



Premkumar Govindarajulu
Process Analytic
Rieter Machines & Systems

Harald Schwippl
Head Technology
Rieter Machines & Systems



Flexibility of Ring Spinning with Compact-Twin Technology and its Application Range in Knitting

Part 1

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1 Introduction

The ring spinning technology is the most flexible spinning system as far as fibres raw material, yarn count and yarn structures are concerned. Depending on the spinning technology, the established range with conventional ring spinning of Ne 4.5 – Ne 200 (130 tex – 3 tex) and with compact spinning of Ne 20 to Ne 250 (30 tex – 2.4 tex) is adequate in practice (Fig. 1).

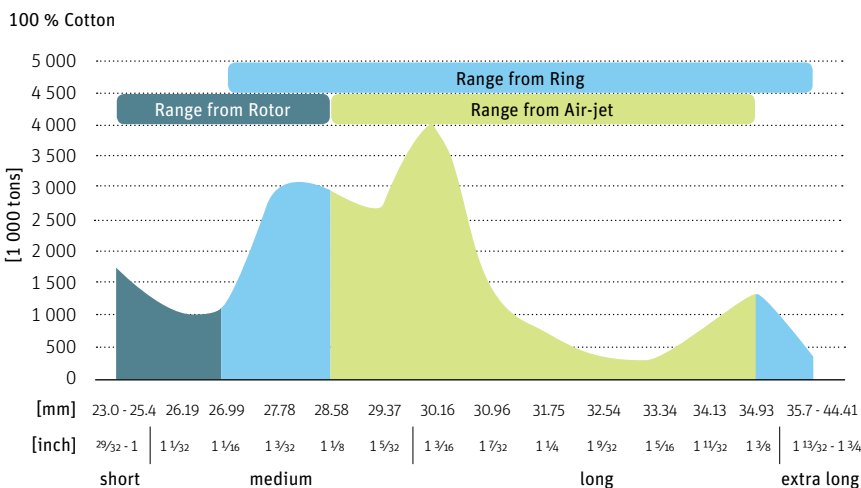
Ring spinning since 1832
Com4®ring yarn
 Ne 4.5 – 200
 cotton, linen, cellulosic, synthetics and blends

Compact spinning since 1997
Com4®compact-ring yarn
 Ne 20 – 250
 cotton, cellulosic, synthetics and blends



Fig. 1 Ring spinning is the most flexible spinning technology

Processing range of spinning technologies



Using the example of cotton, the application range of all end spinning systems can be divided up according to fibre length. It is evident, that the ring spinning technology offers the highest versatility in application range with respect to fibre length. The relative spin-out limits determined by yarn count are limited within a spinning technology, by the raw material and its fibre properties (Fig. 2).

Fig. 2 The fibre length is influencing the application range of the 4 spinning technologies (AFIS Autojet Staple UQL (W) mm)

For spinning various raw materials, the ring spinning offers highest versatility in comparison to the other end spinning technologies.

In this connection, the use of natural fibres or fibres from natural polymers provides a very wide spectrum. In contrast, the processing of synthetic fibres such as Polyester has certain limitations with compact and air-jet spinning (Fig. 3).

Application of spinning technology depends on raw material

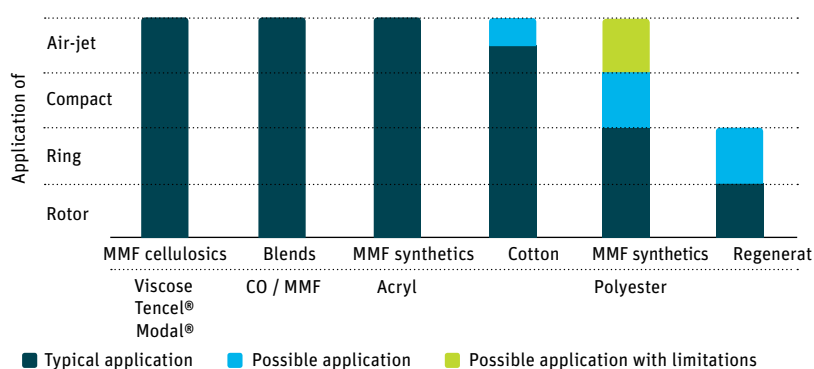


Fig. 3 Ring and rotor spinning are suitable for a wide range of applications

The technology of ring spinning is very flexible. Compared to other technologies, ring spinning can process the most varied raw materials and cover the widest range of yarn counts. In addition, it allows special structures to be produced. Additional installations allow spinning of conventional twin yarn, compact yarn, compact twin yarn, fancy yarn as well as soft and / or hard core yarns.

Special yarn structures such as twin yarn within the ring spinning technology are, of course, not a mass-market product. It would therefore be wrong to assess the technological feasibility for a product or the application of high flexibility with the respective market volumes.

Ultimately, the decision with which product the spinner can successfully supply his customer lies with the yarn manufacturer, whereby the textile machine manufacturer together with the fibre manufacturer must provide the corresponding flexibility.

The production of special yarn structures or yarn designs by means of the ring spinning technology offers opportunities to realise new areas of application. Alongside the already successful application of special yarn designs for technical textiles, new usages in the field of apparel also constantly emerge.

Potentials are then especially extended or created when the respective yarn structures are combined with new raw materials or new fibre characteristics with new product characteristics.

For this reason, thanks to the very high flexibility of the ring spinning technology, the manufacture of a twin yarn will be examined.

With the examination, the following combinations and their effects on the end product will be analysed:

- raw material Micro Modal® Air from Lenzing
- the influence of very fine fibres
- the production of very fine yarns

In the first part of the analysis, the end application relates to the manufacture of high-quality and special knitted fabrics for outerwear. The insights and results gained from the spinning process through to the characteristics in the knitted fabric will be illustrated.

Basic information regarding

- the importance of cellulosic raw materials in the market
- the characteristics of Modal® and microfibres
- the fundamentals of twin yarn manufacture is given in advance

2 Importance of Cellulosic Fibres in the Market

Cotton production with approx. 20 million tons per year has remained relatively constant over the years. In 2005 cotton production rose to a record level of 26 million tons. Cotton is still the dominant raw material for short staple spinning. The increasing worldwide fibre consumption will primarily be satisfied in the mid- and long-term by man-made fibres. Within the group of man-made fibres, synthetic fibres presently occupy first place with a current level of 18 million tons per year. The production of man-made fibres from renewable plant-based raw materials, which are allocated to the category of the cellulose fibres, already reached almost 5.5 million tons in 2013. It is assumed that in the future, a continuous growth can also be expected (Fig. 4).

Staple fibre production worldwide

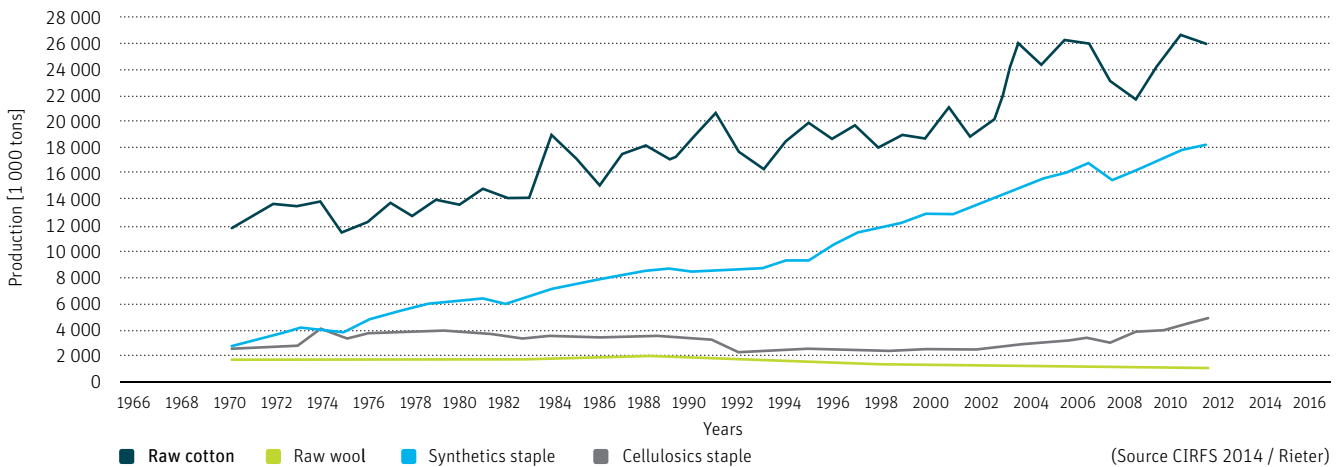


Fig. 4 Staple fibre production from 1969 until today. The share of synthetic fibres is continuously growing

Raw materials from cellulose such as viscose, Lenzing Modal® and TENCEL®, are excellent alternatives to cotton. They surpass many a positive characteristic of cotton and play an increasingly important role in the textile market. These properties are pleasant wearing comfort, moisture absorbency and anti-bacterial effect to mention just a few (Fig. 5).

The application covers:

- fashionable outerwear
- underwear
- bedding
- towels
- medical technology products
- upholstery fabrics
- etc.



Fig. 5 Raw materials from cellulose such as viscose, Lenzing Modal® and TENCEL®, are excellent alternatives to cotton

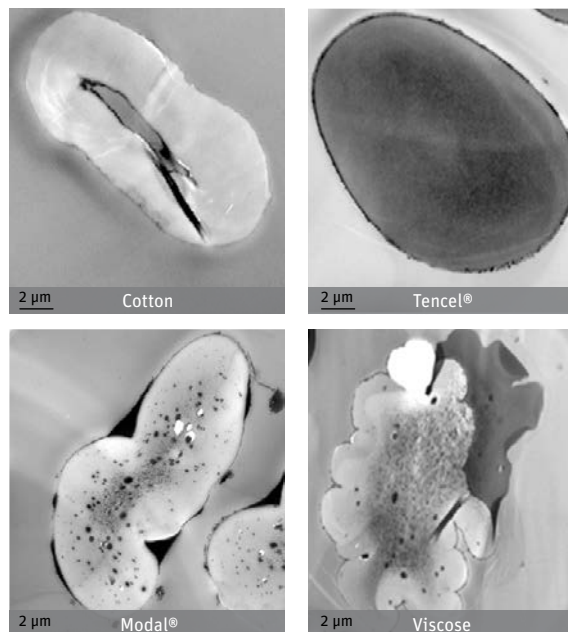
3 The Raw Material Modal® and the Fibre Structure

The fibre cross-section and the moisture absorbency of Modal® greatly differ from cotton, viscose and TENCEL® and synthetic fibres.

The moisture distribution within a fibre and absorption amount can be seen by the dark points and areas (Fig. 6). Here can be clearly seen that TENCEL® has the highest absorption capacity, followed by Modal®. The corresponding distribution of moisture takes place in the fibre cross-section and the respective pores. The extremely uniform moisture distribution of TENCEL® is equally the reason for the extraordinarily low bacterial growth.

With cotton, viscose or Modal®, the moisture is only concentrated in individual areas in the fibre cross-section. As opposed to the cellulose fibres mentioned, with synthetic fibres moisture collects only on the fibre surface from where, however, it more quickly evaporates. The concentration of the moisture on the surface of synthetic fibres offers higher growth conditions for certain groups of bacteria.

According to the function which the end product must fulfil, the optimal raw material or a combination can be accordingly selected.



Black color = Water absorption and distribution

Fig. 6 Microscopic photos of the fibre cross section show die different absorption capability of the fibres. Source; Lenzing AG Austria

| | Viscose | Lenzing Modal® | TENCEL® |
|--|---------|----------------|---------|
| Tenacity cond. [cN/tex] | 25 | 35 | 37 |
| Elongation cond. [%] | 20 | 13 | 13 |
| Tenacity wet [cN/tex] | 13 | 20 | 30 |
| Elongation wet [%] | 23 | 15 | 15 |
| Bisfa modulus | 3 | 3 | 10 |
| Degree of whiteness | 90 | 89 | 87 |
| Natural moisture content [%] (65 % rel. H) | 11 | 11 | 11 |
| Polymerisation degree DPv | 430 | 640 | 850 |

TENCEL® fibres exhibit by far the highest dry and wet tenacity. Compared to Viscose fibres, Lenzing Modal® fibres also possess a clearly increased dry and wet tenacity.

As already mentioned, Lenzing Modal® is characterised by its additional softness compared to cotton, Viscose and TENCEL®. Its area of application is therefore also found in the range of textiles which are worn next to the skin such as knits, outerwear, underwear and socks or home textiles such as hand towels.

The softness, which is already defined by the raw material, can be significantly increased by additionally including fine fibres.



Microfibres make possible the spin-out of very fine yarns at a low ends down rate on the end spinning machine, due to the higher number of fibres in the yarn cross-section. In addition, the very fine fibres create a soft, silky touch in the finished product.

The advantages of microfibres can be categorised as follows:

Spinning stability:

- allows spinning of fine and strong yarns

Applications:

- sports sector for waterproof, airtight and breathable clothing
- lower fabric weight with the same functionality
- outerwear

Features in knitted and woven fabrics:

- silky appearance
- feels silky
- soft touch
- high sheen
- very good moisture transport

4 Principles of Ply Yarn Manufacture

Conventional ply yarn today combines many positive yarn properties, the sum of which cannot be achieved by single yarn.

The structure of a ply yarn is essentially a combination of two or more finished spun yarns where the direction of the ply twist is opposite to that of the spin twist. By means of this process, a two-ply is still often considered as the benchmark for the best possible quality.

The characteristics and advantages of a conventional ply yarn compared to a compact single yarn with the same count can be shown as follows:

- high tenacity
- high mass uniformity
- high washing resistance
- soft fabric drape

The twisted yarn structure is divided into one-stage and multiple-stage plies. With one-stage ply yarns, several single yarns – mostly 2 single yarns – are assembled and in a further process are ply-twisted.

As with the single yarn, the twist direction with ply-twisting is defined in S or Z twist. The twist direction is usually opposite the twist imparted with spinning. The ply twist is categorised in loose, normal and hard whereby the number of twists with ply twisting mostly corresponds to 80 - 100 % of the yarn twist (Fig. 7).

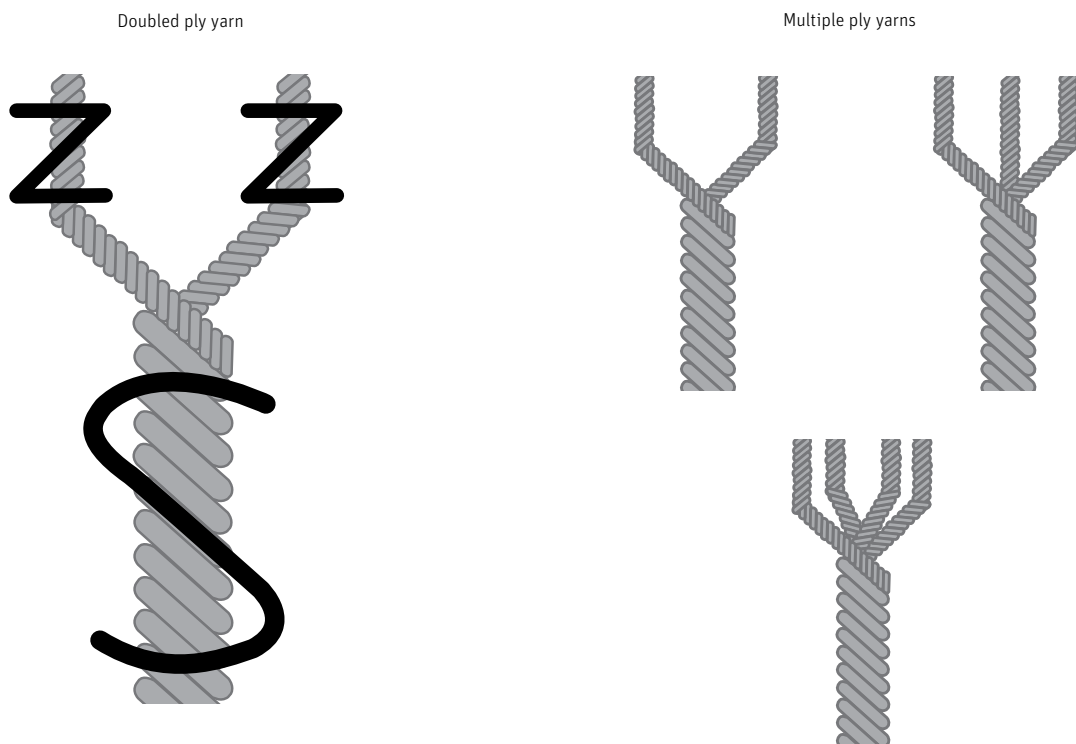


Fig. 7 Principle of ply yarn

Twin yarns, on the other hand, are only twisted in one direction and are produced under another yarn manufacturing principle. The yarn structure is already determined on the ring spinning machine. The spindle speed on the ring spinning machine in this case is lower than with a single yarn, as the yarn tension has to be adjusted to the yarn count and yarn twist which is given in a yarn shank.

As a result of the different yarn manufacturing processes of a ply yarn and a twin yarn, differences arise in the yarn optic as well as the fabric quality. Nevertheless, the properties of a twin yarn are very close to those of a two-ply yarn and can even surpass these. Depending on the application, two-ply yarn is not always necessary and can be replaced by a twin yarn. However, a two-ply yarn is the most expensive variant of a yarn structure, because of the additional processes.

The manufacture of twin yarn was developed and introduced many years ago on conventional ring spinning machines. One reason was to provide an alternative for the two-ply yarn and another was to improve certain quality features of the single yarn.

Within a short period of time, a clear demand for this yarn structure has become obvious. However, the market introduction was very slow. The reason was the unsatisfactory operating reliability. Spin-twist yarn led to a higher ends down rate and faults when only one yarn component broke and the second continued to run uncontrolled.

With the introduction of the compact spinning technology, however, decisive advantages have resulted for the production of a twin yarn and thereby also a higher flexibility (Fig. 8).

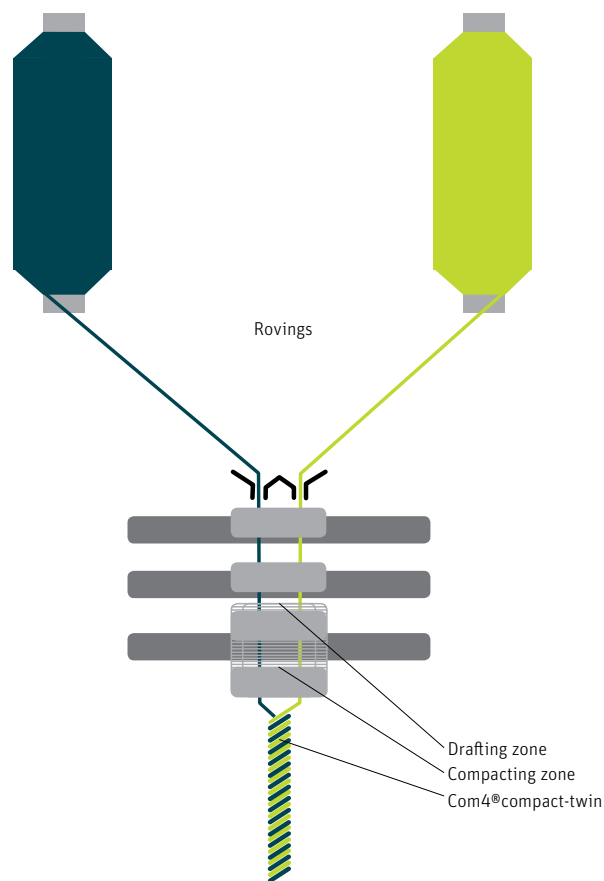


Fig. 8 Principle of compact twin yarn here with the Rieter compacting technology

4.1 Significance of the Yarn Shank Triangle in Twin Yarn Manufacture with the Rieter Com4®Compact-Twin Yarn Process

On the compact ring spinning machines, there are two fundamental and significant advantages compared to the conventional ring spinning machines in the production of Com4®compact-twin yarns, the Rieter compact spin-twist yarn process.

- The smaller spinning triangle reduces the danger of a yarn shank breaking. The compacting process considerably reduces the spinning triangle (Fig. 9).

Operating principle of the reduced spinning triangle

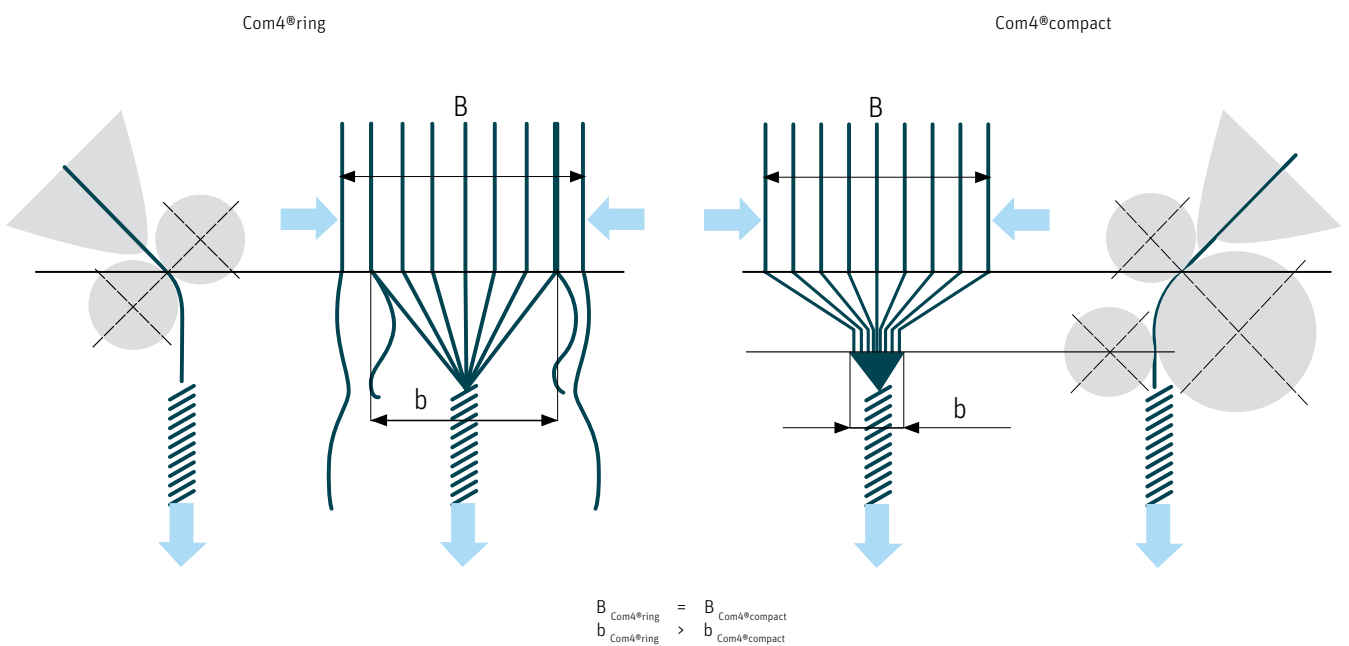


Fig. 9 The spinning triangle of the compact spinning technology (right) is smaller than that of conventional ring spinning (left)

- The controlled and close guiding of the two rovings, resp. two fibre webs in the drafting unit by the suction inserts allows a close distance between the two web components and thereby also a shorter yarn shank triangle.

- The influence of the suction insert can be easily demonstrated when the suction insert is removed (Figs. 10 & 11).

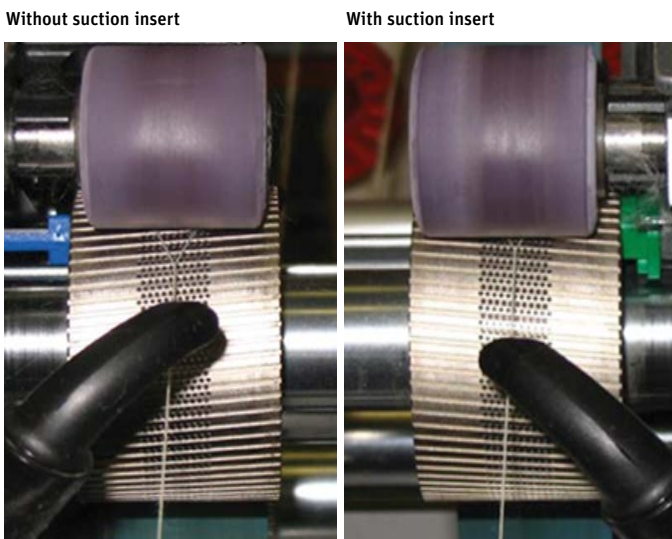


Fig. 10 The shorter yarn shank triangle (right) opens up, if the suction insert is removed (left)

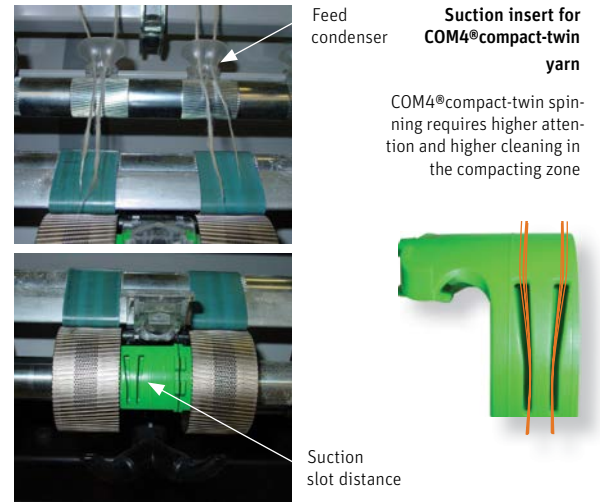


Fig. 11 The suction insert of the compact-Twin technology makes tight distance of the roving possible

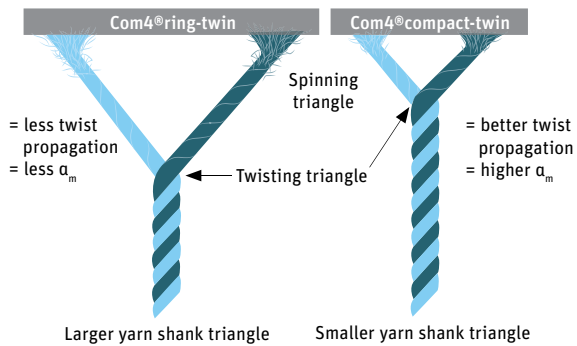


Fig. 12 Conventional ring twin left has longer shanks than compact twin right

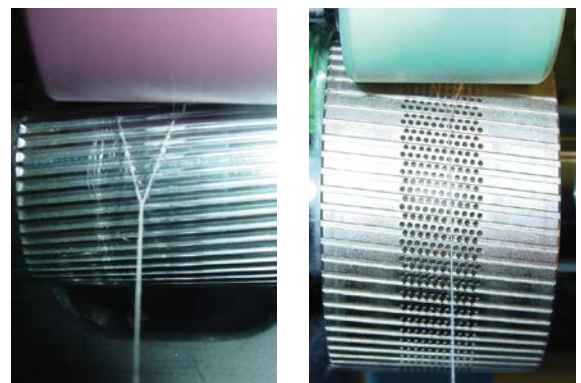


Fig. 13 Conventional ring twin left has longer shanks than compact twin right

A small spinning triangle and a small yarn shank triangle are decisive for an adequate operational reliability to produce a twin yarn (Figs. 12 & 13).

A small spinning triangle and a small yarn shank triangle are decisive for an adequate operational reliability to produce a twin yarn (Figs. 12 & 13).

The yarn breakage risk of one or both yarn shanks is especially high with twin yarn since the yarn mass of the respective end count is distributed over both yarn shanks, but the yarn twist coefficient must be set according to the end yarn count. This creates an additional danger zone for a break in the spinning triangle as the result of the relatively low twist coefficient applying to only one yarn shank mass.

The options of producing a twin yarn on the conventional ring spinning machine are well-known,

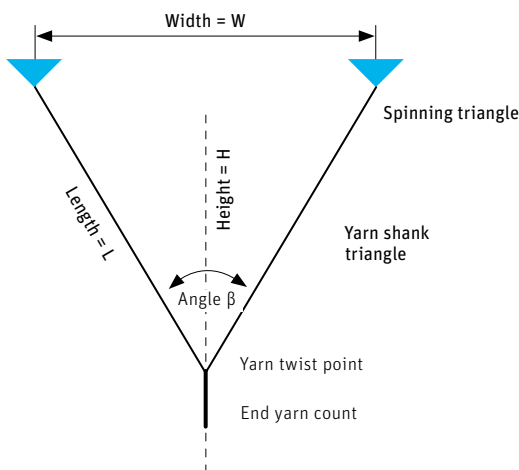
but even today bring just these problems, which have since been greatly improved or even eliminated by using the compact ring spinning machine.

The size of the yarn shank triangle respectively the height and the twist reproduction through to the spinning triangle are decisive for stable running behaviour and depend primarily on the following influencing factors:

- fibre guiding of rovings
- yarn twist setting
- twist transmission from the ring traveller through to the spinning triangle
- yarn tension (spindle speed, traveller weight, spinning geometry)

The critical point for an end down is the spinning triangle. Therefore, a stable spinning triangle with a twin yarn is equally as important as a smallest possible yarn shank triangle (Fig. 14). This is determined by the following parameters:

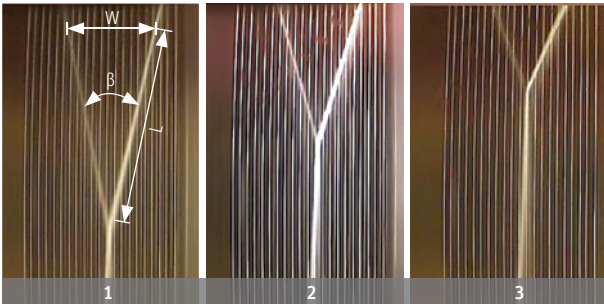
- fibre mass in the spinning triangles
- fibre count
- fibre length
- fibre surface



| | Angle β | Traversing stroke | Entry width Drafting zone |
|----------------------|---------------|-------------------|---------------------------|
| Compact-twin System | 48 Grad | 4 mm | 8 mm |
| Conventionell System | 38 Grad | 10 mm | 8 mm |

Fig. 14 The geometrics of yarn shank and spinning triangle influence the running conditions of twin yarn production

Compact-twin, Twist factor vs. Yarn triangle



| 100 % Modal®, 1.0 dtex, 38 mm, Ne 80/2 | | | | |
|--|------------|-----------|--------|--------|
| Picture | Alpha [ae] | Angle [β] | W [mm] | L [mm] |
| 1 | 3.4 | 25 | 7.4 | 17.4 |
| 2 | 3.8 | 34 | 6.7 | 10.07 |
| 3 | 4.2 | 56 | 5.6 | 6.05 |

Fig. 15 The influence of the traveller weight is more important than the twist coefficient

The influence of the twist coefficients is far greater than the influence of the traveller weight and the spindle speed. To illustrate this, the area of the yarn shank triangle was measured to obtain a relative assessment (Fig. 15).

It is clearly seen that with increasing yarn twist, the area of the yarn shank triangle is exponentially reduced (Fig. 16).

Spinning triangle area of Compact-twin yarn vs. twist factor

100 % Modal®, 1.0 dtex, 38 mm, Ne 80/2, 13 000 rpm

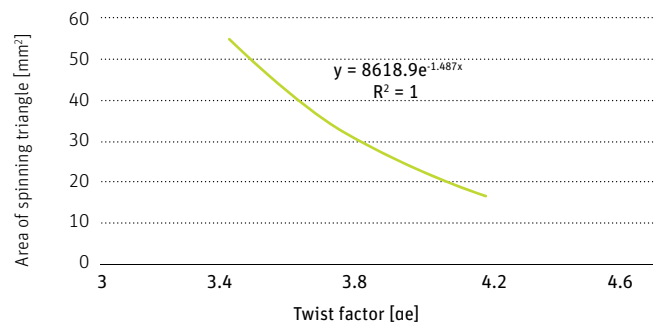


Fig. 16 Compact-twin, twist factor vs. yarn triangle

Traveller weight and spindle speed resp. the yarn tension have a relatively smaller influence in this respect. (Figs.17 & 18)

Compact-twin, Traveller weight vs. Yarn triangle

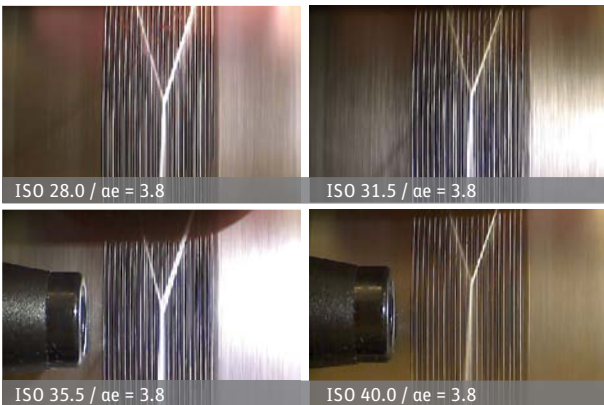


Fig. 17 The traveller weight has little influence on the size of the yarn triangle

Compact-twin, Spindle speed vs. Yarn triangle

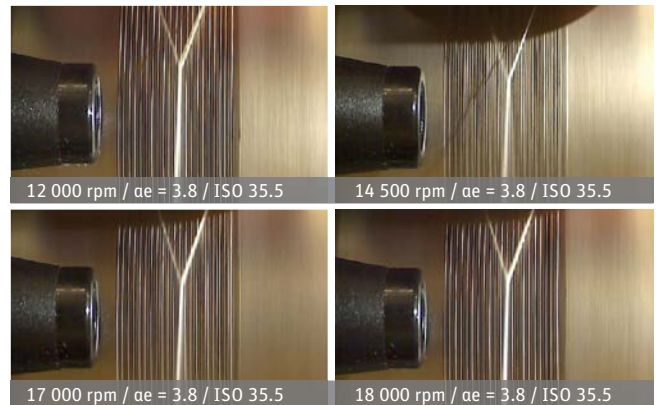


Fig. 18 The spindle speed has little influence on the size of the yarn triangle

4.2 Theoretical Consideration of the Yarn Twist

As the set yarn twist has a far greater influence on the ends down situation with a twin yarn than with a single yarn, the spindle speed must be lowered or the twist coefficient increased. This is illustrated by a sample calculation:

In this example, for the purpose of good running properties and the required yarn tenacity, an optimal yarn twist of 1 565 is assumed.

$$am = \frac{T/m}{\sqrt{Nm}} = am = \frac{1565}{\sqrt{125}} = 140 (ae = 4.6)$$

T/m = Twists per metre set on the ring spinning machine
Nm = Yarn count, metric (Ne 74)

A yarn count of Ne 74 (Nm 125/8 tex) therefore gives a twist factor of ae 4.6 (am 140).

With the manufacture of a twin yarn, however, the twist coefficient of each yarn shank is far lower due to the distribution of the yarn mass on the yarn shank triangle.

In addition, on the yarn twist-in point there is a twist backlog. As a result, the yarn twist is not completely reproduced in the individual yarn shanks and therefore the fibre bonding in the spinning triangle is reduced. Various analyses confirm a twist stop of approx. 20 % at the yarn twist-in point. With a twist yarn, the consequence would be, as also in this example, a twist coefficient of only ae 2.6 (am 79) for each yarn shank.

$$am = \frac{T/m}{\sqrt{2xNm}} \times D = am = \frac{1565}{\sqrt{250}} \times 0.8 = 79 (ae = 2.6)$$

D = Factor for twist backlog at the yarn twist-in point = approx. 0.8

The definite factor “D” for the twist backlog is significantly influenced by the set yarn twist and the angle β of the yarn shank triangle.

The connection between the “set yarn twist” and the number of “yarn twists in the respective yarn shank” can theoretically be determined according to the equilibrium of forces / moments. Thus the twist moment is divided through the set yarn twist, according to the geometric relationships of the two yarn shanks.

The twist in the yarn shank can therefore theoretically be calculated as follows.

$$T_{\text{Twist Yarn Shank}} = T_{\text{Twist Set}} \times (\cos\beta/2)^2$$

The twist transmission in the yarn shank is linear, however this does not increase to the same extent as the twist set on the ring spinning machine. This means that the onward transfer of the twist worsens, which is reflected in a continuously decreasing twist backlog factor.

With an increasing angle β in the yarn shank triangle, the yarn shank length is reduced which is initially positive. The yarn shank length may not be reduced by the increase of the twist setting to such an extent, that the twist stop factor becomes too small. Otherwise, the “shear resp. bending stress” of the fibres at the yarn twist-in point increases excessively, which results in high loss of the yarn tenacity. (Fig. 19).

The yarn twist should thus not be set too high, as this leads to an excessive twist stop and consequently to excessive strain on the fibres.

Correlation of “Twist setting” and “twist in yarn shank”
100 % Modal®, 1.0 dtex, 38 mm, Ne 80/2

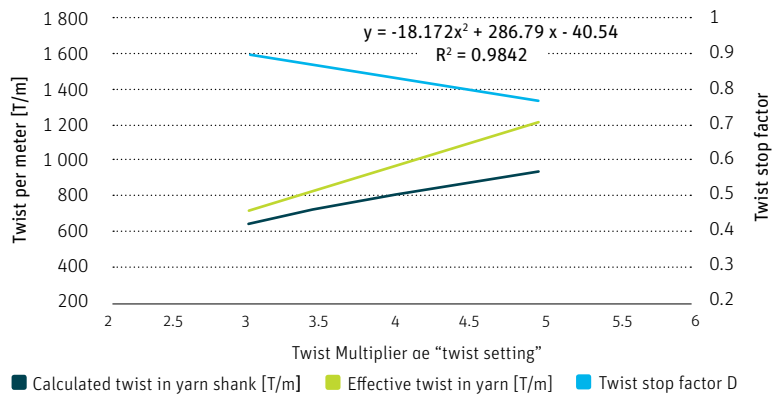


Fig. 19 With rising twist the congestion factor is decreasing. High twist leads to an excessive twist stop and high fibre strain

Correlation of effective twist & tenacity in twin yarn
100 % Modal®, 1.0 dtex, 38 mm, Ne 80/2

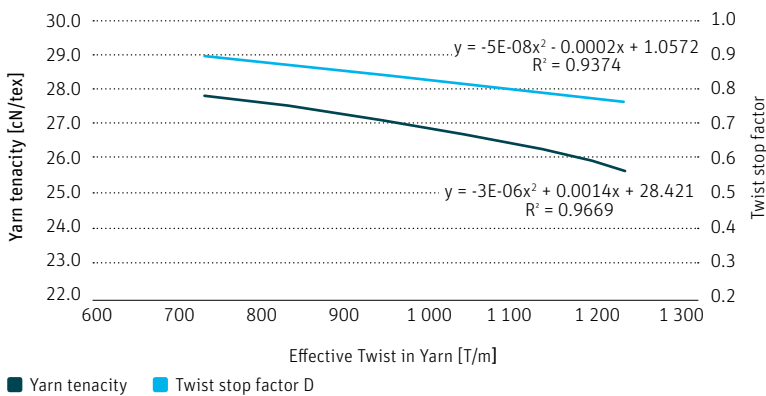


Fig. 20 When the twist stop factor decreases fibre stress increases and yarn tenacity will decrease

The fibre stress is apparent in the yarn tenacity at differing strength according to the raw material and yarn count. Under the respective conditions, the yarn tenacity decreases with increasing yarn twist and a twist coefficient continually, and at a too high twist coefficient already decreases over-proportionally.

In this respect, while taking into account good running properties on the ring spinning machine it should be ensured that there is an adequate twist coefficient in the yarn shank. The yarn shank length should therefore be kept as short as possible and the tenacity as high as possible. In this way, the twist stop factor should not drop below 0.8. Accordingly, in this example the optimal twist coefficient of $ae \geq 3.8$ will result. This will ensure that the stress on the fibres in the yarn twisting point is not too high. (Fig. 20)

With the size of the yarn shank triangle, the balance must therefore be found between the ends down situation, the fibre stress respectively the yarn tenacity, according to raw material and yarn count.

4.3 The Yarn Shank Triangle Influences Fibre Loss

The manufacture of Com4®compact-twin yarns not only results in greater operational reliability in respect of the ends down situation as a result of a smaller yarn shank triangle, but also results in less fibre fly due to the shorter yarn shank length.

The smaller the twist coefficient, the shorter the yarn shank length should be to counteract the fibre fly.

Higher fibre fly creates the additional danger that the yarn tenacity is reduced and / or the yarn weak places increase. The effect can be observed already with the processing of cellulose fibres, in this example 100 % TENCEL®, and must be given special attention in the processing of 100 % cotton. With the conventional ring spinning system, peripheral fibres are clearly visible which get into the suction or collect as fibre fly in the drafting unit. This undesired good fibre loss is even greater, the shorter the staple length of the raw material is.

If a Com4®compact-twin yarn, produced on a compact spinning machine, is compared with one produced twin yarn on the conventional ring spinning machine, then processing 100 % TENCEL® 0.9 dtex, around 2.5 % less fibre loss occurs (Figs. 21 & 22). The following reasons can be given.

- The yarn leg width and yarn leg height and therefore the yarn leg length are shorter. This additionally leads to better fiber bonding in the spinning triangle.
- More yarn twist transmission resp. less twist stop due to less spinning angle “α” resp. less yarn enlacement on the “thread guide eyelet” results in better fibre integration in the spinning triangle.
- The reduced yarn hairiness creates less resistance in the twist transmission. Measuring the twist at the final yarn count also shows and confirms this influence indirectly due to the fact that the conventional twin yarn is more difficult to untwist whereas the “twin yarn from compact” is easier to untwist.

The compact twin yarn technology thus combines the following advantages compared to the manufacture of a twin yarn on the conventional ring spinning machine:

- fewer ends down
- less fibre fly
- lower hairiness
- less fibre loss and consequently better raw material utilisation

Fiber loss due to length of the yarn triangle

100 % Tencel®, LF, 0.9 dtex, 34 mm, am 110



Fig. 21 The loss of good fibres is smaller with the compact twin technology compared with the conventional ring spinning twin technology

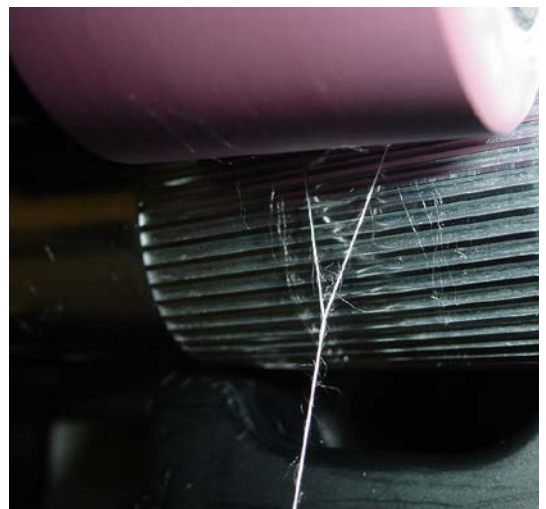


Fig. 22 With conventional ring spinning technology the yarn triangle is clearly bigger and leads to higher fibre loss

5 Carrying Out of the Trial

Change to special yarn structures, yarn counts and raw materials is also today only possible with a very flexible end spinning process such as the ring spinning technology. This approach led to the following objectives of the trial:

- Best running properties on the compact ring spinning machine using an optimal yarn triangle geometry.
- Best characteristics in the knitted fabric through the utilisation of twin yarns.
- Highest softness in the end product due to the raw material Modal®, the use of extremely fine fibres, the manufacture of finest yarns.
- Very good dyeing absorption and highest brilliance in the end product.
- Highest durability of the end product due to maximal yarn tenacity and best pilling and wash resistance.

The trial was divided into two parts because of its scale.

The first part deals with the manufacture and application of Com4®compact-twin yarns in the very fine yarn count from Ne 110/2 up to Ne 190/2 in the knitting plant. In this connection, Micro Modal® Air with 0.8 dtex fineness from Lenzing was used for the manufacture of the yarns.

| | |
|---------------------------------------|------------------|
| Raw material | Micro Modal® Air |
| Origin | Lenzing Austria |
| Assortment | bright, undyed |
| Cut length [mm] | 34 |
| Fibre fineness [dtex] | 0.8 |
| Test instrument | Afis – Autojet |
| UQL (w) [mm] | 35 |
| 5 % Fibre length (n) [mm] | 39 |
| Mean fibre length (n) [mm] | 27.3 |
| Short fibre content < 12.7 mm (n) [%] | 7.3 |
| Neps in Bale [1/g] | 116 |



Fig. 23 The Rieter compact twin unit ensures best running performance

The twin yarns as well as the single compact yarn selected for comparison were produced on the compact ring spinning machine. In addition, comparison yarns from the same raw material were produced on the compact ring spinning machine by one of our industrial partners.

In the second part of the study, the yarn count in a coarser yarn count range of Ne 80/2 when using a Modal® fibre 1.0 dtex is compared to the respective single compact yarn and to the conventional twist yarn. This part of the trial also refers to the application in knitted fabric.

| Machine | Type | Feed [Ne] [tex] | Doubling [fold] | Draft [fold] | Delivery [Ne] [tex] | Twist [T/m] [T/"] | Delivery [m/min] | Spindle speed [min-1] | Remarks |
|--------------|----------|-----------------|-----------------|--------------|---------------------|-------------------|------------------|-----------------------|-----------------------------------|
| Card | C 60 | | | | 0.125 4 750 | | 122.8 | | Production 35 kg/h |
| Draw frame | SB-D 15 | 0.125 4 750 | 6 | 8.1 | 0.17 3 500 | | 250 | | |
| Draw frame | RSB-D 40 | 0.17 3 500 | 6 | 8.4 | 0.24 2 500 | | 250 | | |
| Roving frame | F 15 | 0.24 2 500 | 1 | 12.5 | 3.0 200 | 65 1.7 | 16.9 | 1 100 | |
| Compact twin | K 45 | 3.0 200 | 2 | 36.7 | 110/2 5.4 x 2 | 1 344 34.1 | 8.9 | 12 000 | ae 4.6 |
| Compact twin | K 45 | 3.0 200 | 2 | 47.3 | 142/2 4.2 x 2 | 1 527 38.8 | 7.2 | 11 000 | ae 4.6 |
| Compact twin | K 45 | 3.0 200 | 2 | 47.3 | 142/2 4.2 x 2 | 1 295 32.9 | 7.72 | 10 000 | ae 3.9 Application in knits |
| Roving frame | F 15 | 0.24 2 500 | 1 | 14.0 | 3.3/180 | 69 1.8 | 14.5 | 1 000 | |
| Compact twin | K 45 | 3.3 180 | 2 | 57.5 | 190/2 3.1 x 2 | 1 766 44.8 | 5.66 | 10 000 | ae 4.6 |
| Compact twin | K 45 | 3.3 180 | 2 | 57.5 | 190/2 3.1 x 2 | 1 498 38 | 6.68 | 10 000 | ae 3.9 Application in knits |
| SAVIO | ORION | | | | 110/2 | Web. | 1 000 | | |
| SAVIO | ORION | | | | 142/2 | Web. | 1 000 | | |
| SAVIO | ORION | | | | 190/2 | Web. | 1 000 | | |
| SAVIO | ORION | | | | 142/2 | Tricot | 1 000 | | |
| SAVIO | ORION | | | | 190/2 | Tricot | 1 000 | | |

The technology components for the manufacture of a Com4®compact-twin yarn (abbreviated to twin yarn) are just limited to perforated drums, twin yarn suction insert and the accompanying air guide elements. The choice of the respective drum, plain or fluted, is determined only by the yarn count range respectively to ensure an optimal drafting in the main drafting zone of the drafting unit (Fig. 24).









| Component | Single | Twin |
|-------------------|---|--|
| Infeed condenser | Single condenser  | Twin condenser  |
| Perforated drums | Plain & Fluted  | Fluted  |
| Suction insert | Bright  | Com4®twin  |
| Air guide element | 52 detect & 46 / 0.5 / 2  | 46 / 1 / 1  |

Fig. 24 Technology components Compact-single and Compact-twin

6 Yarn Results When Using Micro Modal® Air 0.8 dtex

To avoid ends down, low spindle speeds were used in operation. In addition, the spindle speed for the manufacture of a twin yarn must be reduced. The spindle speeds of the twin yarn positions can certainly be set 15 % higher in practice with the respective yarn counts.

The spindle speeds in this speed range do not influence the yarn quality. Therefore the differences can exclusively be due to the yarn structure, the yarn count and the twist coefficient.

| | Yarn Count Ne | Spindle speed m/min | Ring diameter mm | Twist coefficient ae (am) | Yarn twist T/m | Ends down n/1 000 Sph |
|---------------------------|---------------|---------------------|------------------|------------------------------|----------------|--------------------------|
| Reference yarn Compact | 71 | 17 000 | 40 | 3.4 (103) | 1 126 | |
| Reference yarn Compact | 95 | 17 000 | 40 | 3.4 (103) | 1 273 | |
| Twin yarn Compact | 110/2 = 55 | 12 000 | 36 | 4.6 (140) | 1 344 | 5 |
| Twin yarn Compact | 142/2 = 71 | 11 000 | 36 | 4.6 (140) | 1 527 | 6 |
| Twin yarn Compact | 190/2 = 95 | 10 000 | 36 | 4.6 (140) | 1 766 | 3 |
| Twin yarn Compact | 142/2 = 71 | 11 000 | 36 | 3.9 (118) | 1 295 | 8 |
| Twin yarn Compact | 190/2 = 95 | 10 000 | 36 | 3.9 (118) | 1 498 | 12 |

6.1 Unevenness, Thin Places and Thick Places

As expected, the compact-twin yarns showed an improvement in evenness of 10 - 15 % in absolute terms compared to a compact single yarn of the same count, independent of the respective twist coefficient and according to yarn count.

The infeed of the two rovings and thereby of the two yarn shanks equalises the thin and thick places and consequently the unevenness, which according to the doubling principle must also result in better evenness.

Provided the drafting on the ring spinning machine with the manufacture of a single yarn and the manufacture of a twin yarn is kept constant, in other words no additional disruption of the drafting process based on a greater draft height occurs, the evenness on the twin yarn must be better than with single yarn of the same count due to the doubling of two yarn shanks.

For a simple view, at this point the negative influence exerted by the finer rovings compared to the coarser rovings with single yarn manufacture can be ignored.

At the yarn twist-in point of the two yarn shanks, however, an unevenness fault occurs which can be estimated with the factor 1.08 - 1.1.

Therefore, the following simplified mathematical relationship can be used.

$$CV_{mTwin} = \frac{CV_{mYarn\ shank}}{\sqrt{n}} \times F$$

n = Number of yarn shanks

F = Factor for deterioration of the evenness at the yarn twist-in point.

The evenness with the twin yarns is not changed by the winding process from the cops to the package. This naturally assumes that the settings are optimal, in particular of the yarn brake and all yarn guide elements on the winder (Fig. 25).

Evenness in relation to yarn count and structure

100 % Micro Modal® Air, 0.8 dtex / 34 mm

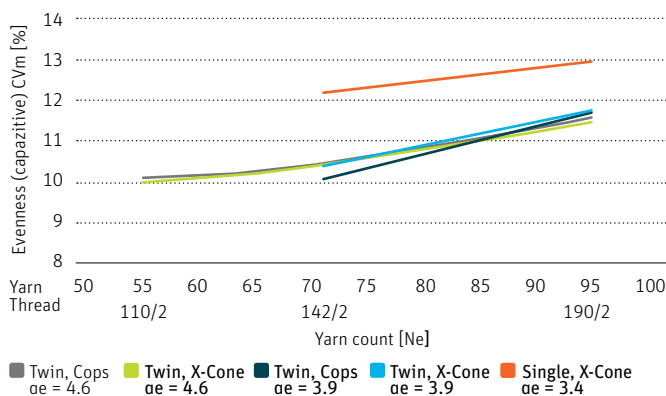


Fig. 25 The mass evenness of the twin yarns is better than that of the single yarn

Technologically, the thin and thick places are very strongly related to the unevenness. This means, twin yarns have far fewer faults due to the doubling than with a single yarn, irrelevant of the twist coefficient. As the sloughing resistance of single yarns is lower than with a twin yarn, it can be assumed that some of the higher levels of thin and thick places are generated on the winder resp. during the rewinding process. How strongly the two positive influences such as “doubling” and the better “sloughing resistance” with twin yarn are now to be rated must be clarified in further trials (Figs. 26 - 29).

Thin places in relation to yarn count and structure

100 % Micro Modal® Air, 0.8 dtex / 34 mm

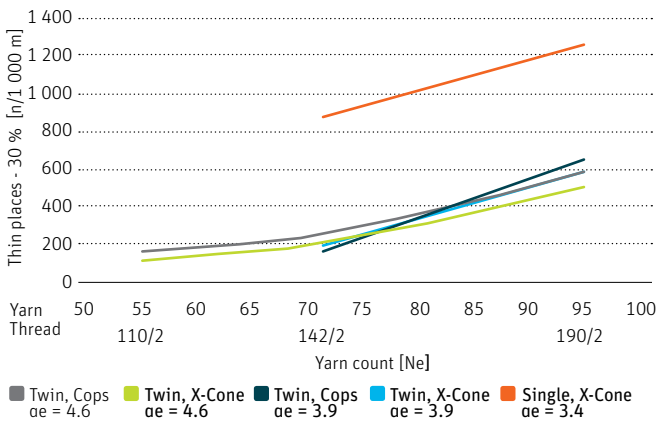


Fig. 26 Thin places are directly related to the yarn evenness. Therefore the number of Thin Places of the Twin yarn is lower compared with the single yarn

Thin places in relation to yarn count and structure

100 % Micro Modal® Air, 0.8 dtex / 34 mm

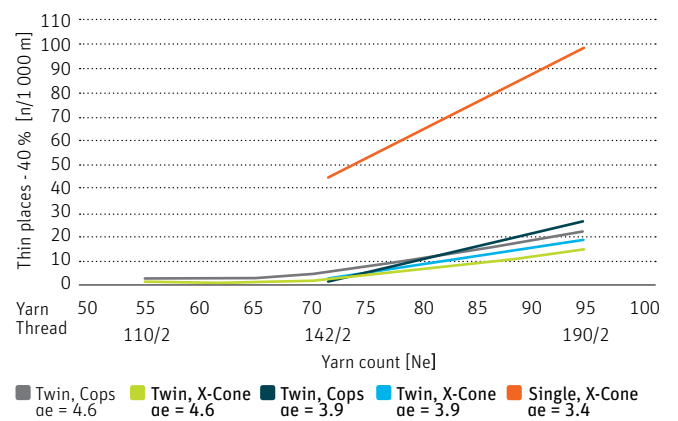


Fig. 27 Thin places are directly related to the yarn evenness. Therefore the number of Thin Places of the Twin yarn is lower compared with the single yarn

Thick places in relation to yarn count and structure

100 % Micro Modal® Air, 0.8 dtex / 34 mm

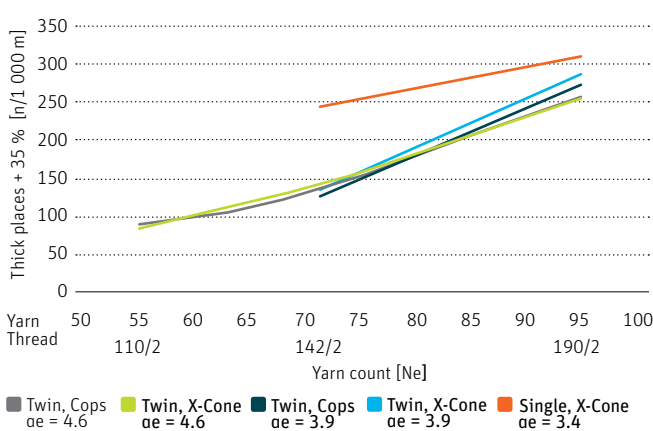


Fig. 28 Thick places are directly related to the yarn evenness. Therefore the number of Thick Places of the Twin yarn is lower compared with the single yarn

Thick places in relation to yarn count and structure

100 % Micro Modal® Air, 0.8 dtex / 34 mm

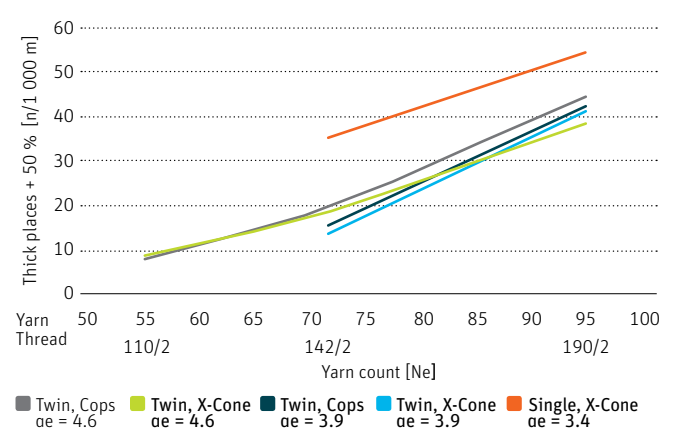


Fig. 29 Thick places are directly related to the yarn evenness. Therefore the number of Thick Places of the Twin yarn is lower compared with the single yarn

6.2 Neps

Between the single yarn and the twin yarn, no differences can be recognised with the finer nep fault categories. Only with the coarser neps are the advantages clearly in favour of the twin yarn, although the difference with increasingly finer yarn becomes smaller (Fig. 30).

The better sloughing resistance of the twin yarn compared to single yarn has a clearly beneficial effect on the compact spinning machine, especially on the ring traveller system and the subsequent winder. The effects on the respective nep fault categories depend, alongside the raw material, on the yarn count and the twist coefficient (Figs. 31 & 32). That means, the lower sloughing resistance in combination with the smaller twist coefficient on the single yarn clearly has a negative influence here on the neps compared to twin yarn.

Neps in relation to yarn count and structure

100 % Micro Modal® Air, 0.8 dtex / 34 mm

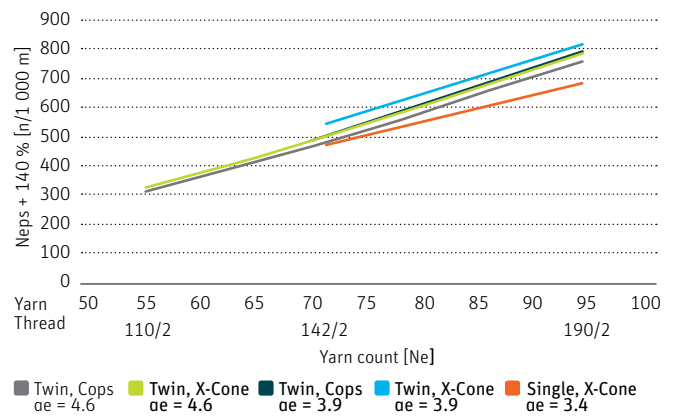


Fig. 30 Between single yarn and twin yarn is no big difference regarding fine nep fault categories

Neps in relation to yarn count and structure

100 % Micro Modal® Air, 0.8 dtex / 34 mm

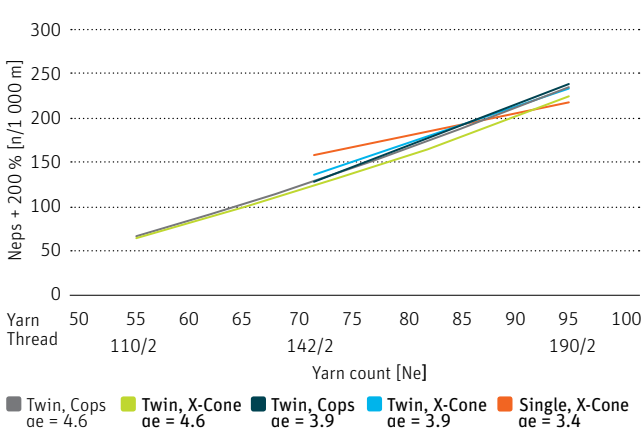


Fig. 31 The effects on the respective nep fault categories depend, alongside the raw material, on the yarn count and the twist coefficient

Neps in relation to yarn count and structure

100 % Micro Modal® Air, 0.8 dtex / 34 mm

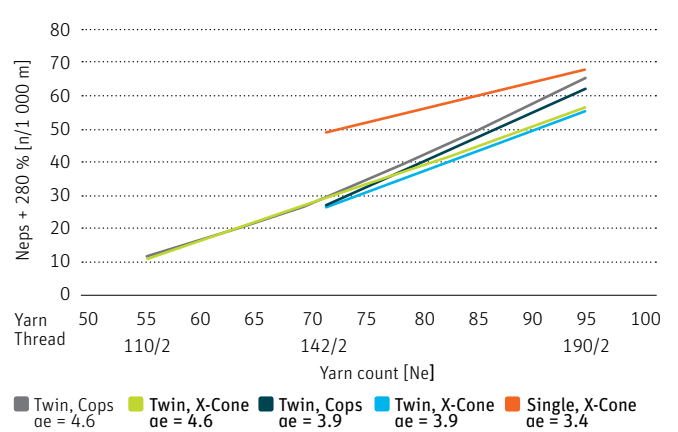


Fig. 32 The effects on the respective nep fault categories depend, alongside the raw material, on the yarn count and the twist coefficient

6.3 Tenacity, Elongation, Working Capacity

The single yarn with the twist coefficient of α_e 3.4 lies in the same tenacity range as the twin yarn with an α_e of 3.9. As already mentioned at the beginning, the spindle speed with twin yarn must be set lower and / or the twist coefficient set higher to secure the best possible running performance. The yarn tenacity, however, is influenced not only by the yarn structure but also by the raw material, the yarn count and the twist coefficient. For this reason, the tenacity of a twin yarn is not in every case higher than with a single yarn. The finer the yarn, the smaller the differences regarding yarn tenacity between the yarn structures. In addition, it is very clearly evident that as a result of the efforts to obtain a very low ends down level with an α_e of 4.6, an obviously excessive fibre stress has already occurred. That means, although an increase of the twist coefficients from 3.9 to 4.6 created a minimal benefit of a lower ends down rate, tenacity was reduced. This is caused by the higher stress on the fibres at the yarn twist-in point (Fig. 33).

Tenacity in relation to yarn count and structure

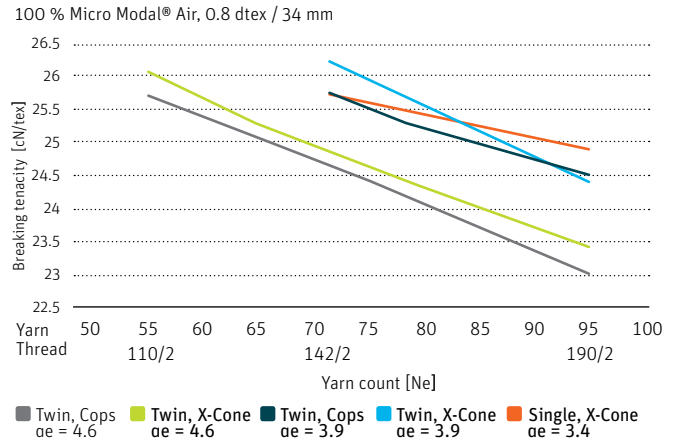


Fig. 33 The higher twist factor lead to higher fibre stress and reduced yarn tenacity

Elongation in relation to yarn count and structure

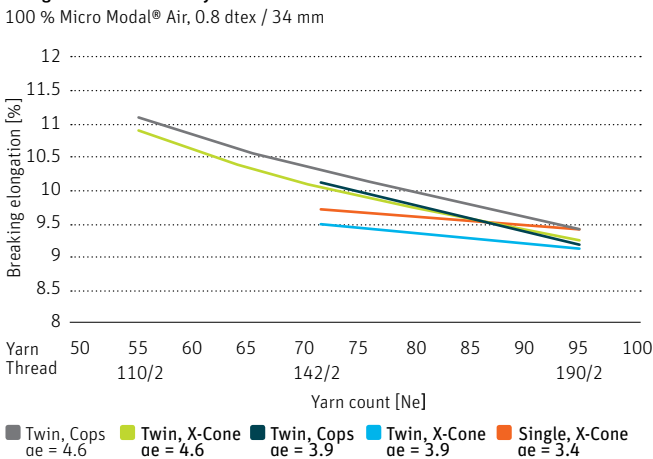


Fig. 34 The yarn elongation decreases with finer yarns and higher yarn tenacity

Raw material, fibre tenacity, yarn count and twist coefficient have therefore, and in this case, greater influence on the yarn tenacity than the yarn structure. Consequently, the optimal fibre substance utilisation, with these general conditions and an end yarn count of Ne 71 - 95 respectively 142/2 - 190/2, lies in the range of 70 - 75 %. As also expected, the winding process has no influence on the yarn tenacity (Fig. 34).

The optimal twist coefficient can therefore be established at α_e 3.9 with this raw material.

The yarn elongation decreases with finer yarns and higher yarn tenacity. As a result of the yarn stress caused by the winding process, the yarn can lose up to absolute 0.5 % elongation.

The working capacity does not significantly differ between the yarn structures. An influence from the winding process is also not apparent. A reduction of the working capacity due to the increased twist coefficient of α_e 4.6 is only shown with very fine yarn such as Ne 190/2.

6.4 Hairiness

As far as hairiness is concerned, the twin yarns show massive advantages in comparison to single yarn. In our experience, these advantages are independent of raw material and yarn count. Part of the respective difference in hairiness is certainly because the twist coefficient of the single yarn was lower. Nevertheless, the extremely low hairiness is primarily due to the twin yarn structure. With comparable raw materials, the twin yarns achieve in general values here, which can only otherwise be achieved by air-jet yarns.

So in this case, also with Modal® Air, a hairiness reduction of 17 - 24 % according to Uster was established on the twin yarn (Fig. 35). The shorter hairs of 1 - 2 mm show a reduction of around 57 % and the longer hairs up to 3 mm even a reduction of up to 80 % (Figs. 36 & 37).

In contrast to the clear loss of tenacity, with an increase of the set yarn twist on the twin yarn from ae 3.9 to 4.6 there is a further slight reduction of the hairiness.

On the other hand, the winding process from the cops to the package has a slight rise in hairiness as a result. This is due to the friction between the yarn and the yarn guide elements on the winder.

The advantages of lower yarn hairiness are apparent not only in the cost-saving potential across the manufacturing process but also in numerous technological benefits such as:

- less fibre abrasion
- more abrasion resistance
- less pilling
- better washing resistance

Hairiness in relation to yarn count and structure

100 % Micro Modal® Air, 0.8 dtex / 34 mm

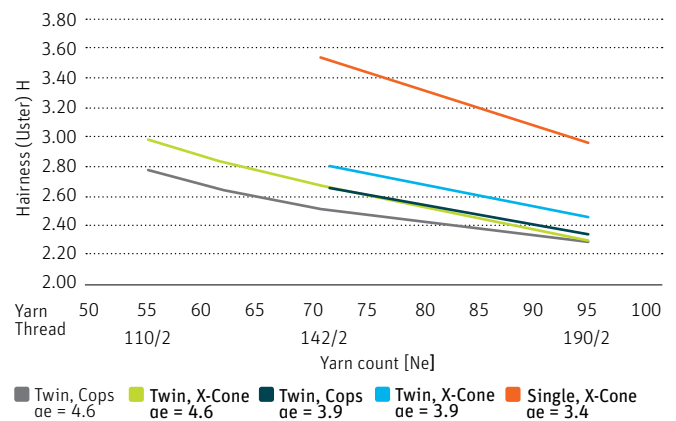


Fig. 35 Twin yarns show in general lower hairiness than single yarns

Hairiness S 1+2 in relation to yarn count and structure

100 % Micro Modal® Air, 0.8 dtex / 34 mm

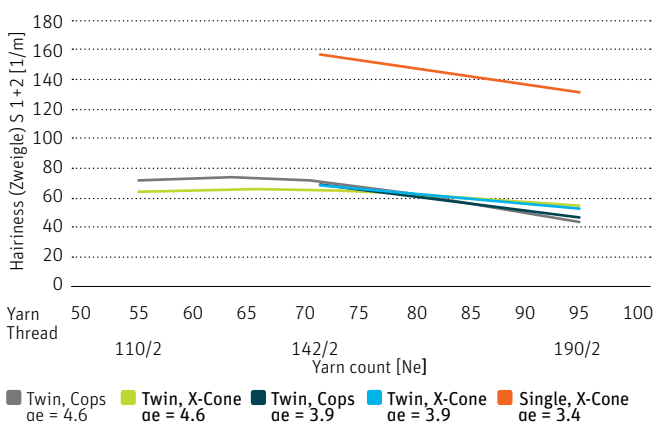


Fig. 36 The shorter hairs of 1 - 2 mm show a reduction of around 57 %

Hairiness S3 in relation to yarn count and structure

100 % Micro Modal® Air, 0.8 dtex / 34 mm

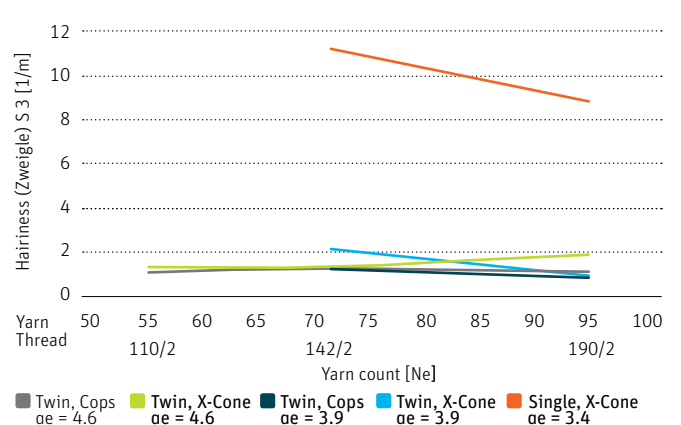


Fig. 37 The longer hairs of up to 3 mm show a reduction of up to 80 %

6.5 Fibre Abrasion

The fibre abrasion is clearly determined by the respective yarn structure and the bonding of the fibres in the yarn strand. The better the protruding fibres on the fibre ends in the yarn strand are anchored, the less fibre abrasion occurs under yarn stress. The twin yarns show far less fibre abrasion than the single yarn, irrespective of the twist coefficient (Fig. 38).

It should be noted that the single yarn in question is a compact yarn and the fibre abrasion is thereby far lower than with a conventional ring yarn.

Fibre Abrasion in relation to yarn count and structure

100 % Micro Modal® Air, 0.8 dtex / 34 mm

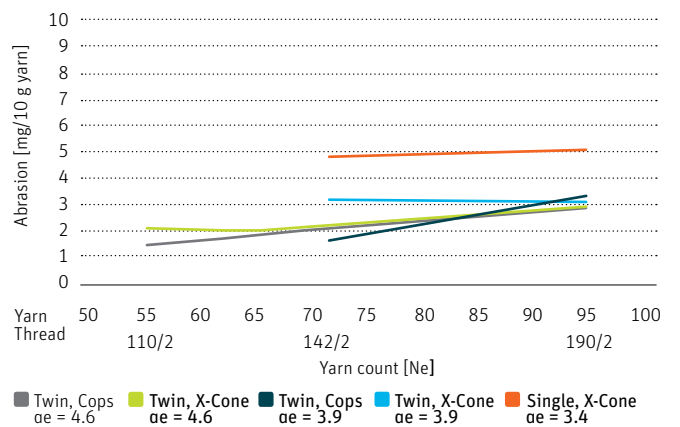


Fig. 38 The twin yarns show far less fibre abrasion than the single yarn, irrespective of the twist coefficient

6.6 Abrasion Resistance

The abrasion resistance of the yarns is a further important criterion in subsequent process stages of downstream processing of the yarns and their serviceability properties in the textile fabric. For this purpose the resistance of the yarns at a given number of wear cycles on the yarn body was measured using the “Reutlinger Weaving Tester”.

This test allows simulation of the abrasion resistance of yarns. This is of special interest when yarns are used in the weaving process as warp. These readings are, however, also an excellent criterion of precise fibre integration in the yarn. It can also be assumed in this case that an abrasion-resistant yarn brings advantages not only in the weaving process, but also at all downstream processing stages right up to the properties of the textile fabric.

It should be noted that the numbers of cycles measured should only be regarded as relative numerical values. The absolute numerical values in this measuring method are very dependent on equipment settings, i.e. the general conditions prevailing with this test method.

The twin yarn with a twist coefficient of α_e 3.9 achieves an abrasion resistance almost twice as high as the single yarn with α_e 3.4. The positive effect is created by the “twin yarn structure” and the higher twist coefficient. It should be noted that the twist coefficient for the twin yarn with α_e 3.9, as already mentioned, was optimised by an optimal ends down rate and had to therefore be set somewhat higher than with a single yarn.

An additional increase of the twist coefficient with twin yarn from α_e 3.9 to α_e 4.6 again shows a massive improvement respectively an increase in the number of attainable cycles (Fig. 39). However, based on the fibre stress it could be clearly seen that the yarn tenacity was reduced. In this respect, it must be considered how far an even better abrasion resistance, combined with a yarn tenacity loss and a lower ring spinning machine production, is reasonable.

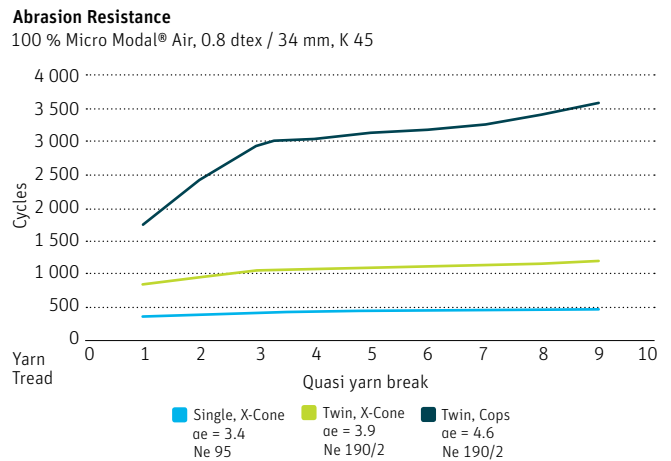


Fig. 39 The twist yarn with a twist coefficient of α_e 3.9 achieves an abrasion resistance almost twice as high as the single yarn with α_e 3.4. The higher abrasion resistance achieved with the twist coefficient α_e 4.6 needs to be balanced with loss in tenacity

Compact and compact-twin

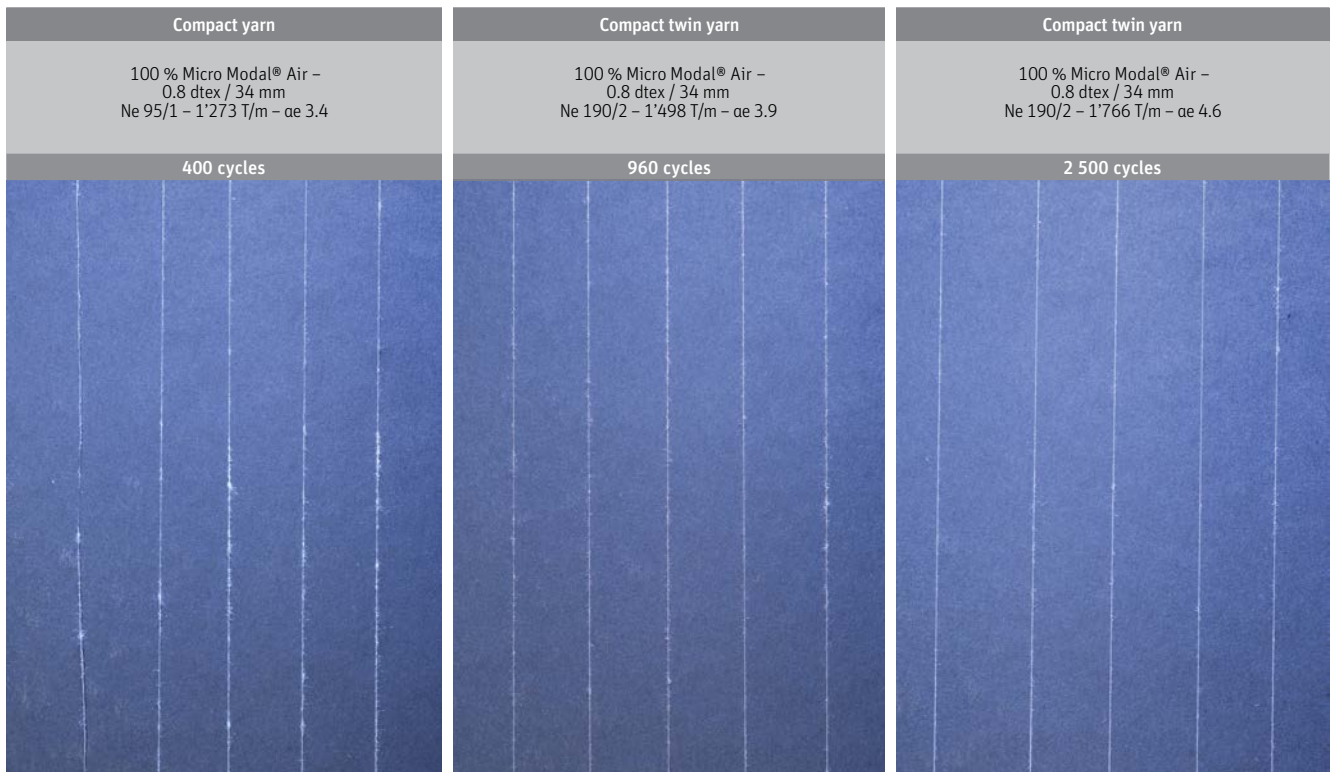


Fig. 40 The abrasion resistance of twin yarns is much higher than that of the single yarn left

The abrasion resistance can be visually demonstrated on the yarns. To do this, the yarns are visually assessed using the testing device after the second yarn break. This shows that even with a twice as high number of 960 cycles, on the twin yarn with ae 3.9 the yarn suffers far less and almost negligible damage than the single yarn after 400 cycles. A further increase of the twist coefficient on

the twin yarn of ae 4.6 resulted in no sloughed fibres on the yarn strand, even after 2 500 cycles (Fig. 40). This yarn was, of course, not foreseen for further processing to knits because of the twist coefficient, and was only used to show the effects on the abrasion resistance. The twin yarn shows its benefits regarding pilling in knitted garments.

6.7 Yarn Structure

The yarn properties are determined by the yarn structure. This is also influenced by raw material and machine settings. Nevertheless, the end spinning process has the greatest influence on the yarn structure. Already, many properties of the yarns and ultimately the textile fabric can be evaluated by closer observation of the respective yarn structure.

The further increase in yarn quality by means of producing a twin yarn on the compact ring spinning machine in comparison to a compact single yarn is based on the better evenness due to the doubling and the better fibre bonding.

The better fibre bonding, however, does not in every case lead to a further increase of the yarn tenacity, compared to a “single” compact yarn.

This is plausible, as the possibilities to increase the fibre – fibre friction are limited.

If very favourable framework conditions exist, such as

- complete twist of the fibres in the yarn as with ring spinning
- compact process
- high fibre tenacity due to the raw material Modal®
- high fibre quantity in the cross-section of micro-fibres
- optimal fibre length in correlation to the fibre count, as is the case with MMF,

then it is clear that a further increase of tenacity via the yarn structure reaches its limits with such excellent framework conditions.

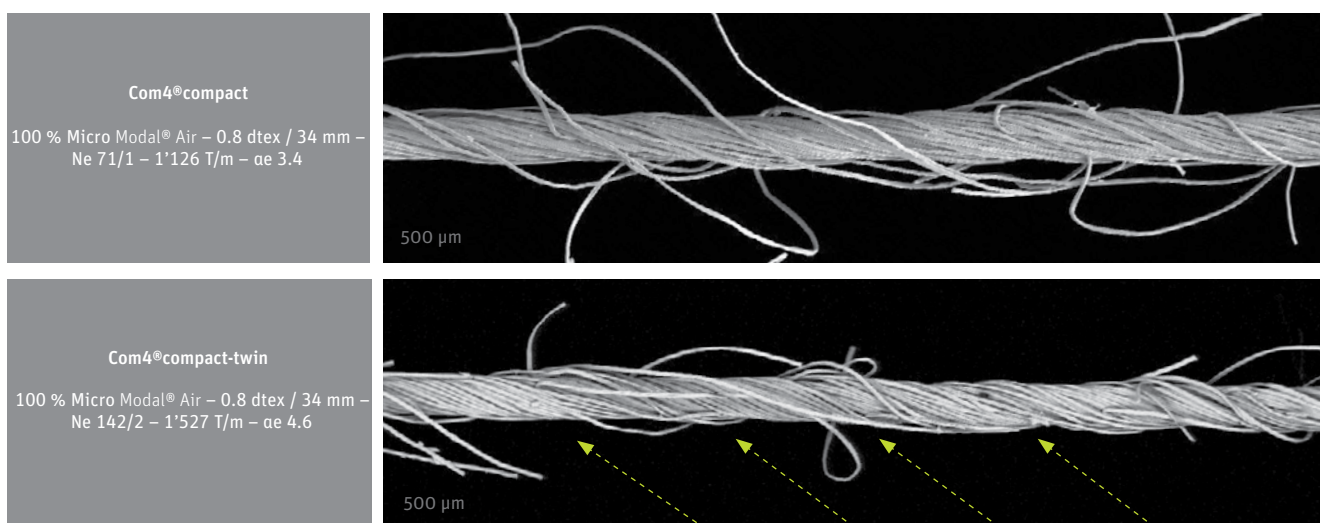


Fig. 41 The structure of the twin yarn is similar to a two ply yarn

As already shown with the positive properties of hairiness, fibre abrasion and the wearing resistance, the yarn structure influences further important characteristics which significantly affect the end article in a positive way.

An initial look at the yarn structure of a twin yarn shows that this clearly differs from the single yarn. The twist direction of the fibres on the single yarn is thereby continuously and uniformly dis-

tributed over the yarn axis length. In contrast, on the twin yarn it is obvious that two yarn sequences run along the yarn axis, similar to the case with a two-ply yarn.

The transition of the adjacent twisted fibre packages cannot thereby always be visually well recognised at all points along the yarn axis (Figs. 41 & 42). The yarn sequences are not as clearly separated as with a two-ply yarn.

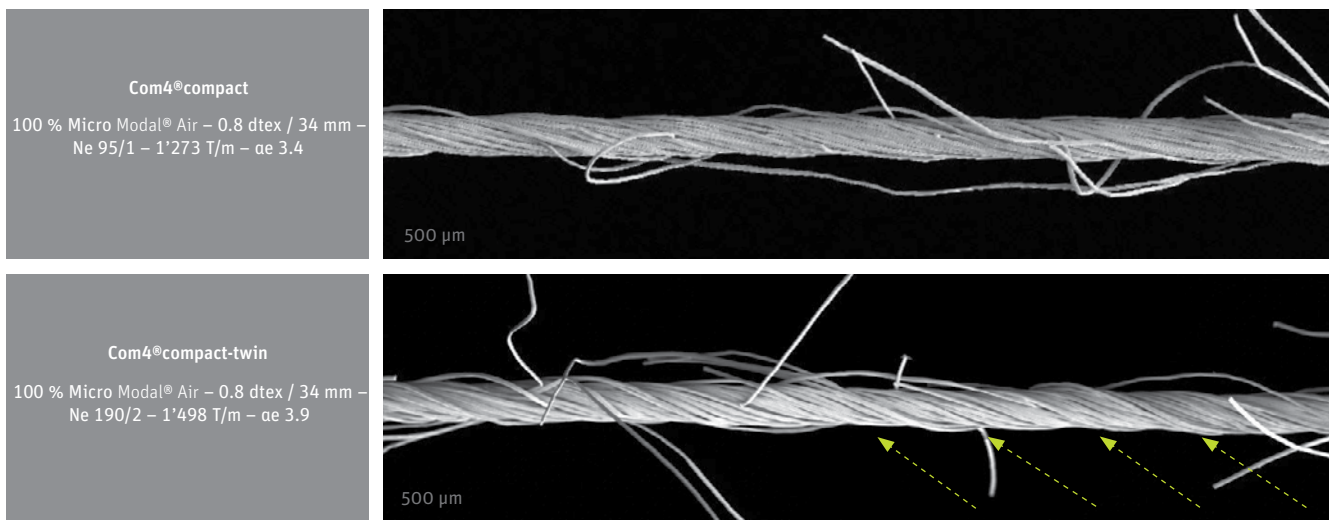


Fig. 42 The structure of the twin yarn is similar to a two ply yarn

The fibre bonding respectively its torsion moment on the twist-in point of the twin yarn is, compared to a single yarn, decisively increased. Nevertheless, in the yarn diameter no reduction in diameter between the twin yarn and the single yarn is shown. The

yarn density of the twin yarn only increases again, respectively the yarn diameter only diminishes, with a considerably greater twist coefficient of α_e 4.6 (Fig. 43).

Yarn diameter in relation to yarn count and compact structure

100 % Micro Modal® Air 0.8 dtex / 34 mm

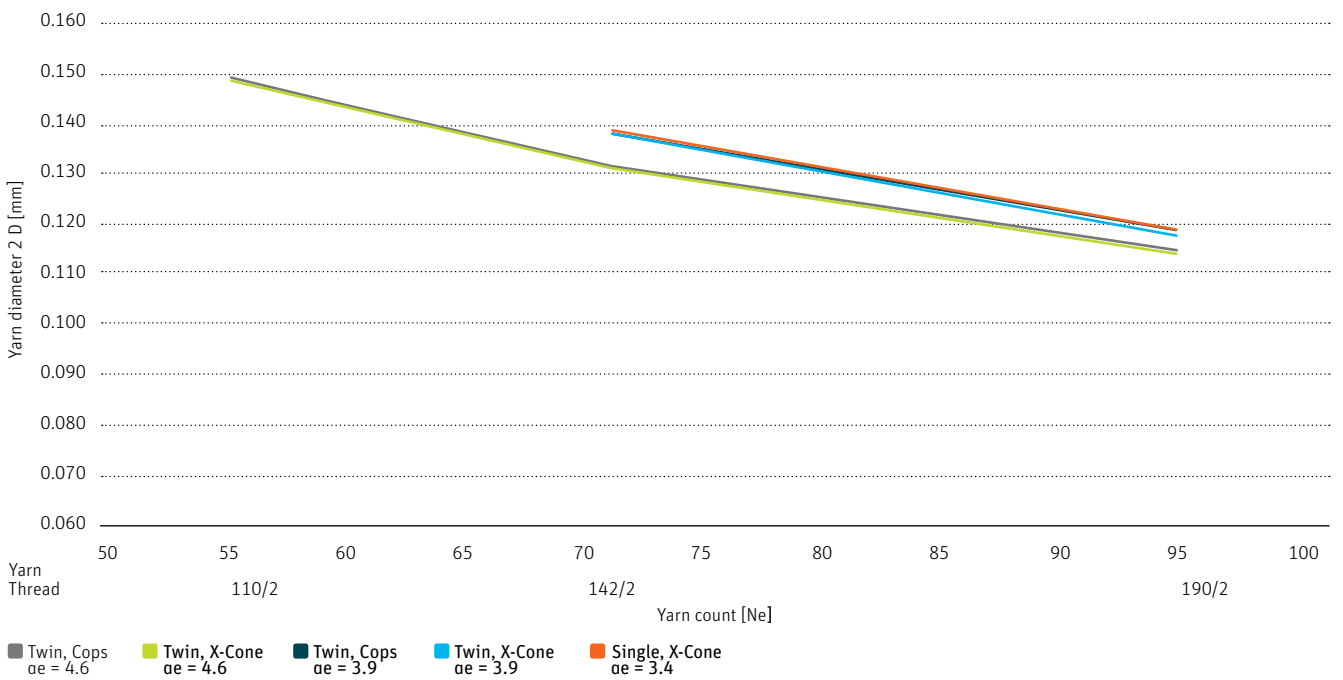


Fig. 43 The yarn diameter shows no reduction between the twin yarn and the single yarn

7 Results with Knitted Fabric Using Micro Modal® Air 0.8 dtex

For the manufacture of knits from single elastic, the same E 40 knitting machine partition was selected. To illustrate the characteristics and differences of the twin yarns under practical conditions and, at the same time, to develop a new application product, the yarns were fully plated on the knitting machine with elastane. The elastane ratio in the knitted fabric amounted to 8.7 %. This was left unchanged with both yarn counts.

It is known that with the manufacture of plated knits, that means by the feeding of a filament onto the knitting machine, all properties of the staple fibre yarn in the knitted fabric are weakened. The influence of the filament on the characteristics of the knitted fabric is clear. Nevertheless, the structure of the knitted fabric based on the requirements of the end product is chosen accordingly.

The running properties on the knitting machine were very good with all yarn positions and achieved an efficiency of over 95 %. Between the yarn structures, no differences in the running behaviour could be detected. The fibre fly on the knitting machine was extremely minimal with all yarn positions, so that due to the relatively short runtime, no differences could be quantified.

The knitted fabrics were dyed using hank dyeing (exhaust process). The shrinkage values were excellent irrespective of the number of washing cycles and, with both yarn structures and regardless of the yarn count, lie between +0.2 up to -3.4 %.

| | Yarn Count Ne | Yarn Count tex | Knitting Machine Partition | Knitting Machine Diameter System | Elastane [dtex] | Elastane Ratio in Knits [%] | Knits - Raw - Finished [g/m] | Machine Type Speed [U/min] |
|------------------------|---------------|----------------|----------------------------|----------------------------------|-----------------|-----------------------------|-------------------------------------|----------------------------|
| Reference yarn Compact | 71 | 8.33 | E 40 | 30 inch 90 | 22 | 8.7 | 133 199 | Orizio John / C 20 |
| Reference yarn Compact | 95 | 6.22 | E 40 | 34 inch 102 | 17 | 8.7 | 104 138 | Beck BSM 2 100 14 |
| Twin yarn Compact | 142/2 = 71 | 4.2 x 2 = 8.4 | E 40 | 30 inch 90 | 22 | 8.7 | 138 188 | Orizio John / C 20 |
| Twin yarn Compact | 190/2 = 95 | 3 x 2 = 6 | E 40 | 34 inch 102 | 17 | 8.7 | 102 150 | Beck BSM 2 100 14 |

7.1 Evenness, Coverage and Haptics in the Knitted Fabric

Alongside the yarn evenness, the evenness in the appearance of the knitted fabric is also influenced by the needle partition, the knit structure and machine setting.

Despite the plating, that is the combination of filament and staple fibre yarn on the knitting machine, a visibly more uniform fabric appearance is apparent with the twin yarns. The optical appearance shows far fewer disturbing thin place packages in the knitted fabric (Figs. 44 & 45).

All yarn positions produced an extremely soft touch and the knitted fabric appears very light. The yarn structure itself, as twin yarn or single yarn, showed no differences in this respect. The end article already receives a unique and extraordinary softness from the raw material type, the fibre count and the fine yarn and it feels light. The produced article can therefore be described as a unique new product.



Fig. 44 The knitted fabric made of twin yarn (right) shows a more uniform appearance than of single yarn (left)



Fig. 45 The knitted fabric made of twin yarn (right) shows a more uniform appearance than of single yarn (left)

7.2 Pilling

Pilling behavior in the textile fabric, especially in knitted fabrics, is one of the most important quality criteria. End products that already display pilling after a short time drastically devalue quality and are therefore unwelcome. Pilling is therefore a constant topic and can be influenced significantly by low yarn hairiness and the yarn structure.

Pilling occurs when fibres protruding from the knitted fabric develop into pills of different sizes due to mechanical stress during wearing. As soon as they become clearly visible due to their size and frequency, they have a negative impact on the appearance of the knitted fabric.

Measuring pilling behaviour is therefore very important for the qualitative evaluation of knitted fabrics. The Martindale and ICI Box testing methods (DIN EN ISO 12945 2 and DIN EN ISO 12945 1, respectively) are customary in mill operations. 2 000 cycles on the Martindale correspond to the worldwide testing conditions for knitted. This in turn corresponds to an approximate testing period of 200 min according to the ICI method.

The filament in the knitted fabric reduces the differences between the yarn structures. Nonetheless, it was decided in this analysis to carry out the tests on plated knits, so as to ultimately establish the benefits of a twin yarn in this newly developed end product.

It should also be noted that when using very fine fibres, the tendency to pilling increases. In this respect, it must also be analysed whether the biggest advantages, which the utilisation of a micro-fibre offers, still fulfill the requirements of the product.

The results are insofar surprising, that despite the positive influence of the filament in this knitted fabric structure, a massive difference in pilling occurred between the two yarn structures.

The twin yarn exhibits here a massively better pilling behaviour. After 2 000 abrasion cycles, the value with twin yarn was one clear grade higher than with single yarn. The yarn count itself, as expected, has no influence on the pilling and confirms the differences between the two yarn structures (Fig. 46).

Pilling in relation to Twin vs. Single

100 % Micro Modal® Air 0.8 dtex / 34 mm

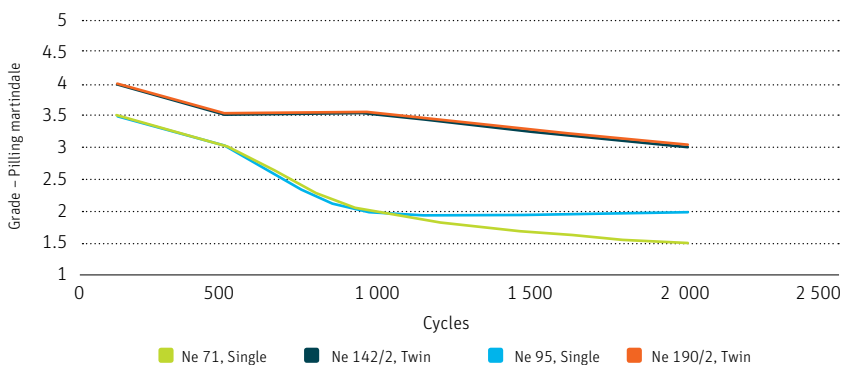


Fig. 46 After 2 000 abrasion cycles, the value with twin yarn was one clear grade higher than with single yarn

Wash pilling after tumbler drying – Twin vs. Single

100 % Micro Modal® Air 0.8 dtex / 34 mm

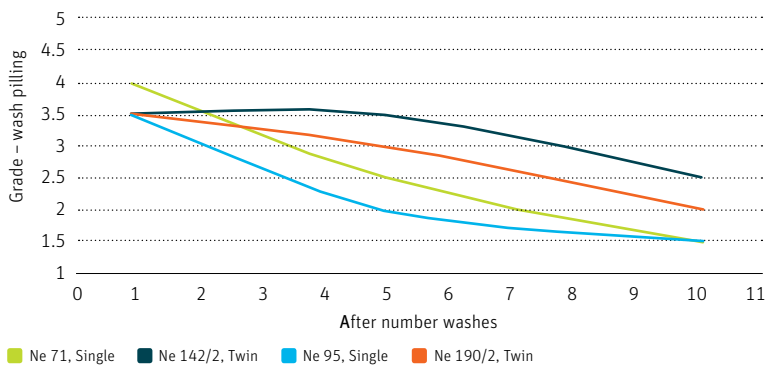


Fig. 47 After tumbler drying the twin yarn shows a better pilling behaviour compared to single yarn

Wash pilling after line drying – Twin vs. Single

100 % Micro Modal® Air 0.8 dtex / 34 mm

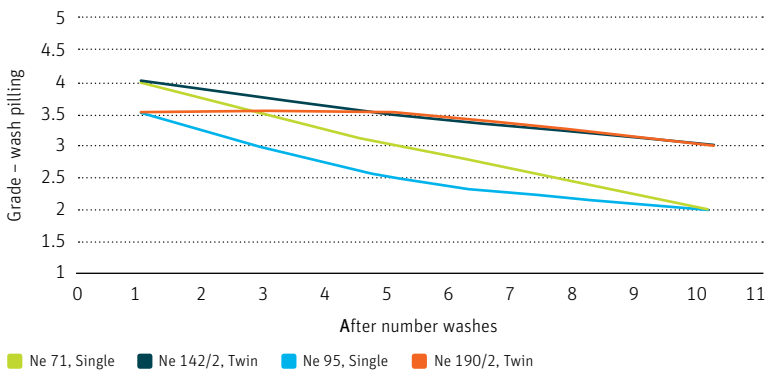


Fig. 48 Also after line drying the twin yarn shows a better pilling behaviour compared to single yarn

A possibility to record the pilling behaviour under standard practice conditions is the test according to the number of washing cycles with linen and also tumble drying. In this particular case, the change in the fabric surface after 10 washing cycles at a washing temperature of 40° was examined. Irrespective of the drying method, this test also shows a clearly better pilling behaviour with twin yarn by half to a whole grade compared to single yarn (Figs. 47 & 48).

The visual differences when assessing the knitted fabric after the washing test of both yarn structures are enormous (Figs. 49 - 52).

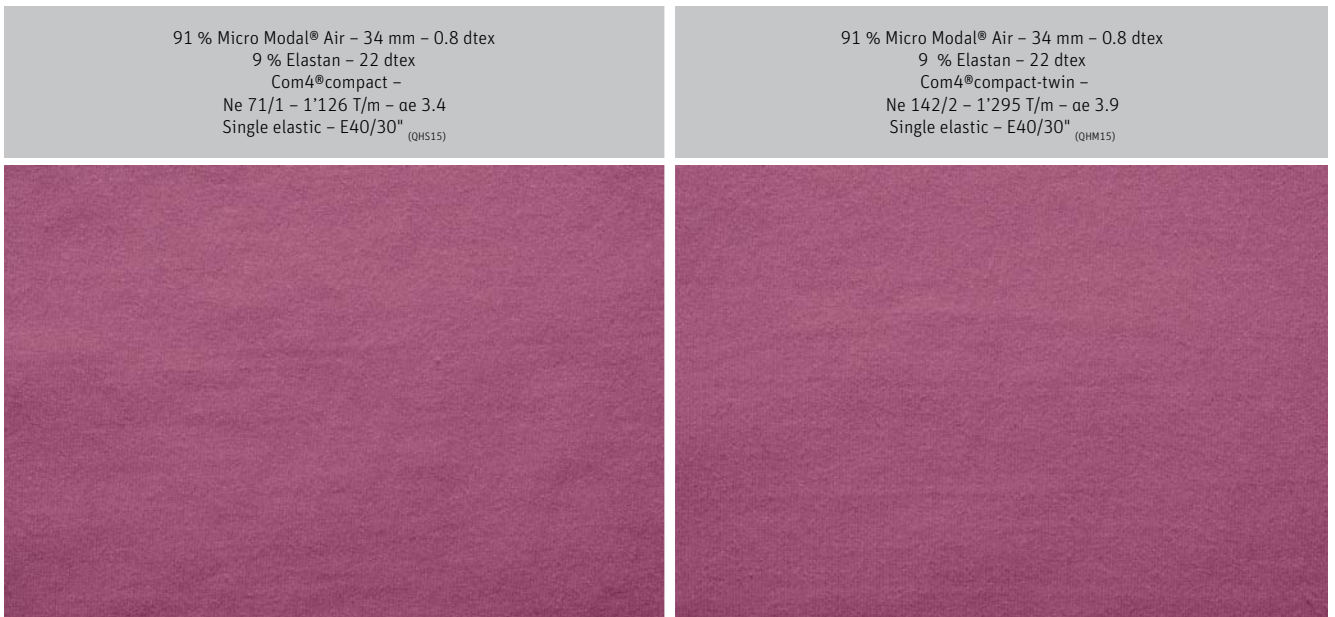


Fig. 49 Fabric original



Fig. 50 Fabric after 10x wash

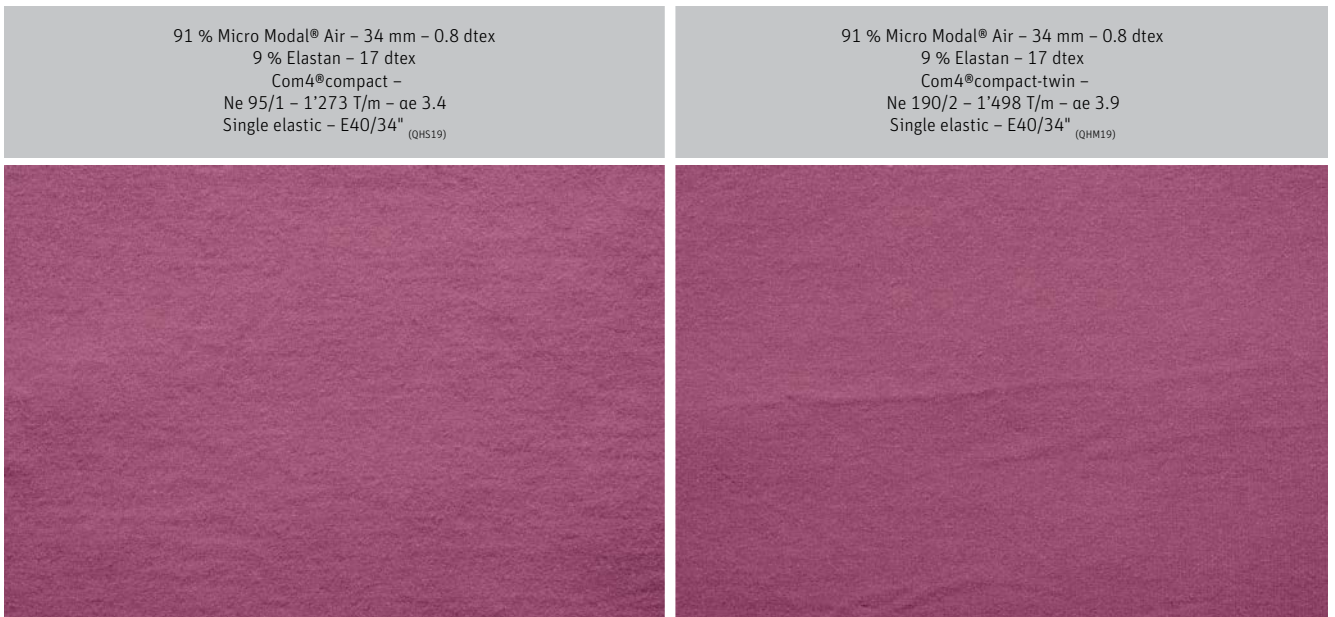


Fig. 51 Fabric original

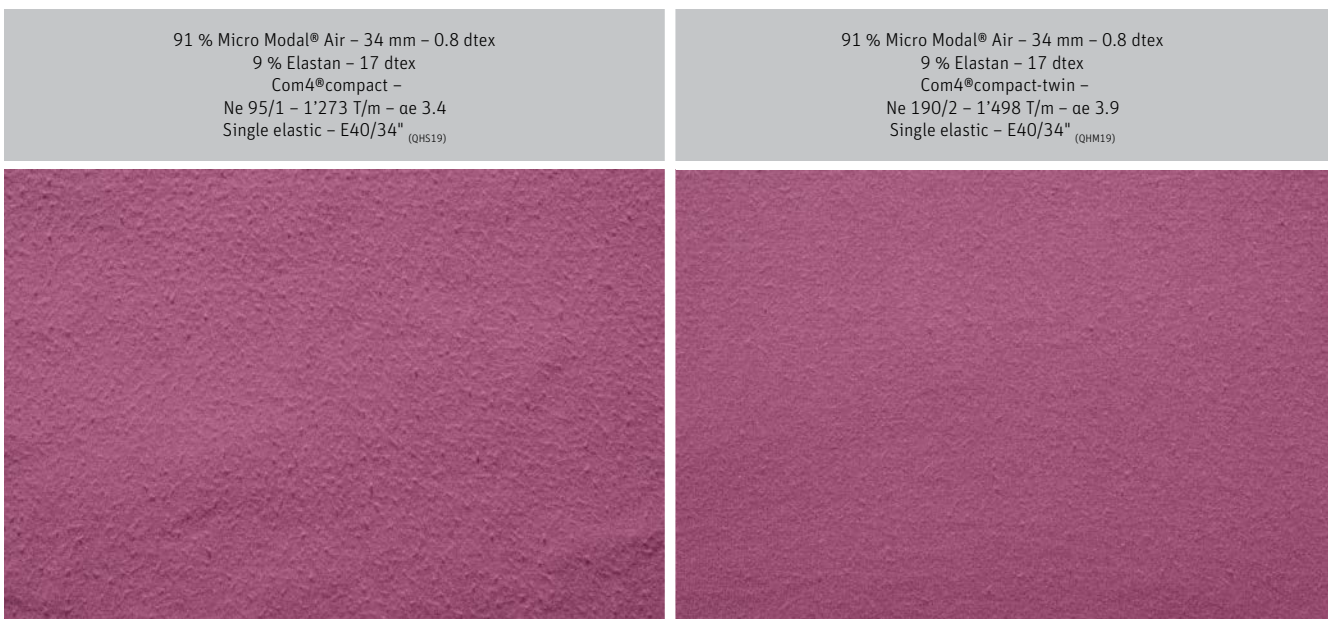


Fig. 52 Fabric after 10x wash

8 Economy

The manufacturing costs of twin yarn are determined by the roving count, the spindle speed and the twist coefficient.

Because of the necessary greater roving frame capacity and the lower spindle speed, the manufacturing costs of twin yarn, depending on the yarn count from 110/2 to 190/2, are 30 to 65 % higher than the respective single yarn. The manufacturing cost of two-ply yarn in the same yarn count range, however, is around 170 % higher than that of twin yarn (Fig. 53).

As far as the manufacturing costs are concerned, the required finer roving has a far greater impact than the higher number of ring spinning spindles with reduced spindle speed and increased twist coefficient.

The costs can, of course, be optimised by trying to use coarser rovings on the ring spinning machine and by working with higher spindle speeds.

| Economics of twin yarn depend on: | Influenced by: |
|-----------------------------------|--|
| Roving count | <ul style="list-style-type: none"> Maximal amount of fibres in the cross-section in the drafting unit on ring spinning machine. Due to the draft force in the ring spinning drafting unit |
| Spindle speed | <ul style="list-style-type: none"> Yarn breakage rate on ring spinning machine. Due to the yarn shank geometry |
| Twist coefficient | <ul style="list-style-type: none"> Hairiness, pilling, abrasion resistance Yarn strength Yarn breakage rate on ring spinning machine |

In this application example, however, there is still great potential to increase the performance limits of the ring spinning machine. As already mentioned at the beginning, it was also the aim of this test to spin extremely low yarn breakage values. The respective optimum as far as the performance limits are concerned naturally also depends on the relevant raw material.

With increasingly finer yarn, the differences also increase. The reason is that the manufacturing costs for twisting compared to the spinning costs are greater in absolute terms. Therefore, when more twisting positions are needed, an increasingly large cost difference to the capacity of respectively alternative spinning capacity occurs.

For the profitability calculation, a 20 % higher spindle speed was already used, which naturally is likely to result in a higher ends down rate of 10 - 20 / 1 000 Spd instead of 5 - 10 / 1 000 Spd. A greater draft or higher spindle speeds on the ring spinning machine, however, may not result in running properties or yarn quality not corresponding to the customer's requirement.

Compact yarn manufacturing costs for Indonesia market

100 % Micro Modal® Air 0.8 dtex / 34 mm, K 45, 10 - 20 breaks / 1 000 Sph

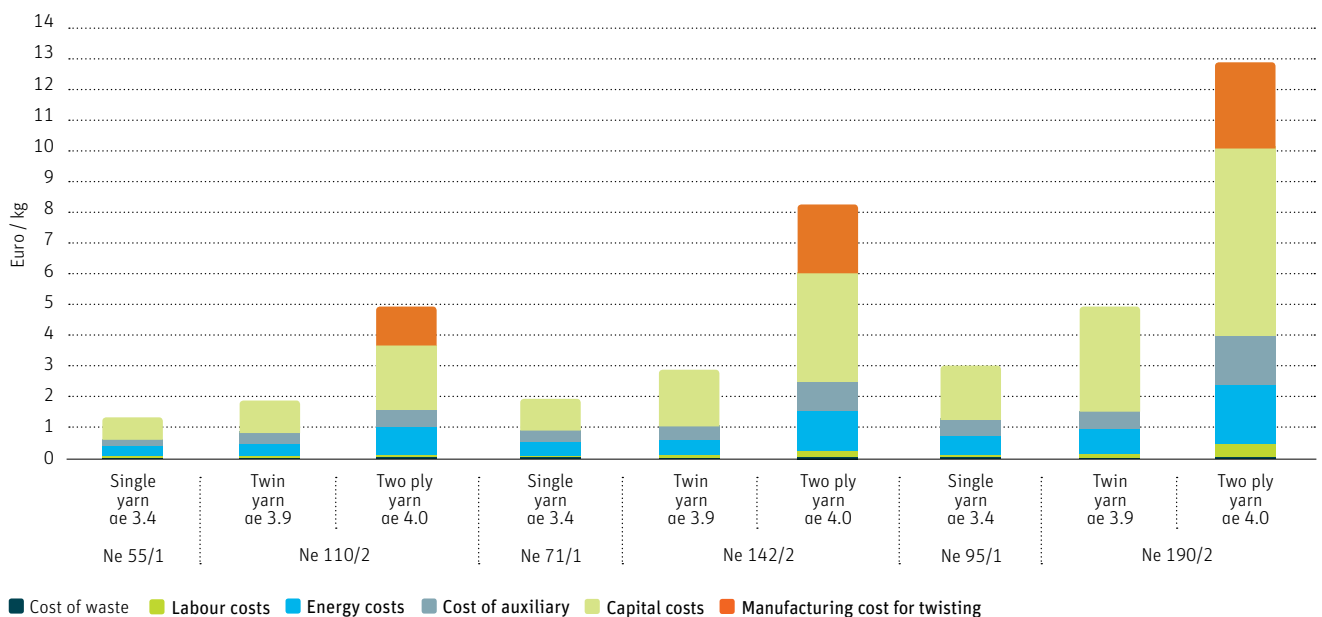


Fig. 53 The manufacturing cost of twin yarn are higher than single yarn caused by the finer roving and lower spindle speeds

9 Summary of Compact Twin Yarns Using Micro Modal® Air 0.8 dtex

In addition to the high flexibility of the ring spinning technology concerning yarn counts and the ability to process very different raw materials, the flexibility to produce special structures, effect and multicomponent yarns should also be highlighted.

These are, for example

- compact yarn
- twin yarns or compact twin yarn
- fancy yarns
- core yarns

The manufacture of a compact twin yarn was analysed in combination with the

- raw material Micro Modal® Air
- fine fibres and
- very fine yarns

The operational reliability for producing a twin yarn can be dramatically improved by using the compact ring spinning machine compared to a conventional ring spinning machine. Despite the very fine yarns of up to 190/2, an ends down rate of < 12 Fbr / 1 000 Sph

can be achieved due to the ideal yarn shank triangle on the compact spinning machine.

As expected, the twin yarns showed an improvement in uniformity of 10 - 15 % in absolute terms compared to a single yarn with the same yarn count, regardless of the respective twist coefficient and according to yarn count.

Nevertheless, an irregularity in the evenness is created by the yarn twist-in point of both yarn shanks.

The better sloughing resistance of the twin yarn has a clear advantage over single yarn on the ring spinning machine, in particular on the ring traveller system and the following winder.

Single yarn with the twist coefficient of $\alpha_e 3.4$ exhibited the same tenacity range with yarn counts of 142/2 - 190/2 as the twin yarn yarn with $\alpha_e 3.9$.

As already mentioned at the beginning, on twin yarn the spindle speed must be set lower and / or the twist coefficient set higher to

secure the best possible running properties. The yarn tenacity, however, is not only influenced by the yarn structure but also by the raw material, the yarn count and the twist coefficient. Therefore, the tenacity of a twin yarn is not in every case higher than with a single yarn.

The optimal twist coefficient for the twin yarn manufacture on the compact spinning machine using Micro Modal® Air 0.8 dtex can be set at with α_e 3.9.

As far as hairiness is concerned, twin yarns show great advantages compared to single yarn. With comparable raw materials, the twin yarns achieve values which can otherwise only be reached by air-jet yarns. So in this case, using Micro Modal® Air for twin yarn, a hairiness reduction of 17 - 24 % according to Uster is shown.

The better the protruding fibres on the yarn surface are anchored in the yarn strand, the less fibre abrasion occurs on the yarn under stress. The twin yarns show far lower fibre abrasion than the single yarn, irrespective of the twist coefficient.

The twin yarn with a twist coefficient of α_e 3.9 reaches an abrasion resistance almost twice as high than the single yarn with α_e 3.4. The positive effect is primarily due to the "twin yarn structure".

It should be noted that the twist coefficient for twin yarns with α_e 3.9 have been optimised due to an optimal ends down situation and must consequently be set somewhat higher than with a single yarn.

The yarn structure of a twin yarn differs greatly from that of a single yarn. The twist development of the fibres with single yarn is continuously and regularly distributed over the yarn axial length. With twin yarn it is additionally obvious that two yarn sequences run along the yarn axis, similar as in the case of a two-ply yarn.

Addition of filament yarns in the knitting process reduces the difference between the two yarn structures. Despite the positive influence of the filament in the knitted fabric, a massive difference in pilling is still shown between the two yarn structures in favour of the twin yarn. After 2 000 abrasion cycles, the value is clearly one grade better than with single yarn.



Rieter Machine Works Ltd.
Klosterstrasse 20
CH-8406 Winterthur
T +41 52 208 7171
F +41 52 208 8320
machines@rieter.com
aftersales@rieter.com

Rieter India Private Ltd.
Gat No. 768/2, Village Wing
Shindewadi-Bhor Road
Taluka Khandala, District Satara
IN-Maharashtra 412 801
T +91 2169 304 141
F +91 2169 304 226

Rieter (China)
Textile Instruments Co., Ltd.
Shanghai Branch
Unit B-1, 6F, Building A,
Synnex International Park
1068 West Tianshan Road
CN-Shanghai 200335
T +86 21 6037 3333
F +86 21 6037 3399

www.rieter.com

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