A study on the impact of spirality on various knitted fabrics

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Abstract

Spirality and shrinkage are the most common problems for knitted fabric due to their asymmetrical loop formation. Spirality is a dimensional distortion in circular knitted fabrics and has an obvious influence on the aesthetic and functional performance. Single jersey cotton weft knitted fabrics tend to undergo a certain dimensional changes due to different yarn parameters and knitting parameters. Weft knitted structures are affected by various forms of dimensional distortion. Inclination and distortion of loops within knitted structures are commonly known as skewness and spirality.

Keywords: *knitting, knitted fabric, spirality, shrinkage, knitting and yarn parameters*

1. Introduction

Spirality is a dimensional distortion in circular knitted fabrics and has an obvious influence on the aesthetic and functional performance. Spirality is a distortion of knitted fabric whereby the wales and courses align at a angle other than 90O .Spirality can cause serious problems when the fabrics are made into garments like displacement or shifting of side-seams, mismatched patterns , sewing difficulties etc.

Single jersey cotton weft knitted fabrics tend to undergo a certain dimensional changes due to different yarn parameters and knitting parameters. This geometrical defect is termed as spirality of knitting in fabrics. Regardless of the term used, this displacement of the courses and wales can be expressed as a percentage or as an angle measurement in degrees. As the dimensional properities of the fabric are affected by spirality it is essential to eliminate it altogether.

There are certain standards and quality parameters for checking of spirality certain

Parameters are described by ASTM Test Method ASTM 276 2000, which are :-

ASTMD3882-3899: standard Test Method for Bow and skew in woven and Knitted Fabrics.

ISO/6330. AATCC Test Method179-2001-Skewness change in Fabric and Garment Twist Resulting from Automatic Home Laundering. IWS276 Test Method

2. Literature review

Causes of spirality :-

1. Yarn twist multiplier is the principle cause of spirality and it is directly proportional.
2. Residual torque in the yarn or the twist liveliness.
3. Spirality occurs in knitted fabric because of asymmetric loops which turns in the wales and course of a fabric into an angular relationship other than 90 degree.
4. Number of feeders-though higher feeder numbers increases production, spirality also increased.
5. Different spinning technologies such as ring, rotor, airjet etc., also influence spirality. The physical properties of these yarns, their geometrical characteristics, their basic fibre properties (i.e. modules, fineness, cross section etc.) and blends are the causes.
6. Variation in knitting tension, yarn frictional properties, yarn/metal coefficient of friction, yarn lubrication, number of contact points in the knitting zone i.e. needles and sinkers) also influence spirality.
7. Washing wet treatments increases fabric relaxation and also increases spirality.
8. Direction of machine rotation has little influence on spirality. Slight inclination of loops occurs in the direction of machine rotation. Multifeed machines rotating clockwise produce spirality to the left and machines rotating anti clock wise produce spirality to the right.

Knitting related Causes ;-

a) Fabric stitch length

This is the length of one loop in knitted fabric. Spirality increases with the length of loop. Fabric structure: More spirality in single jersey due to non-arrest of loops. By adding moisture to such a structure, the twist will try to revert as it swells, that distorts the shape of the loop. In double jersey, the effect of spirality is nullified. Pique and honey comb also show spirality even if sometimes two beds are used. Spirality can be noticed in certain jacquard structures. In stripe pattern, it increases with the size. No appreciable problem of spirality is there in ribs and interlocks.

b) Tightness

Slack fabric presents higher spirality angle compared to tightly knitted fabrics. At each level of yarn twist factor, the degree of spirality decreases linearly with fabric tightness factor.

c) Fabric relaxation

Fabric relaxation (dry and wet) treatment removes the residual knitting tension in the yarn introduced during the knitting process. The relaxation treatment relieves the residual yarn torque as a result of changes in the molecular structure and increasing yarn mobility.

Influence of machine parameters :-

Number of feeders

On the same move, study of de Araujo and Smith has revealed that the number of feeders in machine has significant bearing on spirality of knitted fabrics.The number of feeders in a circular knitting machine also influences the angle of spirality. Due to more course inclination, spirality will be more.

Direction of machine rotation

The direction of machine rotation has influence on spirality. For Z twist yarns, the Wales go to the right and thus, giving Z skew and S twist yarns makes the wales go to the left, giving S skew to the fabric. With multi feed machines, the fabric is created in helix, which gives rise to course inclination and consequently wale spirality. Direction of spirality depends on the rotational direction of the knitting machine.

Gauge

In knitting terminology, number of needles per inch is called the gauge. 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 e.g. torque can be controlled in 20 gauge and 40s count.

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 twist factors of ply and single yarn, loop length, and fiber diameter have significant effects on the angle of spirality, while yarn linear density and fabric tightness factor have comparatively lesser effect. So that it is clearly show that the spirality angle is reduced to a certain level with the other parameters are keep constant.

Anand et al in their studies and it was verified that the causes of instability in the knitted fabrics are fiber, yarn, knit and finishing causes .The causes of this instability in the knitted fabrics are fibre, yarn, knit and finishing causes Causes of spirality are fiber causes, yarn causes, knit causes and finishing causes.

Fibre Causes

Spirality has a larger relationship and variation with the different types of fiber. The cotton fabrics with cotton fiber as raw material exhibit greater spirality behavior than made from Polyester fiber Similarly microdenier fiber produces less spirality. Stabilization of knit wear fabrics is difficult if the raw material is cotton, because it is non-thermoplastic in nature and cannot be heat set to stabilize knitted fabric dimensions. The key fiber parameters influencing rigidity are density, diameter and cross sectional shape ,fiber fineness,twist level and yarn count can significantly affect rigidity. Pistle et al. describe that as knit loops are formed by bending and inter looping so flexural rigidity (stiffness) and torsional rigidity of fiber should be considered as they affect knitting tension and loop dimension. A yarn with less rigidity is soft and flexible but balance should be there otherwise loop distortion during knitting will take place. Fiber parameters significantly influencing rigidity are densit, diameter, and cross-sectional shape. Among these, the diameter has the greatest impact (flexural and torsional rigidity are proportional to the diameter of power.) as flexural rigidity of fiber is less, less will be angle of spirality.

Tao et al. studied yarn types and effect of the rawmaterial on structure of fabric that will affect spirality.

Yarn Causes

Yarn used for making knitted fabric can be continuous filament or staple yarn. Filaments yarns are man-made fiber except silk and produce by extrusions methods or from staple yarns that are normally natural fibers and produced by consolidation/integrating of staple fibers. Continuous filament yarns exhibit less spirality than those made from spun yarn. In general straighter and more un-deformed fiber arrangement will result in smaller tendency for fabric spirality . Lord et al. studied open end, twist less and ring yarns with 100% cotton and polyester cotton blends and made singly jersey fabrics and assessed their performances for spirality The reason for that is residual torque which is responsible for spirality. Residual torque depends on twist multiple, yarn count, fiber type as well as manner and extent of yarn relaxation. Twist less yarns has no residual torque. The conclusion was washing, heating, agitating and dry tumbling result in decrease of angle of spirality. This is due to moisture absorption by fibers and swelling of fibers.These two causes were studied in detail to see the impact and elimination or reduction method. The key conclusions are:-

• As far as the reference of fibers is concerned, it is quite evident that spirality is more commonly found with cotton fibers so use of blends with cotton will reduce the spirality to certain extent.

• Fibers blended with different values of flexural and torsional rigidity when used in fabric or yarn formation produce better results against single nature of fibers.

• Fibers that can be heat set should be used for knitting fabrics as heat setting results in gelling up of the fibers with the blended fibers giving it a stiffer feel and that helps in reduction of spirality.

• Thermoplastic fibers should be preferred over other fibers for the reduction of spirality.

• Air jet spun yarns exhibit better performance against spirality problem than the other spinning techniques for yarn production so recommendation should be use of air jet spun yarns.

• Low twist yarns should be used for knitting as higher the twist
is, more is the tendency of yarn to untwist, this will lead to significant snarling effect and high dimensional instability will be seen in case of high twist yarns.

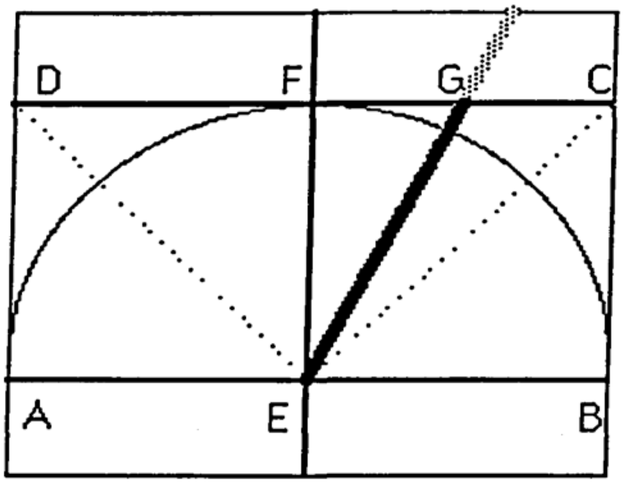
• Fabrics produced with spun yarns are better against the spirality as compared to continuous filament yarns.

• Plied yarns are better against the spirality behaviour than the single yarns. The degree of fabric Spirality increases linearly with stitch length by keeping all other parameter as constant that is yarn tension, no. of feeders, stitch length and yarn TPM .

Mainly two methods for determining the spirality of knitted fabric The manual method and the theoretical method The manual method consists to measure manually the spirality angle on a real fabric by using a protractor. This method presents some difficulties such as wales and courses deformation during measurement and depends on human precision. The theoretical method permits to calculate fabric spirality from fabric and machine parameters(number of feeders on the knitting machine, loop length and number of courses and number of wales per fabric unit length).

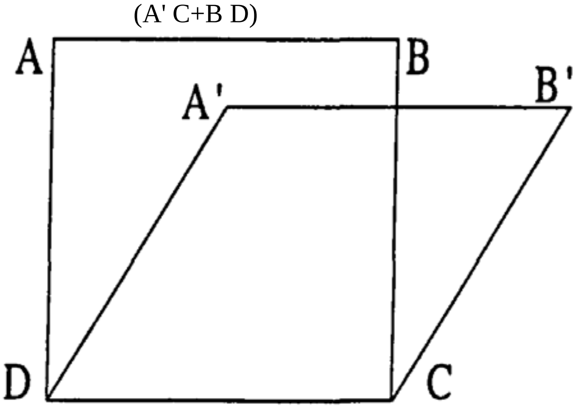
MEASUREMENT OF SPIRALITY

The angle of spirality can be measured with the help of a protractor, or by using a specially designed transparent plastic board . The line EF, which is perpendicular to the sides AB and CD of the rectangle ABCD, plays the role of the reference line of a wale in the ideal perpendicular relation that exists between wales and courses in an undistorted knitted fabric. If the line AB tallies with a course and the line EG lies along the· actual line of the wales, then the angle FEG is the angle of spirality. Arujo and Smith used 100% cotton yarn with variable techniques for production of knitting fabric and then concluded certain things . According to them, as TM increases angle of spirality increases, similarly angle of spirality increases with residual torque. Using the distances AD = 10 cm and FG (h cm), Oinuma and Takeda calculated the "percentage spirality" (PS %) which is expressed by the following equation: PS(%)= (h/l0)xl00 , and it is considered as the sum of the "net" spirality caused by the yam torque and the "additional" spirality caused by all other factors.



Another test method for measuring the spirality of the knitted fabrics has been proposed by AATCC . In this test, the fabric samples are marked with a square before washing and drying and the change in the diagonals of the square is measured to calculate the percentage spirality (PS) given by the following formula :-

$$PS (\%) = \frac{2(B'D - A'C)}{(A'C + BD)} \times 100$$



ACCEPTABLE SPIRALITY

Over many years in dealing with spirality, many workers, researchers and manufacturers have set limits of spirality acceptability. For some, the maximum spirality angle of 5° is acceptable whereas for some others the angle of 7°istaken as the upper limit In United States a percentage spirality of 8% is considered as the maximum a fabric may exhibit to be acceptable by the making-up industry.

Testing Methods for determining spirality

IWS Test Method No. 276: Method of Test for the Measurement of the Angle of Spirality in Knitted Fabrics

With the IWS method, the spirality is determined by placing a protractor on the fat smooth fabric surface with its base-line along the course and reading the angle between the wale line and a line 90°perpendicular to the course line .
A modified IWS test method ASTM 276 was used to measure the fabric spirality both before and after the relaxation treatment .The angle was measured between the wale line and the line parallel to the machine running direction which in this case was the edge of the circular fabric.

ISO 16322 standard Textiles –Determination of spirality after laundering

This standard has been published in three parts:
• Part 1: Percentage of wale spirality change in knitted garments
• Part 2: Woven and knitted fabrics
• Part 3: Woven and knitted garments
In Part 1 a method of measuring the percentage of wale spirality change in weft-knitted jersey garments produced on knitting machines is specified following laundering.

During the testing procedure, the welt or hem of the body of a garment prior to laundering is tensioned until the top edge of the welt or hem is straight. The angle subtended by the wales with a line perpendicular to the top edge of the welt or hem is measured by a protractor. This measurement is repeated after laundering and the change in spirality is computed from the differences in the results.

In Part 2 three procedures: diagonal marking, inverted T-marking and mockgarment marking are specified for measuring the spirality or torque of woven and knitted fabrics after laundering.

For the diagonal marking, square single-layer fabric specimens aligned with the selvedge or tubular fold line of the fabrics are prepared and the corners of the marked square are labelled. The Inverted T-marking procedure using a T-marking device is particularly suited to narrow-width fabrics. Mock-garment marking includes an over-edged seam along each long direction and one short direction of the specimen, forming an open-ended bag or pillowcase-type specimen to simulate a garment panel. Spirality is measured in millimetres, percentage of a marked distance, or angle.

Part 3 specified the procedures for measuring the spirality or torques of woven and knitted garments after laundering.

When measuring, a horizontal reference line across the width of the garment panel is marked above the bottom edge or hem. A benchmark is placed midway along the horizontal reference line. A line parallel to the horizontal reference line is drawn at an appointed distance above the benchmark. Another benchmark in placed on the parallel line directly above the first benchmark. After the laundering, the displacement is measured and spirality calculated.

AATCC Test Method 179-2004 Skewness Change in Fabric and Garment Twist Resulting from Automatic Home laundering

The AATCC test method determines the changes in skewness in woven and knitted fabrics or twist i.e spirality in garments when subjected to repeated automatic laundering procedures commonly used in the home. The changes in skewness in fabric or spirality in garment specimens are measured using bench-marks applied to the specimens before laundering.

The paths of the course lines and the wale lines in the examined knitted structure are determined accurately by either placing the protractor or a ruler along the path or drawing a line with a fine tip pen. The procedures of samples markings are similar to those described in the ISO 16322 standard while the laundering and drying procedures are specified.

ASTM D 3882-2006 standard: Bow and skew in woven and knitted fabrics

The ASTM test method covers the measurement of distortion regarding courses in knitted fabrics from the normal path perpendicular to the fabric length.
The straight line distortion of a marked knitting course is measured from its normal perpendicular to the selvage or edge. . e measurements are performed in three places spaced as widely as possible along the length of the fabric; the minimum examined length is 1m. If possible, no measurements are to be made closer to the ends of the roll or piece of fabric than 1m. A suitable marker should be used to trace the knitting course path. The distance along the straight edge between the two selvedge is measured to the nearest 1mm and recorded as the fabric width.

The distance parallel to the selvedge between the straight edge and the distinctive colour yarn or marked line is measured to the nearest 1mm and recorded as the skew distance. The skew distance should be recorded including the skew direction, right hand as “Z” and left hand as “S” and whether evident on the face or back of the fabric e skew (%) is then calculated from the ratio between the skew distance and the fabric width.

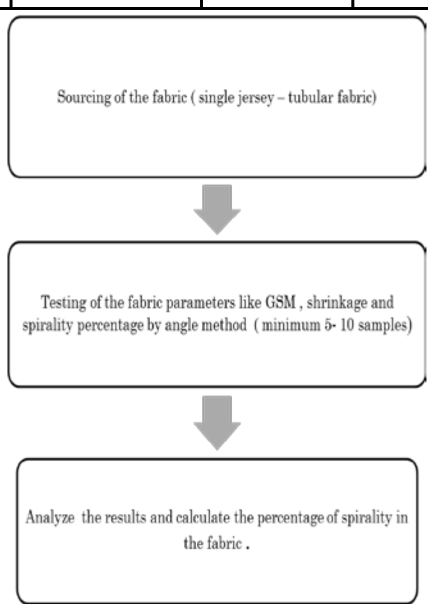
Reduction and elimination of skewness and spirality

The acceptability of the skewness/spirality extent varies with the quality, price and the use of the knitted fabrics .
Some of them include changes in raw material, the other in mechanical processes and/or equipment while the other again concentrate on after treatments .
Spirality can be eliminated by setting the residual twist in the yarn. Twist setting or relaxation relieves the stresses set up in textile fibres by twisting. Setting processes can include storing yarn packages at high temperatures and relative humidity, or steaming.
Fabrics knitted with more tightness factor exhibit less loop movement and yarn movement. Such fabrics give less spirality compared to looser fabrics.
The blending of a small percentage of low-melt PES with cotton and heat treatment resulted in a reduced spirality. Low melt polyester will bind with cotton fibres thus reduces fibre movement.
Primentas reported that partial detwisting reduces significantly and in some cases eliminates the

spirality of weft knitted fabrics produced from single ring- spun yarn.

MATERIALS AND METHODS

S.NO	Type of Fabric	Wales per inch	Course per inch
1.	Bleached fabric (before compacting)	45	42
2.	Bleached fabric (After compacting)	42	40
3.	Dyed fabric (before compacting	44	42
4.	Dyed fabric (After compacting	50	42



RESULTS AND DISCUSSION

Fabric Type – Bleached & Dyed (Single Jersey Tubular Cloth)
Count – 30S (Before & After compacting)

- Wales per inch & Course per inch (bleached and dyed fabric)

Areal density (bleached and dyed fabric)
The areal density of bleached fabric is 160 g/m2
The areal density of dyed fabric is 170 g/m2

Before compacting and After compacting (bleached and dyed fabric)

S.NO	Type of Fabric	GSM
1.	Bleached fabric (before compacting)	140
2.	Bleached fabric (After compacting)	153
3.	Dyed fabric (before compacting	145
4.	Dyed fabric (After compacting)	149

Shrinkage (Before compacting& After compacting – bleached fabric & Dyed fabric)
Before washing – fabric width – 34.5 cm (Before compacting – bleached fabric)
After washing – fabric width – 40 cm (After compacting – bleached fabric)
Before washing – fabric width – 35.5cm (Before compacting – dyed fabric
After washing – fabric width – 35 cm (After compacting – dyed fabric)

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Type of the fabric	Size before washing	Average Lengthwise shrinkage(cm)				Widthwise shrinkage(cm)			
		S1	S2	S3	S4	S1	S2	S3	S4
Bleached fabric (before compacting)	35 x 35 cm	31	34.2	31	31	39	40	40	36.5
Bleached fabric (before compacting)	35 x 35 cm	30.5	32	29.5	30.5	40	40.6	40.8	39
Bleached fabric (before compacting)	35x35 cm	32	33.5	31.5	30.5	41	41	39	36.5
Bleached fabric (before compacting)	35x35 cm	33	35	35	35	40	40	40	40
Bleached fabric (before compacting	35x35 cm	34	36	34	36	40.5	39	39	39
	Average	**25.3**				**51.67**			

Angle method : Bleached fabric & Dyed fabric (Before& After compacting)

S.NO	Type of the fabric	Before washing (Angle in degrees)	Angle in degree (After washing)
1.	Bleached fabric (After compacting)	90^{O}	82^{O}
2.	Bleached fabric (After compacting)	90^{O}	89^{O}
3.	Bleached fabric (After compacting)	90^{O}	86^{O}
4.	Bleached fabric (After compacting)	90^{O}	87^{O}

Bleached fabric (After compacting)

S.NO	Type of the fabric	Before washing (Angle in degrees)	Angle in degree (After washing)
1.	Bleached fabric (After compacting)	90^{O}	86^{O}
2.	Bleached fabric (After compacting)	90^{O}	89^{O}
3.	Bleached fabric (After compacting)	90^{O}	88^{O}
4.	Bleached fabric (After compacting)	90^{O}	87^{O}

Angle Method (Dyed fabric - Before compacting

S.NO	Type of the fabric	Before washing (Angle in degrees)	Angle in degree (After washing)
1.	Bleached fabric	90^{O}	89^{O}
2.	Bleached fabric	90^{O}	88^{O}
3.	Bleached fabric	90^{O}	87^{O}
4.	Bleached fabric	90^{O}	88^{O}

Angle Method (Dyed fabric After compacting)

S.NO	Type of the fabric	Before washing (Angle in degrees)	Angle in degree (After washing)
1.	Dyed fabric	90^O	89^O
2.	Dyed fabric	90^O	88^O
3.	Dyed fabric	90^O	86^O
4.	Dyed fabric	90^O	87^O

CONCLUSION

The main reason of spirality in knit wear fabrics is the presence of residual torque. This residual torque is responsible for loop displacement, formation of skew. There are other contributing factors too but the major factor is residual torque. The problem of spirality was studied under two of its major causes which are fibre causes and yarn causes. These two causes were studied in detail to see the impact and elimination or reduction method. The main comparative advantage of knitted fabric in relation to other textile structures is their comfort due to their handle, permeability, stretchability and elastic recovery. Many standards and other testing methods for measuring the skewness and spirality have been used in research
and industrial practice. The Causes for skewness and spirality have been thoroughly investigated, analyzed and classified.

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