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TEXTILE YARNS TF

Yarn Introduction

A yarn is a relatively strong and flexible assembly of fibres or filaments with or without twist. It is an important intermediate product between fibres and fabrics. The inter-relationships between the structure and properties of fibres, yarns, and fabrics are illustrated in Figure below.

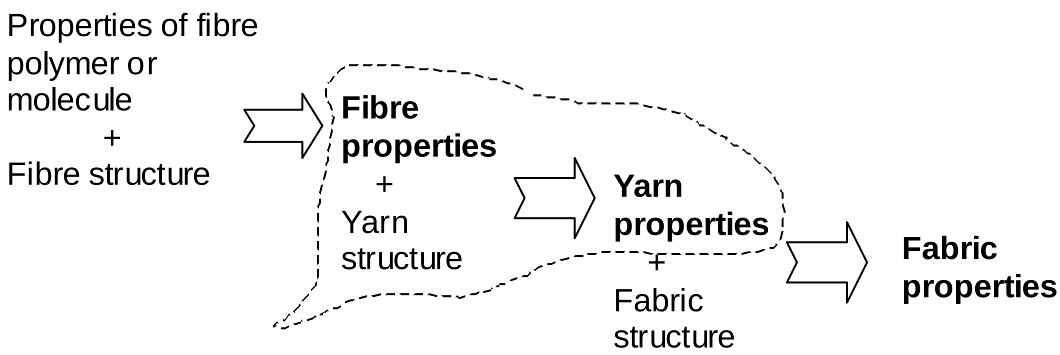


Figure: Interrelations of fibres, yarns, and fabric structure and properties

Yarns come in different sizes and shapes. But for textile applications, two forms of yarn are most common. They are single yarn (or singles yarn) and plied yarn, as indicated in figure below.

A single yarn represents the simplest continuous strand of fibre material. If this strand consists of staple fibres, it is a staple yarn or spun yarn. If the strand is a single continuous filament, it is called a mono-filament yarn or simply mono-filament. If the strand is made of a small bundle of single filaments, then this strand is known as a multi-filament yarn or simply multi-filament. The tape yarn shown in figure below is different to other yarns. It is a flat ribbon, slit from a thin film. Finally, a single strand could also be made of a composite of filaments and staples, with the filaments staying in the centre, wrapped around by the staple fibres. Such a yarn is called a core yarn, which is a form of composite yarns.

The plied yarn is also known as a folded yarn, or a twisted yarn. If two single yarns are twisted together, they make a two-ply or two-fold yarn as shown in figure. If more than two single yarns are involved, we get a multi-ply yarn.

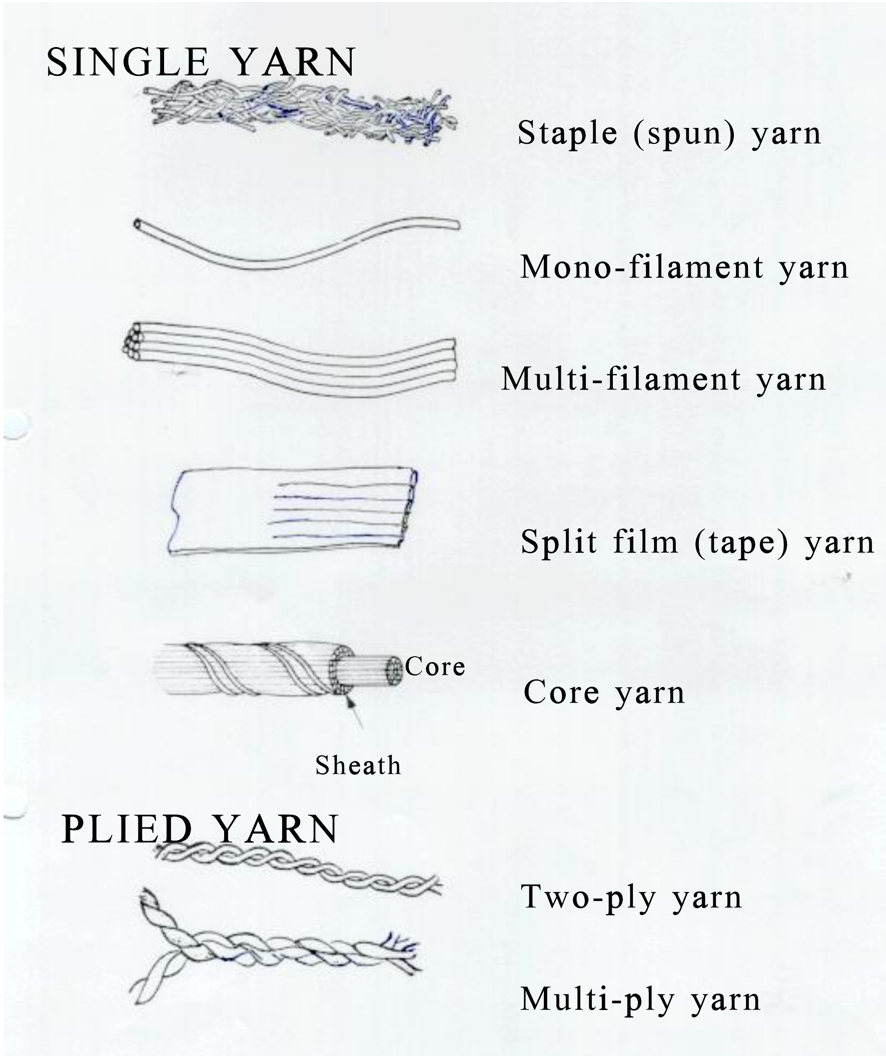
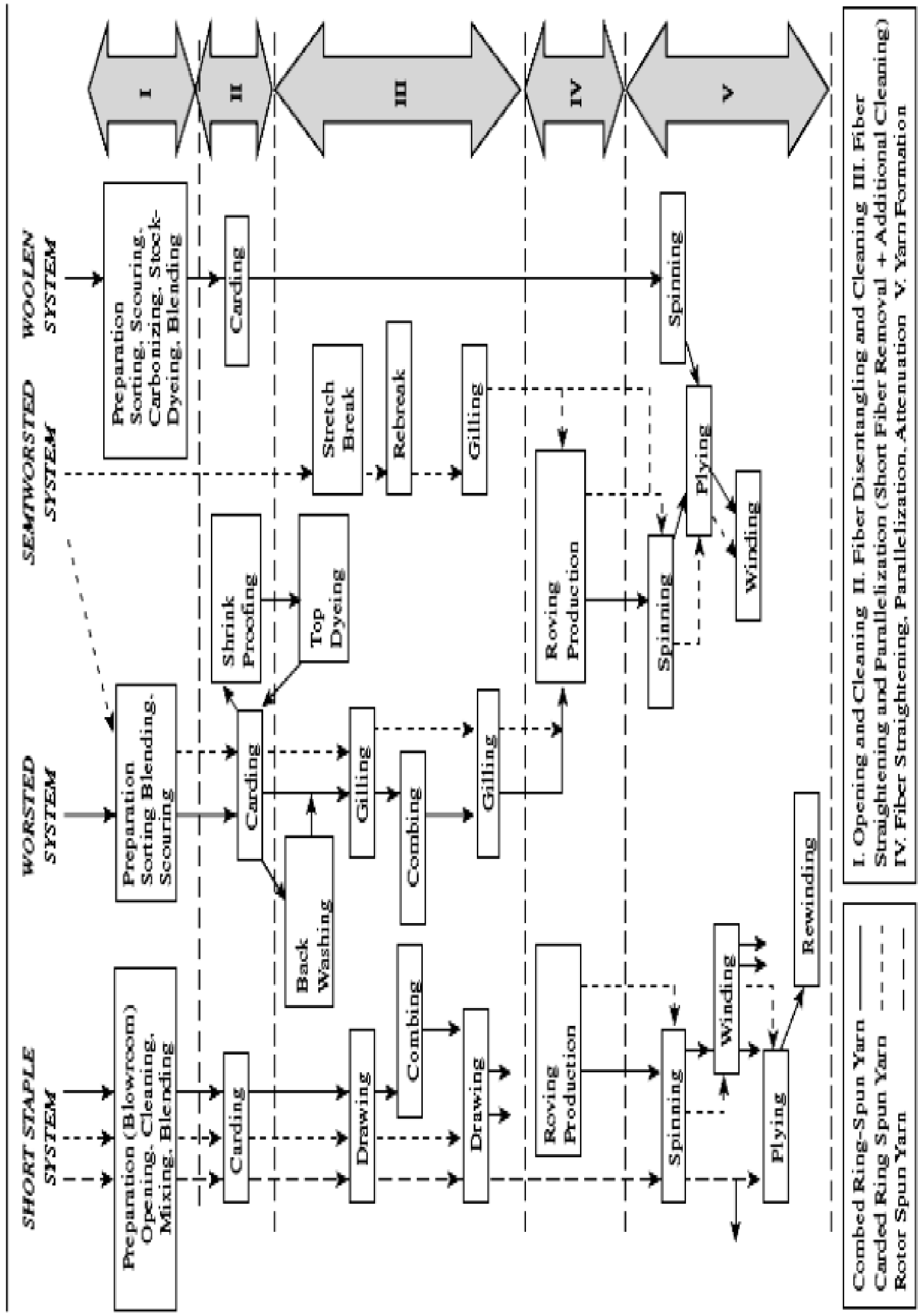


Figure : A sketch of different types of yarn



SHORT STAPLE SYSTEM
WORSTED SYSTEM
SEMIWORSTED SYSTEM
WOOLEN SYSTEM
I
II
III
IV
V
Preparation Sorting, Scouring, Carbonizing, Stock-Dyeing, Blending
Carding
Spinning
Stretch Break
Rebreak
Gilling
Plying
Winding
Roving Production
Spinning
Shrink Proofing
Top Dyeing
Preparation Sorting Blending, Scouring
Carding
Gilling
Combing
Gilling
Back Washing
Preparation (Blowroom) Opening, Cleaning, Mixing, Blending
Carding
Drawing
Combing
Drawing
Roving Production
Spinning
Winding
Plying
Rewinding
Combed Ring-Spun Yarn
Carded Ring Spun Yarn
Rotor Spun Yarn
I. Opening and Cleaning II. Fiber Disentangling and Cleaning III. Fiber Straightening and Parallelization (Short Fiber Removal + Additional Cleaning) IV. Fiber Straightening, Parallelization, Attenuation V. Yarn Formation

Yarn count

Yarns come in different sizes. They can be quite thick, or they can be very thin. Since by their very nature textile yarns are soft and squashy, the 'thickness' of a yarn cannot be easily measured by yarn diameter. But textile yarns are often sold on a weight basis, so it is natural to express the size of a yarn in terms of its weight or mass. The two basic ways of doing this are by indicating either how much a given length of yarn weighs (the direct system) or what the length of yarn will be in a given weight (the indirect system). These two broad yarn count systems are expressed below,

$$Direct\ \ yarn\ count\ = \frac{Weight\ \ of\ \ yarn}{Given\ length},$$

$$Indirect\ \ yarn\ count\ = \frac{Length\ \ of\ \ yarn}{Given\ weight}$$

Because a textile yarn is usually a very slender assembly of tiny fibres, it is conceivable that the weight of a yarn in a given length will be very small while the length of a yarn in a given weight will be quite large. Consequently, the yarn count figures would get either incredibly small (direct system) or large (indirect system) unless special units are used. Over the years, many different units have been used in different sectors of the textile industry.

Direct Count Systems

The direct systems are based on the weight or mass per unit length of yarn. Some typical direct systems are given below, together with their definitions. Please note that while the weight unit is gram, different lengths are used in the definitions.

Tex (g/1000m)
This is the mass in gram of one kilometre, or 1,000 metres, of the product.

If one thousand meters of yarn weigh 20 grams or one hundred meters of the yarn weigh 2 grams, the yarn would be 20 tex. On the other hand, if 100 metres of yarn weigh 5 grams, then the count of the yarn will be 50 tex.

Dtex (g/10,000m)
This is called **deci-tex**. It is the mass in gram of ten kilometre, or 10,000 metres, of the product. It is a smaller unit than tex (1 tex = 10 dtex), and is usually used for fibres and filament yarns.

A 167 dtex polyester filament would weigh 167 grams for every 10,000 meters of the filament.

Ktex (g/m)
This is called kilo-tex. It is the mass in gram of one metre of the product. It is a much larger unit than tex (1 ktex = 1,000 tex), and is usually used for heavy products such as slivers.

If a sliver weighs 5 grams per metre, then the count of this sliver would be 5 ktex.

The tex system (tex, ktex, dtex) is the preferred standard system. By definition,

1 ktex = 1,000 tex = 10,000 dtex

Denier (g/9,000m)
Denier is also used extensively in the industry, particularly for manufactured fibres and silk. It is the mass in gram of nine kilometres, or 9,000 metres, of the product.

By definition,

1 dtex = 0.9 denier

If a 300 denier yarn is made up of 1.5 denier individual filaments, there will be a total number of $\frac{300}{1.5} = 200$ filaments in the yarn.

Indirect Count Systems

Indirect count systems are not as straightforward as the direct ones. In the early history of yarn manufacture, different spinners, often geographically and culturally isolated from one another, devised their own ways of measuring yarn thickness. Consequently, there are numerous indirect count systems that have been, and continue to be, used in the industry. Some examples are given below, together with the mass and length conversions,

Commonly used

- Metric (N_m)	m/g
- English Cotton (N_{ec})	No. of 840 yard hanks per pound
- Worsted (N_w)	No. of 560 yard hanks per pound

The metric count (Nm) is relatively straightforward. It is the length in metre of one gram of the product. For example, if one gram of yarn measures 40 metres, then the metric count of this yarn would be 40 Nm.

Similarly, if one pound of cotton yarn measures 1,680 yards, or two hanks of 840 yards, the English cotton count of this yarn will be 2 $N_{ec.}$ Please note that a hank of yarn is an unsupported coil consisting of wraps of yarn of a certain length.

The conversions between different units will be discussed later.

Less commonly used

- linen, hemp, ramie	No. of 300 yard hanks per pound
- asbestos	" " 50 " " " "
- glass	" " 100 " " " "
- spun silk	" " 840 " " " "
- raw silk (dunce)	" " 1000 " " " ounce

Occasionally used in the woollen industry

- Yorkshire skein	No. of 560 yard hanks per pound
- West of England	No. of 320 yard hanks per pound
- American cut	No. of 300 yard hanks per pound
- American run	No. of 100 yard hanks per ounce
- Dewsbury	No. of 1 yard hanks per ounce
- Galashiels	No. of 300 yard hanks per 24 ounces

You may wonder how the strange length units such as 840 yard hank and 560 yard hank came about. The first mass-production spinner – the spinning-jenny was able to spin yarns simultaneously onto several bobbins and filled the bobbins up at the same time. The bobbins were changed after 840 yards of cotton yarns were wound onto them. To estimate the thickness of the yarns, the spinner simply counted how many full bobbins were needed to balance a weight of one pound. For example, if 6 bobbins were needed to make up one pound, the yarn would be called a 6s yarn. Similarly a 20s worsted yarn means one pound of this yarn would fill up 20 bobbins, each with 560 yards of yarn wound on.

Conversion between Different Yarn Counts

It is often necessary to make conversions between different yarn count systems. For this purpose, the following mass (weight) and length conversions are needed:

1 yard (yd)	= 0.9144m	
1 pound (lb)	= 0.4536kg	
1 ounce (oz)	= 1/16	lb
1 dram 9dr)	= 1/16	oz
1 grain (gr)	= 1/7000	lb

Worked Examples

Question:
What is the conversion factor between worsted count (Nw) and tex ?

Solution:
According to definition, one worsted count (Nw) = one 560 yard hank per pound, or

$$1\ \mathrm{Nw} = \frac{1 \times 560\,\mathrm{yard}}{\mathrm{pound}}$$

Since 1 yard (yd) = 0.9144 m and 1 pound (lb) = 0.4536 kg, the above equation becomes,

$$1\ Nw = \frac{1 \times 560 \times 0.9144\,m}{453.6\,g} = \frac{512.064\,m}{453.6\,g} = \frac{1.12892\,m}{g}$$

Therefore, for a yarn of Nw worsted count, each gram of this yarn would measure 1.12892 times Nw meters. Since tex is the mass in gram of a 1,000 meters of yarn, we need the number of grams in 1000 m of the yarn.

$$\mathrm{No. of\ grams\ per\ 1000\,m\,(tex)} = \frac{1000}{1.12892\ \mathrm{Nw}} = \frac{885.8}{\mathrm{Nw}}$$

The above equation can also be written as: $Nw = \frac{885.8}{tex}$

So the conversion factor is 885.5.

Question:
If a yarn is 20 tex, what is the worsted count of this yarn?

Answer:

Using the conversion factor given above, the worsted yarn count is $\frac{885.8}{20} = 44.3\,Nw$.

Conversion between other count systems can be worked out in a similar way. Table 1.1 lists commonly used conversion factors. You may try to work them out yourself.

Table 1.1: Factors for Yarn Count Conversion

	DIRECT COUNT		INDIRECT COUNT		
	To Tex	To Denier	To Metric Count (Nm)	To Cotton count (Nec)	To Worsted Count (Nw)
From Tex		$9\times Tex$	$\frac{1000}{Tex}$	$\frac{590.5}{Tex}$	$\frac{885.8}{Tex}$
From Denier	$0.111\times denier$		$\frac{9000}{denier}$	$\frac{5135}{denier}$	$\frac{7972}{denier}$
From Metric count (Nm)	$\frac{1000}{Nm}$	$\frac{9000}{Nm}$		$0.5905\times Nm$	$0.8858\times Nm$
From Cotton count (Nec)	$\frac{590.5}{Nec}$	$\frac{5135}{Ne}$	$1.693\times Nec$		$1.5\times Nec$
From Worsted count (Nw)	$\frac{885.8}{Nw}$	$\frac{7972}{Nw}$	$1.129\times Nw$	$0.6666\times Nw$	

Moisture and Yarn Count

Regardless of the yarn count system used, it is necessary to measure the weight and length of a yarn in order to determine its count. But most fibres, particularly natural fibres, absorb moisture from atmosphere. The weight of the yarn will be different at different moisture level. The water content in textiles can be expressed as either **moisture content** or as **regain**. Their definitions are:

$$\text{Regain (R)} = \frac{\text{Mass of absorbed water in specimen (W)}}{\text{Mass of dry specimen (D)}} \times 100$$

$$\text{Moisture content (M)} = \frac{\text{Mass of absorbed water in specimem (W)}}{\text{Mass of original undried specimen (W+D)}} \times 100$$

From these definitions, the conversion between regain (R) and moisture content (M) can be worked out according to the equation below:

$$M = \frac{R}{1+R}$$

In commercial transactions, the mass to invoice is worked out on the basis of an agreed conventional regain level, not on the actual regain of the yarns (or other textiles) being traded. This is very important. Because, in the absence of an agreed conventional regain level, smart sellers may take advantage of the moisture absorption property of their textiles and rip the buyers off with large quantity of water in their products. The conventional regain levels, to be used for calculation of the legal commercial mass, have been established by national or international standards. These commercial regain values are purely arbitrary values arrived at for commercial purposes for interested parties, and they often vary from fibre to fibre and from country to country. In Australia, the conventional regain rates for some fibres are given in Table 1.2.

Table 1.2: Conventional regain rate for selected fibres

Fibre	Conventional regain (%)
Wool and hair fibres	
• Combed (worsted)	18.25
• Carded (woollens)	17
Cotton	
• Normal cotton	8.5
• Mercerised cotton	10.5
Silk	11
Polyester	
• Staple fibre	1.5
• Continuous filament	1.5

Conditioning the whole lot of yarns or other textile materials to the conventional regain rates given above is not practical, because of the time required etc. In calculating the commercial mass to invoice for a lot, the following procedures are often followed:

(1) Extract a sample of mass (gw) from the lot (whose total gross weight is GW)
(2) Determine the dry weight (dw) of the sample by oven drying to completely evaporate the moisture contained in it.
(3) Calculate the commercial mass to invoice (cw), based on a conventional regain R%, by means of the formula:

$$cw = GW \times \frac{dw}{gw} \times \frac{100 + R\%}{100}$$

The following example illustrates this point.

Example:

Suppose a lot of worsted yarn is to be shipped to a buyer, and the gross weight of lot is 1000 kg. We now need to work out the commercial mass to invoice for the lot of yarn.

Answer:

We first extract a small sample (say 500 grams) from the lot. After oven drying of this small sample, the dried mass becomes, say, 450 grams. For worsted yarn, the conventional regain rate is 18.25% according to Table 1.2. Therefore, the commercial mass to invoice should be:

$$1000 \times \frac{450}{500} \times \frac{100 + 18.25}{100} = 1064.25\,(kg)$$

This suggests that the merchandise is actually drier than the conventional value. Had 1000 kg been used as the mass to invoice, the supplier would have been at a loss.

Yarn twist

In the manufacture of staple fibre yarns, twist is inserted into the fine strand of fibres to hold the fibres together and impart the desired properties to the twisted yarns. Without twist, the fine strand of fibres would be very weak and of little practical use. A change in the level of twist also changes many yarn properties, such as strength and softness. This topic describes the nature of yarn twist, the effect of twist on yarn properties, as well as twist measurement.

Nature of twist

Types of twist
There are two types of twist: real twist and false twist.

(1) Real twist
To insert a real twist into a length of yarn, one end of the yarn should be rotated relative to the other end, as indicated in figure 2.1(a).

Spun yarns usually have real twist, which holds the fibres together in the yarn.

(2) False twist
When inserting false twist into a length of yarn, both ends of the yarn are clamped, usually by rollers, and twist is inserted with a false twister between the clamping points, as indicated in figure 2.1(b).

If the yarn is not traversing along its axis, the twist will be in opposite directions above and below the false twister. If the false twister is removed, the opposite twists will cancel out one another, leaving no real twist in the length of yarn. If the yarn is traversing along its axis, then the section of the yarn moving away from the false twister would have no net twist, as indicated in figure 2.1(b).

False twisting is a very important phenomenon, which has considerable practical implications in yarn technology. False twisting is featured in many key processes that we will discuss later, including woollen ring spinning, open-end rotor and friction spinning, air jet spinning, and filament yarn texturing.

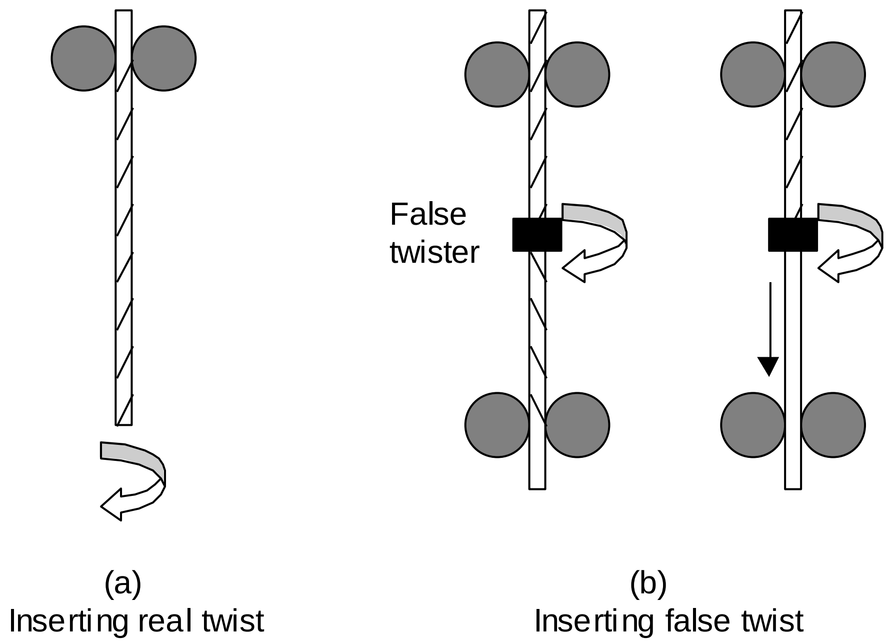


Figure 2.1 Real twisting and false twisting

Twist direction

A twist can be either in Z direction or S direction as indicated in figure 2.2, depending on the orientation of the surface fibre in relation to yarn axis.

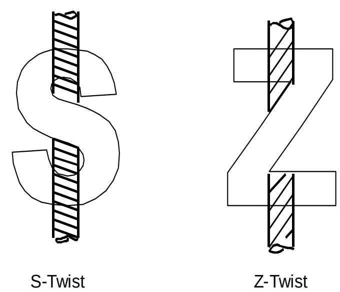


Fig. 2.2: Twist direction

It is worth noting that twist direction affects fabric properties. For example, Figure 2.3 shows two identical twill-weave fabrics with the warp yarn of different twist direction. Fabric A will be more lustrous than fabric B, because light reflected by fibres in the warp and weft is in the same direction. Fabric A will be softer while fabric B firmer, because in Fabric B, the surface fibres on the warp and weft in the region of contact are aligned in the same direction and they may ‘get stuck’ inside each other and reduce the mobility of the intersection. Whereas for fabric A, the surface fibres on the warp and weft in the region of contact are crossed over, and they can move about easily. The freedom of movement at the yarn intersections is the key for fabric softness.

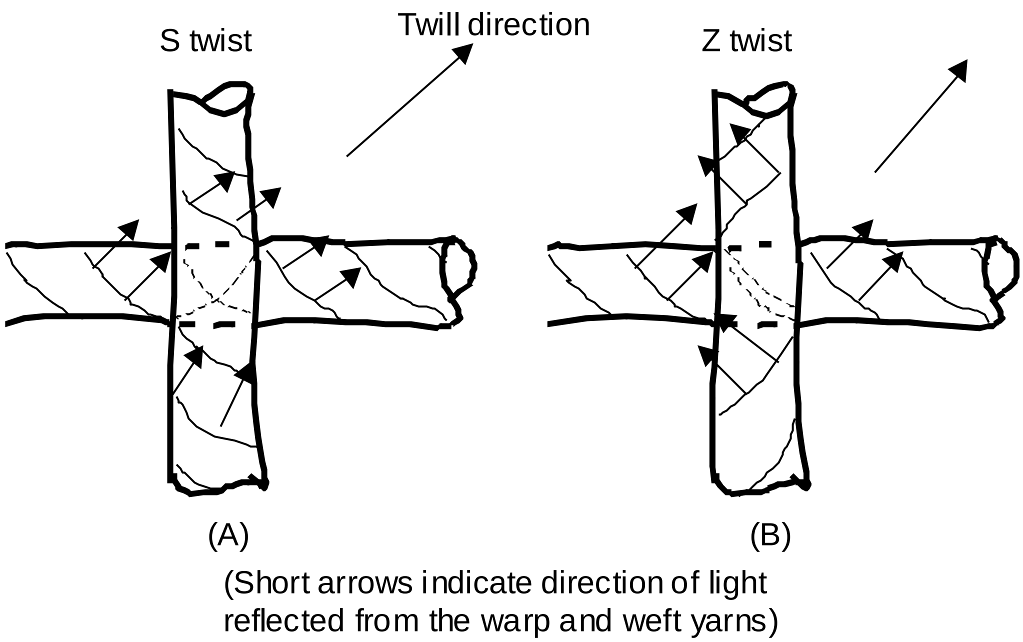


Fig. 2.3: Effect of twist direction on fabric properties

Self-locking effect

Because of twist in a yarn, the fibres on yarn surface take a roughly helical configuration around the yarn. When the yarn is under tension, these surface fibres are also under tension. However, because of the helical configuration, part of the tension is diverted radially, which creates a radial pressure. The radial pressure tends to pack the fibres together, increasing the normal force between them, and so increasing their frictional resistance to slipping past each other. The more tension is applied to the yarn, the more it locks together, hence 'self-locking'. An analogy is, when you wind a string around your arm, as you pull the string along the arm and away from each other, the string bites deeper into the flesh.

Without twist, there won’t be any self-locking effect to prevent fibre slippage. Consequently the yarn would have no strength.

Effect of twist level on yarn strength

The level of twist is usually expressed in number of turns per metre (tpm). Number of turns per inch or twist per inch (tpi) is also used in the industry.

More twist gives greater radial component to any applied tension, so increases resistance of fibres to slip and the strength of yarn increases as a consequence. This is depicted by the '**coherence curve'** in figure 2.5.

On the other hand, if a bundle of parallel filaments is twisted, the twist will put the individual filaments under torsional stress. This stress weakens the filaments and the strength of the filament would decrease as the level of twist increases. This is depicted by the **'obliquity curve**' in figure 2.5.

For staple fibre yarns, these two curves combine to give the actual **'twist-strength curve'** for a staple fibre yarn as shown by the heavy line in figure 2.5.

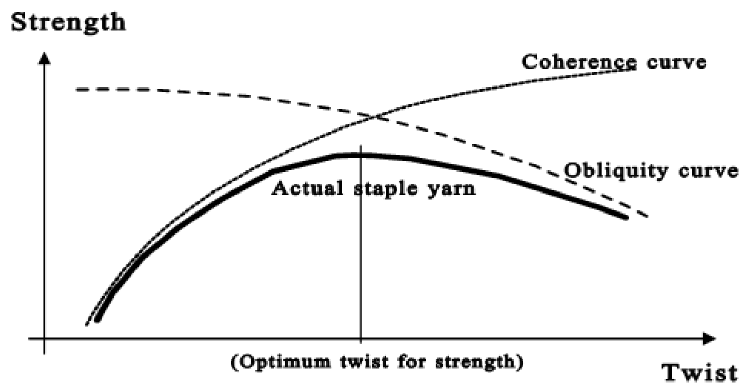


Fig. 2.5: Effect of twist level on the strength of staple (spun) yarn

Figure 2.5 indicates that for staple fibre yarn, increasing the twist level will increase yarn strength to a maximum level, beyond which further increase in twist will reduce yarn strength.

It should be noted that for continuous filament yarn, the obliquity curve applies. In other words, twisting a continuous filament yarn only reduces the yarn strength, regardless of the twist level used. If a continuous multi-filament yarn is twisted, the reason for the twist is to keep the individual filaments together, not for strength.

Twist angle

This is the angle of fibres to yarn axis, and this angle varies throughout yarn, from zero at centre to maximum at yarn surface. The fibres on yarn surface are the most important, as they bind the others into the yarn (refer to self-locking effect discussed earlier).

While it is not common practice to measure the yarn twist angle, the surface twist angle made by the surface fibres in relation to yarn axis is a very important parameter. It determines the essential yarn characteristics such as yarn softness, yarn bulk etc, which in turn govern many essential fabric properties. The following example illustrates the point.

In figure 2.6, yarn 1 and yarn 2 have the same twist level – one turn each. But the surface fibre on the thicker yarn is obviously stretched more to accommodate this twist. This would mean the thicker yarn is more closely packed. As a consequence, yarn 2 will not be as soft as yarn 1. In other words, even though the twist level is the same in these two yarns, the yarn characteristics are quite different. Therefore, we can not simply use twist level to represent yarn character. However, the surface twist angles of yarn 1 (θ_1) and yarn 2 (θ_2) are different. They can better reflect the yarn characteristics, regardless of the difference in yarn thickness.

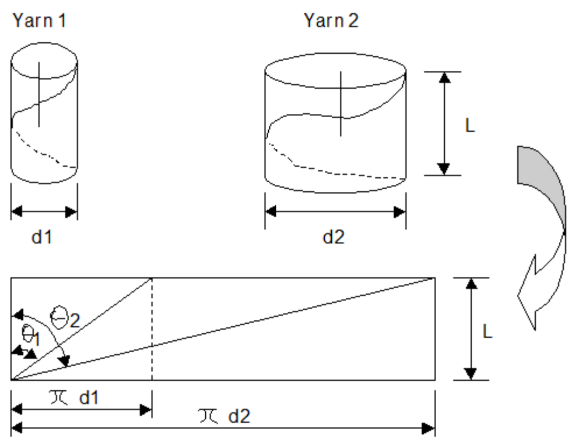


Figure 2.6 Two yarns of the same twist level, but different surface twist angles

Twist factor (Twist multiplier)

This is a very important factor that relates to the angle of twist helix the surface fibres have in a yarn. As we will see later, this factor is very important for a spinner because of the following reasons:

- Like surface twist angle, it governs the yarn characteristics
- It is used to work out the twist to use in spinning, in order to maintain the same surface twist angle and similar yarn characteristics when the yarn count is changed. The twist worked out from twist factor is also needed for setting up the spinning machine.

But how do we relate the twist factor to surface twist angle and how to choose the right twist factor then?

Relate twist factor to twist angle
Because it is much easier to measure twist level in turns per metre than twist angle, we should relate twist level to twist angle.

From figure 2.6, we get,

$$\tan\theta = \frac{\pi d}{L}$$

Also from figure 2.6, the height (pitch) of one turn of twist is L. Since the twist level is normally specified as the number of turns per metre, the twist level in one metre of the yarn would be:

$$twist = \frac{1}{L}$$

so

$$\tan\theta = \pi d \ x \ twist \qquad (1)$$

We also know from experience that yarn diameter is also very hard to measure, because textile yarns by their very nature are soft and squashy. On the other hand, yarn count is normally used as we have discussed in the first topic of this module. But we can relate yarn diameter to yarn count using the expression below:

cubic density (ρ) = linear density (Tex) / cross-sectional area (A)

Assuming a circular cross section for the yarn, we get,

$$\rho\,(g/\,m^3\,) = \frac{Tex\ \ x\,10^{-3}\,(g/m)}{A(\,m^2\,)} = \frac{Tex\ \ x\,10^{-3}}{\pi\; d^2/4}$$

Solve for d:

$$d^2 = \frac{4\,Tex\ \ x\,10^{-3}}{\rho\pi} \qquad (2)$$

Combining equations (1) and (2):

$$twist = \frac{\tan\theta}{2\pi\,\sqrt{tex\ \ x\,10^{-3}\,/\,\rho\pi}}$$

or $$twist\ = \frac{K}{\sqrt{tex}} \quad \text{where} \quad K = 0.5\tan\theta\,\sqrt{\rho\,10^3\,/\pi} \quad (t.p.m\,\sqrt{tex}\ )$$

K is called the twist factor, and is proportional to θ if ρ remains constant.

Thus, K is a factor relating twist level to yarn count. The derivation shows that if two yarns have the same twist factor, they will have the same surface twist angle, regardless of count. Since surface twist angle is the main factor determining yarn character, then twist factor can be used to define the character of a yarn.

It is worth noting though there are minor errors associated with the use of twist factor for the following reasons:

- The cubic density may be different for different yarns. It is assumed in the above calculation that this will not change for yarns of the same surface twist angle.
- Different fibres with different frictional and other properties will create different yarn character.

Nevertheless, the relationship we have just derived between twist, twist factor and yarn count is one of the most important in the study of yarn technology. This relationship is
Expressed in different ways for different yarn count systems.

For the tex system:

$$Twist\,(turns\ per\ metre) = \frac{Twist\ Factor\ (K_t)}{\sqrt{tex}}$$

For the metric count (Nm) system (the twist factor for the metric count system is also known as **alpha metric - α_m**):

$$Twist\,(turns\ per\ metre) = Twist\ \ Alpha\,(\alpha_m)\,\sqrt{Nm}$$

For English cotton (Nec) count system:

$$Twist\,(turns\ per\ inch) = Twist\ \ Factor\ (K_e)\,\sqrt{Nec}$$

For worsted count (Nw) system:

$$Twist\,(turns\ per\ inch) = Twist\ \ Factor\ (K_w)\,\sqrt{Nw}$$

Please note the unit for twist is also different in the above expressions of twist factor. In addition, twist factor is also known as twist multiplier, twist alpha, or twist coefficient.

Choice of twist factors

Yarns intended for different end uses have different characteristics. Since twist factor (like surface twist angle) determines yarn characteristics, the choice of twist factor is often governed by the intended use of the yarns. If maximum yarn strength is of the utmost importance, one would obviously choose the optimum yarn twist (see figure 2.5) and the optimum twist factor for strength. However, the end-use of yarn may be such that other properties may be more important. For example, a yarn to be used for weft or for hosiery may be required to be soft and bulky and therefore a low twist factor is used. A yarn to be used for the production of voile or crepe fabric will necessitate the use of a high twist factor. If one considers staple yarns for the production of plied or cabled sewing threads then soft twisted single yarns are used and this results in the highest strength in the final thread. Another important feature to consider is that the productivity for spinning yarns of lower twist factor is higher. For these reasons, the majority of yarns are spun with a twist factor lower than the optimum twist factor for maximum strength. Table 2.1 shows the twist factor most commonly used for the various types of yarns.

Table 2.1: Twist factors most commonly used

Yarn	Tex count $K_t \ (\sqrt{tex} \times tpm)$	Metric count $K_m \ (\frac{tpm}{\sqrt{Nm}})$ (alpha metric - α_m)	English cotton count $K_e \ (\frac{tpi}{\sqrt{Ne}})$
COTTON			
- Soft knitwear	2400 - 2900	77 - 92	2.5 – 3
- Weft	2900 - 3400	92 - 108	3 – 3.5
- Warp	3900 - 4300	124 - 139	4 – 4.5
- Warp/extra strong	5300 - 6300	170 - 201	5.5 – 6.5
- Crisp	6800 - 8700	216 - 278	7 – 9
WORSTED			
- Knitwear	1700	54	
- Soft	2000	63	
- Medium	2300	73	
- Strong	2600	82	
- Extra strong	2900	92	

Please note these are reference values only, and the recommended values vary from source to source.

Once a twist factor is chosen, the level of twist required for the yarn can be calculated for a given yarn count. This twist level is then used to set up the spinning machine for yarn production.

The distribution of twist in staple spun yarns

If someone twists your head, it is your neck that suffers most. That is because the neck is a 'thin' place and offers little resistance to being twisted. By analogy, if a yarn of varying thickness is twisted, it is usually the thin spot in the yarn that gets twisted the most. Invariably, yarns spun from staple fibres (eg. wool, cotton) are not perfectly uniform, and there are thick and thin spots along the yarn length. This variation in yarn thickness will lead to variation in the twist level along the yarn length, because twist tends to accumulate in the thin place.

The fact that twist tends to accumulate in the thin spot along the yarn has several important implications:

- It exacerbates the variation in yarn linear density

  While variation in yarn linear density is the fundamental cause of twist variation, concentration of twist in the thin places will make those places even thinner, exacerbating the problem of yarn unevenness.

- It improves the evenness of a fibre assembly during "drafting against twist"

In the drafting stage of woollen ring spinning, the woollen slubbing is drafted while twist is inserted into the slubbing (drafting against twist) to control fibres during drafting. Because twist tends to accumulate in the thin spots, the fibres in thin regions in the slubbing are more difficult to draft than those in the thick places, which have less twist. As a result, the thick places are drafted more than the thin places, thus improving the evenness of the drafted material. This is depicted in figure 2.7.

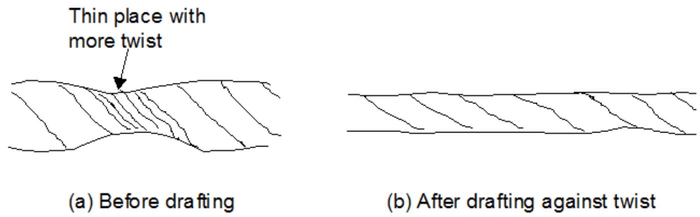


Figure 2.7 'Drafting against twist' improves evenness

- It has implication for twist measurements

  Because the twist level varies along the yarn length, the twist measured at a short length of yarn may not reflect the true average twist of the yarn. Standard test procedures should be followed to measure the yarn twist accurately.

The relationship between twist and yarn count may be expressed by the following formula:

$$Twist \propto \frac{1}{Tex^{p}}$$

where p is usually greater than 1 but less than 2 for most yarns.

Twist contraction

When a bundle of parallel fibres is twisted, the distance between the two ends of a fibre will decrease, particularly for fibres near the surface of the twisted bundle. As a result, the overall length of the twisted bundle is shorter than its length before twist insertion. The reduction in length due to twist insertion is known as twist contraction.

The following formula is used to calculate the amount of twist contraction:

$$\%\ contraction = \frac{L_o - L_f}{L_o} \times 100\,\%$$

where Lo = original length before twisting
Lf = final length after twisting

It should be noted that because of twist contraction and the associated change in length, the count of a yarn will change slightly when twist in the yarn is changed. Twist contraction increases yarn count (tex), because the weight of the yarn is distributed over a shorter length. The following formula can be used

$$N_f = \frac{N_o}{1 - C}$$

where No = count (tex) before twisting
Nf = count (tex) after twisting
C = %contraction

Measurement of twist

Twist measurement is a routine test for yarns. Because of the variation in twist along yarn length as discussed earlier, care should be taken in measuring the twist of staple spun yarns. Some basic principles are discussed here.

Sampling rules
The following rules should be observed when measuring yarn twist:

a. Tests should not be limited to a short length of the yarn package.

b. Beware of "operator bias" **-** tendency to select either thicker or thinner regions. Taking samples at fixed intervals along the yarn length will reduce the bias.

c. Discard first few metres from package. Being a free end, it could have lost twist.

d. Remove yarn from side of package, not over end. Removing yarn over end will change the twist level in the yarn.

e. Tension in Yarn during test
e.g. For single worsted yarns: 5 ± 1 mN/tex

Principles of measuring methods
The two common methods used in twist measurement are **straightened fibre method** and **untwist/retwist** method.

(1) Straightened fibre method

This method involves counting of the number of turns required to untwist the yarns until the surface fibres appear to be straight and parallel to yarn axis. This method is mainly used for ply and continuous filament yarns.

(2) Untwist / Retwist Method

This is the common method used for staple fibre yarns. It is based on twist contraction (hence also known as twist contraction method).

For this method, it is assumed that the contraction in length, due to insertion of twist, is the same for both direction of twist (S and Z). Suppose we want to measure the twist level in a yarn with Z twist, the yarn is first untwisted (by a twist tester), and a counter on the twist tester will record the number of turns. During untwisting, the yarn would increase in length from its original length L to a new length L'. If the operation is continued, the yarn would have its twist completely removed first and then twisted up again in S direction. As the yarn gets twisted, its length will decrease (twist contraction) from L' towards its original length L. When its original length is reached, the total number of turns received by the yarn, as recorded by the counter on the twist tester, would be equal to twice the twist in the original yarn (with a length of L).

Automatic twist testers are now available, such as the Zweigle automatic twist tester.

The designation of yarn structures

The yarns can be spun yarns or filament yarns. They may be single, folded or cabled yarns.

Systems and rules

Two systems can be used for yarn designation.

Single-to-fold notation (preferred)
This is the preferred system, where single component of the yarn is described first, followed by a description of how the components are combined together to make up the resultant yarn.

Fold-to-single notation
This notion is opposite to the single-to-fold notation. The whole structure is described first, followed by a description of its components.

General rules
The following general rules should be noted:

- Use tex for staple spun yarns and dtex for filament yarns
- "fn" indicates n filaments in a single mono (n=1) or multifilament yarn.
- "t0" indicates components combined without twist
- "Rxyz tex" specifies the "resultant" count of the yarn (xyz tex) in its final form.
- specification after a semi-colon is optional

The following sections list examples of yarn designations.

Single yarns

A single yarn, or singles yarn, may be a spun yarn (or staple yarn), a mono-filament yarn, or a multi-filament yarn. The ways of designating these different single yarns are given below.

Spun yarns
The details used in the designation of spun yarns include:

(a) Linear density (tex)
(b) Direction of twist (S or Z)
(c) Amount of twist (turns per metre)

For example, the designation <u>40 tex Z 660</u> describes a spun yarn that has a count of 40 tex, with a twist level of 600 turns per metre, and the twist is applied in Z direction.

Mono-filament yarns
The details used in the designation of mono-filament yarns include:

(a) Linear density (dtex)
(b) Symbol f
(c) Symbol t0 if not twisted; otherwise twist direction and amount

For example, the designation <u>17 dtex f1 t0</u> describes a mono-filament (f1) yarn with a count of 17 dtex, with any twist (t0) in the yarn.

Similarly, the designation 17 dtex f1 S800; R17.4 dtex describes a mono-filament yarn with an initial count of 17 dtex. After applying a twist of 800 turns per metre in the S direction, the resultant count of the filament becomes 17.4 dtex. Please note that the increase in count is due to twist contraction.

Multifilament yarns

The details used in the designation of multi-filament yarns include:

(a) Linear density
(b) Symbol f
(c) Number of filaments
(d) Symbol t0 if not twisted; otherwise twist direction and level
(e) Resultant linear density

For example, the designation 140 dtex f40 t0 means a multi-filament yarn with a count of 140 dtex, consisting of 40 individual filaments which are not twisted. Please note that the linear density of each individual filament will be $\frac{140}{40} = 3.5\,dtex$.

Similarly, the designation 140 dtex f40 S100; R146 dtex means the same multi-filament yarn as described above. But this time, the 40 individual filaments are twisted in S direction with a twist level of 100 turns per metre. Because of twist contraction, the resultant count of this multi-filament yarn becomes 146 dtex.

Multiple wound yarns

These are the yarns that have several components wound up together, without inserting any twist. This is also known as **assembly wound** yarns

Multiple wound yarns with similar components

The details used in the designation of such yarns include:

(a) Notation according to single yarn used
(b) Multiplication sign, ×.
(c) Number of single yarns laid together
(d) Symbol t0

Example: 40 tex S155 × 2 t0
(two 40 tex yarns, each with 155 turns per metre in S direction, wound together without twist)

Multiple wound yarns with dissimilar components

The details used in the designation of such yarns include:

(a) Notation according to single yarn used, connected by the addition sign + and put in brackets
(b) Symbol t0

Example: (25 tex S420 + 60 tex Z80) t0 (Can you describe this yarn?)

Folded or plied yarns

These are the yarns that have several components twisted up together.

Folded yarns having similar components

The details used in the designation of such yarns include:

(a) Notation according to single yarn used

(b) Multiplication sign, ×.
(c) Number of single yarns twisted together
(d) Direction of folding twist
(e) Amount of folding twist
(f) Resultant linear density

Example: 34 tex S600 × 2 Z400; R69.3 tex
(a singles yarn of 34 tex with a twist of 600 turns per metre in S direction is twisted together with another yarn of the same descriptions. The folding twist is 400 turns per metre in Z direction, and the resultant yarn count is 69.3 tex (slightly higher than 34 x 2 due to twist contraction.)

Folded yarn having dissimilar components
The details used in the designation of such yarns include:

(a) Notation according to single yarn used, connected by the addition sign + and put in brackets
(b) Direction of folding twist
(c) Amount of folding twist
(d) Resultant linear density

Example: (25 tex S420 + 60 tex Z80) S360; R89.2 tex
(Can you describe this yarn?)

Cabled yarns
Cabled yarns have several components, which can be either similar or dissimilar in structures.

Cabled yarns having similar components
The details used in the designation of such yarns include:

(a) Notation according to folded yarn used
(b) Multiplication sign, ×.
(c) Number of folded yarns cabled together
(d) Direction of cabling twist
(e) Amount of cabling twist
(f) Resultant linear density

Example: 20 tex Z700 × 2 S400 ×3 Z200; R132 tex

Cabled yarns having dissimilar components
The details used in the designation of such yarns include:

(a) Notation according to single and folded yarns used, connected by the addition sign + and put in brackets.
(b) Direction of cabling twist
(c) Amount of cabling twist
(d) Resultant linear density

Example: (20 tex Z700 × 3 S400 + 34 tex S600) Z200; R96 tex

Single-to- fold versus fold-to-single notations
So far we have used the preferred single-to-fold notation for yarn designation. Examples of fold-to-single notation are given below, together with their equivalent single-to-fold notation.

Example one -
133 dtex f40 S 1000; R 136 dtex (single-to-fold)
R 136 dtex f 40 S 1000; 133 dtex (fold-to-single)

This describes a multifilament yarn of 136 dtex after twisting to 1000 t/m in the S direction. Before twisting, the count was 133 dtex, and the individual filament linear density is 133/40 = 3.3 dtex.

Example two

20 tex Z 700 x 2 S 400 x 3 Z 200; R 132 tex (single-to-fold)
R 132 tex Z 200 / 3 S 400 / 2 Z 700; 20 tex (fold-to-single)

This describes a cabled yarn built up from a singles yarn of 20 tex with 700 t/m Z, plied with itself with 400 t/m S, which is subsequently three-plied with 200 t/m Z twist.

Example three

(25 tex S 420 + 60 tex Z 80) S 360; R 89.2 tex (single-to-fold)
R 89.2 tex S 360 / (S 420 + Z 80); 25 tex + 60 tex (fold-to-single)

This describes a two ply yarn with dissimilar components, plied together in the S direction with 360 t/m.

Finally, the following points are worth noting:

(1) The resultant count is of most use to the user of the yarn
(2) In textile mills, abbreviated notations are often used, i.e. R40/2 tex
(3) For indirect count systems, the single yarn count is normally given, i.e.
2/20 or 20/2 (2-fold 20s); 3/2/60 (3-fold, 2-fold 60s, cabled yarn).