Effect of Knitting Variables on Reference Dimensions

Introduction

The Reference Dimensions of a fabric are the number of courses per unit length, the number of wales per unit width and the weight per unit area of a fabric measured after it has been laundered using the Reference Relaxation Procedure.

They are determined by the average size, weight and shape of the knitted loop. If the average size, weight and shape of the knitted loop are altered then the Reference Dimensions of the fabric change accordingly.

The size, weight and shape of the knitted loop are determined, primarily by the key knitting variables

- Yarn Quality
- Average Stitch Length

Yarn Quality

Several yarn properties can influence the size, weight and shape of the knitted loop and therefore have a direct effect on the Reference Dimensions of the knitted fabric.

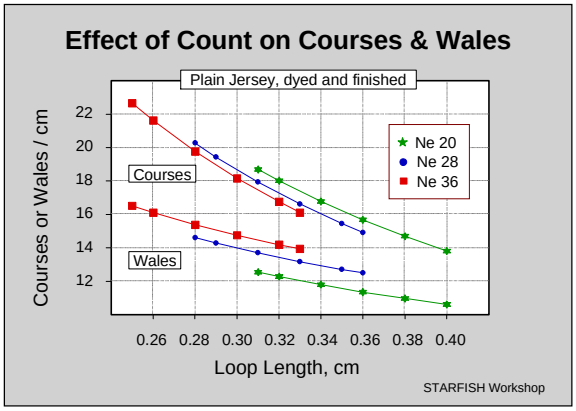
The most important are

- Average Yarn Count
- Yarn Type
- Twist Multiple
- Fibre Quality

The first two are the key yarn variables, which are directly allowed for by STARFISH. The influence of the yarn twist and fibre quality is for the time being taken account of indirectly through the yarn type and yarn count parameters. For practical purposes this is not too serious a disadvantage since only a narrow range of twist factors is actually used for knitting yarns and moreover the quality of fibre used tends to be related to the yarn type and the yarn count. However, it is important for the knitter to understand and monitor the twist in his yarns and to ensure that the fibre quality stays more or less the same from lot to lot in order to ensure the consistency of his finished fabric.

Effect of Yarn Count

The average count of yarn used to produce a given fabric has a direct influence on the size and weight of the knitted loop. A coarser (heavier) yarn, knitted at the same average stitch length and finished to the same dimensions (course density and width) will produce a heavier fabric than if the same fabric had been produced from a finer (lighter) yarn.



In addition, the count of a yarn provides a reasonable approximation for its diameter. The diameter of the yarn affects its stiffness and the amount of

space that a given length of yarn will occupy in a fabric. This influences the number of courses and wales that will be developed in the fabric in the Reference State.

A finer yarn will develop fewer courses per unit length and more wales per unit width when compared to a coarser yarn knitted at the same average stitch length.

If these two fabrics were to be finished to the same dimensions then not only would the weight of the finished fabric be different but the potential shrinkage in the fabric would be different also.

Therefore, it is important that for a given fabric style the average count of yarn is maintained consistently, from lot to lot and from spinner to spinner. Differences in average yarn count between yarn deliveries is probably one of the main sources of variation in the performance of finished fabrics.

Effect of Yarn Type

There are two main spinning systems used for the production of yarns for weft knitting - ring spinning and rotor spinning. In both systems yarn can be spun from either carded or combed fibre. The choice of which type of yarn (preparation and spinning system) to use depends primarily on the quality requirements (and price) of the end product.

The basic fibre quality, the type of fibre preparation and the spinning system used to produce a given yarn count all have a fundamental effect on the properties of the yarn that can be produced. This is most apparent when the appearance and softness of the finished fabric is considered.

What is perhaps less well known, is that certain of the basic yarn characteristics, e.g. stiffness and twist liveliness, also affect the shape of the loop in the knitted fabric, and loop shape influences the Reference Dimensions. These basic yarn characteristics are influenced by the fibre quality, the spinning system and whether the yarn is singles or folded.

Carded vs. Combed

A fabric produced with ring yarn spun from combed fibre develops slightly more courses and more wales in the Reference State compared to an equivalent fabric knitted at the same stitch length and yarn count but produced with ring yarn spun from carded fibre.

This means that if both fabrics are delivered to the same finished dimensions (course density and width), then the fabric produced with the combed yarn will have slightly more potential shrinkage in both the length and width directions than that produced with the carded yarn.

In other words, the same finished fabric specifications can not be applied to both fabrics.

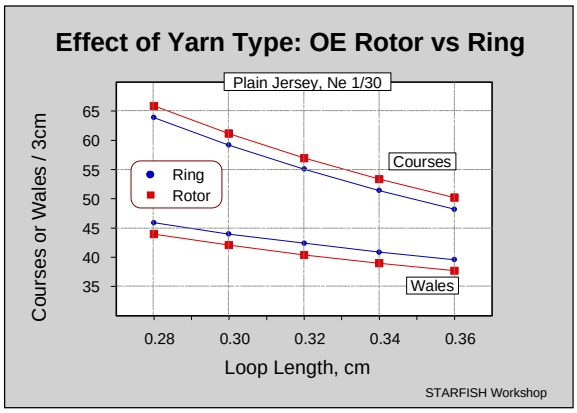
- If both fabrics must be delivered with the same finished weight and width then the shrinkage specification for the two fabrics must be different.
- If both fabrics must be delivered with the same shrinkage specification then the finished weight and width specifications must be different.

If the same finished fabric specifications of weight, width and shrinkage must be maintained then either one or both of the fabrics must be re-engineered in the knitting

mill, i.e. the knitting specifications (yarn count and / or stitch length) for the two fabrics must be altered.

Ring spun vs. Rotor spun

A fabric produced from open-end rotor spun yarn develops more courses and fewer wales in the Reference State compared to an equivalent fabric knitted at the same stitch length and yarn count but produced from ring spun yarn.



This means that if both fabrics are delivered to the same finished dimensions (course density and width), then the fabric produced from the rotor spun yarn will have more potential length shrinkage and less potential width shrinkage than that produced from the ring spun yarn.

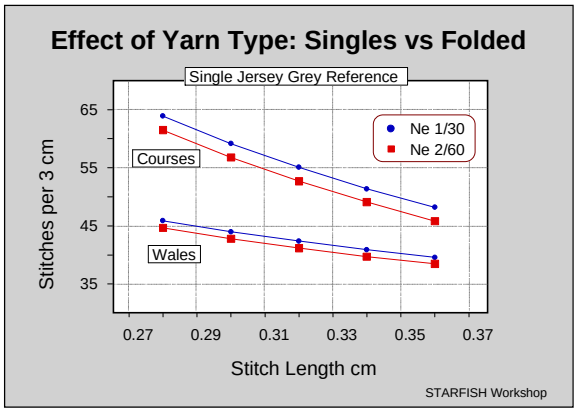
In other words, the same finished fabric specifications can not be applied to both fabrics.

- If both fabrics must be delivered with the same shrinkage specification then the weight and width specifications for the two fabrics must be different.
- If both fabrics must be delivered with the same finished weight and width specifications then the shrinkage specification must be different.

If the same finished fabric specifications of weight, width and shrinkage must be maintained then either one or both of the fabrics must be re-engineered in the knitting mill, i.e. the knitting specifications (yarn count and / or stitch length) for the two fabrics must be altered.

Singles vs. Twofold

A fabric produced from twofold yarn develops fewer courses and fewer wales in the Reference State compared to an equivalent fabric knitted at the same stitch length and yarn count but produced from a singles yarn.



This means that if both fabrics are delivered to the same finished dimensions (course density and width) then the fabric produced from the singles yarn will have more potential shrinkage in both length and width than that produced from the twofold yarn.

In other words, the same finished fabric specifications can not be applied to both fabrics.

- If both fabrics must be delivered with the same finished weight and width then the shrinkage specification for the two fabrics must be different.
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If the same finished fabric specifications of weight, width and shrinkage must be maintained then either one or both of the fabrics must be re-engineered in the knitting mill, i.e. the knitting specifications (yarn count and / or stitch length) for the two fabrics must be altered.

Effect of Twist Multiple

The amount of twist put into a yarn during the spinning process depends on many factors. For example:

- the basic fibre quality, e.g. length and fineness of the fibres,
- the method of fibre preparation, e.g. carded or combed,
- the method of spinning, e.g. ring spun or rotor spun,
- the efficiency of the spinning process, e.g. machinery, production controls
- the properties required of the final yarn, e.g. count, strength,
- the end use for which it is required, e.g. weaving, knitting.

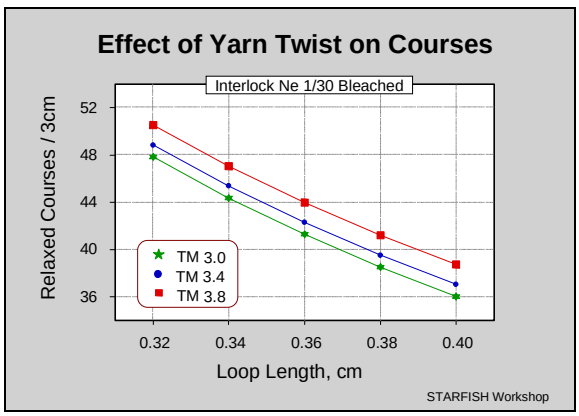
The actual level of twist inserted, together with the basic fibre quality and spinning system, influences such properties as yarn strength, bulk, hairiness, stiffness and abrasion resistance. So far as the Reference Dimensions of the knitted fabric are concerned, however, perhaps the most important effect of these three spinning variables is their influence on the twist liveliness of the yarn.

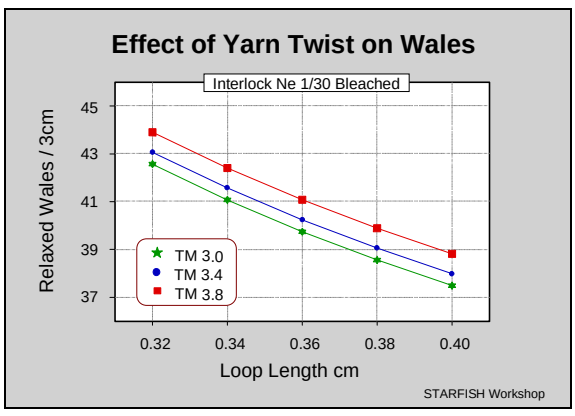
Twist liveliness in yarns can be seen as the snarling and twisting of a yarn on itself when the ends of a hanging loop are brought slowly together. In knitted fabrics this phenomenon causes the loops to distort, twist and incline out of the plane of the fabric.

For yarns of similar quality (e.g. combed, ring spun) twist liveliness is directly related to the number of turns per unit length put into the yarn during spinning. The more turns per unit length the more twist lively the yarn.

In single jersey fabrics yarn twist liveliness is the main cause of fabric spirality but in addition twist liveliness also has an effect on the density of courses and wales which will be developed in the fabric in the Reference State.

For example, two ring yarns, spun to the same yarn count but with a different number of turns per unit length, and knitted with the same stitch length will develop different course and wale densities in the Reference State. The yarns with more turns per unit length will develop more courses and wales than the yarns with fewer turns per unit length.





The same is also true for rotor spun yarns. Yarns spun with a higher twist multiple will develop more courses and wales in the fabric in the Reference State than yarns spun with a lower twist multiple.

In rotor spinning, the method of twist insertion is quite different from that used in ring spinning. This also has an effect on the yarn twist liveliness. In the early days of rotor yarn production twist levels were very high and single jersey fabrics knitted from them often developed higher levels of spirality than those knitted from ring spun yarns of equivalent count.

In modern rotor spun yarns the twist levels have been significantly reduced, although they are normally still higher than equivalent ring spun yarns. In addition, many modern rotor spun yarns produced for the knitting industry are now spun from longer, finer fibres. These two changes have resulted in a decrease in the yarn twist liveliness and consequently a reduction in the spirality that is developed in fabrics knitted from these types of yarns. Often the spirality, which will be developed in single jersey fabrics knitted from modern rotor spun yarns, will be lower compared to that which will be developed in fabrics knitted from equivalent ring spun yarns.

The average twist in the yarn must be maintained consistently between different deliveries and between different suppliers. Variation in average twist will increase the variation in fabric properties between individual finished fabric pieces.

Effect of Fibre Quality

The basic fibre properties - length, strength, fineness, maturity etc. have a direct influence on such yarn properties as strength and regularity, the amount of twist that needs to be inserted and the dyeing properties, as well as the type of yarn which can be spun. In addition, recent research has begun to quantify the effect that the basic fibre properties can have on the Reference Dimensions of the knitted fabric.

Two matched sets of 27 different Interlock qualities averaged over Twist Multiple and Stitch Length

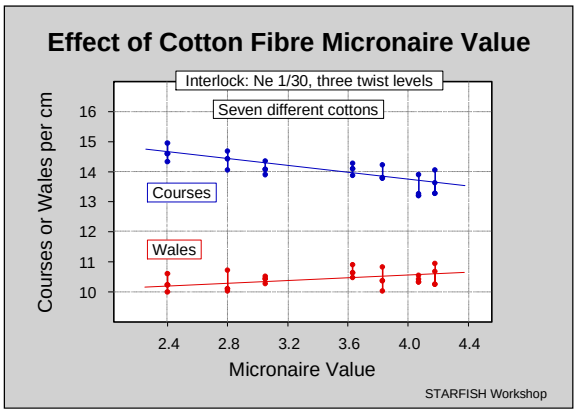
Count	Origin	Courses	Wales	Weight
Ne 22	Texas	12.82	10.42	310.7
	California	12.59	10.62	304.6
	Difference %	**1.8**	**-1.9**	**2.0**
Ne 26	Texas	14.09	11.44	284.8
	California	13.69	11.59	280.1
	Difference %	**2.8**	**-1.3**	**1.6**
Ne 30	Texas	15.03	12.20	264.6
	California	14.88	12.48	262.7
	Difference %	**1.0**	**-2.3**	**0.7**
	Mean Difference %	**1.9**	**-1.8**	**1.4**

A few years ago, the International Textile Center, in the USA, carried out a series of trials that examined the influence of fibre variety, twist level and rotor spinning conditions on the Reference Dimensions of Interlock fabrics. It was found that fabrics knitted from rotor yarn spun from Californian cotton developed fewer courses and more wales in the Reference State compared to similar fabrics (same yarn count and stitch length) produced from yarns spun from Texas cotton.

The differences were not large. Nevertheless, they implied that if a yarn that was normally made from this particular variety of Californian cotton were to be substituted

for one made from the Texas cotton, and the finished fabric was delivered with exactly the same unit weight and width, then the length shrinkage would be about two percentage points greater and the width shrinkage would be about two percentage points less.

Another study investigated the influence of fibre Micronaire Value on Reference Dimensions. A set of OE rotor yarns were spun from a group of seven cottons with widely different Micronaire Values, each spun to the same yarn count at three levels of twist, and all knitted into interlock fabrics with approximately the same stitch lengths.



The data do not conform strictly to our requirements since they refer only to grey fabrics. In addition, the twist multiples were not identical for each cotton which contributed to the scatter in the data. However, the data do imply very strongly that a reduction in Micronaire Value of the raw fibre stock will result in an increase in the Reference Courses and a reduction in the Reference Wales. Over the range of Micronaire from 2.8 to 4.2 the changes in course and wales were about 5% and 2% respectively.

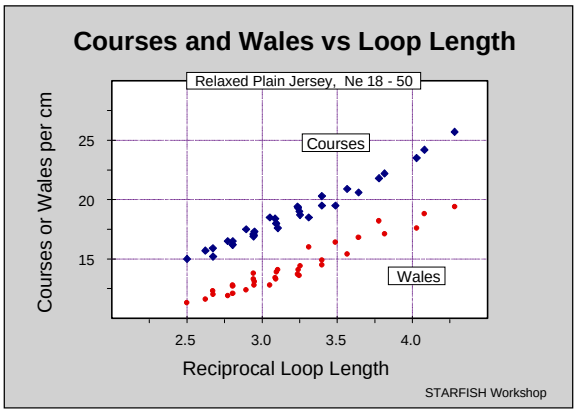
These two sets of data together strongly suggest that the influence of the cotton fibre properties alone could easily amount to two percentage points of shrinkage, with length and width shrinkages moving in opposite directions for a given change in cotton.

Among the world's cotton varieties and origins there are larger differences in basic fibre quality than the ones that were investigated here. Therefore, it is important that the average fibre quality in the yarn remains consistent from lot to lot and delivery to delivery in order to contain variation in the finished fabric.

Average Stitch Length

The knitted loop is the fundamental constructional unit of any knitted fabric and "Stitch Length" is the term used to describe the average length of yarn in a knitted loop.

Stitch length is calculated from the total length of yarn taken in by one feeder during one complete revolution of the knitting machine (course length), divided by the number of needles knitting.



For a given yarn quality, the average stitch length determines the number of courses and wales which will be developed in a fabric in its Reference State of Relaxation. The course and wale densities determine the length, width and weight of the fabric.

The effect of stitch length on the Reference Dimensions can be summarised as follows: -

- The longer the stitch length the fewer courses per unit length; the shorter the stitch length the more courses per unit length.

⇒ Fewer courses mean that the fabric is longer; more courses mean that the fabric is shorter.

- The longer the stitch length the fewer wales per unit width; the shorter the stitch length the more wales per unit width.

⇒ Fewer wales mean that the fabric is wider; more wales mean that the fabric is narrower.

- Stitch density is the product of course density and wale density. The greater the stitch density the more stitches per unit area; the lower the stitch density the fewer stitches per unit area.

⇒ Fewer stitches mean that the fabric is lighter; more stitches mean that the fabric is heavier.

So far as the properties of the finished as delivered fabric are concerned, this means that if two pieces of fabric are knitted with the same yarn but with different stitch lengths then it is impossible for both fabric pieces to be delivered with exactly the same weight, width and length and width shrinkage values.

Stitch length is the single most important variable in the production of a knitted fabric. If the average knitted stitch length is not correctly specified, accurately measured and effectively controlled throughout the production run of a given fabric quality then the inevitable consequence will be variation in the finished fabric properties between different pieces.

Effect of Run-in Ratio

Run-in Ratio is used in STARFISH specifically for Crosstuck (piqué) fabrics containing an all-knit course. It is the ratio obtained by dividing the length of the knit and tuck course by the length of the all-knit course.

- A run-in ratio greater than 1.0 means that the knit and tuck course is longer than the all-knit course.

- A run-in ratio less than 1.0 means that the knit and tuck course is shorter than the all-knit course.

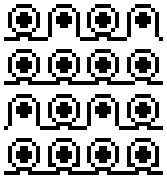
The Run-in Ratio affects the fabric appearance and is often used by knitters to enhance the clarity of the small diamond pattern which is produced by the repeating pattern of knit and tuck loops in crosstuck constructions. However the Run-in Ratio also affects the Reference Dimensions of the fabric.

Course and wale densities are affected primarily because the average stitch length is different between the different courses. Fabric weight is affected, because the total length of yarn per unit area is different.

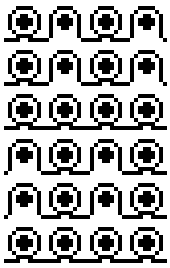
The relative size of the effect on the courses, wales and weight depends on the fabric construction, i.e. the proportion of knit and tuck courses to all-knit courses.

In general terms

- Increasing the knit and tuck stitch length relative to the all-knit stitch length (run-in ratio greater than 1.0) has the effect of decreasing the Reference courses and wales, relative to a fabric produced with a run-in ratio of 1.0.
- Conversely decreasing the knit and tuck stitch length relative to the all-knit stitch length (run-in ratio less than 1.0) has the effect of increasing the courses and wales, relative to a fabric produced with a run-in ratio of 1.0.



In single crosstuck fabrics, since the proportion of all-knit to knit and tuck courses is equal, the changes in course and wale density also result in a similar effect on the fabric weight. i.e. the fabric weight decreases at run-in ratios greater than 1.0 and increases with run-in ratios less then 1.0.



In six-thread crosstuck fabrics the proportion of knit and tuck courses to all-knit courses is not equal. One third of the courses are all-knit courses and two-thirds are knit and tuck courses. This means that changes to the knit and tuck stitch length have a relatively greater effect on the total length of yarn per unit area in the fabric. Thus, although at run-in ratios greater than 1.0 fabrics will have lower course and wale density, the fabric weight is actually increased, relative to a fabric produced with a run-in ratio of 1.0. Conversely at run-in ratios less than 1.0 the course and wale densities increase but the fabric weight is reduced relative to fabrics produced with a run-in ratio of 1.0.

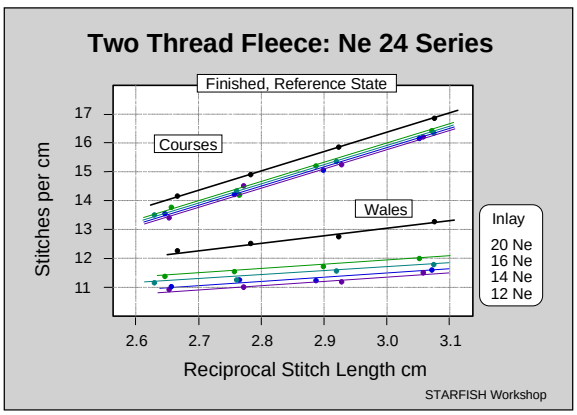
These changes to the fabric Reference Dimensions mean that it is not possible to deliver the same fabric properties - weight, width and shrinkage values - in fabrics that have been knitted with dissimilar run-in ratios.

It is essential, therefore, that the course length of the knit and tuck course is measured and controlled as accurately as the all-knit course. If differences are allowed then the Reference Dimensions of the fabric will be affected. This in turn will have an influence on the balance of properties that can be delivered in the finished fabric.

Important Note: Although STARFISH can calculate the effect of run-in ratio on the finished fabric properties, it should be remembered that STARFISH predictions do not take account of the relative effects on the fabric appearance. It is important that fabric manufacturers establish the effect of changing the run-in ratio on the fabric appearance as well as the fabric dimensions in the context of their own production and processing conditions and the requirements of their customers.

Two-thread Fleece

The basic effect of stitch length on the Reference Dimensions is the same for two-thread fleece fabrics as for plain jersey, i.e. a shorter stitch length produces more courses and wales per unit length, a longer stitch length fewer courses and wales per unit length. However, the density of both courses and especially wales is reduced compared to plain jersey due to the introduction of the inlay yarn.



In this example, course and wale densities are plotted as a function of stitch length and yarn count for a series of fabrics produced from Ne 24 face yarn with inlay yarns of Ne 20, 16, 14 and 12. The uppermost solid lines indicate the plain jersey controls.

The heavier the inlay yarn, and the greater the difference between face and inlay yarn counts, the greater is the reduction in stitch density.

For a given combination of face and inlay yarns it is the stitch length of the face yarn that has the greatest effect on fabric dimensions. The length of the inlay yarn has the greatest effect on the fabric weight. Therefore, correct specification, accurate measurement and effective control of both stitch lengths is essential.

Knitting Machine Variables

The gauge of the knitting machine (needles per inch) does not have an independent effect on the basic reference dimensions of the fabric i.e. the courses and wales per unit length. Provided that the yarn quality and stitch length is the same then the reference courses and wales will be the same on two machines of different gauge.

However, different combinations of gauge and diameter do affect the total number of needles in the machine cylinder and the total number of needles together with the number of reference wales per unit length determines the reference width of the fabric.

Consequently, it is very important that knitting specifications include the number of needles not just the gauge and diameter.