THE SPECIAL STRUCTURE OF COMPACT YARNS - ADVANTAGES IN DOWNSTREAM PROCESSING

Peter Artzt
ITV
Denkendorf, Germany

Abstract

Compact spinning forms fibres into a narrow sliver by drafting in a virtually tension-free process withing a compacting zone. The compact sliver is twisted in a very small spinning triangle, thereby eliminating perpiheral fibres. This novel yarn structure gives compact yarns better strength, better elongation, and reduced hairiness. Compact spinning produces superior ring yarns which offer special advantages in downstream processing.

Compact spinning produces a novel yarn structure. The particular features of these yarns are better strength and elongation connected with reduced hairiness. The unique yarn structure offers major advantages in downstream processing. The degree of weaving warp sizing can be greatly reduced. The low degree of contamination by fly results in increased efficiency in knitting and weaving. The possibility of reducing yarn twist also results in a considerable reduction of doubling twist. Yarn hairiness is equivalent to that of gassed ring yarns.

In the light of today's knowledge, compact spinning produces yarns which represent a superior ring yarn. It is therefore really a new spinning process, although the yarn looks very much like ring yarn. Spinning without spinning triangle results in uniform fibre integration tension through the yarn cross-section, and consequently in different behaviour in downstream processing.

At compact spinning, the fibres are compacted into a narrow sliver after a virtually tension-free drafting process within a compacting zone and they are twisted after the nipping point as a compact sliver. As in the classic spinning triangle, peripheral fibres are eliminated. The principle is shown in *fig. 1*.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:798-803 (2000)
National Cotton Council, Memphis TN

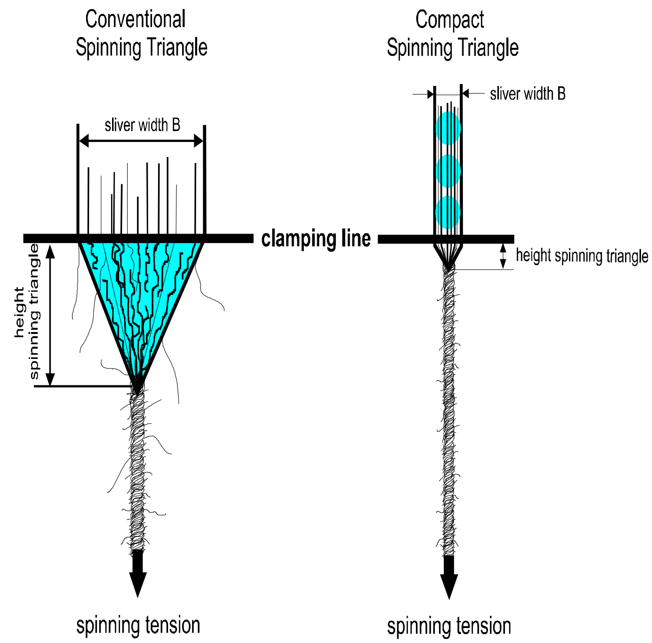


Figure 1. Yarn Formation

Fig. 2 shows the compact system of ITV, which is worldwide patented and licensed to Zinser.

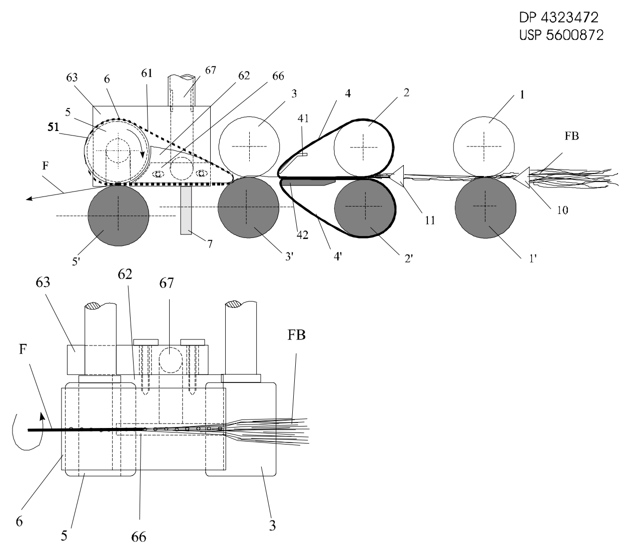


Figure 2. Principle of ITV-Compact Spinning

The classic double apron drafting system is followed by the compacting zone, which consists of a revolving perforated apron. The underside of the perforation is suctioned above the apron mounting in such a way that the fibres accumulate on the perforated track. A small percentage transitional draft can be set between drafting mechanism exit and compacting element. The collected fibres on the perforated track are shown in *fig. 3*.

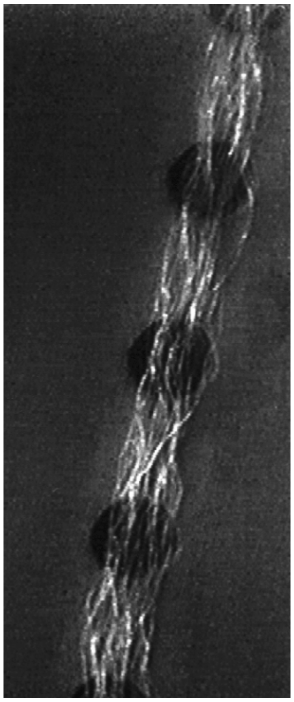


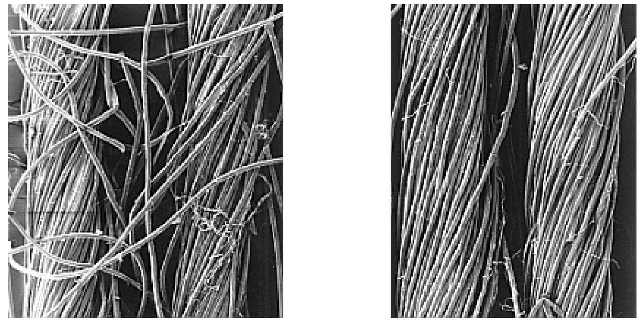
Figure 3: Fibre Compacting on Perforated Track

The extent of compacting is determined by the size of the perforations. The hole diameter is about 1 mm, and can be matched to the yarn count.

Yarn Structure

‘Yarn structure’ is an undefined idea, and can only be described with difficulties. An extraordinary good visual impression of the yarn structure is obtained by electron microscopy (SEM). The photo below shows a small piece of yarn appearing almost three-dimensional.

The yarn structure is extremely impressively visualized. Comparison immediately reveals the clearer fibre arrangement at compact yarns, a distinct twist spiral and a small number of fibre elements which haven’t been sufficiently integrated. With a more orderly arrangement, a specific quality improvement is obtained which also occurs in staple fibre spinning. *Fig. 4* demonstrates the two yarn structures according to SEM.



Conventional Yarn Compact Yarn

Figure 4. Yarn Structure (SEM)

A significant reduction in hairiness is the result. In this respect, hairiness today can be determined in various ways. When we talk on the one hand of normal hairiness, we mean the short protruding hairs, 1-2 mm in length, and, on the other hand, a disturbing hairiness within a range between 6-8 mm. Normal hairiness ultimately gives spun yarn its unique character. Long hairs interfere with the processing operation, due for example to abrasion, fly formation, snagging and hooking. For this reason, efforts are made in ring spinning to reduce this disturbing hairiness by combing, good raw material selection and ring-/traveller optimization.

Compact yarn provides a completely new approach to the problem of hairiness. With carded yarn, Ne 30, (*fig. 5*), frequencies as they are reached today only with combed yarns are obtained in terms of disturbing hairiness. The normal hairiness of both yarn structures is kept, in other words compact yarn results in fabrics with textile character. *Fig. 5* shows the Uster values regarding hairiness: It gets clear that conventional yarn is more hairy than carded compact yarn.

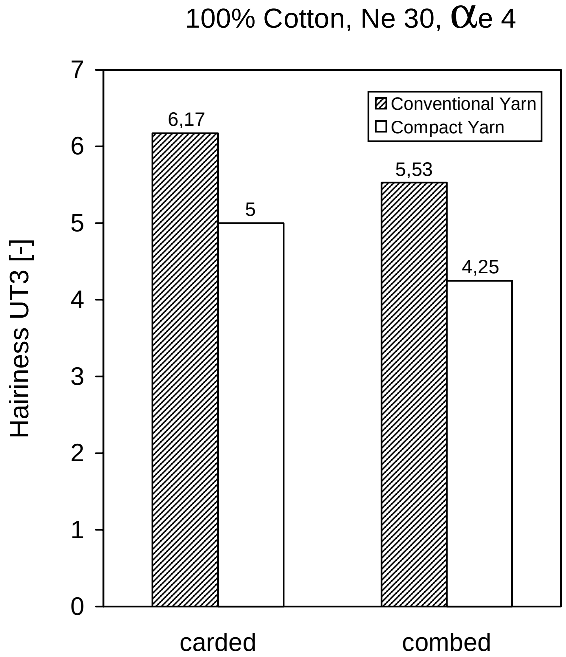


Figure 5. Uster Hairiness

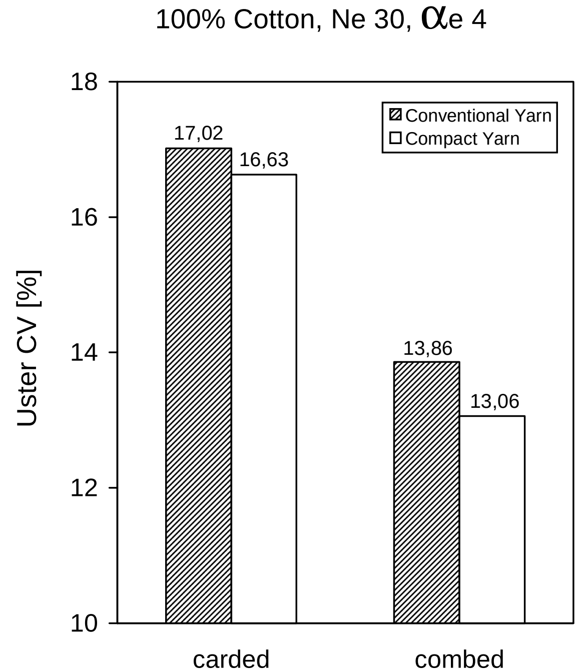


Figure 7. Uster CV

On the other hand, short hairs up to 2 mm in length still exist in both yarn structures but the disturbing long hairs are virtually eliminated (*fig. 6*). Only approx. 10% of the long hairs are kept.

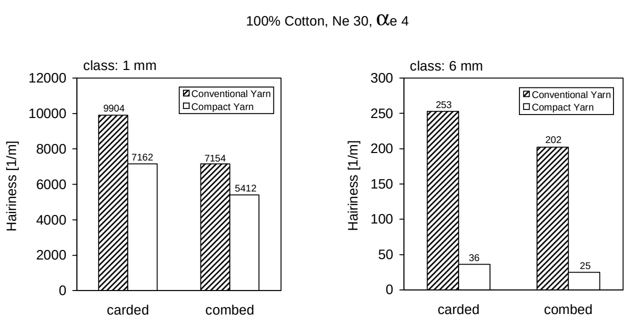


Figure 6. Zweigle Hairiness

The processing behaviour of carded yarns in weaving and knitting has consequently been improved. The advantages resulting thereof, however, shouldn't be ignored.

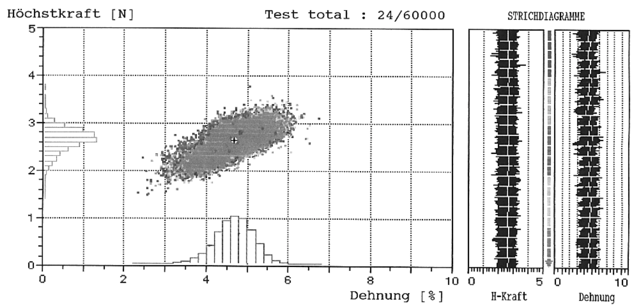
As there could be be expected, comparative studies on yarns of identical count and twist coefficient revealed advantages in terms of evenness variation. Here compact yarns always show better values. This tendency is also confirmed by "Uster-UT3" in terms of mass variation (*fig. 7*). Although both yarns are drafted on identical rovings and under identical conditions, compact yarn shows more evenness.

Yarn twist measurement also reveals a structural difference between ring and compact yarn. In all cases, more twists are measured in compact yarn by the double-sensor method. At about 5 %, the difference is considerable, and clearly indicates an enormous difference in yarn construction through the cross-section.

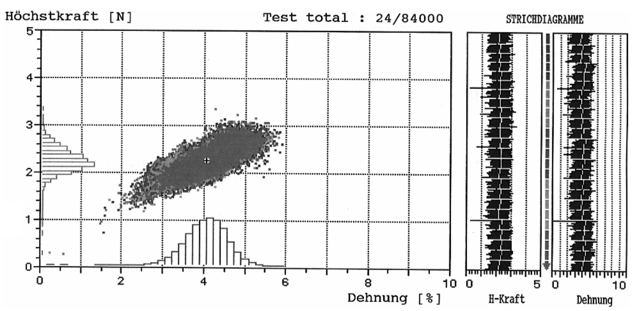
The coefficients of variation of yarn twist are also lower in the case of compact yarn. Twist measurements over short lengths show that twist distribution is substantially more uniform in compact yarn. Here, compact yarn shows clear advantages.

Low mass variations and better twist distribution must have an effect on the rare disturbing weak places. "Tensojet" trials repeatedly revealed distinct advantages for compact yarns. A trial series on combed yarn showed minimum strength values in a range between only 2.2 cN/tex at conventional yarn and 12.6 cN/tex at compact yarns (*fig. 8*).

100% Cotton – Compact Yarn



100% Cotton – Conventional Yarn



Strength [cN/tex]	Compact Yarn	Conventional Yarn
Minimum	12,56	2,20
Average	22,51	19,13

Figure 8. USTER TENSOJET

The difference will not always be so striking, but has significantly been present in all comparative trials. On the other hand, the rise in mean values with identical yarn twist is obvious. Compact yarn strength and elongation increases by approx. 15 %, a fact that is demonstrated by the work to break factor (*fig. 9*).

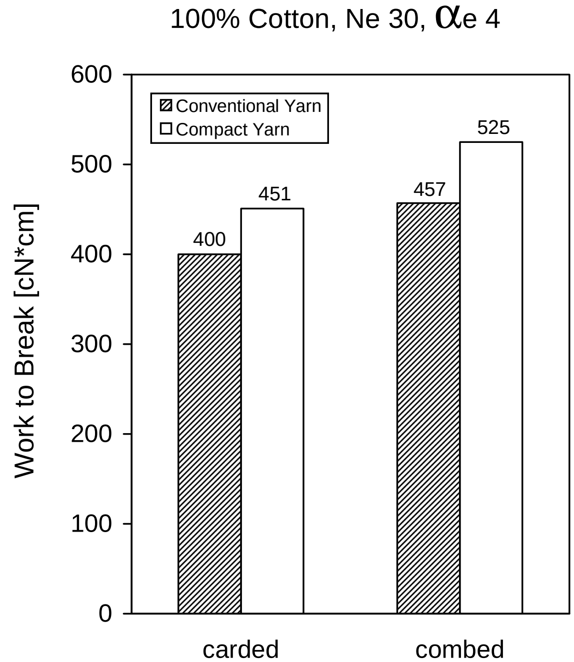


Figure 9. Work to Break

Fibre strength utilisation leads to values hitherto unknown in literature, being evidence of the fact that not only qualitative ring spinning improvement but actually a new yarn structure is given. This must have effects on processing operations, finishing and end-product appearance.

Present Winding Technology

A problem of today's winding technology is the change in yarn quality during high-speed winding. Here, the yarns are exposed to marked roughening, the restraining action perhaps also increasing the number of neps. Due to their proven smoother structure, compact yarns slide much more easily than conventional yarns. This already gets visible by means of the so-called Staff test, abrasion being determined by rubbing a yarn loop (*fig. 10*).

This test correlates with fibre fly formation in knitting, weaving and quality change in winding. In the case of yarns with currently used industrial twist factors between 100 and 125 α_m abrasion is almost halved according to Staff testing. Changes during winding is less distinct.

Strength- and elongation behaviour didn't change through winding. The values lay in the normal variation range. Distinct differences emerged as increase of hairiness, revealing clear advantages for compact yarns.

The hairiness of the wound yarns was clearly below the initial hairiness of the conventional spun yarns on the cops (*fig. 11*).

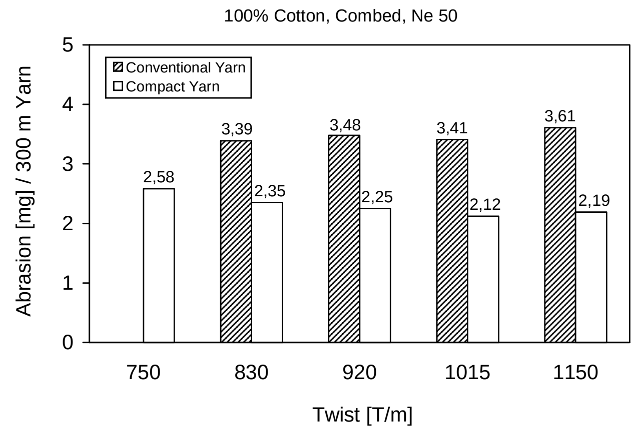


Figure 10. Abrasion

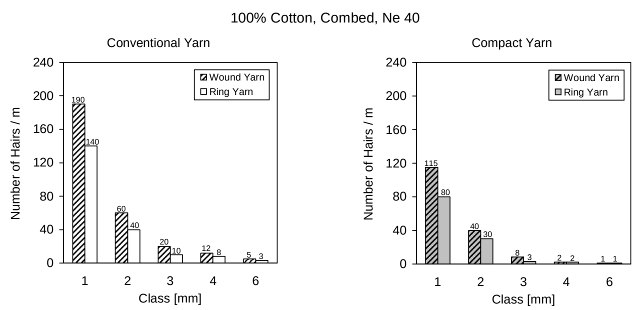


Figure 11. Zweigle Hairiness

A certain increase in hairiness is also imparted by the winding process in the case of compact yarn. The advantage, of course, also remains after winding, so that downstream processing benefits from the low degree of yarn hairiness.

Sizing (Weaving Preparation)

Sizing has always been an expensive process but it is necessary for making yarn capable of being warped. Yarns were spun at different twist levels as compact yarns, and only in the standard twist α_e 4. The yarn was exposed to different degrees of sizing.

The degree of sizing was varied between 2 and 12%. Fibre abrasion in the rear shed and warp-end snagging due to separating force during weaving was determined.

The applied separating force which is a measure for sticking tendency was equivalent to 2% size application in the case of compact yarns, and equivalent to 12% size application in the case of conventional yarns (*fig. 12*).

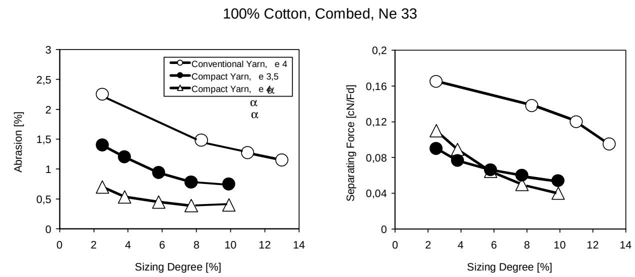


Figure 12. Sizing Trials

On the other hand, no differences were detected regarding separating force between the two twist variants with compact yarn. Here the data from the structural studies are confirmed in downstream processing behaviour.

Gassing / Singeing

The gassing process is largely applied in order to reduce hairiness, the resultant gassing dust in the form of burnt-off particles playing an important role. The gassing dust settles on the yarn on the gassing machine. It is around 2 - 4 % and has a disturbing influence. For this reason, gassed yarns as a rule must be rewound on to dyeing bobbins before being dyed. Reducing the amount of dust could save these rewinding processes. With conventional yarns on the other hand, an increase in gassing speed succeeds in reducing the effect of hairiness reduction.

The hairiness level of combed yarns was determined on the basis of gassing speed and length class, even with the highest speed of 900 m/min the hairiness of gassed compact yarns being less than that of conventional yarns at a minimum speed of 600 m/min *(fig. 13)*. The effect of gassing on compact yarns is much stronger than on current conventional yarns. In length classes, more than 3 mm, the frequencies with compact yarn were virtually zero, and an illustration of this effect consequently would be meaningless. Thus, gassed compact yarns definitely represent new yarn quality.

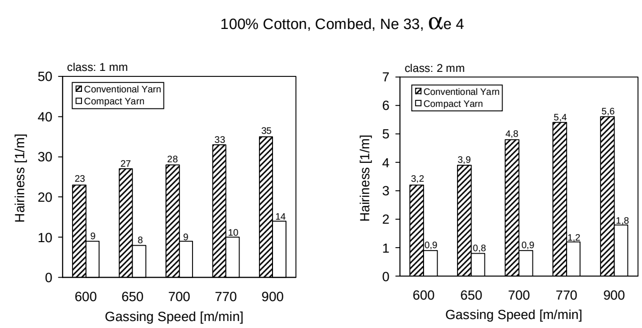


Figure 13. Zweigle Hairiness (Gassed Yarn)

Much less gassing dust is generated, a fact which could make it possible to produce dyeing bobbins directly on the gassing machines on a wider basis. The clear structure in the case of compact yarns in contrast to that of conventional yarns is extraordinarily marked. There arises the question of lustre in the end-product. Mercerizing can possibly be dispensed with in some cases. Results of compartative studies aren't available yet.

Twisting

Yarns with different twist factors were produced for the purpose of twisting trials. The trials were planned under conditions of classic ply yarn construction. Yarn twist was reduced to a residual twist of approx. 120 tpm. This means that yarns with higher yarn twist also get more doubling twist.

The necessary doubling turns decrease in the same ratio as single yarn turns do. This has decisive effects on the economics of the doubling process. Each doubling process is costly and every reduction of twist increases productivity.

If one considers ply yarn strength, higher profit in strength becomes visible through doubling in the case of compact yarn. Comparable strength values are obtained with ply yarn at less yarn twist and consequently, at about 25 % lower doubling twist. In other words, the advantage of using reduced twist is reproduced in ply yarn. Once again it should be noted that residual yarn twist is virtually constant at all variants. The same applies to elongation behaviour. From this follows that we are pushing forward into completely new fields as regards ply yarn work capacity (*fig. 14*).

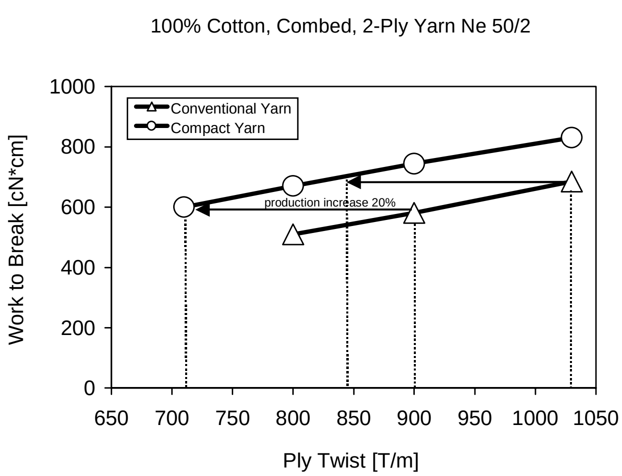


Figure 14. Work to Break

As far as handle is concerned, there is also the possibility of achieving softer handle with using coarser wool. This means an extension of the application range of higher μ-value wools, since yarn and doubling twist can be reduced.

Summary

Compact spinning leads to a new yarn structure which gets still closer to the ideal staple fibre yarn construction. This has positive effects on:

a) raw material use
b) productivity
c) downstream processing, and on
d) product appearance.

It has become obvious that benefit per kg yarn is enormous in downstream processing and higher than in the spinning process itself. Future will show what can be achieved with new products regarding endproducts. Different product developments, however, already prove that compact spinning is no niche process at all: Cost advantages are too obvious. Thus, the new compact spinning process gives the opportunity to realize further advantages in the field of international competition - through innovation.