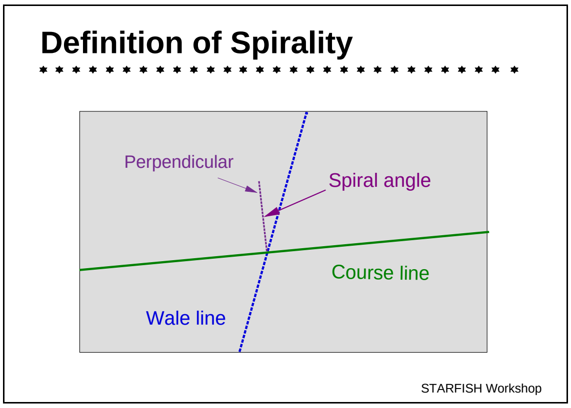
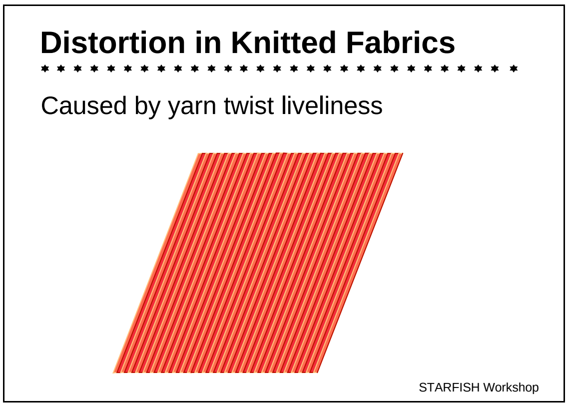
The Problem of Spirality in Single Jersey Fabrics

Introduction

Spirality is defined as the angle made between the wales and a line drawn perpendicular to the courses. Positive 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 single 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. Therefore, to judge the performance of a given fabric, it is necessary to measure the spiral angle in the Reference State. We have studied, and are continuing to study the causes and the extent of spirality in a range of single jersey fabrics with the ultimate objective of providing prediction model equations for future versions of STARFISH.

Causes of Spirality

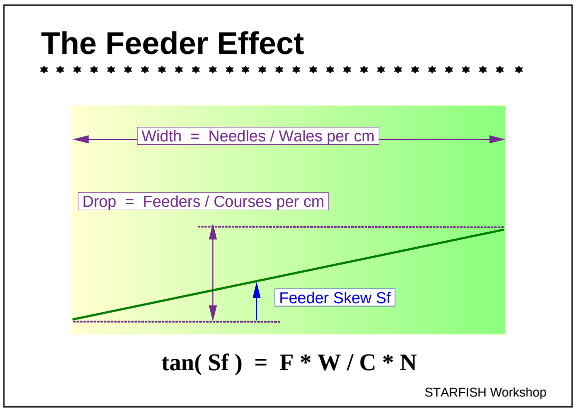
Spirality in the Reference State is determined by three basic factors: -

1. Skewing of the courses in multi-feeder knitting machines,
2. Twist liveliness in the yarn,
3. The geometry of the fabric.

Effect of the Number of Feeders

Spirality caused by the number of feeders is a relatively small effect and 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 cm, and the narrower the fabric, the greater will be the spirality from this cause.

The direction of the feeder spirality 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 cm, C, whereas the width is given by the ratio of the number of needles, N and the number of wales per cm, W.

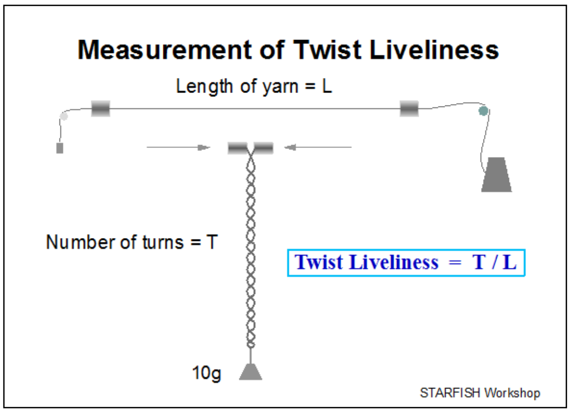
Thus	Drop	=	F / C
	Width	=	N / W
Therefore	tan (Sf)	=	(F * W) / (C * N)

The number of feeders and the number of needles are known, and 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.

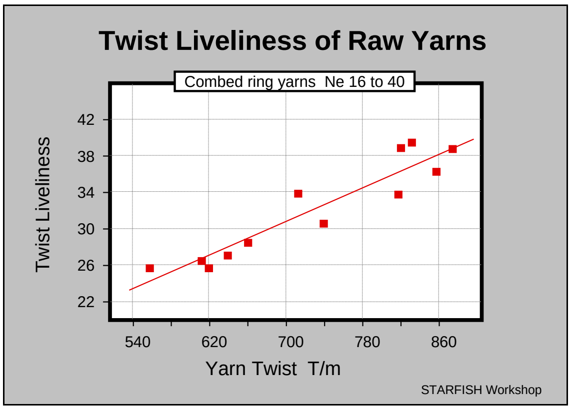
For example:

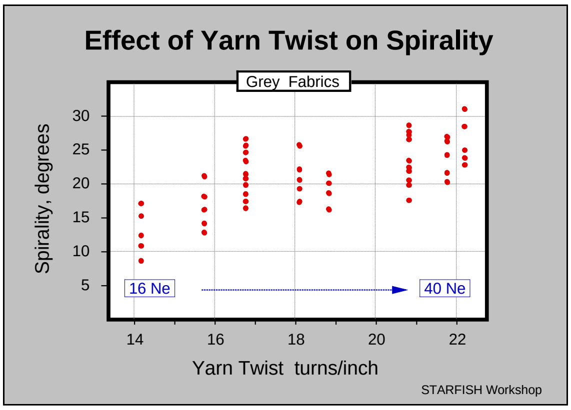
- A fabric made from 30 Ne yarn knitted with a stitch length of 2.7 mm on a 28 gauge, 30 inch machine will have feeder skew of 0.5 degree for 30 feeders but 1.9 degrees for 120 feeders.
- A fabric made from 20 Ne yarn knitted with a stitch length of 3.4 mm on a 20 gauge, 24 inch machine will have feeder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

Effect of Twist Liveliness



The twist in a singles yarn causes torsional forces to develop in the fibres which 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 cm in the yarn, the greater the twist liveliness and the greater the spirality.





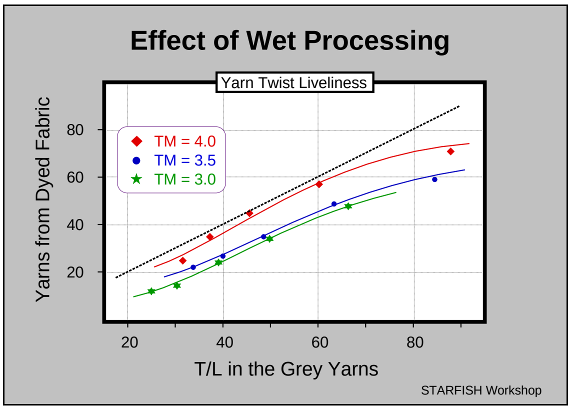
Different types of yarn, made from different qualities of fibre can exhibit different degrees of twist liveliness. In the early days of open-end rotor spinning, it was generally found that rotor yarns were more twist lively than the corresponding ring yarns. However, the modern rotor yarns tend to be 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 metre, than coarse fibre types but this aspect has not been thoroughly investigated.

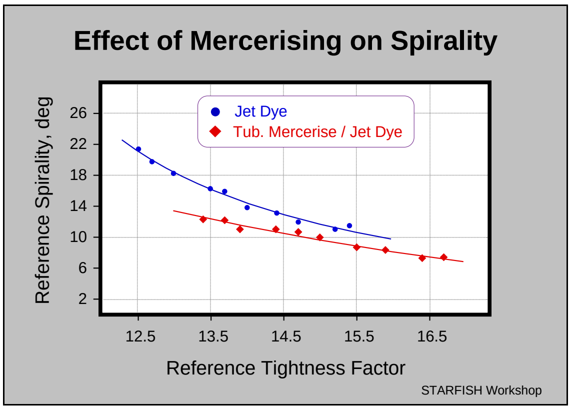
With twofold yarns which are perfectly balanced, there will be no twist liveliness and hence no spirality. If the twofold yarn is not perfectly balanced, then spirality will be generated in direct proportion to the magnitude and the direction of the net residual twist.

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 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 fibres 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 Reference State dimensions caused by different wet processing treatments.





Effect of Fabric Geometry

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

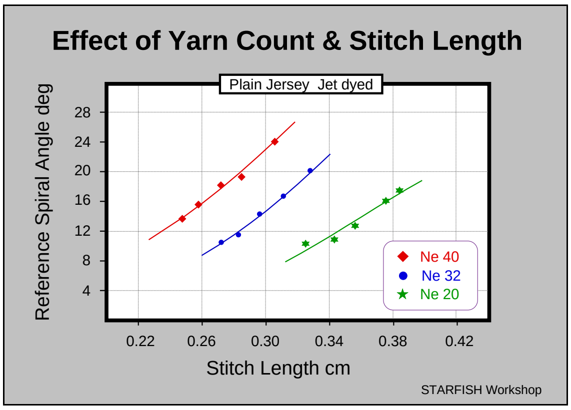
- the fundamental nature of the fabric, as determined by the key construction parameters - yarn type, yarn twist, yarn count, stitch length, and
- distortions imposed by manufacturing and processing.

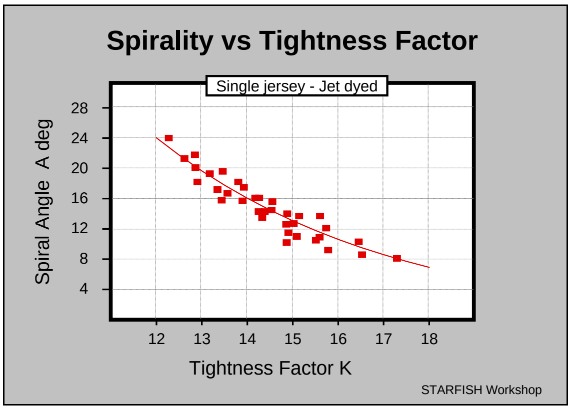
The amount of spirality that will be measured in the finished fabric, as delivered, is critically dependent on the deformation and relaxation history of the fabric. A fabric that has been pulled out in its length, and has a high length shrinkage with a low width shrinkage, will show a lower spirality than one which has high width shrinkage but low length shrinkage. Therefore, once again, if we want to make valid comparisons between fabrics, we have to measure the Reference Spirality as that which is found in the Reference State, and relate this to the actual dimensions of the fabric.

In the case of spirality, we have 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, which will not affect the reference spirality. It can not be calculated in advance but has to be assumed as a finishing target.

Thus, the reference spirality can be examined in the same way as we examine the reference courses and wales and a few results from our research work are given below.

The following two diagrams show the angle of Spirality, A, measured in the reference state on a series of dyed and finished plain jersey fabrics made from a series of yarns all with similar twist factors (3.6 to 3.8).





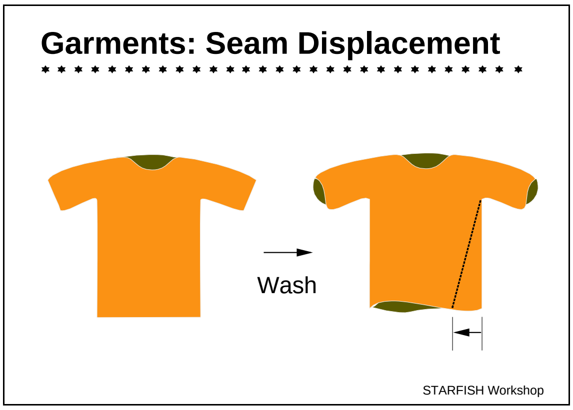
The left hand diagram illustrates the effect of yarn count and stitch length on the reference spiral angle for three yarn counts Ne 20, Ne 32 and Ne 40. The right hand diagram shows the reference spiral angle plotted as a function of the fabric tightness factor for a similar series of fabrics made from Ne16 to Ne 40 yarns.

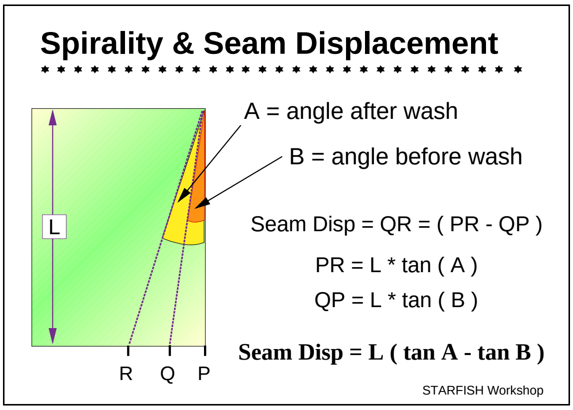
Seam Displacement

The relationship between spirality and the amount of garment twisting or seam displacement (SD), which 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:-

$$SD = Lf (\tan A - \tan B)$$





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.

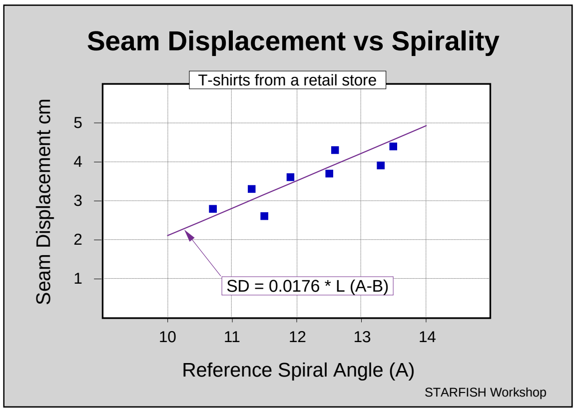
For practical purposes, this equation can be simplified further since, for the small angles which are normally encountered in fabric spirality, (tan A - tan B) is given approximately by

$$\frac{\tan A}{A} . (A-B)$$

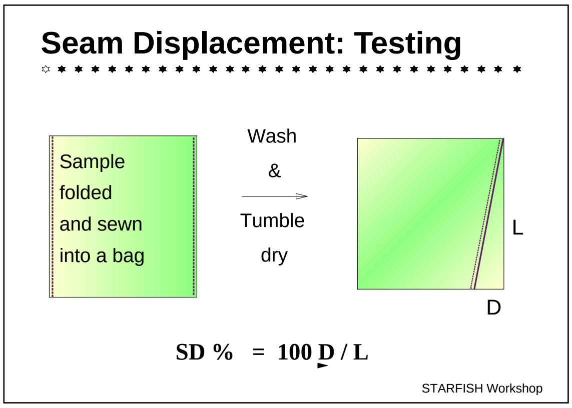
and $\frac{\tan A}{A}$ is approximately equal to 0.0176

Thus the following equation can be used with negligible loss in accuracy to predict the seam displacement in laundered garments.

$$SD = 0.0176 * Lf (A-B)$$



The diagram shows the results of some measurements of seam displacement made on a series of plain jersey T-shirts, compared to those predicted by the simplified equation.

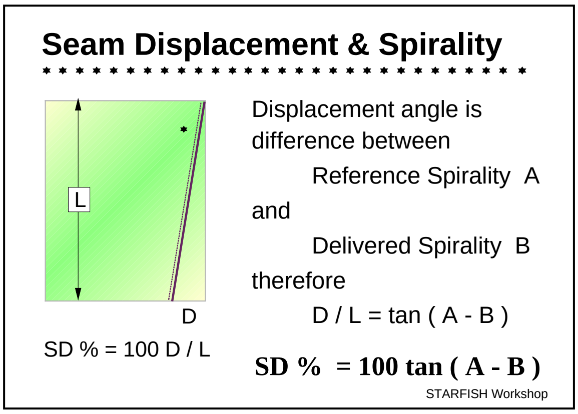


A practical test for seam displacement is carried out by taking a rectangular sample of fabric, whose length is double its width, and sewing it into a bag - a kind of simulated garment.

The bag is then given the standard wash and tumble dry (shrinkage test) laundering. The amount of seam displacement can then fairly easily be measured. The amount of seam displacement is expressed as a percentage of the seam length.

If D is the displacement, and L is the length, then:-

$$\%SD = 100 * D/L$$



The percentage seam displacement can be related to seam displacement, as described earlier, by means of the following facts.

- The displacement angle must be the difference between the after-wash spirality, A, and the before-wash spirality, B. and
- D/L is equal to the tangent of the displacement angle.

Therefore,

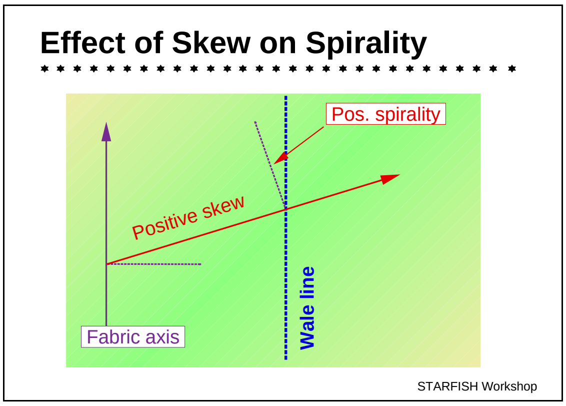
$$\%SD = 100 * D/L = 100 * \tan(A - B)$$

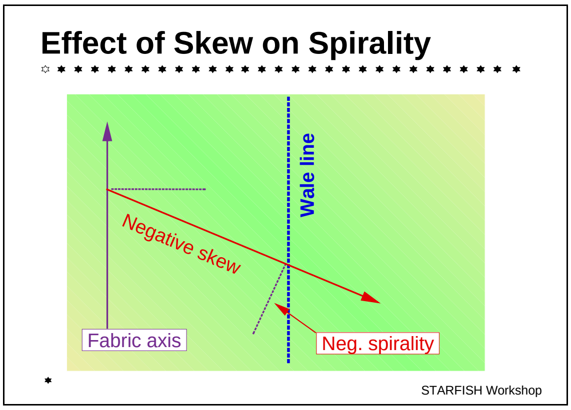
If the Reference spirality, for a given fabric quality, is established by calibration trials, then it is a simple matter to work out what will be the percentage seam displacement for any proposed spirality which can be delivered in the finished fabric. The actual displacement for a given garment style is obtained by multiplying by the effective garment length.

Spirality, Skew and Bow

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 can extend for ten metres or more into the pieces, on each side of the ties, and 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.

The practical effect of fabric skew is either to accentuate or to reduce the twisting, or seam displacement of the garment which 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.



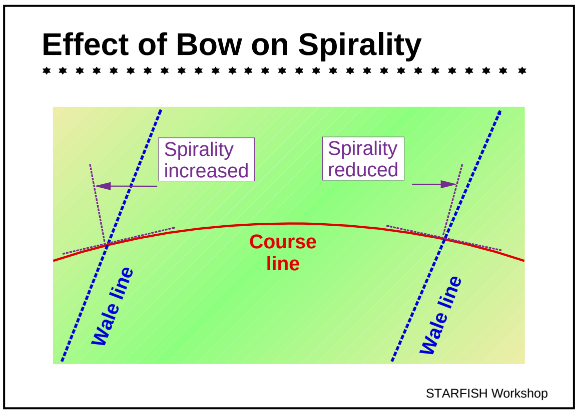


If the natural spirality is positive, then a negative skew will reduce spirality, and vice versa. This effect is sometimes used by finishers (especially in open width finishing on a stenter) to reduce the amount of seam displacement in garments. However, the technique can not be pressed too far otherwise 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 that the Reference spirality is not affected by skew. The effect of introducing negative skew is to change the spirality of the finished fabric, so that the difference between finished and Reference spiralities is lower. It is this difference which is responsible for fabric and garment twisting.

After laundering, any part of the skew angle that 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 for him 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 skew will be removed in laundering and the natural feeder drop will reappear.

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



In the simplest 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 effects of bow and skew can be analysed quantitatively, by simple trigonometry, but this is hardly worthwhile because the clear lesson of the qualitative analysis is that bow and skew 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 laid down on the fabric for marking with its edge along a wale line. These rules are laid down so that the course and wale measurements will be compatible with the shrinkage measurements and therefore calculations of shrinkages based on the changes in the values of course and wale densities will be valid.

However, it has to be recognised that, when a fabric shows significant spirality, the length and width shrinkages measured by the STARFISH method may not correspond exactly to changes in the length and width directions of a piece of fabric or a garment. This is because the original square shape of the test piece has been distorted into a parallelogram after washing. This can be 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 which are normally encountered in practice.