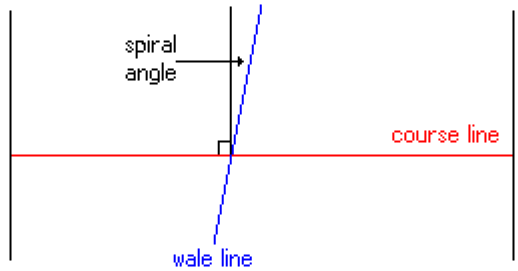
Introduction

Spirality is defined as the angle made between the wales and a line drawn perpendicular to the courses. Positive spirality, or "Z" spirality indicates that the wale line is displaced to the right, or clockwise. It is caused by the use of "Z" twist yarns. Negative, or "S" spirality has the wales displaced to the left or anti-clockwise and results from the use of "S" twist yarns.



This distortion is most noticeable in Plain Jersey fabrics and is a source of problems in finishing, in garment making, and in garment appearance. Spirality usually appears only after a garment has been laundered. This is because the finisher will attempt to deliver the fabric more or less straight, i.e. with the wales running parallel to the fabric width. Therefore, to judge the performance of a given fabric, it is necessary to measure the spiral angle in the Reference State.

During the collection of the STARFISH Database and the development of STARFISH Technology considerable research effort has been devoted to the study of Spirality.

From the evidence of this research it can be concluded that Spirality in the Reference State has three basic sources

- Skewing of the courses in multi-feeder knitting machines
- Twist liveliness in the yarn
- The geometry of the fabric

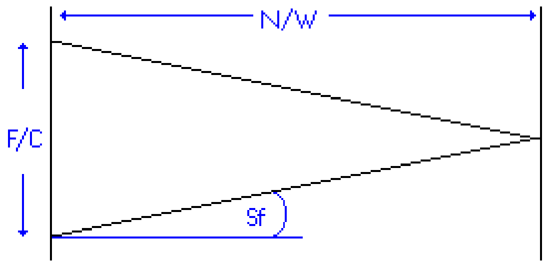
This research continues with the ultimate objective of providing model equations for predicting spirality in future versions of the STARFISH software.

Sources of Spirality

Effect of the Number of Feeders on Spirality

Spirality caused by the number of Feeders is a relatively small effect. Its magnitude can easily be calculated from the number of feeders, the width of the fabric and the number of courses per unit length. The larger the number of feeders, the fewer the courses per unit length, and the narrower the fabric, the greater will be the spirality from this cause.

The direction of the feeder spirality, also known as Feeder Skew, depends on the direction of rotation of the knitting machine. "Z" spirality is produced by machines that rotate anti-clockwise, "S" spirality is produced on machines that rotate clockwise.



If the spiral angle caused by the feeders is denoted as Sf, then the tangent of this angle is given by the ratio of the distance between successive courses from the same feeder (the drop) and the fabric width:-

tan (Sf) = Drop / Width

But the Drop is given by the ratio of the number of Feeders, F, and the number of Courses per unit length, C, whereas the Width is given by the ratio of the number of Needles, N and the number of Wales per cm, W.

Thus: Drop = F / C and Width = N / W

Therefore tan (Sf) = F * W / C * N

The number of feeders and the number of needles are known; the course and wale densities can be calculated using STARFISH. Therefore, the contribution to spirality made by the feeder effect can be calculated for any combination of fabric structure and knitting machine.

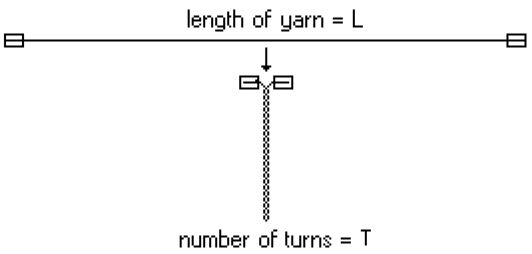
For example:

- A fabric made from 30 Ne Yarn knitted with a Stitch Length of 2.7 mm on a 28 gauge, 30 inch machine will have feeder skew of 0.5 degrees for 30 feeders but 1.9 degrees for 120 feeders.
- A fabric made from 20 Ne Yarn knitted with a Stitch Length of 3.4 mm on a 20 gauge, 24 inch machine will have feeder skew of 0.8 degrees for 30 feeders but 2.5 degrees for 90 feeders.

Effect of Yarn Twist Liveliness on Spirality

The Twist in a singles yarn causes torsional forces to develop in the fibres that tend to make the yarn try to untwist. If a length of singles yarn is held at each end and the ends are slowly brought together, the yarn will twist up upon itself. This effect is called snarling and the torque in the yarn that causes it is called twist liveliness.

When the yarn is knitted into a fabric, the consequence of twist liveliness is that the loop twists and bends out of shape. Its twisted shape is such that Spirality is generated in the fabric. The higher the number of turns per unit length in the yarn, the greater the twist liveliness and the greater the spirality.



Twist Liveliness = T / L

Different types of yarn, made from different Fibre Qualities can exhibit different degrees of twist liveliness. In the early days of Open end Rotor Spinning, it was generally found that rotor yarns were more twist lively than the corresponding Ring Spun yarns. However, the modern rotor yarns tend to be significantly less twist lively. In principle, finer fibre qualities should be expected to give lower levels of twist liveliness, for a given number of turns per unit length, than coarse fibre types but this aspect has not been thoroughly investigated.

With Twofold Yarns which are perfectly balanced, there will be no twist liveliness and hence no spirality. If the twofold yarn is not perfectly balanced, then spirality will be generated in direct proportion to the magnitude and the direction of the net residual twist.

If a fabric is knitted with alternate "Z" Twist and "S" Twist yarns, then the net effect on the magnitude and direction of Spirality is similar to the case where a twofold yarn is used although, of course, the fabric appearance and dimensions will be quite different.

In a Three-thread Fleece fabric, if the Binder (tie) yarn has equal and opposite twist to the ground yarn, then spirality will be drastically reduced.

Wet processing treatments tend to produce setting and stress release in the yarns with a consequent reduction in twist liveliness and hence in spirality. However, it is sometimes found that a wet processing treatment can upset the balance of twist in a twofold yarn so that spirality may actually be increased. By reducing twist liveliness, wet processing alters the shape of the loop and this effect may be an important source of differences in the Reference State Dimensions caused by different wet processing treatments.

Effect of Fabric Geometry on Spirality

Fabric geometry affects Spirality much in the same way as it affects shrinkage. In other words, spirality in the fabric before relaxation is a combination of:

- the fundamental nature of the fabric, as determined by the key construction parameters - yarn type, yarn twist, yarn count, stitch length, and
- the distortions imposed by manufacturing and processing.

The amount of spirality that will be measured in the finished fabric, as delivered, is critically dependent on the deformation and relaxation history of the fabric. A fabric that has been pulled out in its length, and has a high length shrinkage with a low width shrinkage, will show a lower spirality than one which has high width shrinkage but low length shrinkage. Therefore, in order to make valid comparisons between fabrics, it is the Reference Spirality which must be measured and related to the actual dimensions of the fabric.

In the case of spirality, there is the added complication that distortion of the fabric can be not only in length and width but also in twisting. Indeed, most finishers will attempt to twist the fabric so that spirality is at a minimum when the cloth is delivered. This is a purely temporary deformation that will not affect the Reference Spirality. It cannot be calculated in advance but has to be assumed as a Finishing Target.

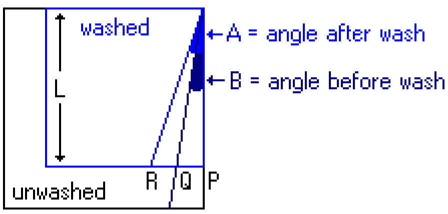
For a given Yarn Type (twist liveliness) and Wet Process, the Reference Spirality is roughly inversely proportional to the knitted Tightness Factor. The tighter that the fabric is knitted the lower will be the spirality in the Reference State.

Spirality and Seam Displacement

The relationship between Spirality and the amount of garment twisting or Seam Displacement (SD) that can develop in a garment after laundering is a simple geometrical one. It can be derived from the spiral angle (B) in the new garment, the spiral angle (A) in the laundered garment, and the length (Lf) of that part of the garment which is free to twist.

It is given approximately by :-

SD = Lf (tan A - tan B)



SD = QR = (PR - QP)

PR = L * tan (A) and QP = L * tan (B)

Therefore SD = L * (tan A - tan B)

For most garments, the free length is significantly less than the total garment length. For T-shirts it seems to correspond roughly to the distance from the hem to the underside of the arm.

For practical purposes, this equation can be simplified further because, for the small angles which are normally encountered in fabric spirality,

(tan A - tan B) is given approximately by (tan A / A) * (A - B)

and (tan A / A) is approximately equal to 0.0176

Thus, the following equation can be used with negligible loss in accuracy to predict the Seam Displacement in laundered garments.

SD = 0.0176 Lf (A - B)

Therefore, if the Reference Spirality is known, for a given fabric quality, then the expected seam displacement can be calculated from the as-delivered spirality and the length of the garment.

Spirality, Bow and Skew

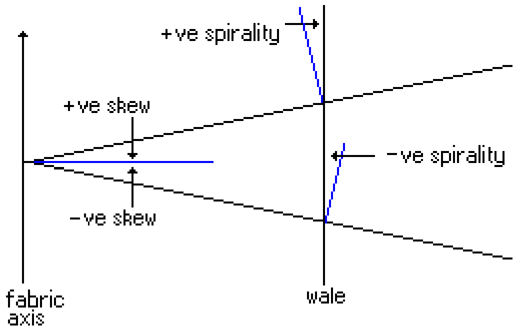
During wet processing, fabric can become distorted by bowing or skewing of the courses. One of the most common causes of such fabric distortions is poor alignment of sewings when the grey pieces are assembled for dyeing or, in extreme cases, the practice of tying grey pieces together instead of sewing. The distortion caused can extend for ten metres or more into the pieces, on each side of the ties.

In this situation there is a strong temptation for the garment maker to include some of this distorted fabric into his garments in order to avoid making a large quantity of waste. The inevitable consequence is that the garment will become more or less heavily distorted after laundering, as the fabric recovers its natural alignment of courses and wales.

Spirality and Skew

The practical effect of fabric skew is either to accentuate or to reduce the twisting, or Seam Displacement of the garment that occurs during laundering as a result of Spirality.

Skew is defined as the angle between the courses and a line drawn perpendicular to the fabric edges (i.e. perpendicular to the length axis). Positive, or "Z" skew results in a positive spirality in the fabric; negative, or "S" skew results in a negative spirality. If the wales are disposed parallel to the length axis of the fabric, then the skew angle is equal to the spirality angle.



If the natural spirality of the fabric is positive, then a negative skew will reduce spirality, and vice versa. This effect is sometimes used by finishers (especially in open width finishing on a stenter) to reduce the amount of seam displacement in garments. However, the technique cannot be pressed too far otherwise a different type of garment distortion will be introduced. Spirality should first be contained by appropriate choice of yarn and fabric construction. Only then may a controlled amount of skew be used to effect a partial compensation for the fabric twisting caused by spirality.

Note:

The Reference Spirality is not affected by skew. The effect of introducing negative skew is to change the spirality of the as-delivered finished fabric, so that the difference between the spirality in the finished, delivered fabric and the Reference Spirality is lower. It is this difference which is responsible for fabric and garment twisting during laundering.

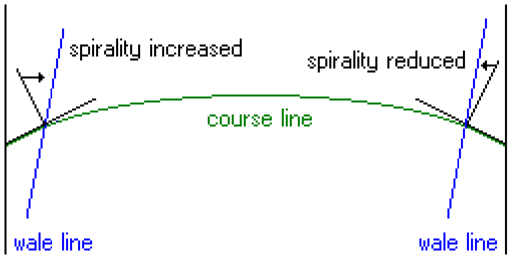
After laundering, any part of the skew angle, which is not due to the natural drop in the course line caused by the feeder effect, will disappear and only the "natural" skew of the fabric will remain. If a garment has been made up from heavily skewed fabric, then it will develop a skewed and possibly buckled shape after laundering.

In fabrics that have horizontal stripes, the finisher will naturally attempt to deliver the fabric with the stripes going straight across the fabric. The best way to do this is to slit the fabric and re-sew it with the stripes matching at the sewn edge to eliminate the feeder drop. Special equipment is available for this operation. However, if the fabric is not cut and re-sewn, then the finisher is simply delivering the fabric with an angle of skew which is equal and opposite to the feeder drop. This imposed skew will disappear in laundering and the natural feeder drop will reappear.

The effects of skew can be analysed quantitatively, by simple trigonometry, but this is hardly worthwhile because the clear lesson of the qualitative analysis is that excessive skew must be avoided.

Spirality and Bow

Bow is when the angle of Skew changes over the width of the fabric.



In the most simple case, the angle is positive at the left side of the fabric, decreases to zero at the centre, and then decreases further to negative skew of equal magnitude at the right side. In such cases, Spirality will be increased at the left side of the fabric, will be unchanged at the centre, and will be reduced at the right side.

Garments made up from pieces cut from such fabrics can display quite serious and complicated patterns of distortion after laundering, depending on exactly where in the fabric the main garment components have been cut.

The effect of bow can be analysed quantitatively, by simple trigonometry, but this is hardly worthwhile because the clear lesson of the qualitative analysis is that bow must be avoided.

Spirality and Shrinkage

In the standard STARFISH testing procedures, courses are counted along a wale and wales are counted in a direction perpendicular to the wales. In addition, the shrinkage template is placed on the fabric with its edge located along a wale line. These rules were established to ensure compatibility between the measurement of courses and wales and the measurement of shrinkage so that calculations of shrinkage based on changes in the values of course and wale densities are valid.

It has to be recognised, however, that when a fabric shows significant Spirality the length and width shrinkages measured by the STARFISH method may not correspond exactly to the changes which may be observed in the length and width of a piece of fabric, or a garment, when the original square shape of the test piece is distorted into a parallelogram after washing. This can be especially important when assessing length changes in garments because the garment hem will rise by slightly more than the amount expected from the measured length shrinkage, and the width will be slightly greater.

The extent of this "error" can be calculated by examining the geometry of the test piece and the changes brought about by the development of spirality. It depends on the magnitude of the Reference Spirality and the difference between the spirality before washing and that after washing.

To a first approximation it can be said that the difference between the measured shrinkage and the actual change in length of a garment will not exceed about 3 percentage points, for the maximum levels of spirality that are normally encountered in practice.