic tests generally measure tension at elongation as well as elongation and relaxation.

A static test is conducted by clamping one end of a fabric on a flat plane. The other end is then displaced by applying a fixed load or by stretching to a set elongation. Static tests generally only provide elongation and load information. However, they are commonly used to measure recovery after a long period of loading. [2]

**1.5.4. Fabric abrasion resistance**is defined as the wearing a way of any part of the fabric by rubbing against another surface. Fabrics are subjected to abrasion during their lifetimes and this may result in wear, deterioration, damage, and a loss of performance. However, the abrasion resistance is only one of several factors contributing to wear performance or durability. Abrasion can occur in many ways and can include fabric-to-fabric rubbing when sitting, fabric to ground abrasion during crawling, and sand being rubbed into upholstery fabric, and it is difficult to correlate conditions of abrasion of a textile in wear or use with laboratory tests. This may explain the reason there are many different types of abrasion testing machines, abrasive, testing conditions, testing procedures, methods of evaluation of abrasion resistance and interpretation of results.

To abrade for a set time or number of cycles and assess the fabric for change in appearance, loss of mass, loss of strength, change in thickness or other relevant property. The length of the test for the first approach is indeterminate and requires the sample to be regularly examined for failure. This need for examination is time consuming as the test may last for a long time. The second approach provides for simpler measurements; however, the change in properties such as mass loss can be slight. [6]

**1.5.5. Fabric 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. 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 conversion of fiber loops into free fiber ends by pulling out of one of the two ends of the loop. The greater the breaking strength and the lower the bending stiffness of the fibers, the more likely they are to be pulled out of the fabric structure producing long protruding fibers. Fiber with low breaking strength and high bending stiffness will tend to break before being pulled fully out of the structure leading to shorter protruding fibers.

**1.5.5.1. Pilling tests**after rubbing of a fabric it is possible to assess the amount of pilling quantitatively either by counting the number of pills or by removing and weighing them. However, pills observed in worn garments vary in size and appearance as well as in number. The appearance depends on the presence of lint in the pills or the degree of color contrast with the ground fabric. The more usual way of evaluation is to assess the pilling subjectively by comparing it either with standard samples or with photographs of them or by the use of a written scale of severity. [5]

**2. Experimental work**

The main purpose of this study is to find out the effect of using different weft yarns with different production techniques on the pilling properties of jeans fabrics, these are namely: core spun yarn, dual core spun yarn with welding, and dual core spun yarn without welding. The dual core yarns are composed by using three different textile materials, which are connected to each other in the spinning process to form the final yarn. Advantage of using dual core yarns is to have the benefits of each type of textile materials, which take part in the yarn formation.

**2.1. Yarn specifications**

The following are all the technical specifications for the three types of yarns in the study, which are the count of each textile yarn before and after the manufacture, the production parameters for each yarn count, the ratio of cotton blending, the ratio of each fiber contributed in manufacturing the final yarn for each type and yarn count.

**2.1.1. Core Spun yarns specifications**table (1) shows all the Core Spun yarns specifications used in the study experiments.

**2.1.2. Dual Core yarns specifications** table (2) shows all the Dual Core yarns specifications used in the study experiments.

**2.2. Fabric specifications**

The fabric specifications are divided into warp specification, which is constant for all the samples, and specifications for each weft count which is used in the study. Same warp specification was used to weave the nine spinning samples to produce nine jeans fabrics, in order to carry out the Laboratory tests and determine effect of yarn specifications on the fabric properties. All fabric samples were executed by using 3/1 twill weave structure. Following tables illustrate the warp and weft specifications of fabric samples.

**2.2.1. Warp specification**table (3) shows Warp Specifications used in the study experiments.

Table (1): Core Spun yarns specifications.

| Core spun yarns specifications | | | |
|---|---|---|---|
| | **Ne 16 Core Spun** | **Ne 20 Core Spun** | **Ne 24 Core Spun** |
| **Final Yarn Count:** | Ne 16 | Ne 20 | Ne 24 |
| **Lycra Yarn Count:** | Dtex 78 | Dtex 78 | Dtex 78 |
| **Lycra Manufacture Country:** | Turkey | Turkey | Turkey |
| **Alpha Twist:** | 4.7 | 4.7 | 4.7 |
| **Twist Number /Inch:** | 740 | 830 | 906 |
| **Lycra Draft:** | 3.7 | 3.7 | 3.7 |
| **Roving Cotton Draft:** | 1.16 | 1.16 | 1.16 |
| **Lycra Yarn Count After Draft:** | 18.9 | 18.9 | 18.9 |
| **The percentage of mixing All Materials:** | 94%Co + 6%El | 93%Co + 7%El | 92%Co + 8%El |

Table (2): Dual Core yarns specifications.

| Dual core yarns specifications | | | |
|---|---|---|---|
| | **Ne 16 Dual Core** | **Ne 20 Dual Core** | **Ne 24 Dual Core** |
| **Final Yarn Count:** | Ne 16 | Ne 20 | Ne 24 |
| **Poly Ester Yarn Count:** | Den 75 | Den 75 | Den 75 |
| **Lycra Yarn Count:** | Dtex 78 | Dtex 78 | Dtex 78 |
| **Poly Ester Manufacture Country** | Egypt | Egypt | Egypt |
| **Lycra Manufacture Country:** | Turkey | Turkey | Turkey |
| **Alpha Twist:** | 5.5 | 5.5 | 5.5 |
| **Twist Number /Inch:** | 840 | 945 | 1038 |
| **Lycra Draft:** | 3.7 | 3.7 | 3.7 |
| **Poly Ester Draft:** | 1.37 | 1.37 | 1.37 |
| **Roving Cotton Draft:** | 1.16 | 1.16 | 1.16 |
| **Poly Ester Yarn Count After Draft:** | 54.7 | 54.7 | 54.7 |
| **Lycra Yarn Count After Draft:** | 18.9 | 18.9 | 18.9 |
| **The percentage of mixing All Materials:** | 75%Co + 19%Pes + 6%El | 69%Co + 24%Pes + 7%El | 63%Co + 29%Pes + 8%El |

Table (3): Warp Specifications.

| Warp Specifications | |
|---|---|
| **Yarn Count** | Ne 10 |
| **Yarn Type** | 100% Cotton |
| **Yarn Appearance** | Slub |
| **Yarn Status** | Dyed |
| **Dye Type** | Vat (Indigo) |
| **Ends per width** | 4980 |
| **Reed** | 6.5 |
| **Yarn per cm** | 26 |
| **Reed Width** | 191.5 cm |

**2.2.2. Weft Specifications** Dual core yarns are composed of synthetic Material in form of continuous filament, which is responsible for the physical and mechanical properties such as tenacity, tensile strength, and durability. The other core is the spandex yarn that add the elasticity properties to both the final yarn and the fabric, which give the yarn amount of relaxation and extension during the tension and use that lead to feel comfortable in wearing the cloth. Also having the recovery and growth properties better than the rigid yarns. In the end both cores are covered by cotton filaments which look like the rest of the body and become responsible of giving the final yarn the hydrophilic properties, so that the ratio of both cores count to the total final yarn count is not more than 33%.

In this part of the study, three different types of yarns were produced as the following:

- Core spun yarns.
- Dual core yarns with welding the cores.
- Dual core yarns without welding the cores.

The following table "Table (4)" shows all the Dual Core yarns specifications, which used as weft threads to manufacturethe weaving experiments.

Table (4): Weft Specifications.

| Weft Specifications | | | |
|---|---|---|---|
| **Yarn Count** | Ne 16 | Ne 20 | Ne 24 |
| **Yarn Types** | Core Spun | Dual Core with welding | Dual Core without welding |
| **Yarn Appearance** | Even | Even | Even |
| **Yarn Status** | Raw | Raw | Raw |
| **Picks /cm** | 20 | 25 | 30 |
| **Number of Weft yarns in Raw Fabric** | 21 | 26 | 31 |
| **Number of Weft yarns in Finish Fabric** | 24 | 30 | 34 |

**2.3. Pilling test device Specifications**

This test was carried out by using Martindale Pilling and Abrasion Tester. The pilling test was achieved according to ISO standard no. 12945-2 in year 2000. The evaluation of the pilling of tested samples was assessed subjectively by comparing them with a standard samples, and tested samples was rated from 1 to 5, as 5 is the best with less pilling and 1 is the worse with more pilling.

**3. Results and Discussion**

Figures (3, 4, 5, 6) which represent the relationship between the yarn types and fabric pilling, we can see that both types of dual core yarns present higher values with less pilling, comparing to the core spun yarn. The correlation coefficient and the linear regression equation were found for each yarn type separately as follows:

Core spun yarns:

R = .87 Correlation strong extrusive.

Y = 2.92 + .06 X.

Dual core yarns with welding:

R = .87 Correlation strong extrusive.

Y = 3.42 + .06 X.

Dual core yarns without welding:

R = .87 Correlation strong extrusive.

Y = 3.42 + .06 X.

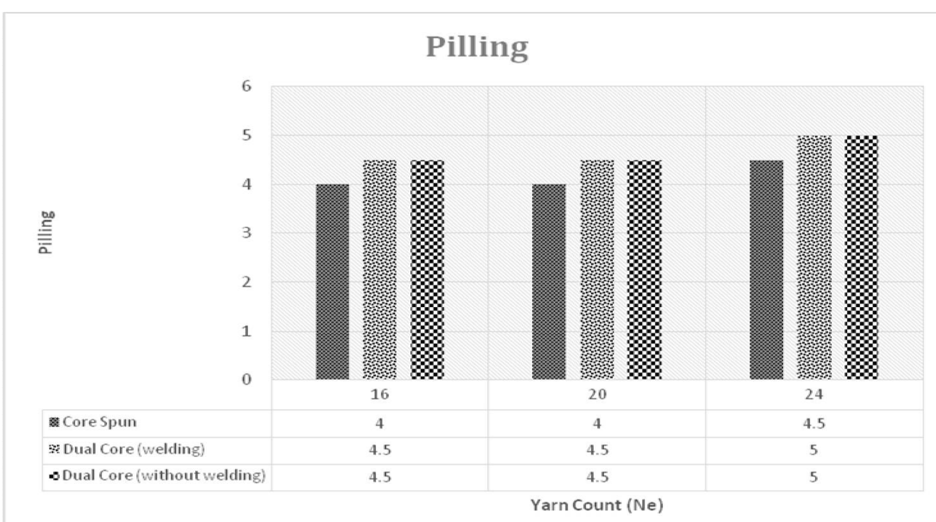


Figure (3): Represents the relationship between different yarn counts and fabricpilling.

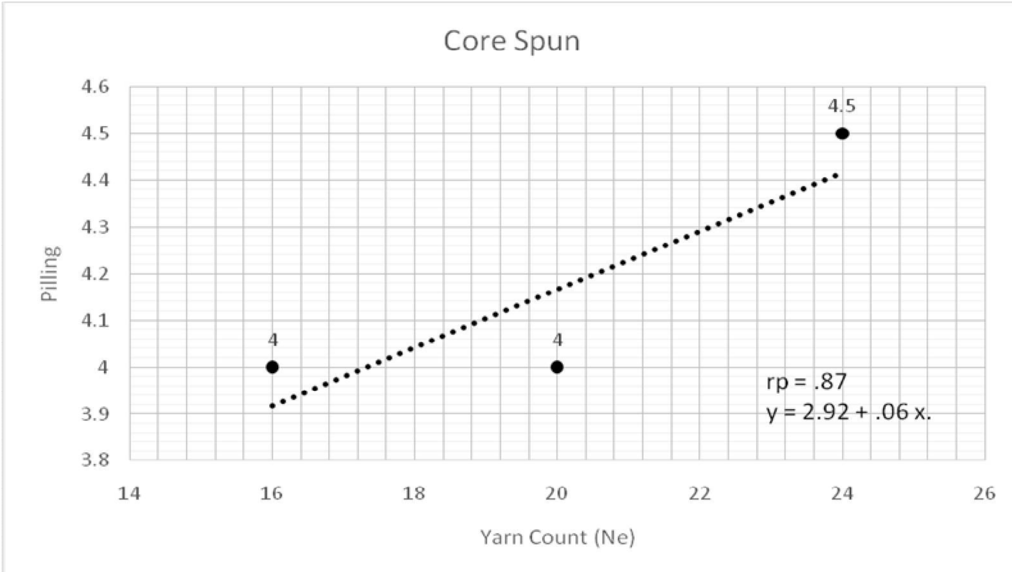


Figure (4): Represents correlation between core spun yarn and fabric pilling.

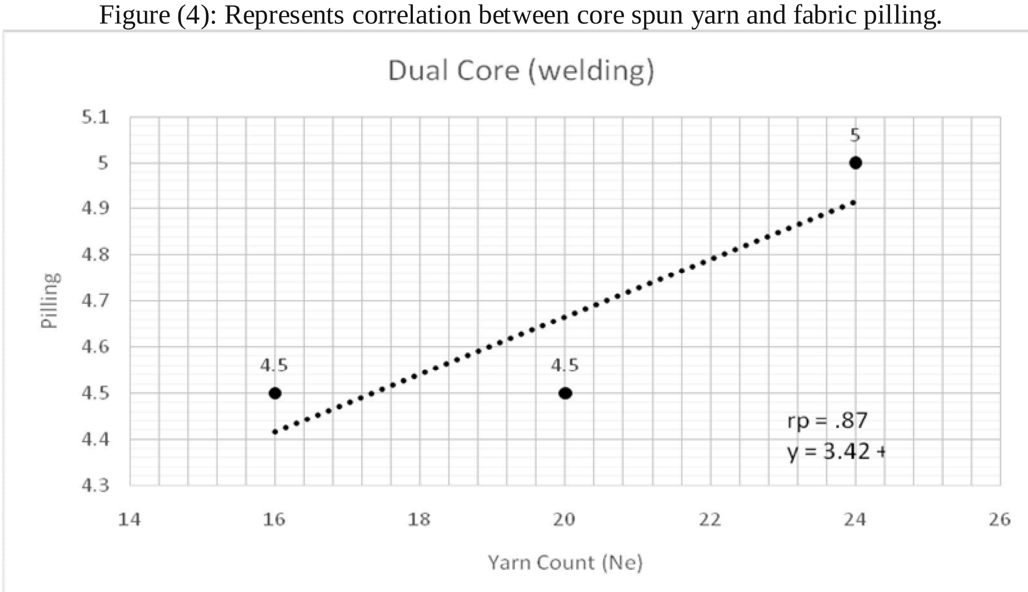


Figure (5): Represents the correlation between core spun yarns with welding andfabric pilling.

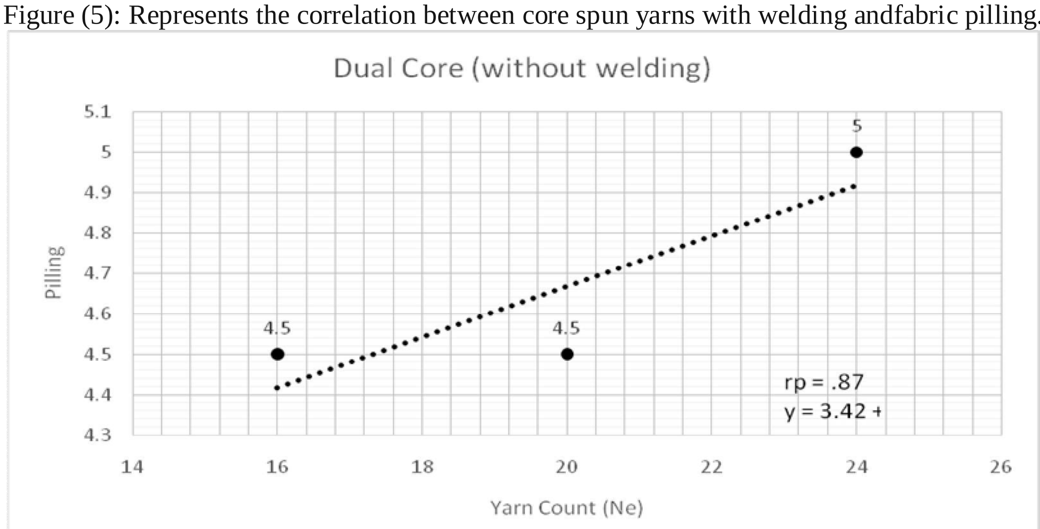


Figure (6): Represents the relationship between dual core yarns without welding and fabric pilling.

From the above results it was found that both dual core spun yarns gave slightly higher degrees in pilling rating with less pilling presence more than normal core spun yarns with more pilling presence. The correlation between the yarn count and the fabric pilling is strong extrusive. That means if the yarn count is fine, the fabric pilling will be increased. In addition, the opposite is correct if the yarn count is thick, the fabric pilling will be decreased. With the increase in the yarn count in English numbering system the diameter of the yarn is finer and the number of the filament in the cross section is less, so the fabric ability to resist the pilling will be lower.

## 4. Conclusion

Results have indicated that the best results of fabric tests for fabric pilling property are both dual core yarn types with yarn count 24.

In general, jeans fabric, which contain dual core yarns with welding, gives the best values for fabric pilling property, which is considered the best samples among all samples of this study.

In general, jeans fabric, which contain core spun yarns, gives the least values for fabric pilling property, which is considered the least sample among all samples of this study.

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