Reprint **ISSN 2076-3972 (Web Version)**

Institutional Engineering and Technology (IET)

(*Inst. Engg. Tech.*)

Volume: 2 **Issue: 2** **August 2012**

Inst. Engg. Tech. 2(2):8-14(August 2012)

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IET** issn 2076-3972, HQ:19-10 cantral place, saskatoon, saskatchewan, s7n 2s2, Canada

ISSN-2076-3972 (Online)
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ANALYSIS ON THE IMPORTANT FACTORS INFLUENCING SPIRALITY OF WEFT KNITTED FABRICS

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Accepted for publication on 10 July 2012

ABSTRACT

Afroz N, Alam AKMM, Mehedi H (2012) Analysis on the important factors influencing spirality of weft knitted fabrics. *Ins. Engg. Tech.* 2(2), 8-14.

Single jerseys knitted fabrics were produced from different yarn count ($26^s/1$, $28^s/1$, and $30^s/1$) using different stitch length (2.60mm, 2.75mm, 2.80mm and 2.85mm) with positive feed device in Jiunn long knitting machine. The fabrics were dyed by a winch dyeing machine, dried in compactor machine using selected parameters. The results showed that spirality% were lowest for 26/1 Ne, 28/1 Ne and 30/1 Ne knitted fabrics at stitch length 2.60mm, 2.75mm, 2.80 & 2.85mm before compacting and at stitch length 2.68mm, 2.73mm, 2.78 & 2.82mm after compacting respectively. Spirality is particularly serious problem for single jersey knitted fabrics due to their asymmetrical loop formation. This paper focuses on spirality of the single jersey knitted fabrics as key aspects. This paper investigates the different studies such as effect of Yarn tension, No. of feeders and Stitch length on the spirality of single jersey knitted fabrics. The paper also explicitly determined the theoretically approach of the causes and remedies of spirality. The paper also focuses on the effect of fabric weight on the spirality of single jersey fabrics at both stages i.e. gray and finished state. The results of this study have concluded that the spirality is increases strongly when increasing the no. of working feeders with constant machine diameter. The result also concludes that the stitch length and yarn tension is also influences on fabric spirality. There is direct relationship of fabric spirality and yarn tension is observed by keeping other factors are constant. The study also concludes that stitch length is inversely proportional to fabric spirality. The fabric spirality is minimized up to 50% after the finishing process as compared to its gray stage spirality.

Key words: *yarn, count, single jersey, stitch length, spirality*

INTRODUCTION

The single jersey knitted structures, used widely in knitted garments, has a particularly serious problem for plain knitted fabrics due to asymmetric loops (Shah 2003). The most important problem of the single jersey structure is fabric spirality, which affects all the fabric and creates big problems at the clothing step. Spirality can be defined as a fabric condition resulting when the knitted wales and courses are angularly displaced from that ideal perpendicular angle. Other terms such as torque, skew, bias and shear distortion are often used to refer to the same phenomena. 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. Examples of skew can be seen in figure 1.

Wale Skew Course Skew

Fig. 1. Example of wale skew and course skew

It affects the garments as the displacement of the side seams and this causes an important quality problem. This problem is prevented during the finishing and dyeing processes by different methods, however these preventions are temporary and after washing processes, on the clothes the displacement of side seam is occurred. Spirality depends on feed density, machine cut, and loop shape, but the magnitude of spirality can be offset by the selection of yarn twist direction. In addition, reduction in yam "torque" can only partially reduce fabric spirality, but the use of plied yams and plaiting techniques may completely eliminate it (Saufley1992).

Cotton single jersey knits exhibit a tendency for the course and wale loops to skew (spirality) when allowed to relax. The ideal model for a single jersey fabric would have the courses and wales aligned at a perpendicular angle with the wales oriented parallel to the edge of the knitted tube or open width fabric which is shown in figure 2.

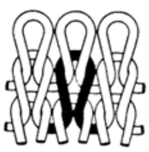
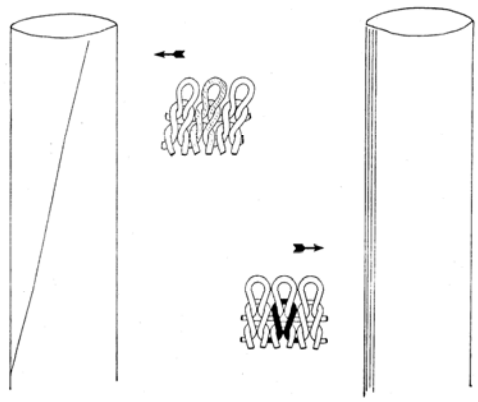


Fig. 2. Ideal alignments of Course and Wales

Manufacturing of knitted fabrics involves intermeshing of yarn loops where one loop is drawn through another loop to form a stitch. Since the last few years knitted fabrics are used in manufacturing of fashion garments and even it has the potential in the formal wear segments also. Accordingly, many developments have taken place in the machinery for processing of knitted fabrics in both tubular process and open width forms. Specification methods of knitted fabrics, usually, include loop density, width of the fabric, weight per square meter and the loop length. Flexibility exists at the various stages of wet processing in terms of process machinery and methods followed by calendaring or compacting which is often, the final operation prior to the packaging step. The level of shrinkage control needed, composition of yarn (100% cotton, blends) and type of chemicals applied to the fabric decide the final process, i.e., whether calendaring or compacting. Variable compactors are used to achieve specific stitch count and wet compacting is also carried out in certain cases. Yarns of different counts knitted to the same loop length display different physical properties such as drape, openness, permeability, handle and spirality etc. (Bourah 2004).

It is necessary that the wale on the knitted fabric be perpendicular to the course. However, the wales are not always perpendicular to the course and skew to the right or left, forming a spirality angle. This creates a serious problem, especially in the apparel industry. If the wales are skewed from the vertical, the resulting configuration will be called "wale skew". Conversely, if the courses are skewed from the horizontal, the resulting configuration will be called "course skew".



Wale Skew No Skew

Ideal Condition

Fig. 3. Knit fabric skew or spirality caused by wale loop distortion

When knitted fabrics are allowed to relax off the knitting machine, they will spiral. Some relaxation of yarn and knitting stresses occurs when the fabric is first unrolled after knitting. If the goods are subsequently wet processed, relaxation certainly occurs. Finally, drying without tension will maximize spirality (Tendulkar and Kulkarni, 1994).

When knitted fabrics are allowed to relax off the knitting machine, they will spiral. Some relaxation of yarn and knitting stresses occurs when the fabric is first unrolled after knitting. If the goods are subsequently wet processed, relaxation certainly occurs. Finally, drying without tension will maximize spirality.

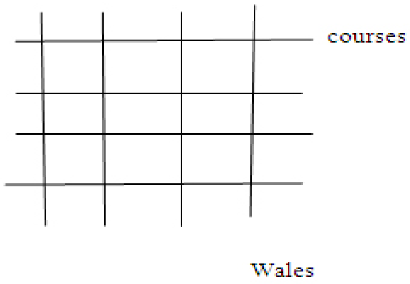
Spirality is a dimensional distortion in circular plain knitted fabrics. Spirality of knitted fabric is obtained when Wales is not perpendicular to course, forming an angle of spirality with vertical direction of the fabric. Weft knitted fabrics tend to undergo certain dimensional change that causes distortion in which there is a tendency of the knitted loops to bend over, causing the Wales to be at diagonal instead of perpendicular to the courses.

This is a very common problem 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. 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.

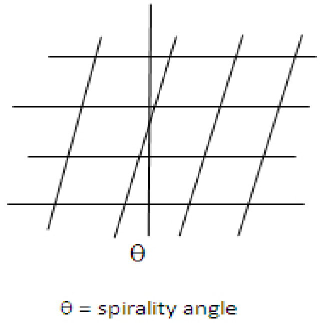
Course spirality is a very common inherent problem in plain knitted fabrics. It affects generally single jersey knits and produce serious problem during garment confection and use. Problems occur due to Spirality are:

- Mismatched patterns.
- Sewing difficulty.
- Displacement of side seams to the back and front of the body.
- Garment distortion.

These problems are 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.



Fabric with normal loop position



Fabric with spirality

Percent change in spirality can be represented as follows:

Where, X = AA/AB x 100
X = % change in spirality.
AA = Angle create due to spirality.
AB = Length from the angle.

The residual torque in the component yarn caused due to bending & twisting is the most important phenomenon contributing to spirality. The residual torque is shown by its twist liveness. Hence the greater the twist liveness, the greater the spirality. Twist liveness of yarn is affected by the twist factor or twist multiplier. Besides the torque, spirality is also governed by fiber parameters, x-section, yarn formation system, yarn geometry, knit structure & fabric finishing. M/C parameters (no. of feeder, m/c gauge etc.) also contributes to spirality. For instance, with multifeeder circular knitting m/cs, course inclination will be more, thus exhibit spirality. The following are some predominant causes of spirality in knitted fabrics.

The ultimate benefit of studying the spirality phenomenon is to understand the various factors influencing the dimensional stability of knit fabrics, particularly fabric spirality so that ways to select appropriate levels of these factors that result in optimum dimensional stability can be established. This can be achieved through a cause and effect analysis of the various potential factors influencing fabric spirality. The importance of cause and effect analysis stems from the fact that several theoretical approaches were taken to analyze the spirality phenomenon, yet because of the complexity of the phenomenon, each study focused on a limited number of factors, either for the sake of simplifying the analysis, or due to limited ability to verify the theory using experimental approaches. Other studies dealt with the analysis of spirality from strictly experimental view by examining the effects of a number of factors some of which were machine-related and others were fabric-related on the extent of spirality of knit structures. Obviously, these approaches resulted in many common causes and effects of this critical phenomenon. However, these were scattered in the bulk of literatures presented to such an extent that makes it difficult for researchers to have a complete view of all factors that can potentially result in an increase or a reduction in knit fabric spirality. It was important, therefore to perform this analysis in this study by examining causes and effects of fabric spirality on the basis of observations obtained in this study as well as the findings of the massive literatures available. Figure shows the various causes of fabric spirality and they are divided into four main categories: yarn causes, knit causes, fiber causes, and finishing causes.

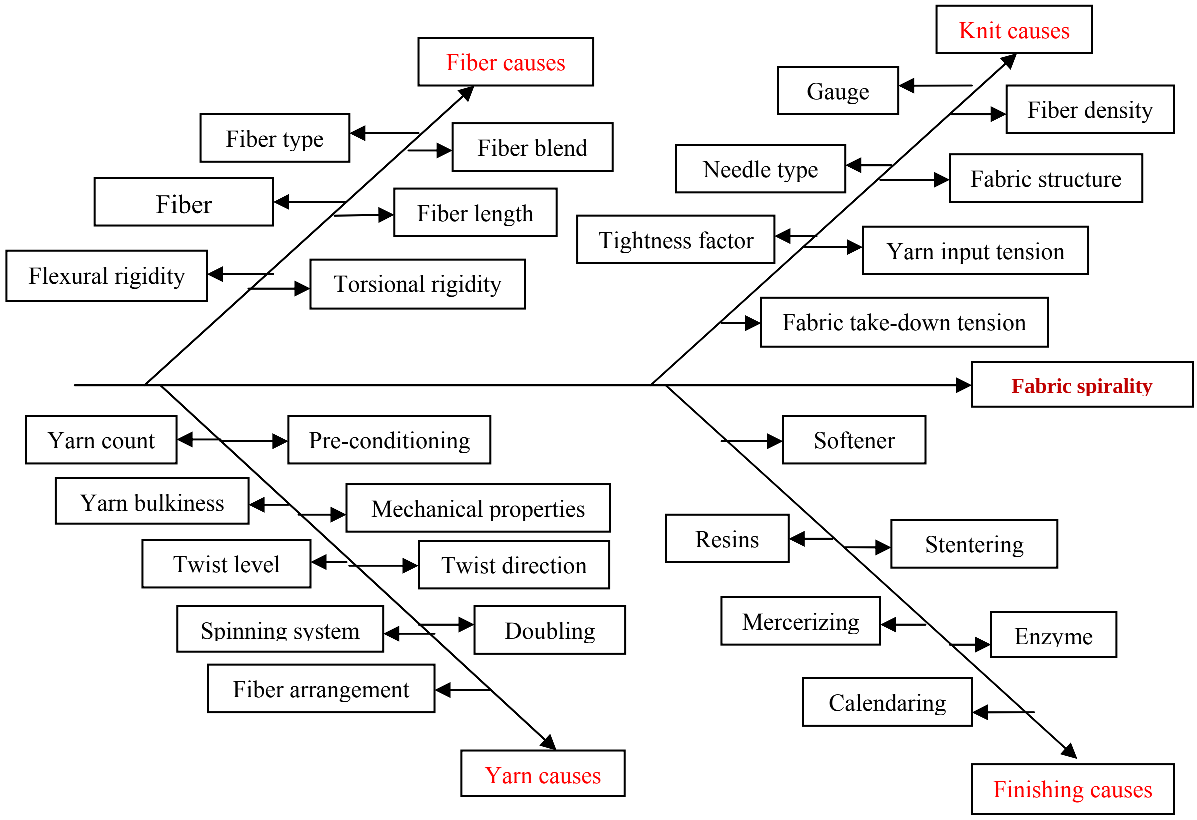


Fig. 4. Causes and Effect Diagram of Fabric Spirality

MATERIAL AND METHODOLOGY

The single jersey knit fabrics were produced from selected three different yarn count ($24^s/1$ $26^s/1$, $28^s/1$, and $30^s/1$) by Jiunn long (Taiwan) knitting machine with three different stitch length. The single jersey fabrics were dyed by a winch dyeing machine with reactive dye and then the fabrics were dried with Unitech Stenter machine at a temperature 150°C and over feed 70%. Finally fabrics were compacting by Ferraro compactor with compaction 2%, over feed 25% and diameter setting 50″ using selected parameters. Spirality of the produced fabrics were measured before compacting and after compacting at 20°C ± 2°C, and 65% ± 2% relative humidity condition (Euscher and Jayachandran, 1997).

KNITTING

The same parameters and machine was used for knitting $26^{s/}1$ $28^s/1$ & $30^s/1$ yarn using positive feed device. Parameters of the knitting machine were as follows:

Brand name of machine	Jiunn long (Taiwan)
Diameter of machine	: 25"
Number of feeder	: 75
Number of needle	: 1872T
Machine gauge	: 24G
Machine speed	: 26 rpm

COMPACTING

The fabrics were compacted in Ferraro compactor with compaction 2%, over feed 25% and diameter setting 50″. Parameters of the compacting machine were as follows:

Brand Name of Machine	: Ferraro
Compaction %	: 2 %
Diameter setting	: 50"
Over feed	: 25 %
Machine gauge	: 24G
Machine speed	: 25 m/min
Set diameter	: 127"
Upper felt tension adjust	: 4.75 bar

SPIRALITY TESTING

For measuring spirality, firstly, samples were collected from stenter. They 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 %:

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

Blending of fiber:

In general, 50/50 cotton/polyester blends have a lower tendency to produce spirality in fabrics than the 100% cotton yarns. Spirality can be virtually eliminated by using 50/50 cotton/polyesters blend of air jet and rotor yarns.

Fabric structure:

More spirality in s/j 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 multifeed pique & 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 & interlocks.

Fabric tightness:

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.

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. At each level of yarn twist factor, the degree of spirality decreases linearly with fabric tightness factor.

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.

Figure 4 shows the cause and effect diagram of fabric & machine related causes of fabric spirality. Discussions of these causes are presented below.

Reasons for Spirality:

The Spirality is a symptom which is made from the construction of knitting with spun yarn. Depending on the yarn and knitting parameters the fabric has more or less spirality. Every knitting which is made out of spun yarn will have spirality.

There are two main reasons for the spirality:

- The System Height
- The Twist of the Yarn

The numbers of knitting systems gives the length which will knitted every turn of the knitting machine and makes an angle to the courses.

RESULTS AND DISCUSSION

Table 1 shows the yarn evenness results that were measured by Uster Tester – 5.

Table 1. TPI and evenness results of different yarn count

Actual Count	TPI	Um %	CVm %	CVm 3m %	CVm 10m %	H	Sh	Thin -40% /km	Thin -50% /km	Thick +35% /km	Thick +50% /km	Neps +200% /km
25.90	17.15	11.07	14.11	3.36	2.26	5.67	1.24	11.0	3.3	827.3	142.5	168.8
28.00	18.62	11.60	14.82	4.09	2.66	5.58	1.29	223.0	6.3	931	169.0	242.0
30.05	19.90	11.98	15.35	3.78	2.66	5.57	1.29	227.5	5.3	1169	243.5	353.5

The spirality % of the samples produced from three different count (26/1 Ne, 28/1Ne and 30/1) at five different values of stitch length were measured and compared before and after compacting. The results are listed in the table 2. The minimum spirality of the observed fabrics were found before compacting for 28/1 Ne 26/1 Ne fabrics at stitch length 4.45 mm, for 28/1 Ne fabrics at stitch length 2.70 mm and for 30/1 Ne fabrics at stitch length 2.73 mm and after compacting at stitch length 2.68 mm, 2.70 mm, 2.73 mm for 26/1 Ne, 28/1 Ne and 30/1 Ne fabrics (Abdel-Megied and Bakry Ahmed, 2008).

Table 2. Spirality % at different yarn count and stitch length before and after compacting

Stitch Length (mm)	Spirality %					
	26/1 Ne		28/1 Ne		30/1 Ne	
	Before compacting	After compacting	Before compacting	After compacting	Before compacting	After compacting
2.58	4.45	2.0	5.00	4.5	7.22	5.0
2.63	5.51	4.0	6.31	4.5	6.13	5.5
2.68	5.57	1.0	6.04	2.0	7.21	4.5
2.70	4.52	2.0	4.70	4.1	4.80	5.5
2.73	6.10	2.5	4.73	4.1	4.00	2.5

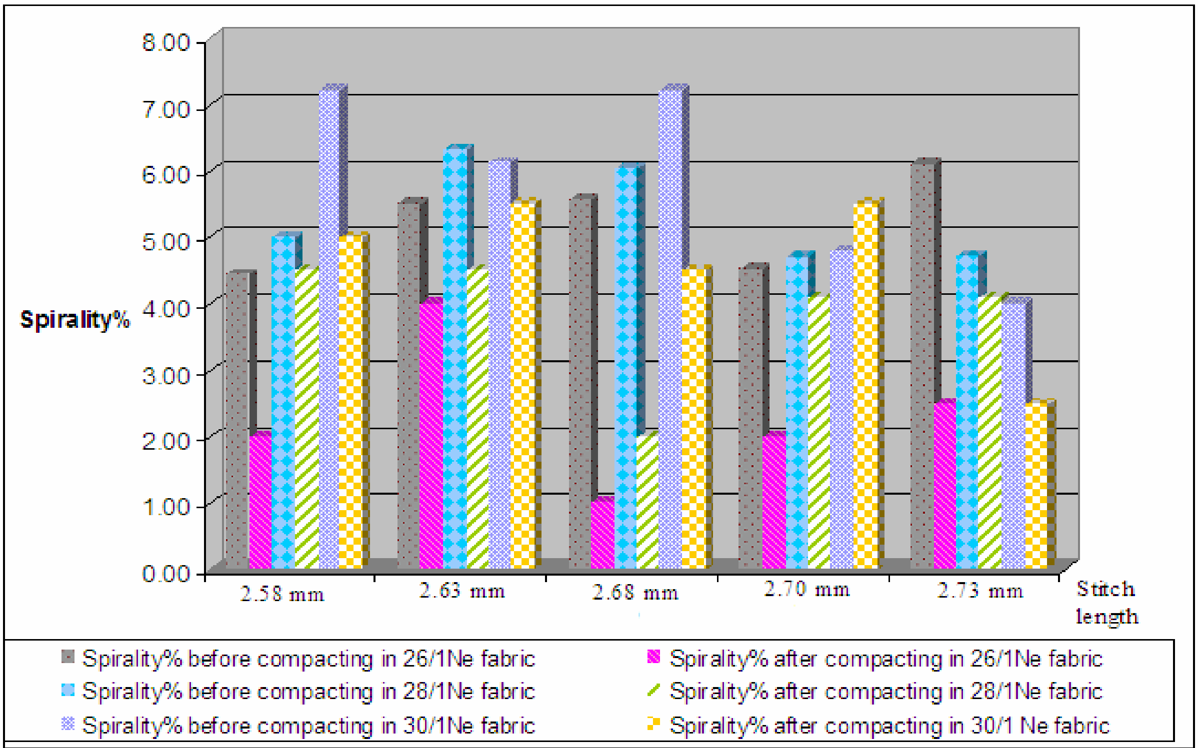


Fig. 5. Comparative study on spirality before and after compacting

Table 3. GSM for 26/1 Ne, 28/1 Ne and 30/1 Ne at different stitch length

Stitch Length (mm)	GSM		
	26/1 Ne	28/1 Ne	30/1 Ne
2.58	162	149	136
2.63	160	147	136
2.68	158	146	134
2.70	155	145	133
2.73	157	142	132

The actual GSM of the dyed fabrics after stentering are given in table 3. GSM (grams per square meter) of the fabrics was degreased with stitch length increasing remaining yarn count constant and GSM of the fabrics were also degreased with yarn count was increasing remaining stitch length constant.

CONCLUSION

The lowest spirality% of the single jersey knit cotton fabrics produced from 26/1 Ne, 28/1 Ne and 30/1 Ne yarn was minimum at stitch length 2.58 mm, 2.72 mm & 2.78 mm before compacting and 2.60 mm, 2.75 mm & 2.78 mm after compacting respectively. The results show that the increase in stitch length from 2.58 mm to 2.78 mm has not a specific trend for single jersey fabric spirality after compacting.

GSM of the fabrics degreases with increasing the stitch length remaining the yarn count constant. Further study can be done in future to observe the effect of yarn elongation, yarn twist, tightness factor and different fabric construction on spirality of cotton or blended knitted fabrics. The research refers that the control of fabric spirality is therefore a team effort. A knitter contributes by the choice of yarn and stitch length, and a finisher can contribute by the method of finishing he may choose to adopt. By reading this paper one can easily observe and understand the important factors which are responsible for changing spirality and also know the points, where this spirality can be minimized. In general the angle of spirality values are decreasing, when the tightness factor values are getting tight in the all knitted fabric samples. In slack knitted fabric structures, the loop can easily find area to rotate so spirality is increasing.

The spirality angle of the fabrics knitted with ring yarns are very high comparing with the fabrics knitted with open-end yarns. This shows the effect of the spiraled on twist liveliness. Because the twist liveliness of the ring yarns used in producing single jersey fabric is higher than the open-end yarns used in producing single jersey fabrics.

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