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Processing of TENCEL® microfibers

Processing characteristics of TENCEL® LF microfibers
on Rieter high performance spinning machinery

Fiber production world wide

In 2005, out of global man-made fibers production of 39,5 million tons, cellulosic staple fiber production accounts for 7% (Fig. 1). Relative to man-made staple fiber production alone, the proportion of cellulosic staple fibers is already 15%.

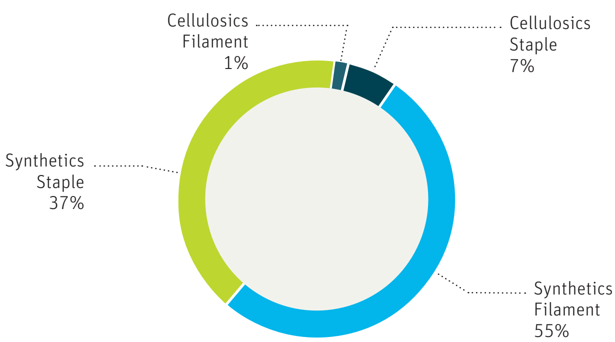


Fig. 1 Man-made fiber production separated into synthetic and cellulosic raw materials.

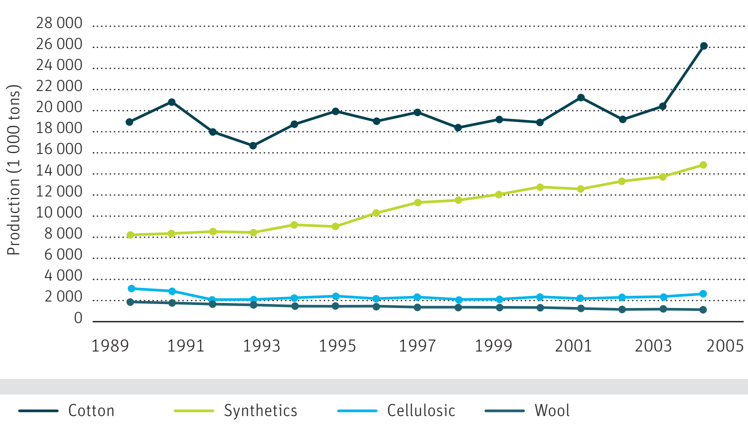


Fig. 2 Worldwide staple fiber production

Cotton production has more or less remained constant over the years, at about 20 million tons per year. In 2004 the production rate was increased to 26 million tons, which seems to be a new record. Synthetics are the number two with 14 million tons (Fig. 2). The celluloses with 2,7 Mio tons are actually a big market for staple fiber yarn with a great potential. Celluloses like Viscose, Modal, TENCEL® are a very good alternative to cotton and play an important role in the textile market of fashion cloths, beddings and towels.

PROPERTIES OF CELLULOSE FIBERS

Generally speaking, cellulosic fibers display very good moisture absorbency, better than that of cotton, and they dye readily, are antistatic, have a soft handle, are pleasant to the skin and easy-care. Compared with other cellulosic fibers, such as viscose and Modal, TENCEL® features higher wet strength (see table below), has a better dimensional stability and lower washing shrinkage. TENCEL® is produced with an environmentally friendly solvent spinning process. The special feature of this process is the almost total recirculation of the solvent. 99,5% of the solvent is recovered, and the very small emissions remaining are degraded in specially adapted biological clarification plants.

Wet strength of cellulosic fibers in cN/tex

Viscose	12-14
Modal	17-20
TENCEL®	31-37

New machine technologies

ADVANTAGES OF MICROFIBERS

Microfibers enable finer or stronger yarns to be produced. Knitted and woven fabrics manufactured from them have a silky appearance and drape. They have a pleasant feel, and the luster of the fabric and its moisture transport are improved. The larger the fiber surface, the more efficient the moisture transport. When microfibers with a count of 0,9 dtex are used, moisture transport with the same yarn count can be increased by about 50%. By comparison, the fibers usually have a count of 1,3 - 1,5 dtex.

While the proportion of micro staple fibers in 1991 was merely approx. 3 000 - 4 000 tons per year, today the whole micro staple fiber production of all raw materials amounts to approx. 600 000 tons per year.

DIVERSE FIELDS OF APPLICATION

TENCEL® is to be found in a very wide range of applications; in sportswear and leisurewear TENCEL® absorbs more water vapor than cotton and thus ensures optimum moisture transport. In shirts and blouses the fiber guarantees an ideal fit and dimensional stability as well as outstanding wearability. In bed linen an ideal sleeping climate is created – cool in summer and comfortably warm in winter.

Demand for TENCEL® will increase as more fields of application in woven and knitted goods are added in future.

TENCEL® MICRO

CARDING SYSTEM C 60

The C 60 carding technology has totally pushed feasible productivity limitations. The whole geometrical condition especially the working width has changed from 1 m to 1,5 m (Fig. 3).

This results in a much lower carding force. The carding force between cylinder and flats has a big influence on productivity and quality. The benefit becomes dramatically evident, when working with man-made fibers, especially with very fine fibers like microfibers.

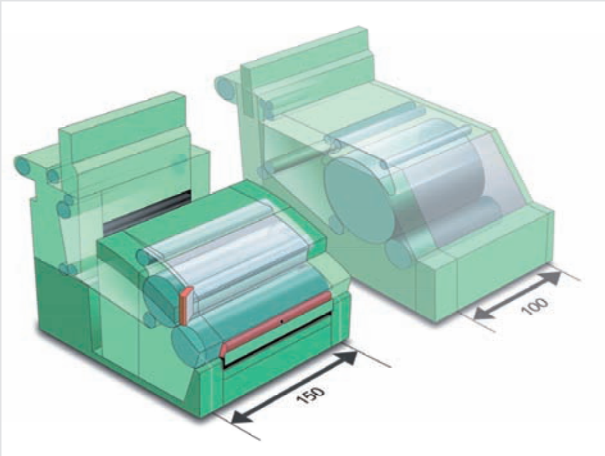
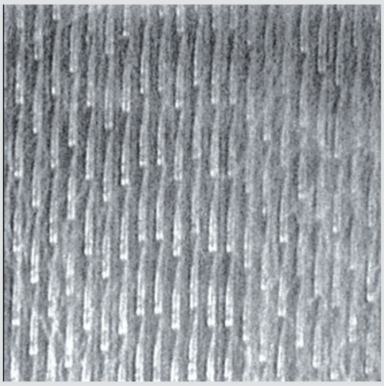


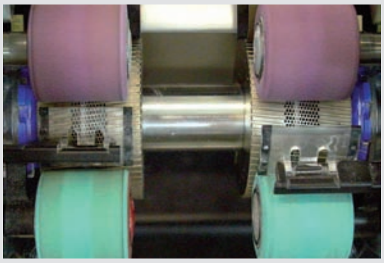
Fig. 3 Difference in working width between the carding technology of the card C 60 compared to conventional cards.



90 kg/h, Conventional card

90 kg/h, C 60 card

Fig. 4 Fiber density on cylinder



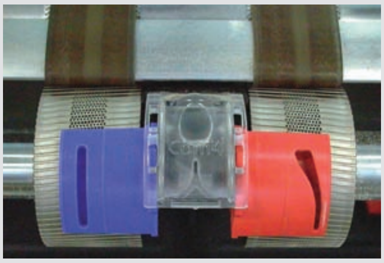


Fig. 5 COM4® technology ring frame K 44

FIBER DENSITY ON CYLINDER

You can see the fibers on the cylinder with the new carding system C 60 in comparison with the conventional card technology. (Fig. 4) If the density of fibers is too high the carding force will increase. Too much carding force results in lower carding quality. The fibers are spread out over a working width of 1,5 m with the C 60. This gives a lower fiber density, which results in a better carding quality or much higher productivity with the same quality.

COM4® TECHNOLOGY

The ComforSpin system features non-wearing technology components, such as a perforated drum, suction inserts and air guide elements. (Fig. 5) Depending on the raw material and the number of fibers in the cross section, i.e. the yarn count, the technology components and settings differ for achieving the best possible compacting result. (Fig. 6)

Suction insert

primo

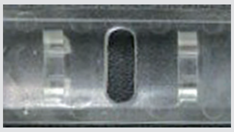
linea

COM4®twin

Air guide element

46/0,5/2

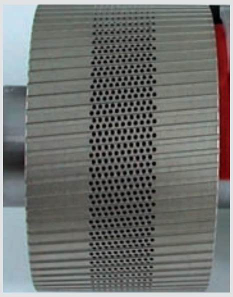
52/0,5/2



46/1,0/1

Perforated drums

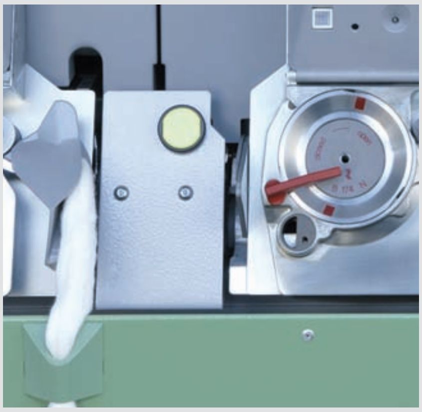
plain



fluted

Fig. 6 Technology components COM4®

Fig. 7 R 40 rotor spinning machine



The SC-R spinning box

R 40 ROTOR TECHNOLOGY

The unique SPEEDpass, for example, has proved to be of great advantage when processing these microfibers. Optimal fibre control for man-made fibers and large fibre mass is additionally supported by the SPEEDPass. This achieves a greater volume flow and high air speed in the fiber channel, which is noticeable in constant and stretched transport of the fibres.

Furthermore, particles of fibre finish are sucked away by the SPEEDPass after the fiber is detached from the opening roller. Rotor contamination due to fiber finishing deposits are therefore significantly reduced.

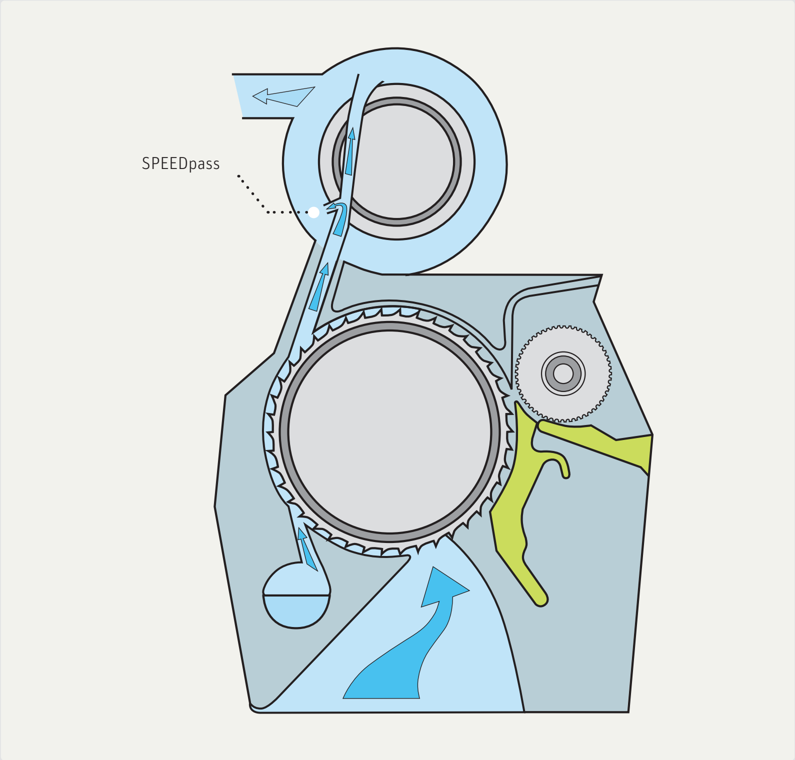


Fig. 8 SPEEDpass channel, additional airflow for constant fiber transport

Fig. 9 Standard channel insert

1. – SPEEDpass

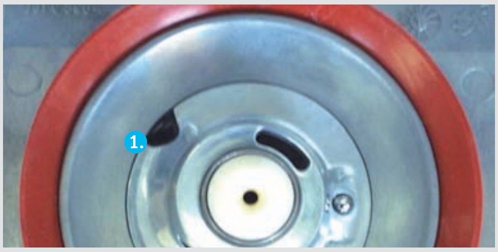


Fig. 10 Channel insert with SPEEDpass for additional airflow

Lenzing – Rieter study

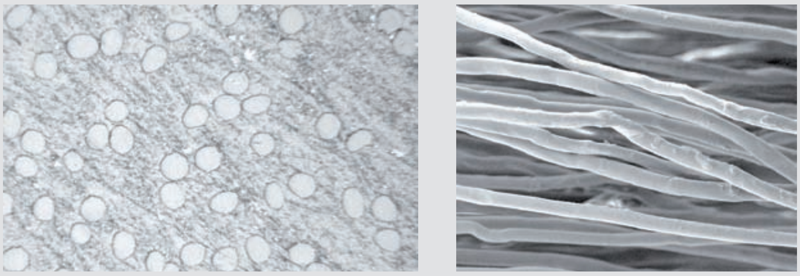


Fig. 11 Raw material TENCEL® microfiber 0,9 dtex

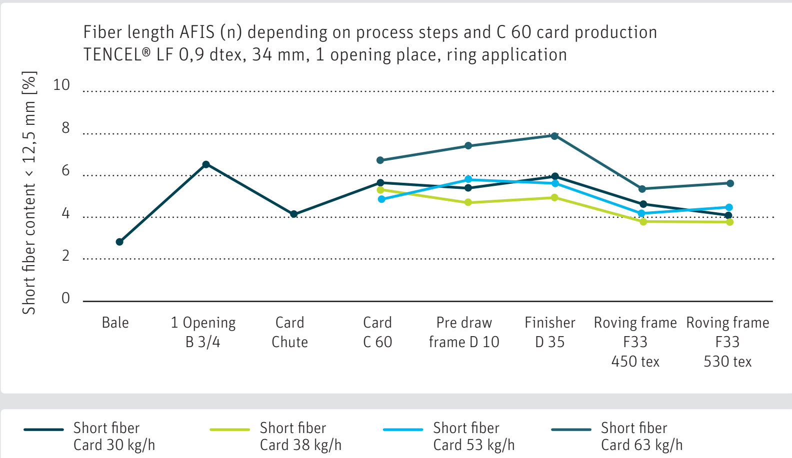


Fig. 12 Fiber length AFIS (n) depending on process steps and C 60 card production

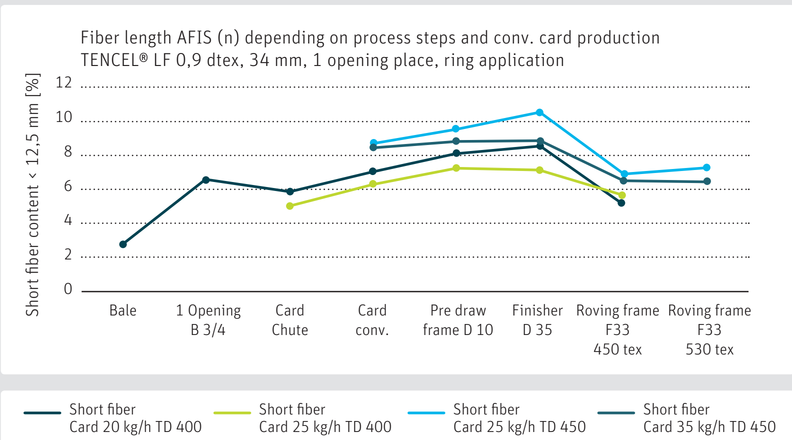


Fig. 13 Fiber length AFIS (n) depending on process steps and conventional card production

RAW MATERIAL SELECTION

The study was intended primarily to obtain information on the following aspects of processing Tencel microfibers:

- The performance limits of the C 60 card, also in comparison to conventional cards
- Compactability with COM4® compact spinning technology using the K 44 compact spinning machine
- The yarn count that can be achieved using rotor technology with the high productivity of the R 40 rotor spinning machine

Basic specification of the TENCEL® microfiber:

- Content 100%
- Producer Lenzing
- Low Fibrillation (LF)
- Staple length 34 mm
- Fiber count 0,9 dtex

RESULTS RAW MATERIAL

The question of the number of opening positions arises at the beginning of the spinning process. When one opening position is used in fiber preparation, no increase in short fibers is apparent up to a card production of 53 kg/h on the C 60.

Only at a card production of 63 kg/h fiber stress and thus the short fiber content does increase slightly, by 1-2 % in absolute terms. (Fig. 12)

On the basis of short fiber content, higher fiber stress is apparent on the conventional carding system compared with the new C 60 card system. In spite of an increasing card production a slight decline in short fiber content on the conventional card can be observed. This apparent contradiction can be explained by an insufficient carding effect. (Fig. 13)

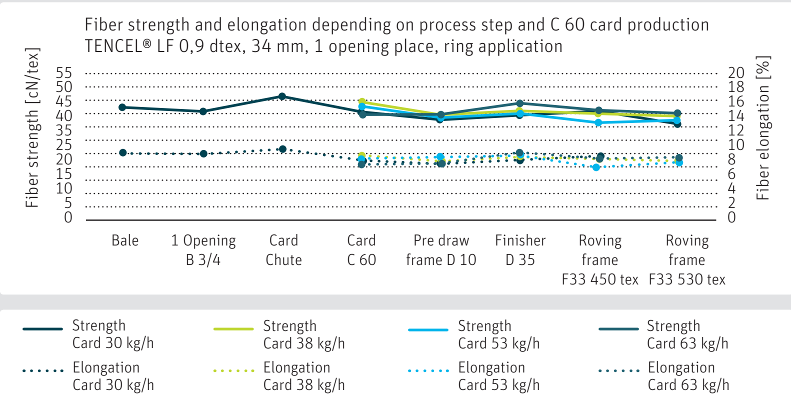


Fig. 14 Fiber strength and elongation depending on process step and C 60 card production

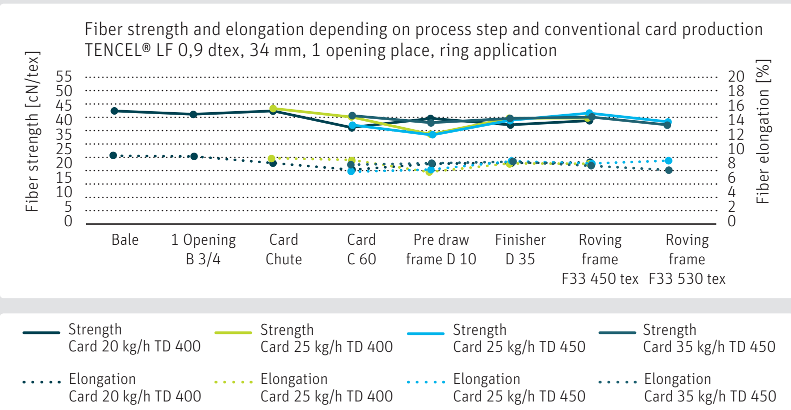


Fig. 15 Fiber strength and elongation depending on process step and conv. card production

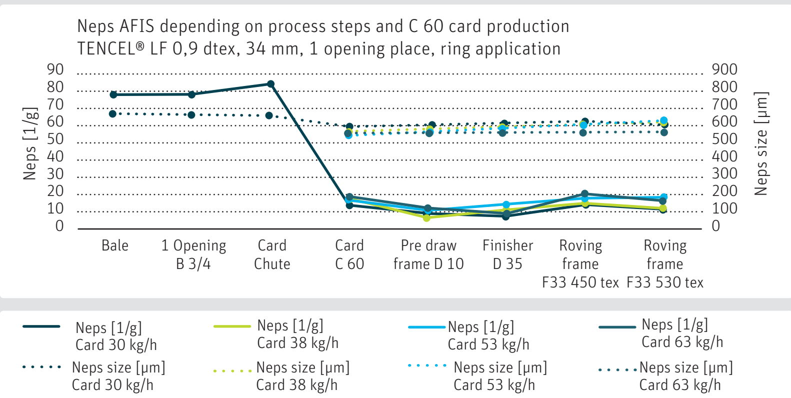


Fig. 16 Neps AFIS depending on process steps and C 60 card production

The system is already at the optimum qualitative level here. Higher card production has an adverse effect on carding results due to an already excessive fiber mass on the cylinder. This reduces fiber stress again, resulting in a lower short fiber content of barely 1%. There is thus an interaction between carding intensity and fiber stress.

At a similar card production of 35-38 kg/h there is a 3% reduction in short fiber content in absolute terms on the C 60 card compared with the conventional card. The fibers lose approx. 1-2 cN/tex and 1% elongation due to fiber stress during the entire spinning process. The greatest fiber stress usually occurs in the carding process. (Fig. 14)

Despite the far higher carding performance on the C 60, strength and elongation turn out the same as on the conventional card, which is an indication of gentle carding on the C 60 system. (Fig. 15)

The nep count on the card was reduced by approx. 80% with one opening position. (Fig. 15) The nep count before card infeed increased by approx. 20% when a second opening position was added in the spinning process. When processing man-made fibers additional opening positions always entail the risk of additional nep formation, which may have an adverse effect on results with regard to cleaning in the subsequent carding process.

On the other hand, of course, the fiber material must be adequately opened to ensure good carding and good nep removal. The nep count characteristics in fiber preparation indicate that one opening position is adequate where bale opening is good, as being achieved with the UNIfloc A 11 automatic bale opener.

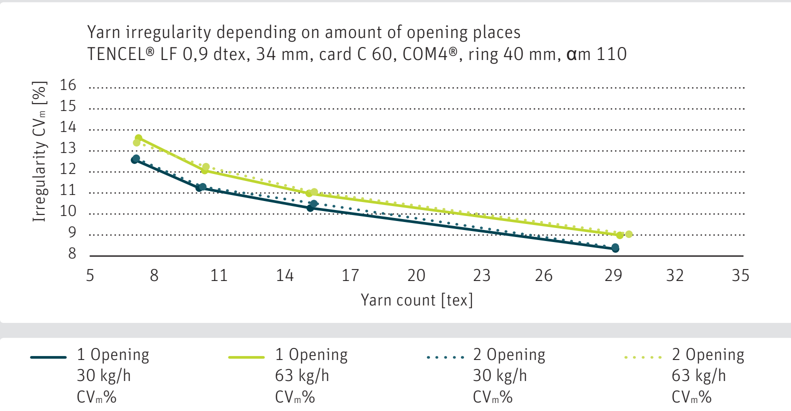


Fig. 17 Yarn irregularity depending on amount of opening places

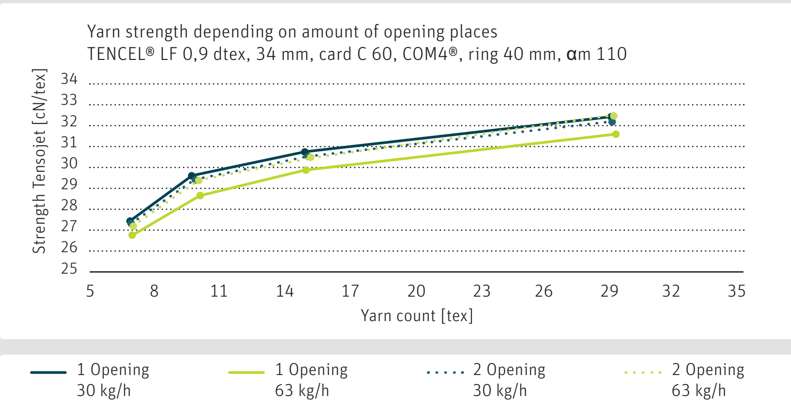


Fig. 18 Yarn strength depending on amount of opening places

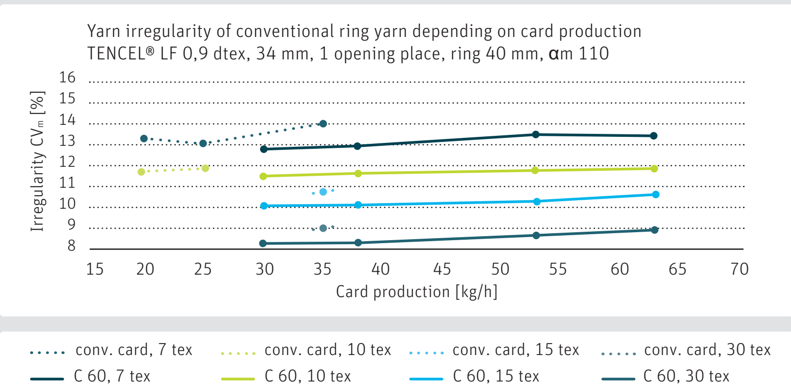


Fig. 19 Yarn irregularity of conventional ring yarn depending on card production

RESULTS RING YARN

The number of opening positions depends on various factors, such as:

- bale opening system
- type of raw material and its fiber cohesion
- fiber count
- residual moisture in the bale
- bale weight and compression

The number of opening positions displays no differences in terms of capacitive and optical yarn irregularity. (Fig. 17)

At a very high card production of 63 kg/h and in a yarn count range of 7 tex to 30 tex a second opening position has a positive effect on average yarn strength and elongation. Strength can thus be increased by approx. 0,7 cN/tex in absolute terms and elongation by 0,2%. (Fig. 18)

The limits on card performance come mostly out by working with man-made fibers especially with microfibers in high carding forces between the flat and the cylinder. This results in a decrease of yarn quality like IPI and yarn evenness. (Fig. 19) These can manifest themselves in a reduction in cylinder speed and more difficult fiber transfer from the cylinder to the doffer.
In order just to achieve card production of 35 kg/h on the conventional card system, various settings and technology components had to be selected to cope with the high carding forces.

The conventional carding system had reached its limits at card production of 35 kg/h, despite

- higher cylinder rotation speed
- a 5° reduction in the front angle
- lower point density on the cylinder.

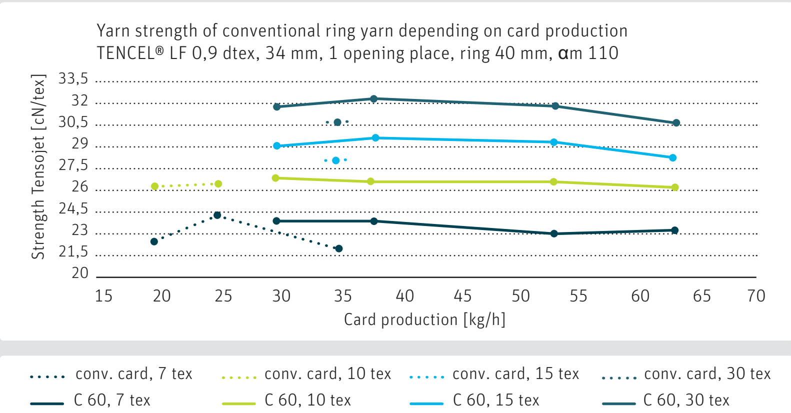


Fig. 20 Yarn strength of conventional ring yarn depending on card production

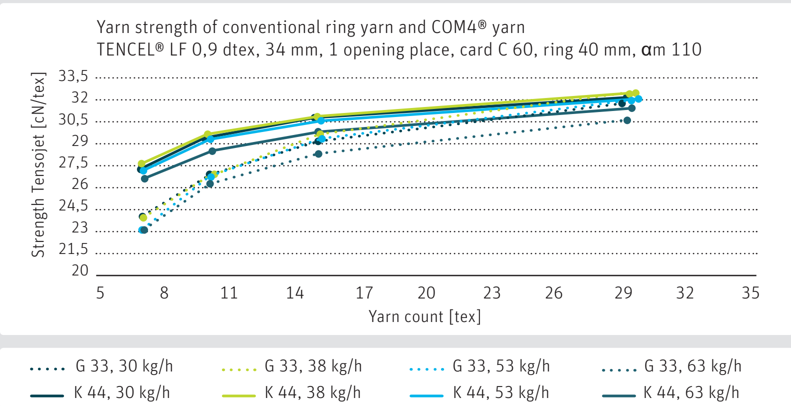


Fig. 21 Yarn strength of ring and COM4® yarn depending on yarn count and card production

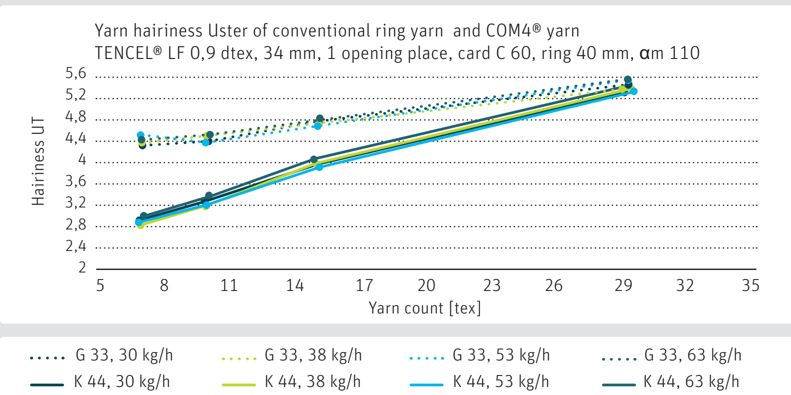


Fig. 22 Uster hairiness of ring and COM4® yarn depending on yarn count and card production

Carding performance on the C 60 system was increased up to 63 kg/h. This shows that also with regard to yarn strength a massive reduction in carding force with constant fiber can ultimately only be achieved, without drawbacks in carding quality, by a reduction in fiber density. (Fig 20)

The C 60 system distributes the fibers over a larger carding gap surface due to the wider card, which results in a massive reduction in fiber density and thus in carding force.

The final spinning system has a very high influence on yarn strength and elongation. An increase of up to 3,5 cN/tex in yarn strength is achieved using the COM4® system compared with the conventional ring spinning system at a yarn count of 7 tex. (Fig. 21)

As a result of the significant increase in strength by using the COM4® it was to be expected that this was due to the improved integration of the fibers in the yarn bundle. The hairiness of COM4® yarn measured according to the Uster method is 1,6 points lower than on conventional ring-spun yarn. (Fig. 22)

The difference in favor of COM4® yarn declines with increasing yarn count, and significant differences are no longer apparent from a yarn count of 30 tex, due to the greater resistance of the fibers to the suction of the air.

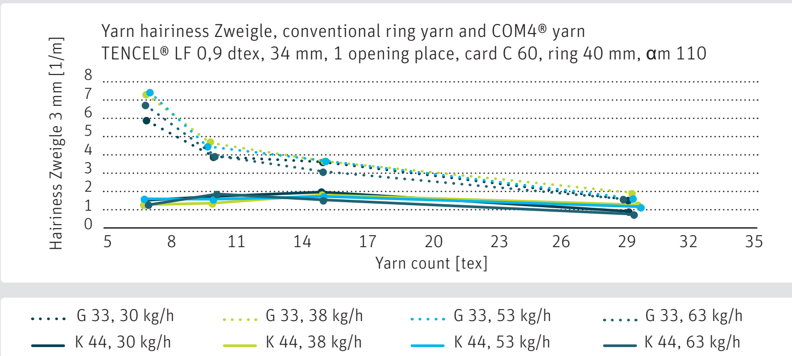


Fig. 23 Yarn hairiness Zweigle, conventional ring yarn and COM4® yarn

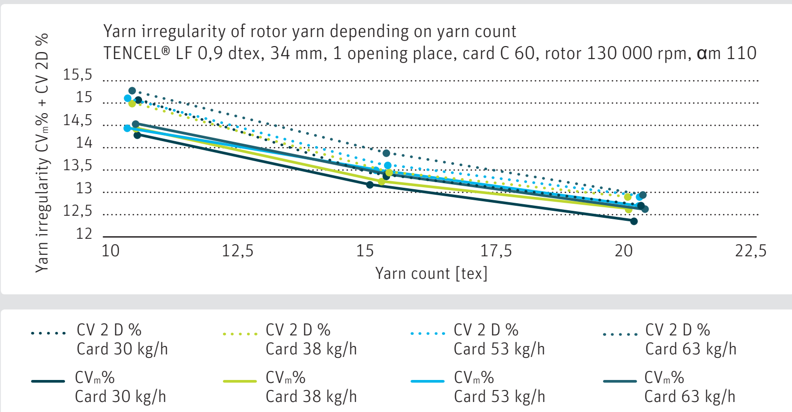


Fig. 24 Yarn irregularity of rotor yarn depending on yarn count

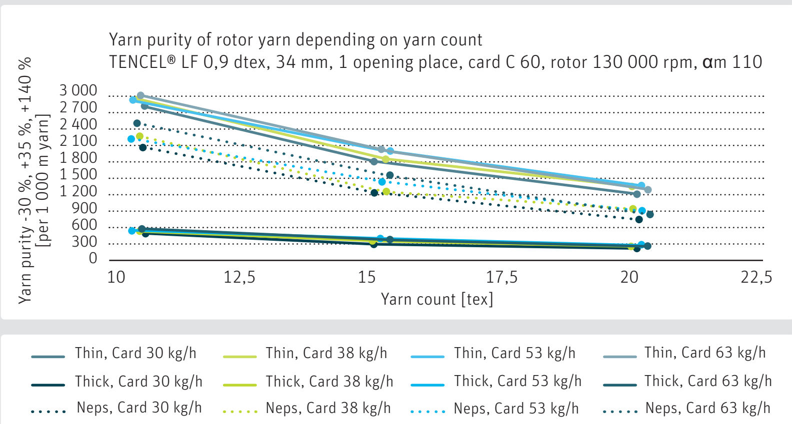


Fig. 25 Yarn purity of rotor yarn depending on yarn count

Yarn hairiness measured using the Zweigle method is also much lower for the COM4® system, especially for the disturbing long fibers of > 3 mm.

The differences also decline in this case as the yarn becomes coarser, and no longer exist from a yarn count of approximately 30 tex on. (Fig. 23)

RESULTS ROTOR YARN

By increasing card production of 30 - 63 kg/h only small differences were apparent in yarn regularity as well as thick and thin places.

With rising card production only in nep count is an increase of 10% to 25% apparent (Fig. 25). Despite the high rotor speed of 130 000 rpm and a twist factor of αm 110, running properties on the rotor spinning machine were excellent even at a yarn count of 10 tex. (Fig. 26)

The advantages of the new machine technology such as SPEEDpass in combination with TENCEL® LF microfibers enable very fine yarns to be produced with 110 fibers in the cross section and very high productivity.

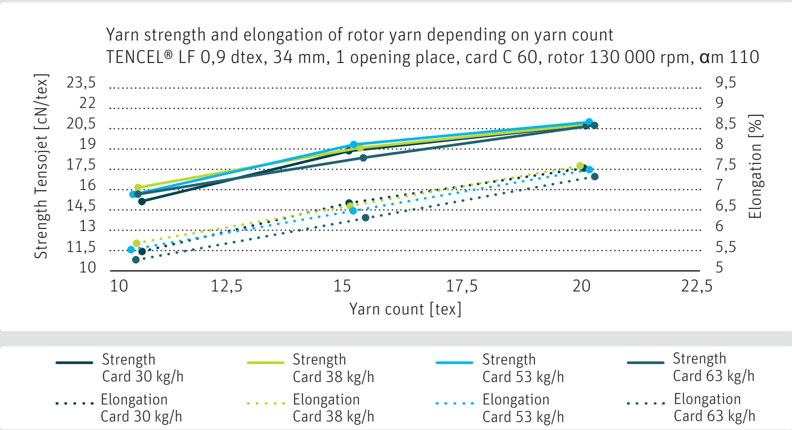
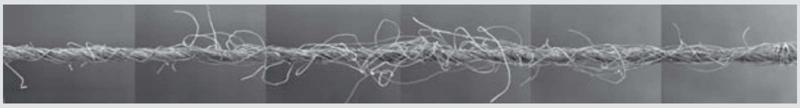


Fig. 26 Yarn strength and elongation of rotor yarn depending on yarn count

Conventional card, 25 kg/h, ring yarn conventional, αm = 110



Card C 60, 30 kg/h, ring yarn conventional, αm = 110

Card C 60, 30 kg/h, ring yarn COM4®, αm = 110

Card C 60, 30 kg/h, Siro yarn conventional, αm = 110

Card C 60, 30 kg/h, COM4®twin, αm = 110

Card C 60, 30 kg/h, rotor yarn, αm = 110

Fig 27 Yarn structures (15 tex, magnified)

FURTHER PROCESSING

Yarn density in g/cm^3 is considerably influenced by yarn twist and the final spinning process, or rather fiber preparation (Fig. 28).

Yarn density can thus be calculated by means of optical diameter measurement on the UT 4.

Yarn density in turn influences fabric handle in the textile fabric and dyeing.

Yarn diameter influences the covering capacity of the textile fabric.

Covering capacity, therefore, turned out best with rotor-spun yarn, whereas fabric handle was softer with compact yarn.

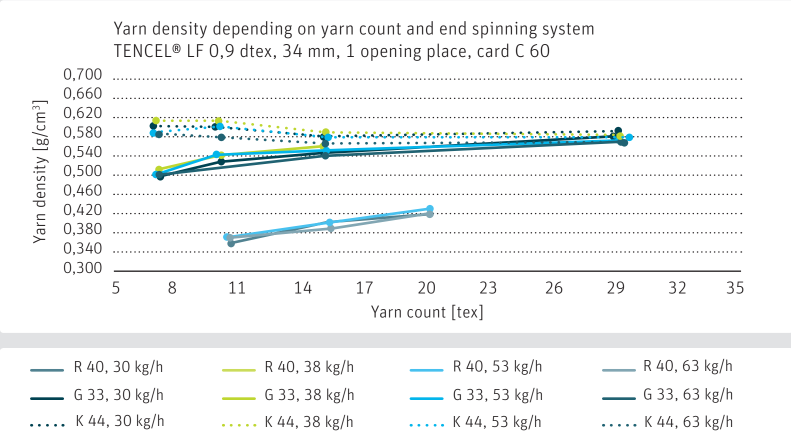


Fig. 28 Yarn density depending on yarn count and end spinning system

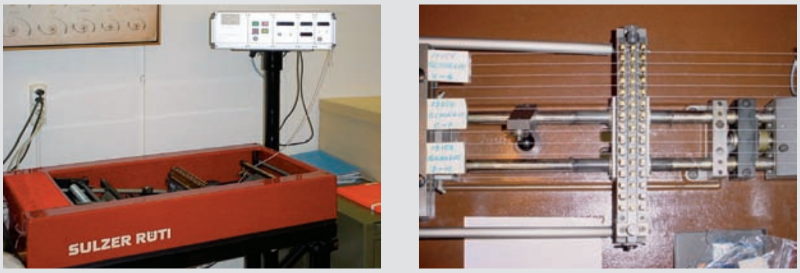


Fig. 29 Reutlinger Webtester

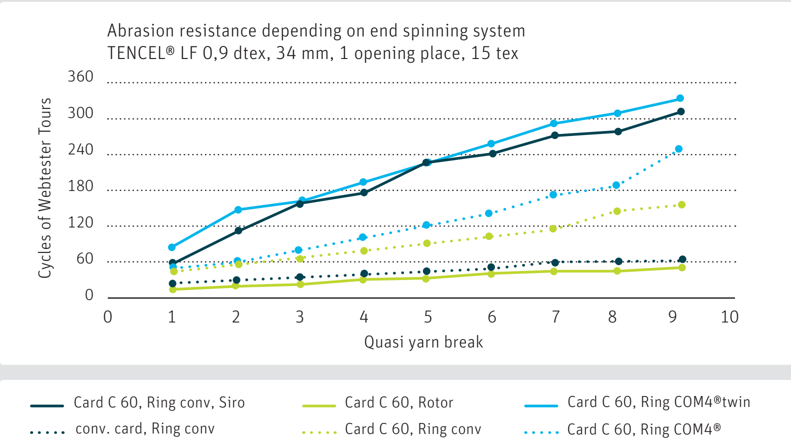


Fig. 30 Abrasion resistance depending on end spinning system

REUTLINGER WEBTESTER

Abrasion resistance is an important criterion in the downstream stages of yarn processing and the serviceability properties of textile fabrics.

The abrasion tendency after a certain number of cycles was tested for this purpose using the Reutlinger Webtester (Fig. 29). This measuring method enables the resistance of the yarns when used as warp ends in weaving to be simulated very accurately. At this point the measured values should be consulted as a criterion for the precision of fiber integration in the yarn.

The chart (Fig. 30) shows the number of cycles up to the yarn break. The highest number of cycles was measured with the conventional Siro yarn and COM4®twin.

Fiber preparation obviously has also an influence on the number of abrasion resistance. The conventional card operating at 25 kg/h with a short fiber content (SFC) (n) of 8% recorded twice more short fibers as the C 60 at 30 kg/h in conventional ring-spun yarn. (Fig. 31)

The ring-spun Siro yarns recorded the highest abrasion readings in these items. No fiber abrasion was apparent here, even after 330 abrasion cycles and 9 quasi yarn breaks. (Fig. 32)

Rotor-spun yarn structure is also very resistant to fiber abrasion, but the limit of 9 thread breaks set for this test was already reached after 49 abrasion passes.

However, a positive influence can again be exerted via yarn twist. The other yarn properties and the productivity of the rotor spinning machine then also change accordingly.

Conv. card, 25kg/h, 62 cycles Ring conventional | C 60, 30 kg/h, 154 cycles Ring conventional | C 60, 63 kg/h, 112 cycles Ring conventional | C 60, 30 kg/h, 245 cycles COM4®

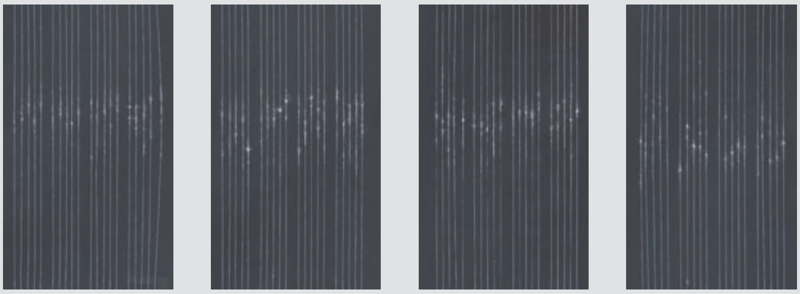


Fig. 31 Yarn abrasion in dependence of card production and spinning system

C 60, 30kg/h, 311 cycles Siro conventional | C 60, 30kg/h, 330 cycles COM4®twin | C 60, 30kg/h, 49 cycles Rotor

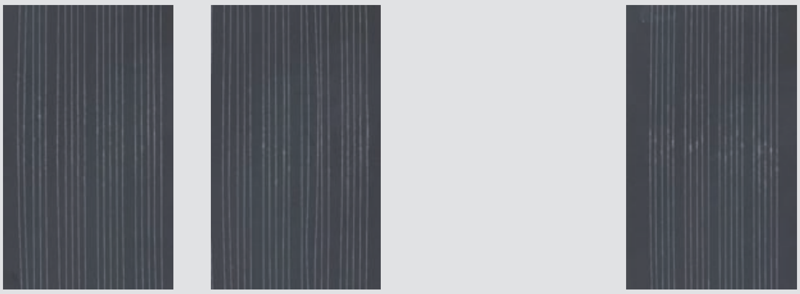


Fig. 32 Yarn abrasion in dependence of spinning system

SUMMARY

The following findings can be recorded on the basis of processing TENCEL® LF 0,9 dtex / 34 mm microfibers:

- The C 60 carding technology sets new standards for productivity and quality when processing new fiber technologies such as microfibers. Card production is 80% higher than conventional carding systems.
- TENCEL® microfibers results in significant compacting success up to yarn counts of 30 tex. Hairiness was substantially reduced further with fine yarn. Strength increased accordingly by up to 3,5 cN/tex.
- COM4®twin technology enables massive improvements to be achieved in hairiness / strength and abrasion resistance with this raw material.
- R 40 rotor spinning technology enabled final spinning counts of 10 tex to be achieved with TENCEL® microfibers – at rotor speeds of 130 000 rpm.

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