An Investigation about Spirality Angle of Cotton Single Jersey Knitted Fabrics Made from Conventional Ring and Compact Spun Yarn

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Abstract: Spirality is particularly serious problem for single jersey knitted fabrics due to their asymmetrical loop formation, and it may exist in grey, washed or finished state. Spirality is a dimensional distortion in circular plain knitted fabrics and has an obvious influence on both the aesthetic and functional performance of knitted fabrics and the garments produced from them which appear as the displacement of the side seams and this causes an important quality problem. This paper focuses on the yarn types as key aspects of spirality. Yarn spinning system is a parameter which can control knitted fabric spirality, in other words spinning technology influences the degree of spirality in fabrics. Previous studies has been reported that spirality angle of the fabric knitted with ring yarns are very high comparing with the fabrics knitted with open-end yarns. But ring yarns (conventional and compact) have always been considered as a quality reference among all the yarns produced by other spinning system in textile industry, also open-end spinning is suitable only for coarse and middle yarn count. Then there are some fabrics or garments orders need fine yarn count, or high quality and appearance which cannot be obtained and achieved by using open- end yarns. The aim of this work was to compare the spirality angle of the compact spun yarn knitted fabric and conventional ring spun yarn knitted fabrics. For this aim, 100% Egyptian cotton yarns of Ne 60s/1, were spun according to conventional ring (combed) and compact methods from the sliver produced by using the same cotton grade (Giza 86). The yarns were knitted on a single jersey circular knitting machine with the same stitch length and taking into account that the other production parameters constant. The experiment showed that spirality degree is higher for compact yarn more conventional ring spun yarn. In other word the conventional ring spun yarn knitted fabrics noticed lower spirality angle. The paper also explicitly determined the theoretically approach of the causes and remedies of spirality and the main difference between compact and conventional ring spinning technology. This research will be helpful for particularly knitwear industries and designer who are dealing with compact spun yarn knitted fabric and garments. Thus, before starting manufacturing in factory, it can be easily predict the spirality angle of cotton single jersey fabrics and garments using the defined factors.
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Key words: Spirality of knitted fabric, Spirality measurement, Spirality calculation, Compact spinning, Conventional ring spinning.

1.Introduction:

The ever increasing demand of knitted apparels has attracted attention in global niche market. Knitted fabrics are used in manufacturing of fashion garments and even it has the potential in the formal wear segments also.[1] The dimensional stability of knitted fabrics is an important factor of the knitting industry.[2]

On the knitted fabric, it is necessary that the wale be perpendicular to the course, but Weft knitted fabrics tend to undergo certain dimensional change that causes distortion in which there is a tendency of the knitted loops to bend over, causing the wales to be at diagonal in-stead of perpendicular to the courses. However, the wales are not always perpendicular to the course and skew to the right or left, forming a spirality angle which creates a serious problem, especially in the apparel industry. [1] Spirality is a dimensional distortion in circular plain knitted fabrics and has an obvious influence on both the aesthetic and functional performance of knitted fabrics and the garments produced from them which appear as the displacement of the side seams and this causes an important quality problem.[1, 2] The spirality problem is that when we knit a rectangular piece of fabric, it leans towards one side and becomes a parallelogram. The wales are no longer at right angles with the courses.[3] In other words spirality of knitted fabric is obtained when wales is not perpendicular to course, forming an angle of spirality with vertical direction of the fabric. Spirality is a very common inherent problem in plain knitted fabrics and the most important problem of the single jersey structure, and it may exist in grey, washed or finished state which affects all the fabric and creates big problems at the clothing step and produce serious problem during garment confection and use. However, it does not appear more in interlock and rib knits because the wale on the face is counter balanced by a wale on the back.

Knitted fabric Spirality

1.1 What is Spirality?

Spirality can be defined as a fabric condition resulting when the knitted wales and courses are angularly displaced from that ideal perpendicular angle. This displacement of the courses and wales can be expressed as a percentage or as an angle measurement in degrees. There are another terms are often used to refer to the same phenomena such as: Skew, torque, bias and shear.

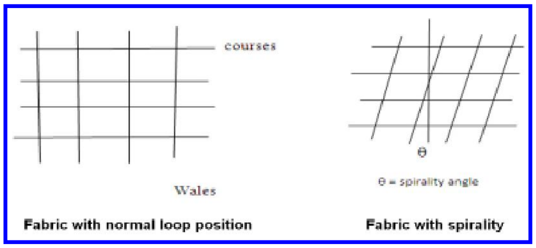


Fig. 1, (a) Fabric with normal loop position, (b)Fabric with spirality. [1]

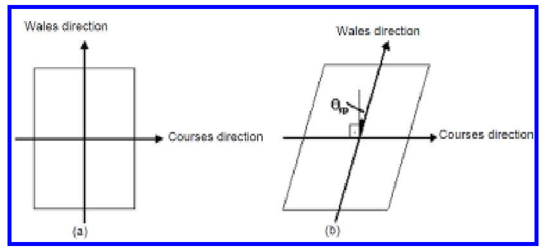
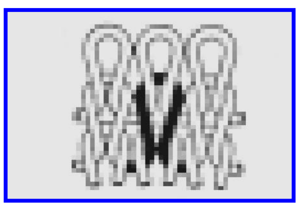
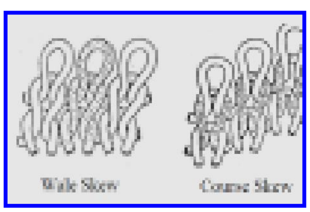


Fig. 2, Schematic representation of spirality problem: (a) normal fabric; (b) spiral fabric[3]



(a)



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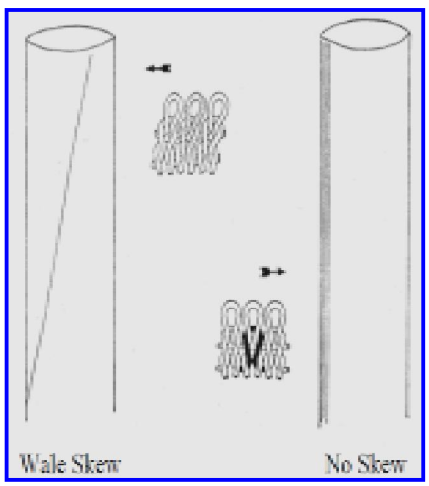

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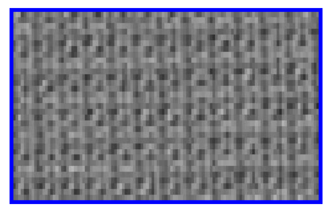

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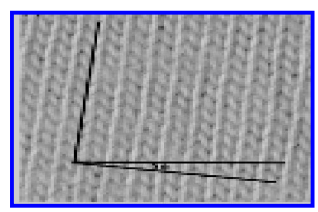
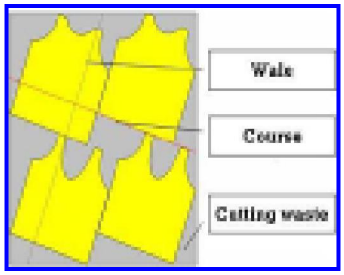
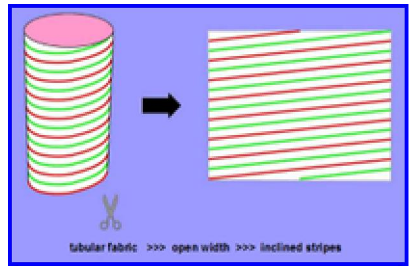


(e)

Fig.3, (a) The ideal model for a single jersey fabric which the courses and wales aligned at a perpendicular angle, (b) Wale skew and course skew, (c) Knit fabric spirality caused by wale loop distortion.[(1)]**, (d) Appearance of no skew single jersey fabric,Source:www.ruili-company.com., (e) Spirality in jersey fabrics physical appearance of spirality in wale line.** [(5)]





(a) (b) (c)

Fig. 4, (a) Seam displacement on a knitted sweater, (b) Cutting waste wales aligned at a perpendicular angle[7], (c) manufacturing yarn dyed, striped, knitted fabric is a circular process creating tubular fabric. The stripes are a spiral and when the fabric is opened, the result will be that the stripes will become slanted lines. **Source: www.veith-system.de.com**.

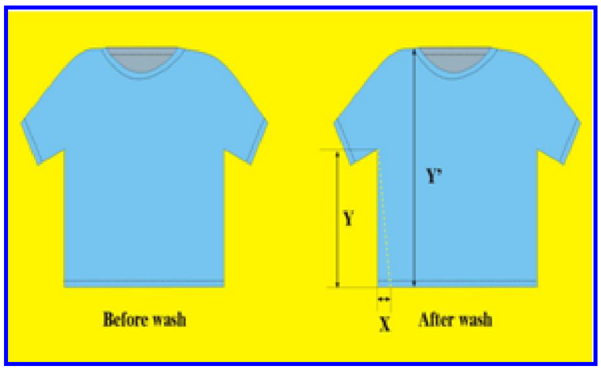


Fig.5 measuring the spirality of a fabric, a garment sample (half sleeve T-shirt) and measure twisting percentage of garment side seam. Spirality% = 100* X/ Y or 100*X/Y 'Where, X is displacement of side seam at bottom after wash, Y is side seam length and Y' is T-shirt body length. Source: *www.OCS.com*, online clothing study.

1.2 Spirality and garments problems

Ready-made knitted garments, t-shirts, underwear and lingerie are an important part of the textile sector. [4] Single jersey fabric spirality is the most important problem which creates big problems at the clothing step. The t-shirt production, for example, suffers from many quality problems linked to fabric spirality such as mismatched patterns, sewing difficulties, displacement of side seam to the back and front of the body and garment distortion. [1, 5, 6] Spirality or the distortion in the wale lines is not only influences the fabric aesthetics shown in figure 4, but also decreases fabric utilization yield during the cutting process shown in figure 5, and leading to the increase of the material cost.

Spirality becomes more prominent when widthwise striping is produced using two or more coloured yarns in a machine with very high number of feeder. In that case the value of'd' will be F/cpi, where F is the number of feeders. Some of the practical problems arising from spirality encountered in garment production are displacement or shifting of seams, mismatching of patterns, sewing difficulties, etc. Spirality has an obvious effect on both aesthetic and functional performances of knitted structures and garments produced from them. (See Fig.4,5)

1.3 Spirality of different weft knitted structure

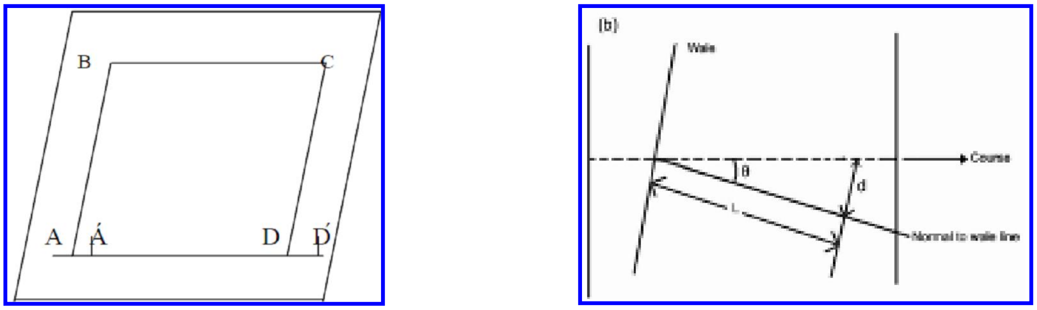
Spirality, a common defect, is generally found in single jersey structures, that due to non-arrest of loops. [8] Also spirality can be noticed in Pique & honey comb, and certain jacquard structures. In stripe pattern it increases with the size. However there is no appreciable problem of spirality is there in ribs & interlocks, because the wale on the face is counter balanced by a wale on the back.

1.4 Spirality Measuring

The spirality is measured with an angle θsp which is the angle between the direction at right angles with the courses and the distorted wale (b) direction as seen in Figure 5. If the spirality angle.sp exceeds 5° it is considered an important problem.[3] For measuring spirality, samples were marked with two sets of markers in each direction (length and width), a minimum of 50cm apart and at a distance of approximately 3cm from the edge. No tension was applied to samples during measuring spirality percentage.

Calculation of spirality %:

$$Spirality\% = \frac{\frac{Left\ side\ +\ Right\ side}{2}}{Length} \times 100$$



(a) (b)

Fig.6, (a) Spirality % = 100 × [(AA. +DD.)/ (AB+CD)][1]., (b) Technique of measuring spirality degree[5]

1.5 Spirality Test

There are two well known standard test methods available for determining the spirality of knitted fabrics :

- British standard 2819 (BS 2819:1990, Methods for determination of bow, skew and lengthway distortion in woven and knitted fabrics (British Standard)[1].

- ASTM D 3882-08/2012 (ASTM Standard), which covers the determination of bow and skew of filling yarns in woven fabrics and the courses in knitted fabrics[9].

ATTCC Test Method 179-2012 Skewness change in fabric and garment twist resulting from automatic home laundering [10].

2 Various parameters can control knitted fabric spirality

Various experimental studies have explored the different contributory factors on spirality. Some are machine related like use of multiple feeders and gauge, whereas some are associated with constituent yarns like twist liveliness and linear density.[1] The factors other than twist liveliness (high twist multiplier) which affect spirality are given below:

• Tightness factor of the fabric (spirality decreases with increase in tightness factor).

• Feeder density in the machine (spirality increases with increase in number of feeders).

• Machine gauge.

• Yarn linear density.

• Variation in knitting tension and yarn frictional properties.

• Spinning technology (friction >ring > rotor > air jet).[8]

That mean fabric spirality comes mainly from two sources: from the yarn and from the machine.[3]

Depending on the yarn and knitting parameters the fabric has more or less spirality. It was important to understand the various factors influencing the fabric spirality to select appropriate levels of these factors that result in optimum dimensional stability can be established. Other studies divided the various causes of knitted fabric into four main categories:

1- Yarn causes.
2- Knit causes.
3- Fibre causes.
4- Finishing causes.

The following discussions will be focused on the major ones.

Spirality can be eliminated by setting the twist in yarn or by using balanced twofold yarns where possible. But with single yarns of natural fibres, the set is not generally permanent to washing. The effect of the direction of machine rotation to the direction of twist in yarn has some effect on spirality but it becomes negligible after the washing of the fabrics. The easiest and popular technique of minimizing spirality in knitted structure is to use 'S' twisted and 'z' twisted yarns in alternative feeders during knitting. The neighbouring yarns twisted in opposite direction act in an opposing manner and neutralize the tendency of spiral formation. Plating is an effective way to produce spirality-free fabric. [8]

2.1 Yarn Parameters

2.1.1 Yarn Spinning System

The type of yarn production (ring, compact and open-end) impressed the physical features of yarns and fabrics produced from these yarns would be demonstrated different performance properties.[3] The spirality angle of the fabric knitted with ring yarns are very high comparing with the fabrics knitted with open-end yarns which is due to the following: [6]

- As already known, twist direction in open end spinning is from inward to outward, opposite of the ring and compact spinning. So the amount of twist is lower at the outer region with respect to the inner region in open end yarns. This means, the amount of torque created in open end spinning is lower with respect to ring and compact spinning during the knitting process.
- Also lower values of twist tendency created by yarn twist in open end yarns decrease the spirality angle of a fabric knitted by open end yarns. [3]
- The modifying open end yarns effectively reduced yarn twist liveliness to a very low or zero level. It was confirmed that the modified rotor yarn would greatly reduce fabric spirality in all the cases studied. [4]

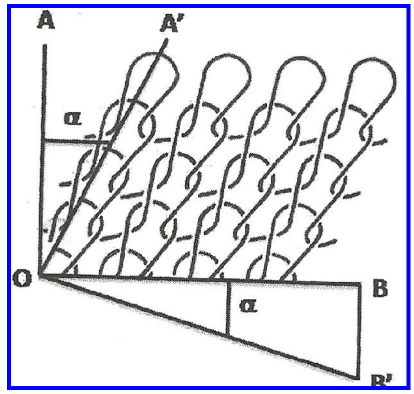


Fig.7 Spirality can be measured in term of degree of spirality {ά= tan -1(d/L)} where ά = spirality angle, d (BB') = displacement of the course from a normal line to the wale of a fabric measured at a distance L (OB) from the identified wale line.[8]

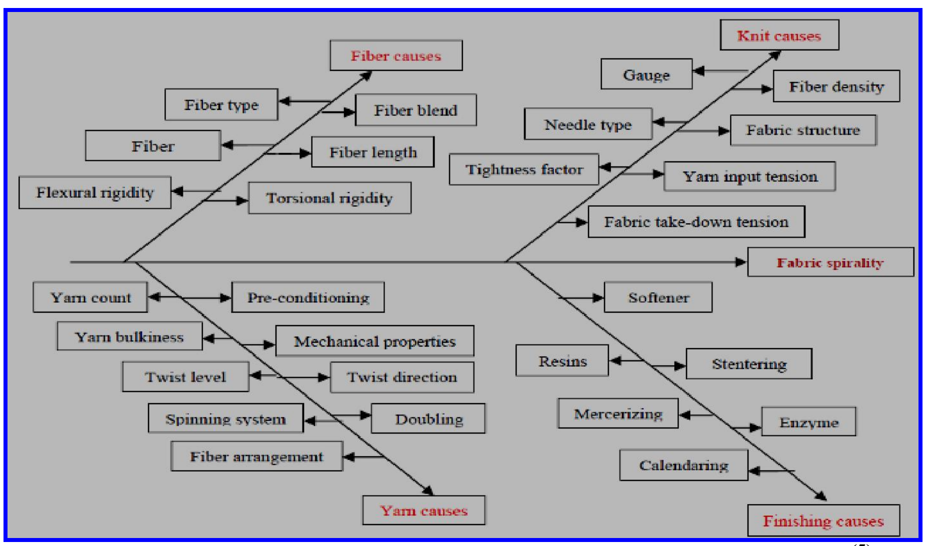


Fig. 8 is a fishbone chart showing causes influence the fabric spirality. [5]

2.1.2 Yarn residual torque (Twist-liveness)

The first and the man source of spirality is the twist liveliness of the yarn used. Loop formation involves both twisting and bending, resulting in twist redistribution in the arms of the loop. If the yarn is twist lively so that it tends to snarl upon itself, then the loop shape is affected as the yarn in the fabric is prevented from snarling by its contact with adjacent loops. [8] That mean the yarn will attempt to rotate inside the fabric resulting in unsymmetrical or local distortion of the loops causing the whole wale to be inclined. [7] The net result is that all the loops in the fabric take up an inclined position giving the fabric a skewed or spiral appearance and the wale lines are no more at right angles with the courses. [8] It usually works with other factors such as knitting parameters, fabric construction etc. to affect the magnitude and direction of the spirality. Normally, the bigger the residual torque the greater the fabric spirality. In details, some aspects determine the yarn residual torque. The first is the first used. The fiber moduli (including tensile, bending, and torsional modules) affect the torque generated when a straight fiber is curved into a spatial path. During the deformation, the energy is stored in the finer, and it will release in the downstream processes.[7]

2.1.3 Twist yarn direction

The lowest spirality values belonged to carded S yarn fabric, whereas the highest belonged to carded Z Yarn fabric. 4) The twisted yarn is the major factor that has influences on fabric dimensional changes, partially the fabric spirality. Twisted yarn, its torque direction is deter-mined by the twist direction. A Z-twist yarn has an opposite torque direction to the S-twist yarn. Normally, Z-twisted yarn will cause the knitted loops to learn to the right, resulting in a fabric with a Z direction of spirality. Alternatively, S-twisted yarn will cause the knitted loops to lean to the left, resulting in a fabric with a S direction of spirality. [7]

2.1.4 Yarn Count

Yarn linear density also has influences on fabric spirality. Coarser counts reduce the spirality. [5] Coarser yarn has more fibers in its cross section; the number of fiber as well as their radial position partially determines the magnitude of the yarn torque, partially the fabric spirality. [7]

2.1.5 Twist factor

The yarn twist was the most predominant factors contributing to fabric spirality.[4] Yarn with higher twist multiplier always produces higher spirality than a yarn with low twist multiplier. [8]

The twist factors of ply and single yarn has significant effects on the angle of spirality, with the other parameters are keeping constant.[6] Increasing twist factor increases twist liveliness in yarn leading to large spirality angle. [5]

2.1.6 Effect of the twist direction on spirality versus the machine rotation direction

They suggested using S-twist yarns in machines rotating counterclockwise and Z-twist yarn in machines rotating clockwise. [11]

2.2 Knitting machine parameters

2.2.1 Number of feeders

The number of feeders in a circular knitting machine also influences the angle of spirality. Due to more course inclination, spirality will be more. The increase of fabric spirality with the number of knitting feeders at a constant machine diameter is due to the nature of weft circular knitting. A fabric course knitted in a given feeder has to be inclined with a certain angle in order to permit the knock over of the row of stitches knitted in the following feeder. This angle depends on the number of feeders per machine diameter. The increase of the feeder density in circular knitting machines is the subject of high competition between machines manufacturers because of its impact on machines productivity. Mayer & Cie holds the record in this matter with the single jersey machine Relanit 4.0 which has 4 feeders per inch of machine diameter. These technological advances will certainly increase the importance of fabric quality problems linked to spirality.

2.2.2 Knitting tension

The effects of various knitting tensions including the whole process of loop formation on fabric spirality had been could not establish consistent trends with respect to variations in fabric quality with knitting tensions. The tension on yarn during knitting as quite strongly effect on spirality decreases linearly with yarn tension with quite strong.

2.2.3 Gauge

Higher machine gauge reduce the spirality. In other words smaller the gauge lesser will be the spirality keeping other parameters constant. A Proper combination of linear density and gauge is required to reduce spirality. [6]

2.3 Knits parameters

2.3.1 Fabric tightness

In general the angle of spirality values are decreasing, when the tightness factor values are getting tight in the all knitted fabric samples. Tightness factor ranges from 11(for slack fabrics) to 19(for tight fabrics) and an average of 15 is preferable, which is optimum in general. Slack fabric presents higher spirality angle compared to tightly knitted fabrics because the loop can easily find area to rotate so spirality is increasing.

2.3.2 Loop length

As the loop length increases, spirality angle increases. The reason for this behavior can be explained by concerning the chanced of loops to turn freely in loose fabric structure.

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2.5 Finishing

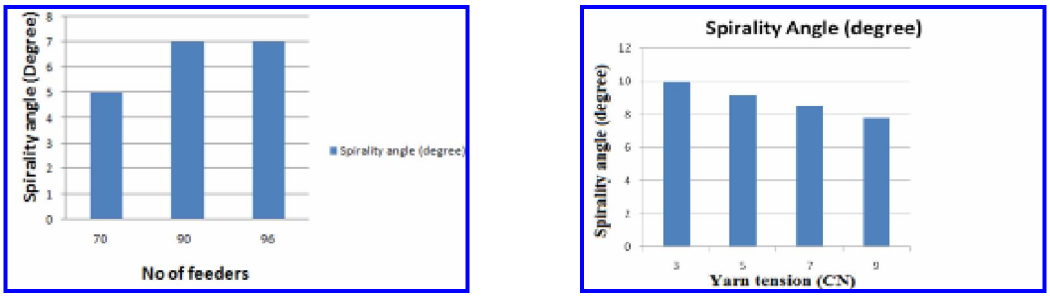
Finishing helps to reduce the Spirality, only results that can be obtained from data is that the Spirality decreases by half after dyeing process. [6] Spirality is often corrected by finishing steps such as setting/treatment with resins, heat and steam, so that wale lines are perpendicular to the course lines. Such setting is often not stable, and after repeated washing cycles, skewing of the Wales normally re-occurs. [1] If the fabric is then finished in a tubular manner and the wales are not straightened, then the distortion of the wales will be realized. For open-width finishing, one or several adjacent needles may be left out of the knitting machine cylinder to create a gap in the wales of the fabric. [12]

2.6 Relaxation

The spirality value generally increases after washing due to relaxation of the residual torque of the yarn. [8]

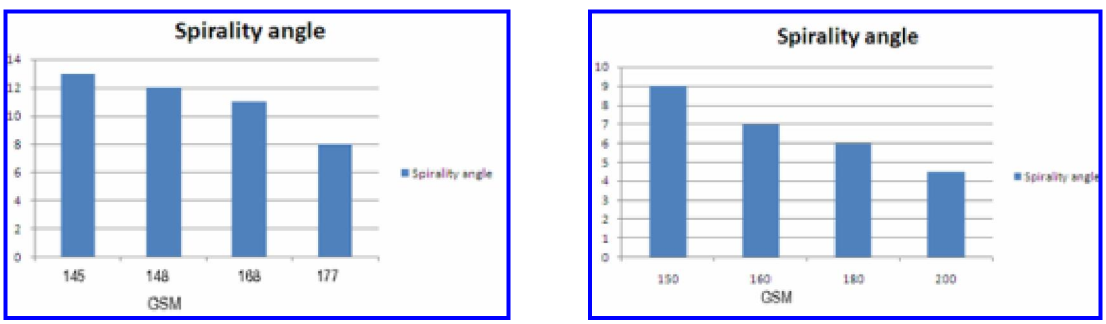
2.7 Fibre

The 100% cotton yarns showed a greater angle of spirality than the 50/50 blend in a fully relaxed state. [4] 50/50 Cotton /polyester blends have a lower tendency to produce spirality in fabrics than the 100% cotton yarns. [1]



(a) (b)

Fig. 9, (a) Graphical relationship between no. of feeders and Spirality angle, it shows spirality increases strongly when increasing the number of working feeders on the machine, [6] (b) Graphical relationship between yarn tension and Spirality angle.[6]



(a) (b)

Fig. 11, (a) Spirality of grey fabrics versus fabric weight, (b) spirality of dyed fabrics versus fabric weight. [6]

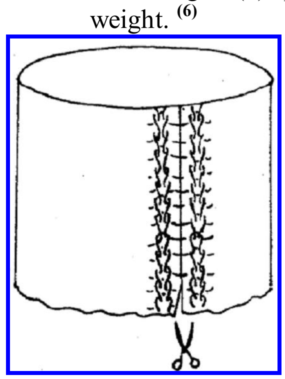


Fig. 12, Slitting of a knit tube on a needle-out slit line. [12]

3 Compact and conventional ring spinning technology

Spinning technology influences the degree of spirality in fabrics. (2) No doubt, modern yarn spinning techniques have a remarkable production edge on ring spinning, but still the characteristics of ring spun yarn are matchless and presently it looks very difficult to replace ring spinning with any other spinning system. (13) Conventional ring yarns have always been considered as a quality reference among all the yarns produced by other new spinning system in textile industry. (14)

A revolutionary version of ring spinning process is called compact spinning achieves remarkable improvement in yarn quality through better utilization of fibre properties which gives benefit in the downstream. Compact spinning produces a novel yarn structures and the development of compact spinning has set new standards in yarn structures. (58) It has been reported that the structure and mechanical properties of compact yarns are different from that of ring yarns. Several studies have been compared the properties of compact spun yarns versus conventional ring-spun yarns. It was found that tenacity and elongation of compact spun yarns are 17%, and 20% respectively higher than that of ring yarns. Compact yarns are uniformly oriented and having better tenacity, elongation and hairiness properties. (59)

The better tenacity properties of compact yarn provide opportunities to work with lower twist coefficients result in an increase in production rate and also better handling properties of end product. (16)

3.1 Principle of Ring Spinning

In ring spinning the roving is attenuated by means of a drafting arrangement until the required fineness is achieved, then the twist is imparted to the fine fiber strand emerging from the front rollers by the traveler, and the resulting yarn is wound onto a bobbin tube. Each revolution of the traveler inserts one turn of twist to the fiber strand. The traveler, a tiny C-shaped metal piece, slides on the inside flange of a ring encircling the spindle. It is carried along the ring by the yarn it is threaded with. Due to the friction between the traveler and the ring and air drag on the yarn balloon generated between the thread guide and the traveler, the speed of the traveler is less than that of spindle, and this speed difference enables winding of the yarn onto the package. Figure 2.1 shows the principle of ring spinning.

3.2 Spinning Triangle

In the ring spinning frame the fiber bundle follows a path between the drafting system and yarn take-up on the cop. This path involves the drafting arrangement, thread guide, balloon control ring, and traveler. These elements are arranged at various angles and distances relative to each other. All these distances, inclinations and angles are referred to as the spinning geometry. The spinning geometry has a significant effect on the end breaks, tension conditions, and generation of fly, yarn hairiness, and yarn structure. Twist is imparted by the traveler, and goes up as close as possible to the nip line of the front rollers. However, twist never penetrates completely to the nip line. Consequently, at the exit from the front rollers there is always a triangular bundle of the fibers without twist, which is called "spinning triangle". (17)

Many researchers have pointed out that the main factor which is responsible for the different in the structure is, the spinning triangle; the zone between the line of contact of the pair of delivery rollers and the twisted end of the yarn. In this zone, the fiber assembly contains no twist. Edge fibers splay out from this zone-ring spinning in particular, and make little or no contribution to the yarn strength. The spinning triangle is the critical weak spot of the ring spinning process. The spinning triangle prevents the edge fibers from being completely incorporated into the yarn body. However, in compact spinning, the drafted fibers emerging from the nip line of the front roller of the drafting arrangement are condensed in a line; hence the spinning triangle is very negligible. (15) In compact spinning, "spinning triangle" is eliminated and almost all fibres are incorporated into the yarn structure under the same tension. This results in increased tenacity, as more fibres contribute to the yarn tenacity. This leads to significant ad vantages such as increasing yarn tenacity, yarn abrasion resistance and reducing yarn hairiness. (18)

The spinning triangle is the weak point of a ring spinning system, but also provides an opportunity for further improvement in ring spinning. In order to obtain fundamental improvements in ring spinning, the modification of the ring machine is necessary. Compact spinning aims at eliminating the spinning triangle and the problems associated with it.

3.3 Principle of Compact Spinning

This system consists of an additional "drafting zone", which is mounted on a standard 3-roll ring spinning machine (Figure 15.a). In this drafting zone an air–permeable lattice apron (Figure 15.b) runs over a suction tube. The suction tube is under negative pressure and there is a slot tilted in the direction of fiber movement for each spinning position. After the fibers leave the front roller nip line, they are guided by means of the lattice aprons over the openings of the suction slots where they move sideways and are condensed due to suction air flow. The openings of the suction slots are at an incline to the direction of fiber flow. This helps condensing by generating a transverse force on the fiber band during the transport over the slot and causing the fiber band to rotate around its own axis. The lattice apron carries the fibers attached to it up to the delivery nip line. The diameter of delivery (driven) top roller is slightly bigger than the diameter of the front top (driving) roller. This generates a tension in the longitudinal direction during the condensing process. The tension ensures the straightening of curved fibers, and therefore, supports the condensing effect of the negative pressure acting on the fiber band in the slot area of the suction tube.[17]

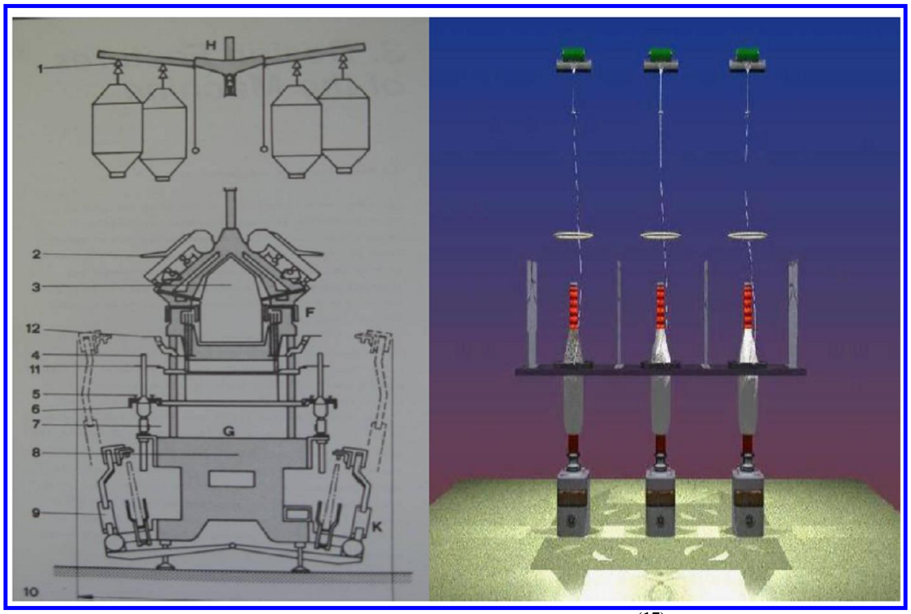
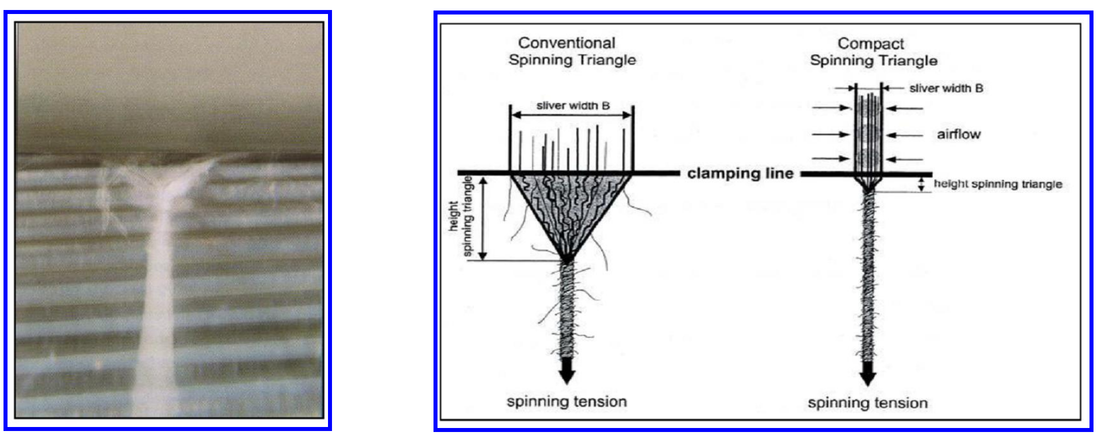
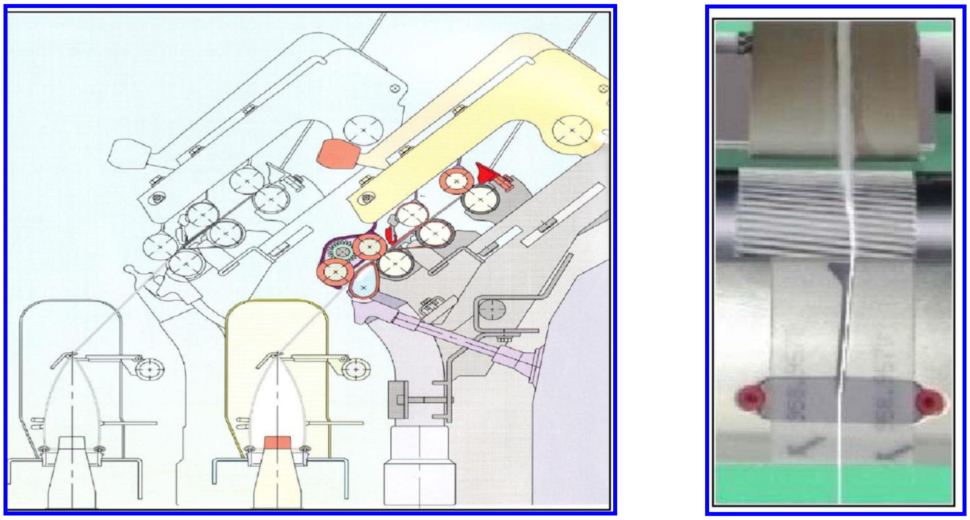


Fig.13: Principle of Ring Spinning[17]



(a) (b)

Fig.14, (a) Spinning Triangle[17],(b) Comparison of spinning triangles at conventional ring and compact spinning systems. [17]



(a) (b)

Fig.15, (a) Additional Drafting zone in compact spinning [17], (b) Lattice apron with a slot underneath. [17]

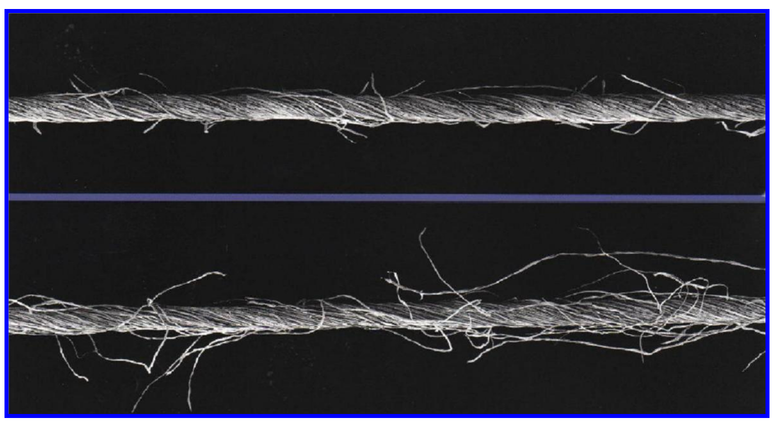


Fig.16, yarn structure of 100% cotton 17 Ne compact spun yarn (top) and conventional ring yarn (bottom).[17]

4 Advantages of compact versus conventional ring-spun yarn fabrics

4.1 Physical Properties

1- It was established that knitted fabric made from compact yarn have better physical properties than the fabric made from conventional ring (combed) yarn from the viewpoint of hairiness, neps, Unevenness, strength and elongation etc.

2- Compact yarn based fabric have better bursting strength and pilling resistance which means they are more durable than conventional ring (combed) yarn based fabric. So knitted fabrics made of compact yarn can be used to make high quality garments with higher productivity.[14]

3- Abrasion Resistance and seam stretchability are the two important properties of knitted garments. Compact yarn based fabric have abrasion resistance and seam stretchability which means they are more durable than conventional ring(combed) yarn based fabric. So knitted fabrics made of compact yarn can be used to make high quality garments with higher productivity. [16]

4- Higher brilliancy and softer handle.

5- Fabric appearance is enhanced due to the uniformity and low yarn hairiness.[19]

4.2 Comfort properties

1- The thermal resistance is substantially higher in ring-spun yarn fabrics than in compact-spun yarn fabrics due to lesser packing coefficient, large diameter and more hairiness of ring-spun yarns which ultimately lead to increased thermal resistance.

2- Compact-spun yarn fabrics in general, exhibit significantly higher water vapour permeability than their ring-spun counterparts, possibility due to more compactness, lesser hairiness and smaller diameter of the former, which result in reduce fabric thickness with increased inter-yarn spaces, leading to easy passage of vapour and hence higher water vapour permeability.
3- Compact-spun yarn fabrics exhibit higher air permeability as compared to the ring-spun yarn fabrics.
4- Invariably, ring-spun yarn fabrics exhibit considerably higher wickability than the equivalent compact-spun yarn fabrics possibly due to lesser packing density of the former.[20]

5 Experimental

This section provides detailed information about the factors that were used and the method followed to carry out the experiment in order to study, in depth, the effect of each of the spinning methods on the spirality angle of single jersey fabrics.

5.1 Methodology

To achieve the objectives of the study, the following research methodology will be employed:

1- A literature review will be conducted with the aim of gaining relevant background knowledge and to find out about recent developments within the study areas.(Figure 16)
2- Egyptian cotton grade Giza 86 fibers were subjected to the usual spinning preparation, and then spun using conventional ring spinning and compact spinning to give 2 different types of yarns.
3- The spun yarns were then tested for tensile properties, etc.
4- The yarns were knitted on a single jersey circular knitting machine; all the parameters of these fabrics were kept constant except the yarn type
5- These fabrics were then tested for spirlaity to observe which one performs better.

Each of these steps are shown in the schematic in Figure 17.

5.2 Methods

5.2.1Spinning

Steps of production the yarn are show in schematic in figure 17. The output expected of this experiment is a 60/1 s cotton knitting yarn by conventional ring and compact spinning systems.

5.2.2 Knitting

Single jersey knitted fabrics were made from conventional ring spun yarn and compact yarn with the same stitch length using circular knitting machine which is used specially for laboratory purposes. The gauge is 28 needles/inch.

5.2.3 Physical testing of yarns

Yarns were tested for various properties, like tensile properties of yarn (breaking strength, elongation), TPI (Twist per inch) and yarn count. All the tensile properties of yarn (breaking strength, elongation) are measured on the Uster®. The working principle and the procedure can be found in ASTM D2256. 10 measurements are taken per bobbin, and individual as well as average results are reported.

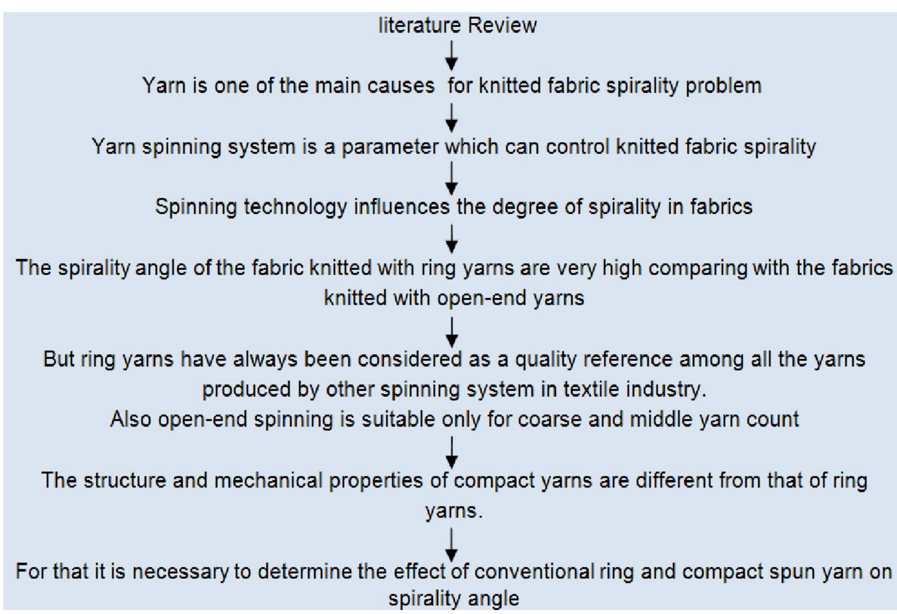


Fig. 17, shown the relevant gained background knowledge

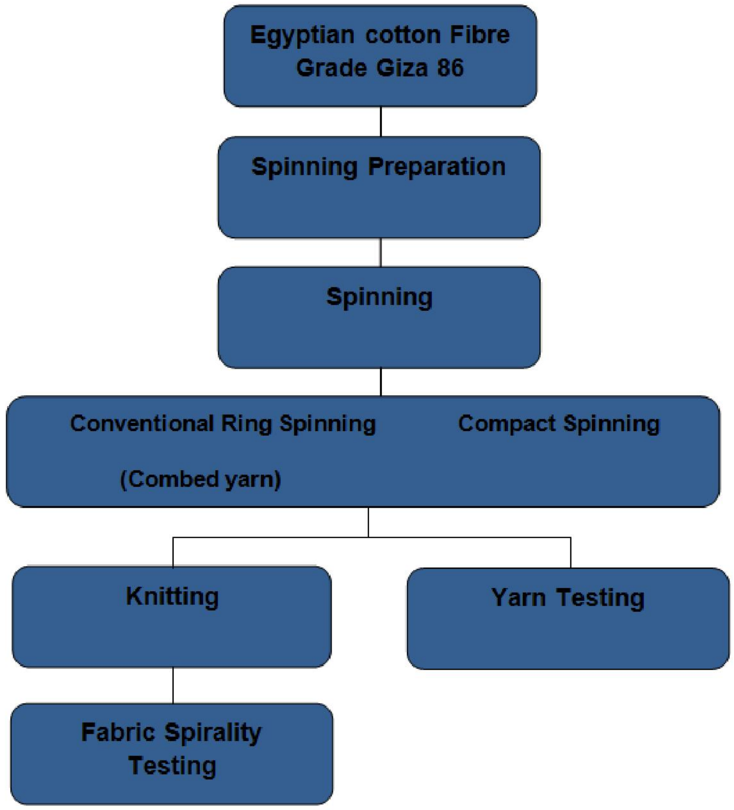


Fig. 18, Schematic representing the process steps followed for the experiment

5.2.4 Physical fabric properties testing

The samples were kept in standard atmosphere for 24 hours to allow for relaxation and conditioning.

- The physical fabric properties like weight (ASTM D 3776), wales and courses per unit length(ASTM D 3887) and loop length (ASTM D 3887) were evaluated (Table 2).
- The weight of the knitted fabrics was measured by cutting the samples and weighing in the electronic balance.
- The loop length was derived by unraveling 12 courses and their total length was measured.

5.2.5 Spirality testing

The working principle and the procedure can be found in ISO 16322-2/ 2005. Specimens was processed a minimum of 4 hours in the standard atmosphere. Spirality test was performed as follow:

- Determining accurately the path of the course line; this can be achieved by either placing the base of the protractor or a rule along the course line or drawing a line parallel to the course with a fine tip pen.
- Determining accurately the path of the wale line that intersects with the drawn course line, draw along this wale line.
- Placing the protractor along a course line ensuring wale intersects with the bottom of the 90° line on the protractor (Figure 18), it must taking into account no tension is applied to samples during measuring spirality degree.
- The angle between the 90° line and wale line is measured and the direction of spirality (+ right, - left) is recorded.
- The process was repeated more times so that the results are recorded and the mean is determined in both gray fabrics and after washing.
- It was taken into account no tension was applied to samples during measuring spirality degree.

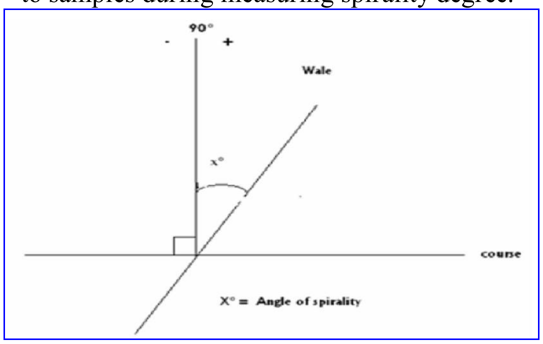


Fig. 19, Schematic representation of the measurement of spirality angle[21].

6. Results and Discussion

6.1. Yarn tests results

From table 1 Compact yarns are stronger due to the improved fiber binding, and have higher yarn elongation, and R.K.M compared with conventional ring yarns. As a result, compact yarns have tremendous potential to offer several advantages compared to conventional ring yarns.

Table 1. The yarn tests results.

Item		Compact yarn 60/1	Conventional ring spun yarn (Combed) 60/1
Raw cotton		Giza 86	Giza 86
Yarn count	Ne	59.7	60.0
	CV%	1.0	1.1
TPI	Direction	Z	Z
	Standard	29.5	29.5
	Actual	29.5	29.7
	CV%	2.0	1.4
Strength	(g)	258	196
	CV%	8.9	9.8
	R.K.M g/tex	26.1	19.9
	Elongation	6.0	4.2

6.2 Fabrics physical properties tests results

Table 2. The fabric tests results.

	Fabrics physical tests results		
Sample No.	Weight (gm.)	Stitch density Wales × Courses /cm	Loop Length (cm.)
Sample No. 1(produced from compact spun yarn)	99	18.5 x 21	0.259
Sample No. 2 (produced from Conventional ring spun yarn)	103	18 x 21.3	0.261

6.3 Spirality test results

From table 3, it is found that:-

- Sample no. "1" produced from compact spun yarn, has higher spirality% than sample no. "2" produced from conventional ring spun yarn.
- Spirality of both two samples is clearly visible, objectionable and more than 5o after washing.
- The spirality value increases after washing due to relaxation of the residual torque of the yarn.

Table 3: Spirality % of different fabric produced from different yarn

	Spirality test	
Sample No.	Spirality degree before washing	Spirality degree after washing
Sample No. 1(Compact yarn)	7.1°	11.3°
Sample No. 2 (Conventional ring spun yarn)	1.2°	7.1°

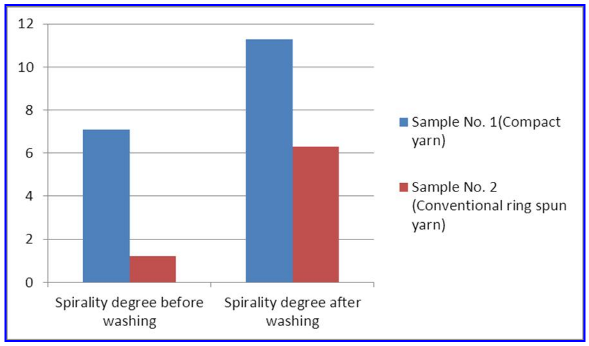


Fig. 20, Graphical relationship between no. of feeders and Spirality angle, it shows the spirality angle of the fabrics knitted with compact yarns are very high comparing with the fabrics knitted with conventional yarns.

Data analysis

- Compact-spun yarn, exhibit significantly higher spirality angle than their counterparts conventional ring-spun yarn, at a constant TPI (Twist per inch), this observed difference in fabric spirality can be explained possibility due to the fibres binding and more compactness of compact yarn which make it more twist liveliness than conventional ring-spun yarn.
- The more twist liveliness of compact spun yarn than conventional ring spun yarn due to the system of compact spinning which consists of an additional "drafting zone", which is mounted on a standard 3-roll ring spinning machine, in this drafting zone an air–permeable lattice apron runs over a suction tube. This helps condensing by generating a transverse force on the fiber band during the transport over the slot and causing the fiber band to rotate around its own axis.
- So that it tends compact spun yarn to snarl upon itself more than conventional ring spun yarn, then loop formation involves both twisting and bending, resulting in twist redistribution in the arms of the loop and the loop has a higher tendency to rotate inside the fabric, the net result is that all the loops in the compact-spun yarn fabric take up an inclined position giving the fabric a skewed or spiral appearance and the wale lines are no more at right angles with the courses more in than conventional ring spun yarn fabric.
- Spirality angle increase by the increase of yarn elongation, that can be explained possibility due to that the more elongation helps yarn to rotate around its own axis also help the loop to rotate inside the fabric, the result is that all the loops take up an inclined position giving the fabric a spiral appearance.

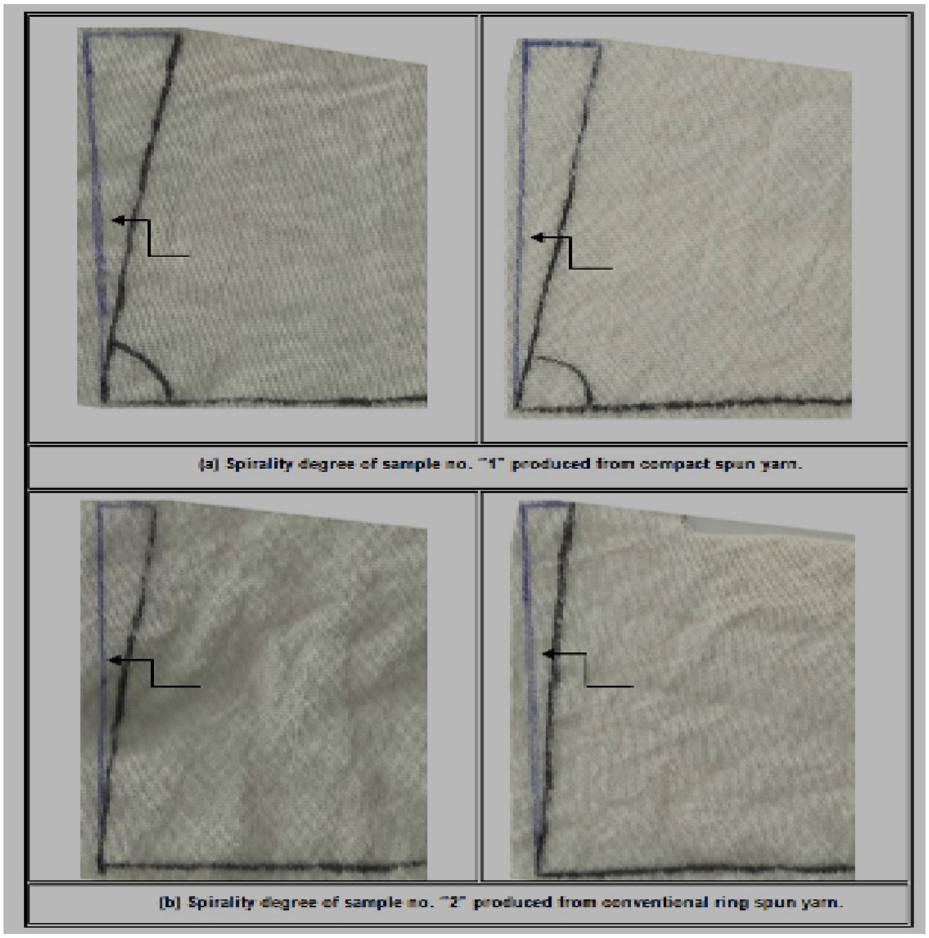


Fig. 20, Photo shows the spirality angle of the tested fabrics

7. Conclusions

After getting the result it has been concluded that

- Spirality is a very common inherent problem in plain knitted fabrics special in single jersey knits and it may exist in grey, washed or finished state and has an obvious influence on both the aesthetic and functional performance of knitwear. Some of the practical problems arising out of the loop spirality in knitted garments are: displacement or shifting of seams, mismatched patterns and sewing difficulties.
- There are different factors contributing on spirality problem. Some are machine related, whereas some are associated with constituent yarns.
- Spirality angle changes with the changes of yarn structure and types.
- The structure and mechanical properties of compact yarns are different from that of ring yarns.
- Compact spun yarn fabric shows high spirality degree by keeping all other parameter as constant that is (machine parameter, stitch length and all yarn parameters except spinning technology).
- Compact spinning helps to increase the Spirality, only results that can be obtained from data is that the spirality decreases by half with conventional ring spun yarn by keeping all other parameter as constant that is (grade of row cotton, Twist per inch, twist direction).

Terminology & Definition

Tightness factor is the ratio of the area covered by the yarn in one loop to the area occupied by that loop. We know, K =.Tex/l, where l is loop length in cm. [1]

Twist liveliness: The tendency of a yarn is to twist or untwist spontaneously. The direction of twist liveliness or torque S or Z twist change that place spontaneously when an end or hanging loop is allowed to rotate freely. Higher amount of twist leads high liveliness and creates fabric Spirality.

R.K.M: This can be expressed by the "length of yarn in km" at which yarn will break of its own weight. This equivalent to breaking load in g/tex the ratio of the area covered by the yarn in one loop to the area occupied by that loop. We know, K =.Tex/l, where l is loop length in cm. [25]

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